ACRONYMS AND ABBREVIATIONS

To ensure a more reader-friendly document, the U.S. Department of Energy (DOE) limited the use of acronyms and abbreviations in this environmental impact statement. In addition, acronyms and abbreviations are defined the first time they are used. The most common acronyms and abbreviations used in the text of this document are listed below.

CFR	Code of Federal Regulations
DOE	U.S. Department of Energy (also called *the Department*)
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	*Federal Register*
LCF	latent cancer fatality
MTHM	metric tons of heavy metal
NEPA	National Environmental Policy Act, as amended
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act, as amended
PM_{10}	particulate matter with an aerodynamic diameter of 10 micrometers or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 micrometers or less
REMI	Regional Economic Models, Inc.
RMEI	reasonably maximally exposed individual
Stat.	United States Statutes
TSPA	Total System Performance Assessment
U.S.C.	United States Code

UNDERSTANDING SCIENTIFIC NOTATION

DOE has used scientific notation in this EIS to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers of 10. The number written in scientific notation is expressed as the product of a number between 1 and 10 and a positive or negative power of 10. Examples include the following:

Positive Powers of 10
$10^1 = 10 \times 1 = 10$
$10^2 = 10 \times 10 = 100$
and so on, therefore,
$10^6 = 1,000,000$ (or 1 million)

Negative Powers of 10
$10^{-1} = 1/10 = 0.1$
$10^{-2} = 1/100 = 0.01$
and so on, therefore,
$10^{-6} = 0.000001$ (or 1 in 1 million)

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3×10^{-6} can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (for example, a fatal cancer) will occur in the period covered by the analysis.

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7. REPOSITORY DESIGN, PERFORMANCE, AND AFFECTED ENVIRONMENT

7 (897)

Comment - 010135 / 0001

Page 2-15, first paragraph, nowhere have I seen any reports on the success rate of encapsulation of high-level waste. Is this still in development? And if so, what happens to the plan if the process is found to be defective?

Response

Vitrification, rather than encapsulation, is the process that DOE plans to use for long-term storage of high-level radioactive waste. The vitrification process solidifies and immobilizes high-level radioactive waste into a borosilicate glass or ceramic form inside stainless-steel canisters. Although vitrification poses technical challenges, DOE has used it successfully for several years at the Savannah River Site in South Carolina and the West Valley Demonstration Project in New York (see Section A.2.3 of the EIS). It is a viable process for immobilizing high-level radioactive waste. The more than 1,000 canisters of high-quality borosilicate glass produced to date at the high-level radioactive waste vitrification facilities at the West Valley Demonstration Project in New York and the Defense Waste Processing Facility at the Savannah River Site in South Carolina are evidence of the vitrification process as a proven technology.

7 (899)

Comment - 010135 / 0003

Implementing a fuel blending procedure will be very difficult near the end of the program when there are fewer waste packages to blend.

Response

The fuel blending process takes into account the remaining commercial spent nuclear fuel that would need to be blended. DOE has performed studies to determine the overall feasibility of fuel blending and to estimate the type and size of facilities that would be needed to implement the process (DIRS 153849-DOE 2001, Section 2.2.1).

7 (900)

Comment - 010135 / 0004

Page 2-22, DOE makes the statement that 70 percent of the heat generated by the waste packages will be vented. The forced air mode will mean that air is drawn out, and the failure of a waste package would require that the ventilation system be shut down to prevent dangerous particles from being vented to the outside atmosphere. This shutdown would result in significant heating within the repository. I did not see this scenario analyzed.

Response

It is true that if the ventilation systems were not operating the drift wall and waste package temperatures would increase. The *Yucca Mountain Science and Engineering Report* discusses the impact of a ventilation shutdown for the lower-temperature design (DIRS 153849-DOE 2001, Section 2.3.4.3.1.3). It would take a period of 2 to 3 weeks for the maximum drift wall temperature [96ºC (205ºF)] to be exceeded. However, even assuming no ventilation for 15 years, the peak temperature of the waste package would still be less than 460ºC (896ºF) (DIRS 154278-CRWMS M&O 2001). Because the waste package has been analyzed to not fail prior to 600ºC (1,112ºF), the waste packages would not release gases or material due to fans failing for at least 15 years, thus providing ample time to repair the ventilation system or retrieve the waste packages.

7 (6780)

Comment - 010169 / 0001

I urge the project to consider use of self-shielded waste packages so the repository tunnels and waste packages could be directly inspected and (if necessary) maintained. Direct observation and maintenance is generally superior to remote operation and maintenance.

In this context, the government has in excess of 500,000 tons of depleted uranium and in excess depleted uranium and 2,000,000 tons of potentially contaminated steel. One shielding option to consider is use of these materials to produce a depleted-uranium-dioxide cermet as a shielding material. This would simultaneously dispose of these materials while improving repository performance. There are also other self-shielding waste package options.

Response
Self-shielding would not necessarily make direct inspection of the tunnels and waste packages possible. The expected operational temperatures within the drifts would not allow human access to the tunnels without significant additional cooling, and the self shielding would interfere with inspections of the waste packages because the barriers relied on for protection from corrosion would not be visible. Shielding waste packages could also make it more difficult to maintain peak fuel cladding temperatures below 350° C (600° F), required to protect the integrity of the cladding from creep rupture. The present design therefore does not include provision for self-shielding, and would not require human access should retrieval be required.

While accidents and malfunctions are not discussed in the Supplement to the Draft EIS, other project documents do discuss them. (See for example DIRS 153849-DOE 2001, Section 2.3.4.6.4.) During the preclosure period, which could be for more than 300 years, the repository will be open and subject to inspection and maintenance.

Management of the materials mentioned in this comment is the responsibility of DOE, but it is not within the scope of this EIS. The *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DIRS 152493-DOE 1999) describes the DOE depleted uranium inventory. DOE does not presently plan to dispose of depleted uranium in the proposed repository at Yucca Mountain.

7 (9324)
Comment - 010267 / 0001
In reading the supplementary report by the engineers on the Yucca Repository, we failed to find a description of the open pool that we have learned would be used for the cooling of spent nuclear waste (2.3.2.1.) North Portal Operating Area, Figure 2-5. We have also found detailed information about the plan to cover a 200 acre parking lot with asphalt for above-ground fuel storage. These intentions represent potential hazards that are not addressed adequately in the report and they need to be considered in the planning for such a facility.

Intensive studies must be conducted on the impacts to surface water and storm run-off from the above-ground cooling ponds and waste [canisters], as well as evaporative ponds. This is completely different from the impacts of deep geological storage previously studied. These potential hazards also call into serious question the wisdom in the planning for the total project.

Response
Accidents involving the spent nuclear fuel storage modules in the surface aging facility and the Waste Handling Building (which includes the fuel blending facility) are evaluated in Section H.2 of the Final EIS. These facilities would be designed and constructed to comply with all applicable Nuclear Regulatory Commission licensing requirements which would include seismic design criteria specific to the repository.

The treatment of water from the fuel pools is discussed in the Science and Engineering Report (DIRS 153849-DOE 2001, Section 2.2.4.3.1). As discussed in this section, liquid low-level radioactive waste will be recycled for reuse or reduced in volume by use of an evaporator and solidified in grout for offsite disposal.

The design of the repository includes a cooling tower adjacent to the utility building to support heat rejection from the utility building systems, such as the hot-water boilers. Water from the cooling tower, among other industrial streams would be collected in one of two evaporation ponds. The purpose of these ponds would simply collect and dispose of any sediment that could be contained in these water streams. Water from these industrial streams would not contain any radioactive or hazardous materials.

The design of the repository is still evolving. The Department would ensure that the industrial wastewater-evaporation system meets all applicable design requirements (including development of adequate maintenance and inspection programs) and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7 (12004)
Comment - 010135 / 0009
DOE must supply a timeline that is realistic with the analysis that shows that the temperature rise will not be exceeded if the vents are closed while the casks are being removed. From what I have read I doubt the worst case condition DOE has demonstrated by this analysis. I haven't seen any yet.

Response
If ventilation failed during retrieval operations, waste package heating would be very slow. In a recent assessment, it was determined that the peak temperature of the outer surface of the waste package [369º to 454ºC (700º to 849ºF)] would not occur until 15 years after a ventilation loss that took place immediately after emplacement (DIRS 154278-CRWMS M&O 2001). Thus, ample time would be available to restore ventilation. Furthermore, current plans include provisions for a high-efficiency particulate filtration system that could be used to filter the ventilation flow and eliminate most of the radionuclide particulate releases to the atmosphere if any radionuclide releases were to occur in the underground.

7 (12164)
Comment - 010319 / 0011
The idea of "resorting" waste is also a scary idea, considering the fact that it has never been done before, and that it would involve many opportunities for error arising from possible faulty record keeping and spent fuel originating from so many different sites.

Response
The processes planned for the blending of commercial spent nuclear fuel are the same that are being used successfully for fuel management at nuclear plants through out United States. The considerations mentioned in the comment regarding record keeping are routinely and safely done at the nuclear facilities.

Further information on blending strategy and proposed facilities can be found the Science and Engineering Report (DIRS 153849-DOE 2001, Sections 2.2.1 and 2.2.2.2).

7 (12183)
Comment - 010367 / 0009
Water in closed repository is expected to evaporate. How much water? Will it evaporate or react like a pressure cooker?

Response
Naturally occurring water would travel through the repository. Water that was able to flow into the vicinity of the emplacement drifts would be heated by the heat from the waste packages. If that heat was warm enough, the water would evaporate and travel through the emplacement drift or its surrounding rock structure. The pathways would be similar to the pathways that originally allowed the water to travel into the vicinity of the waste packages.

7 (12226)
Comment - 010325 / 0008
The margin for human error in record keeping alone seems enormous. Potentially deadly problems that have happened at other reactor sites, such as cranes getting jammed when lifting rods out of pools, lids being dropped on canisters, or gases threatening explosion, and I heard one story tonight about somebody dropping a soda can in a reactor, I don't know the details on that, could be magnified enormously.

Response
Blending would involve some additional handling of the commercial spent nuclear fuel, the only waste form to be blended. Blending is merely the selective loading of disposal containers to control waste package temperature. Accidental assembly drops, during handling and loading operations, are evaluated in Appendix H of the Final EIS and impacts from such accidents are provided (Section H.2.1.5). Releases from assembly drop accidents in the pool are mitigated by retention in the pool water, and all accidents within the confines of the Waste Handling Building are mitigated by the ventilation system which controls the flow of any radioactive release and filters any airborne discharge to the atmosphere. Further information on blending strategy and proposed facilities can be found the Science and Engineering Report (DIRS 153849-DOE 2001, Sections 2.2.1 and 2.2.2.2).

7 (12239)
Comment - 010135 / 0007
DOE writes about their magic bullet, Alloy 22. The welding and bending of this material changes its properties. DOE mentions that the materials will form an oxide coating that protects the metal. This will change when the material is welded. I doubt the cask can be remotely placed in a repository without breaking the oxide layer at various contact points.

On that same subject when you use two different metals and even if you combine them very tightly there's slight motion so the oxide layer will be broken between those two. I use the outboard motor industry as a classic example. If you use your aluminum housing and stainless steel screws, it doesn't take long before you can't get the screws out because they have corroded together. And that's because when you go in and tighten down the screw, you break the oxide layer.

Page 2-25, the statement that different corrosion-resistant materials will reduce the probability that a single mechanism can cause a failure of both materials, I don't think that's correct. How about electrolysis caused by dissimilar metals?

Response
The welding and bending of Alloy-22 was an important consideration in the modeling of waste package degradation. Several corrosion processes, including stress corrosion cracking were considered. Loss of passive films was also considered. Several of these processes are very important in the modeling outcomes. The low rate of Alloy-22 corrosion in a humid air or an aqueous environment would depend on the stability of the passive film on the surface. For the nickel-base Alloy-22, the film would be an oxide consisting primarily of chromium with nickel, tungsten, and molybdenum. Corrosion testing reported in research literature, as well as that performed by DOE, shows that this film would be stable under conditions expected at Yucca Mountain. These tests included service-condition testing and accelerated testing. However, the long-term stability of these films under expected Yucca Mountain conditions is uncertain because long-term tests have been underway for only a few years. New microanalytical techniques are being used to better quantify the corrosion rates and further elucidate film stability. These include atomic force microscopy, X-ray photoelectron spectroscopy, electrochemical impedance spectroscopy, and linear polarization. DOE plans to grow thicker oxides at higher temperatures using autoclaves to accelerate growth for composition and structure studies. In addition, DOE has initiated the development of an analytical, mechanistically based model for projecting long-term general and localized corrosion behavior and passive film stability.

The only contact between dissimilar metals would be between the stainless-steel inner sleeve and outer Alloy-22 layer. No credit is taken for the stainless-steel sleeve, which is considered only as a structural reinforcement prior to breach of the Alloy-22. Until the Alloy-22 was breached, the interface would not be wet or exposed to oxygen. Therefore, any damage to the passive layer would be of no consequence. After the Alloy-22 became breached, corrosion would proceed from the inside; the analysis has accounted for and such things as the presence of stainless steel.

The two dissimilar metals for defense-in-depth would be the titanium drip shields and Alloy-22 waste packages, which would be widely separated and not immersed in water. Therefore, there would be no likelihood of significant electrolysis effects. In addition, if contact did somehow occur, the interactions between the Alloy-22 waste package material and the drip shields would be negligible because they are very close on the galvanic series. Rather, because both corrode independently and by different processes, they would offer two layers of defense. However, the waste package could interact with the carbon steel of the ground support or invert system. This could accelerate the generation of insoluble ferric oxides or oxyhydroxides. These corrosion products are unlikely to be detrimental to the performance of Alloy-22, as discussed in Section 4.2.3.2.3 of the Science and Engineering Report (DIRS 153849-DOE 2001).

7 (12240)
Comment - 010135 / 0008
Page 2-25, second paragraph, if the drip shields are placed on the packages just before closure, what is the timeline from placement of the first drip shield to the last and what happens if there's a failure of the first waste package that received the shield as the last drip shield is put in place? This is a worst case that should be analyzed.

I believe that the timeline will be long enough that material will be emitted to the outside and again will violate the requirement that the natural barrier shall ensure that the material cannot contact the outside environment.

Response

Placement of the drip shields is estimated to require approximately 2.5 years. Although failure of any waste package during this period is highly unlikely, they will continue to be monitored for failure potential. The drip shields only serve a purpose long after closure (all ventilation ceases) and the wall rock cools sufficiently to allow water to condense and drip in the emplacement drifts (see DIRS 153849-DOE 2001).

Failure of a waste package has been considered in the repository accident analysis (Appendix H of the Final EIS). In this case, transporter runaway resulting in waste package collision with the access tunnel wall was found to be a credible event. This event was assumed to damage fuel rods in the waste package, and release radionuclides. The ventilation system was assumed to be operating for this accident, causing the maximum atmospheric release. Results are provided in Section H.2.1.5. Failure of an emplaced waste package with or without drip shields in place during the first 300 years was not considered a credible accident.

The goal of geologic disposal is to concentrate and isolate high-level radioactive wastes in a relatively small area for a very long time. The Department intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. In other words, the eventual release of some material is inevitable because all systems will degrade given sufficient time.

This EIS provides the Department's best estimate of the impacts that could occur when the containment system inevitably degraded. The EIS confirms that the Proposed Action would likely result in the small release of radioactive contamination to the environment within 10,000 years after repository closure. However, the EIS also shows that these releases under the Proposed Action would not exceed Environmental Protection Agency standards (40 CFR Part 197) within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations.

7 (12300)

Comment - 010135 / 0006

Page 2-23, section 2.3.4.1, nowhere have I found the time required to remove a worst case position a waste package that has failed prematurely. And I don't want to hear that they're not going to have any failures for 10,000 years. They can't prove that, and that has to be an absolute because they're saying that nothing is going to be out for 10,000 years, so that's a guarantee. That's not any kind of a percentage.

When one includes a worst case when both the forced air failed and a cask has failed, what will be the amount of material emitted to the atmosphere? What is the maximum temperature a waste package container can withstand before it releases material?

Has a cask been tested to ensure that it can prevent emitting gases and material? And if it hasn't been tested, how do you know that the temperature rise that you're planning for is adequate if the temperature rose because they failed?

Response

Premature waste package failure has been considered through an evaluation of a runaway waste transporter colliding into an access tunnel wall and releasing radionuclides that are then drawn into the ventilation system and discharged to the atmosphere. The results are provided in Section H.2.1.5 of the EIS. This accident would produce greater impacts than the same event with a failed ventilation system because without operation of the ventilation system, there would be minimal airflow to transport the radionuclides to the atmosphere.

In the unlikely event of a waste package failure and radionuclide release during forced ventilation, the ventilation monitoring system would detect the release and ventilation could be terminated. Repository heating would begin, but the rate of heating would be extremely slow. A recent assessment determined that the peak temperature of the waste package outer surface [369ºC to 454ºC (696°F to 849°F) would not occur until 15 years after a ventilation loss that took place immediately after emplacement (when the maximum heat generation would occur) (DIRS 148608-CRWMS M&O 2000). Thus, ample time would be available to restore ventilation. Furthermore, current plans include provisions for a filtration system that could be installed and used to filter the ventilation flow and eliminate most of the radionuclide particulate release, if any occurred.

The potential for early failures was determined by the analysis of both defects and degradation models. The potential for undetected defects would be very small, as shown in Section 4.2.4.3.1 of the Science and Engineering Report (DIRS 153849-DOE 2001). The degradation models were developed for each of the active degradation modes. These were combined in the WAPDEG (Waste Package Degradation) computer program, which was exercised as a function of time to determine the lifetime of the waste package in each of the regions of the potential repository. Details of this program are in the Science and Engineering Report (DIRS 153849-DOE). A range of cases was analyzed.

The results of the conservative analyses of waste package performance indicate that waste packages would not fail for at least 12,000 years. However, some process not defined or expected could lead to a failure before 10,000 years. Sensitivity runs were analyzed with a number of early failures, which were assumed to occur before 10,000 years. The dose to the public resulting from these early failures would be below regulatory limits (DIRS 153849-DOE 2001). A range of cases was analyzed.

7 (12403)
<u>Comment</u> - 010242 / 0021
Page 2-28: Section 2.3.6 - Repository Closure

Because of the possible large number of ventilation shafts (7 to 17) intersecting the repository, the Supplement should provide information on the current state of technology for sealing these shafts in a manner that will not result in creating conditions adverse to long-term repository performance. Ineffective shaft seals could have performance consequences of greater magnitude than inadvertent human intrusion.

<u>Response</u>
Supporting documents to the EIS such as the *Monitored Geologic Repository Project Description Document* (DIRS 151853-CRWMS M&O 2000), and other referenced supporting documents, discuss shaft-seal design. It has been established that the current technology for shaft sealing would sufficiently integrate the sealed openings so that they would perform as well as the host rock.

7 (12469)
<u>Comment</u> - 010242 / 0013
Page 2-15: Section 2.3.2.1 - Waste Handling and Approach to Fuel Blending

Fuel blending would be a very complex operation. The additional handling of highly radioactive SNF [spent nuclear fuel] in the pool building will create additional opportunities for accidents such as dropping of assemblies due to grapple failure or operator error. Releases of radioactive materials from accidents may or may not be contained in the pool storage and blending area. The mixing of SNF assemblies of different sizes and different radiological characteristics, from different fuel batches and/or reactors, will create numerous opportunities for errors (e.g., insertion of incorrect assembly in disposal canister, insertion of assembly in incorrect disposal canister cell, etc). Cleanup after accidents will likely increase worker exposures and generate additional streams of LLW [low-level radioactive waste], Mixed Wastes, and possibly HLW [high-level radioactive waste]. Indeed, the very feasibility of large-scale fuel blending is questionable.

<u>Response</u>
Blending is the selective loading of disposal containers to control waste package temperature. Blending would involve some additional handling of commercial spent nuclear fuel, which is the only waste form DOE would blend. Accidental drops of assemblies during handling and loading operations is evaluated in Appendix H of the EIS and the impacts from such accidents are described in Section H.2.1.5. The release of radionuclides from such an accident in the pool would be mitigated by retention of the radionuclides in the pool water. Accidents within the confines of the Waste Handling Building would be mitigated by the ventilation system, which would control the flow of any radioactive release and filter any airborne discharge to the atmosphere. Misloading of a waste package

could occur, and such events could result in excessive temperatures. The possibility of such events has been considered, and procedures for loading disposal containers would be developed (DIRS 150198-CRWMS M&O 2000). These procedures would be based on thermal analyses of the various waste package configurations such that a sufficient margin would be available to ensure that the temperature criterion would not be violated for any credible misload.

7 (12470)
Comment - 010242 / 0020
Page 2-23: Section 2.3.4.1 - Waste Package and Drip Shields

The Supplement does not, but should, acknowledge the uncertainty in the corrosion resistance of Alloy-22 and the titanium proposed for drip shields, nor does it acknowledge the uncertainty in the knowledge of the subsurface environment in which these metals are asserted to be “extremely corrosion resistant.”

Response
The uncertainty associated with many processes, including corrosion and repository environments, is acknowledged and discussed in detail in the Science and Engineering Report (DIRS 153849-DOE 2001). DOE referenced the Science and Engineering Report in the Supplement to the Draft EIS. See Chapter 5 and Appendix I of the Final EIS, and supporting documents referenced therein, for additional discussion of how these uncertainties are accounted for in the modeling of long-term performance. Even considering the very large range of simulated environments and a very wide uncertainty range in corrosion rates, these materials are still extremely corrosion resistant.

7 (12555)
Comment - 010242 / 0012
Page 2-15: Section 2.3.2.1 - Waste Handling and Approach to Fuel Blending

Fuel blending is not discussed in detail in either the DEIS [Draft EIS] (see Appendix E, Pp. 11-12) nor in the SEIS [Supplement to the Draft EIS] (p.2-15). The SEIS refers the reader to Section 2.2.1 of the Science and Engineering Report (DOE 2001a). The SEIS should contain a full description of the proposed fuel blending process.

Response
The detail of discussion of fuel blending in the Supplement to the Draft EIS is similar to the detail provided in the Draft and Final EISs for other features of the waste handling process. DOE believes that this level of detail is sufficient for the EIS. As mentioned in various places in the Draft EIS, Supplement to the Draft EIS, and the Final EIS, additional information on repository facilities is contained in the Viability Assessment, the Science and Engineering Report, and the Site Recommendation Report. Please see those documents for additional information about fuel blending.

7 (12560)
Comment - 010116 / 0008
Nowhere have I found at the time required to remove in the worst case position a waste package that has failed prematurely. This entire EIS assumes that there will be no waste package failing prematurely. I think that’s very optimistic. When one includes the worst case when both the forced air fails and the cask fails, what will be the amount of material emitted into the atmosphere? What is the maximum temperature a waste package container can withstand before it releases material? Has the cask been tested to ensure that it can prevent any emitting gases or material if the temperature rose after the fans failing?

Response
Retrieval of a waste package at any time during repository operations is a design requirement for the facility. Provisions would also be made to retrieve a waste package under off-normal conditions (DIRS 153849-DOE 2001). Failure of a waste package has been considered in the repository accident analysis (Appendix H of the EIS). For example, a credible accident would be a runaway waste transporter colliding into an access tunnel wall. This event was assumed to damage all fuel rods in the waste package, and release radionuclides. The ventilation system was assumed to be operating during the accident, resulting in the maximum release of radionuclides to the atmosphere. The impacts from such an accident are described in Section H.2.1.5.

Heatup of a cask following ventilation failure is very slow. In a recent assessment, it was determined that the peak temperature of the outer surface of the waste package [369º to 454ºC (696º to 849ºF)] would not occur until 15 years after a ventilation loss that takes place immediately after emplacement (DIRS 154278-CRWMS M&O 2001). Thus, ample time is available to restore ventilation prior to significant overheating. Furthermore, current plans include provisions for a high-efficiency particulate filtration system that can be used to filter the ventilation flow and eliminate most of the radionuclide particulate release to the atmosphere if any radionuclide releases were to occur in the underground.

7 (12594)

Comment - 010371 / 0003

The proposed action in the Supplement calls for DOE to establish an interim storage facility to age waste before emplacement. It is questionable whether the proposed surface aging facility violates the provisions of the Nuclear Waste Policy Amendments Act which forbids a monitored retrievable storage facility to be constructed at the proposed repository site. Coincidentally, the proposed aging facility has the approximate capacity of the proposed private fuel storage at Skull Valley, Utah. DOE should have incorporated Skull Valley in the Supplement as a possible alternative to the surface aging facility at Yucca Mountain, particularly in light of the prohibition to an MRS. The surface aging facility is a significant departure from the proposals in the DEIS and yet there appears to be very limited discussions of its impacts in the document.

Response

Although the flexible design described in the Supplement to the Draft EIS includes a surface aging facility for storage of as much as 40,000 metric tons of heavy metal over a 50-year period, this facility has been proposed as a repository operational option that could provide a cost-effective method of achieving a lower-temperature repository. DOE does not agree that the siting limitations for interim storage facilities contained in the Nuclear Waste Policy Act constrain the operational flexibility of the repository or ultimately the long-term performance of the repository. Therefore, DOE believes that the surface aging facility option constitutes a potential operational element of a proposed repository.

The purpose of the EIS is to provide a reasonable estimate of environmental impacts that could result from the Proposed Action to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain. Therefore, the Final EIS has included the impact estimates for the Proposed Action, which include both higher- and lower-temperature operating modes. DOE believes that the range of impacts presented for these operating modes, which include impacts resulting from construction, operation, and decommissioning of a surface aging facility (for the lower-temperature operating mode) provide adequate information to inform the decisionmaking process.

Since DOE published the Draft EIS, the Nuclear Regulatory Commission has published the *Draft Environmental Impact Statement for the Construction and Operation of an Independent Spent Nuclear Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah* (DIRS 152001-NRC 2000). That EIS evaluates the potential construction and operation of an interim storage facility that would be licensed by the Nuclear Regulatory Commission for storage of commercial spent nuclear fuel. Because of the similar size and function, impacts from this facility are likely to be similar to those of a surface aging facility at the proposed repository.

7 (12607)

Comment - 010242 / 0010

The Supplement states, “Under the S&ER flexible design, DOE could vary other operating parameters such as ventilation rates and the blending of hotter and cooler spent nuclear fuel in the same waste packages.” Forced ventilation rate is indicated to be a fixed operating parameter, at 15 cubic meters per second, in Table 2-l of the supplement. If it is intended to be varied, the extent of the variation must be described and analyzed in the Supplement.

Response

Table 2-1 in the Supplement to the Draft EIS, as described in the text, lists “…key underground design and operating parameters…” The 15 cubic meters per second (about 32,000 cubic feet per minute) is a design parameter estimated to provide the desired operating goal of removing approximately 70 percent of the waste-generated heat during the preclosure period. This parameter is needed for various designed features of the repository operating modes. If variations changed the thermal loading in the emplacement drifts, the volume of ventilating air could be varied accordingly. Under variations in operating conditions, the volume of ventilation air could also be varied, though DOE does not currently anticipate the need to vary the ventilation rate.

For details of the higher-temperature repository operating mode ventilation estimates, see *FEIS Update to Engineering File – Subsurface Repository* (DIRS 150941-CRWMS M&O 2000).

7 (12773)
Comment - 010116 / 0003
S-2, paragraph one, DOE intends to control the temperature. The method of control is similar to maintaining a water level in a bathtub with the drain open and the faucet partially open. The drain must continue to have the same restriction. The water pressure must remain constant and the water temperature shall remain the same or the level will not remain constant. This is a simple problem in open control. DOE expects all the parameters affecting temperature source to have the same temperature grading until the site is closed. It's a very optimistic plan.

Response
In the first paragraph on page S-2 of the Supplement to the Draft EIS, DOE might have inadvertently implied more temperature control than is actually intended or required. The intent would be to provide thermal management so that the rock temperature in the pillars, the waste package surface temperature, or the drift wall temperature would not exceed specified values. Thermal management is not intended to "control" the temperature at specific values. In general, the approach would be to use forced air cooling in the emplacement drifts to remove up to 70 percent of the heat generated by the waste and transfer it to the atmosphere. The remaining heat, which could cause the waste packages or the rock in the repository to heat up, would be managed using other variables such as waste package spacing or spent nuclear fuel aging. A typical thermal response would show rock temperatures in the pillars, drift walls, and waste package walls dropping below specified values while the fans were still running, and increasing, but not reaching, specified values after the fans were turned off, then decaying to much lower levels in the long term.

7 (12818)
Comment - 010299 / 0011
"Fuel Blending" -- the process of mixing fuel assemblies of different temperatures to lower a waste package temperature has never been done before. To do this safely, the exact history of each fuel assembly must be known. Any mistakes in record keeping could lead to mistakes in packaging, and more uncertainties in the repository performance. The Supplement fails to talk about any specific plans or mechanics for fuel blending. The Supplement makes no mention of possible impacts of incorrect record keeping and unknown waste package temperatures from blending.

Response
The processes planned at Yucca Mountain for blending commercial spent nuclear fuel are the same as those being used successfully at nuclear plants throughout the United States. The considerations mentioned in the comment regarding record keeping are routinely and safely done at these nuclear facilities. Further information on blending strategy and proposed facilities can be found in the Science and Engineering Report (DIRS 153849-DOE 2001).

7 (12828)
Comment - 010305 / 0004
Is the repository to be hot or cold? How hot is hot?

Response
As discussed in Section 2.2.2.2 in the Supplement to the Draft EIS, the flexible design discussed in the Science and Engineering Report (DIRS 153849-DOE 2001) includes the ability to operate the repository in a range of operating modes that address higher and lower temperatures and associated humidity conditions. Higher-temperature means that at least a portion of the emplacement drift rock wall would have a maximum temperature above the boiling point of water at the elevation of the repository [96ºC (205ºF)]. The lower-temperature operating mode ranges include conditions under which the drift rock wall temperatures would be below the boiling point of water, and conditions under which waste package surface temperatures would not exceed 85ºC (185ºF).

7 (12858)
Comment - 010262 / 0011
"Fuel Blending"- the process of mixing fuel assemblies of different temperatures to lower a waste package temperature has never been done before. To do this safely, the exact history of each fuel assembly must be known. Any mistakes in record keeping could lead to mistakes in packaging, and more uncertainties in the repository performance. The Supplement fails to talk about any specific plans or mechanics for fuel blending. The Supplement makes no mention of possible impacts of incorrect record keeping, and unknown waste package temperatures from blending.

Response
The processes planned at Yucca Mountain for blending commercial spent nuclear fuel are the same as those being used successfully at nuclear plants throughout the United States. The considerations mentioned in the comment regarding record keeping are routinely and safely done at these nuclear facilities. Further information on blending strategy and proposed facilities can be found in Science and Engineering Report (DIRS 153849-DOE 2001).

7 (12902)
Comment - 010314 / 0010
Even the operating history of the fuel rods of a single reactor will have varied from year to year, including such parameters as fluctuating temperatures, pressures and water chemistries -- resulting in a range in the volume and curie content of (1) the gaseous and solid fission products and transuranics within the fuel rods, and (2) the activation and corrosion products on the inside and outside of the rods. The varied operating history would also have affected the integrity of each fuel rod's cladding (the rod's hollow metal tubing in which some 250 uranium pellets are stacked) and the rod's top and bottom welds, which in turn would affect the leakage rate of the fission products during the rod's submersion in the fuel pool (a period of at least 20 or 30 years) and during the rest of the life of the rod. That's forever.

A typical thousand-megawatt pressurized reactor, like the Callaway plant here in Missouri, will have approximately 50,000 fuel rods fissioning in its reactor vessel at any one time. The history of one rod, and hence its radioactive contents, will differ from every other rod. For example, the history of the cladding of the rods near the center of the fuel core in the reactor will have been vastly different from the history of assemblies of rods near the periphery.

Other contents of the casks are also worrisome. Because of the probable presence of pyrophoric zirconium and zirconium hydride from the fuel rod cladding in the spent fuel casks, an explosion from inside the cask would be possible during transport, storage, or disposal.

Response
DOE agrees that the commercial spent nuclear fuel rods shipped to the repository would have different operating histories that would influence the amount and location of radionuclides. However, provisions have been made to accommodate these differences in the design of the repository. Fuel rods with damaged cladding would be packaged separately in sealed canisters before shipment. Radionuclides that leaked from the fuel rods during submersion in the repository pools would be removed by the water treatment system. Although finally divided zirconium can react pyrophorically in air, there would be no significant amount of zirconium particles in the waste packages. Since the waste packages would be backfilled with an inert gas, helium, and pyrophoric materials would not be permitted in shipping casks or waste packages, explosions involving the waste materials would not be possible.

7 (12921)
Comment - 010281 / 0006
Increased Ventilation The DEIS and the Supplement fail to provide adequate analysis of the ventilation design ability to maintain flow through when blocked, or partially blocked, by the accumulation of organic matter (vegetation, rodent or bird feces) or wind-driven soil drifts over the design time scales.

Response
Although specific analyses of the maintenance operations were not provided in the Supplement to the Draft EIS, the design includes appropriate maintenance of the ground support system and the ventilation system to ensure effective operation of the systems. In addition, the thermal transients likely occur if the ventilation system was temporarily

shut down would be very slow. If additional maintenance beyond what has been planned was required, the system could be shut down for long periods to complete required repairs without consequences from lack of cooling.

7 (13028)
Comment - 010071 / 0001
In case a volcanic eruption or earthquake disrupts Yucca Mountain, what then?

Who pulls out the [canisters]?

Where are they to be taken?

Who transports them?

How fast will they be removed?

Who's going to foot the bill, for not only that, but also for medical care of the residents?

An emergency plan has to be ready.

Response
The EIS contains analyses of impacts that could arise from disruptive events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probabilities and effects of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

DOE has evaluated the long-term geologic stability of Yucca Mountain, including the potential for volcanoes. Volcanic activity has been waning in the recent geologic past; the probability of a volcano that could disturb the repository is very low (see EIS Section 3.1.3.1). Nevertheless, DOE presents an analysis of the effects of both a volcanic eruption, which could release volcanic ash and entrained wastes into the atmosphere, and the intrusion of magma into the emplacement drifts, which could damage waste packages and contaminate the underlying aquifer. DOE estimated potential impacts on the nearest population to the south, conservatively assuming wind in that direction.

The dose history for volcanic disturbances is presented above as a probability-weighted annual dose resulting from events occurring at uncertain times throughout the period of simulation. This approach to calculating and displaying the probability-weighted annual doses is consistent with the approach specified in 40 CFR Part 197 and is required for determination of the overall expected annual dose. However, displays of the probability-weighted annual dose do not allow direct interpretation of the conditional annual dose, which is the annual dose an individual would receive if a volcanic event occurred at a specified time. For conditional analyses, the probability of the event is set equal to one, and the time of the event is specified. Conditional results do not provide a meaningful estimate of the overall risk associated with igneous activity at Yucca Mountain, but they provide insights into the magnitude of possible consequences for specific sets of assumptions. A sensitivity calculation was performed to provide results for this conditional case (DIRS 154659-BSC 2001). Conditional mean annual dose histories were calculated for eruptive events at 100, 500, 1,000, and 5,000 years. The conditional mean dose in the first year after an eruptive event at 100 years after repository closure would be approximately 13 rem. The conditional dose in the first year after an eruption would decrease to approximately one half this level for an eruption 500 years after closure, and would be approximately 10 percent of this value for an eruption 5,000 years after closure. The calculation was made with a previous Total System Performance Assessment model (DIRS 153246-CRWMS M&O 2000) that has some differences from the model used elsewhere in this EIS for long-term performance (DIRS 157307-BSC 2001). The differences that affect the analysis described above are that dose factors were revised to conform to 40 CFR Part 197 and the distance analyzed is 18 kilometers (11 miles) rather than 20 kilometers (12 miles) from the repository. These changes would be expected to increase the dose values at 100 years and 500 years by a factor of between 2 and 3. The results at the later times would increase by about 20 percent.

Sensitivity studies for the Total System Performance Assessment suggest that the probability-adjusted dose from a volcanic eruptive event at 18 kilometers (11 miles) in the direction of wind transport of an ash plume would peak at a few tenths of a millirem per year.

As discussed in Section 5.2.3.5 of the Draft EIS, the major effect of an earthquake at Yucca Mountain would be ground motion (shaking) rather than direct offset along a fault. The *Disruptive Events Process Model Report* (DIRS 151968-CRWMS M&O 2000) discusses the effect of offset along a fault. Past movement has been along existing faults, and the probability of new faults forming is low. DOE would not emplace waste packages near existing faults, so the probability of shearing a waste package would be very low.

Although the probability of an earthquake or volcano disrupting the repository prior to closure is highly unlikely, provisions have been considered for recovering from accidents or malfunctions. While accidents and malfunctions are not discussed in the Supplement to the Draft EIS, other project documents do discuss them [see, for example, the Science and Engineering Report (DIRS 153849-DOE 2001)].

Section 122 of the NWPA requires DOE to maintain the ability to retrieve emplaced spent nuclear fuel and high-level radioactive waste. Nuclear Regulatory Commission regulations [10 CFR Part 63, particularly Section 63.111(e), require that the repository be designed so that any or all of the waste could be retrieved on a reasonable schedule starting at any time up to 50 years after the start of waste emplacement. In accordance with these requirements, the operational plan for the Yucca Mountain Repository provides a design that would maintain the ability to retrieve emplaced materials for at least 100 years and possibly as long as 300 years. The EIS evaluated retrieval as a contingency action, and describes potential impacts if it was to occur (see Section 4.2). DOE evaluated only actions it could predict with any certainty (that is, removal of emplaced waste materials and subsequent onsite storage). Because future actions regarding the management and disposal of these materials following retrieval would be at the direction of Congress, are highly speculative, and are unnecessary to support current decisionmaking, DOE believes it is inappropriate to evaluate impacts that could result from these actions.

In 1988, the Price-Anderson Act was amended to provide liability coverage to DOE activities (including transportation) involving spent nuclear fuel, high-level radioactive waste, and transuranic waste. The Act provides liability coverage for commercial activities operating under a license from the Nuclear Regulatory Commission and DOE activities by establishing a system of private insurance and federal indemnification that generally ensures that up to $9.43 billion is available to compensate for damages suffered by the public, regardless of the causes of the damage. Payment would be from government funds or, if public liability arose out of nuclear waste activities funded by the Nuclear Waste Fund (for example, activities at a geologic repository), from the Nuclear Waste Fund. Appendix M contains more information.

If the proposed repository became operational, DOE would enter into discussions with potentially affected units of local government and consider appropriate support and mitigation measures. In addition, as required by Section 180(c) of the NWPA, DOE would provide technical assistance and funds to States for training for public safety officials of appropriate units of local government and Native American tribes through whose jurisdictions DOE would transport spent nuclear fuel and high-level radioactive waste. Training would cover procedures required for safe routine transportation of these materials, as well as procedures for dealing with emergency response situations. Sections 116(c)(2) and 117(c)(5) of the NWPA also set forth assistance guidelines covering a number of issues, including emergency preparedness and response, respectively].

7 (13106)
Comment - 010227 / 0024
This suggestion of fuel blending has never been done before. It requires the knowledge of the exact history of each fuel assembly. It requires perfect record keeping. The nuclear industry does not have a history of perfect record keeping.

Response
The processes planned at Yucca Mountain for blending commercial spent nuclear fuel are the same as those being used successfully at nuclear plants throughout the United States. The nuclear industry has been using historical data for many years as the basis for performing core reload and criticality calculations and has an excellent record for

accurately predicting the response of the reactor. The records and data that will be used for fuel blending are the same records that the utilities have used to calculate core reloads and criticality.

Further information on blending strategy and proposed facilities can be found in the Science and Engineering Report (DIRS 153849-DOE 2001).

7 (13118)

Comment - 010298 / 0005

In addition to the instability of the site, there are serious concerns about the stability of the irradiated fuel rods within the casks. I remember when the melted Three Mile Island fuel was transported to Idaho. Recombiner catalysts were installed in the top and bottom of the canisters to prevent the buildup of a flammable gas mixture or internal pressure within the cask, and to prevent a fire or a hydrogen explosion from occurring. The catalyst was intended to combine the radiolytically-generated hydrogen and oxygen gases released from the residual water entrapped within the fuel back into water in order to prevent the formation of combustible or explosive gas mixtures. However, I understand that the catalyst cannot function if submerged in water.

Response

Based on requirements for shipping casks and waste packages, no water would be permitted inside the containers. Thus, generation and buildup of hydrogen from radiolytic decomposition of water would not occur. In addition, the greatly reduced radiation fields from fuel that must be cooled 5 years prior to shipment would limit the generation of hydrogen even if water was present.

At the repository, casks containing disposable containers (such as DOE and naval spent nuclear fuel and high-level radioactive waste) that had already been thoroughly dried and purged with inert gases as noted above, would remain sealed and be processed through the Canister Transfer System for placement in a disposal container (DIRS 153849-DOE 2001). Casks that contained commercial spent nuclear fuel in dual-purpose canisters or individual fuel assembles would go to the Assembly Transfer System (DIRS 153849-DOE 2001), where the drying, purging, and inert gas filling process would occur.

The waste handling processes would prevent the potential problems noted in this comment during shipping and handling and during packaging and emplacement in the repository.

7 (13119)

Comment - 010298 / 0006

On the other hand, fine particles of zirconium, from the fuel rod cladding, must be kept either virtually dry or completely submerged if an explosion or spontaneous ignition is to be prevented. This seems a rather precarious technology. Storing the waste in a geologically unstable environment only adds to the chances of a cataclysmic failure and the potential for release of highly radioactive materials to the environment.

Response

Although finely divided zirconium can react pyrophorically in air, there would be no significant amount of zirconium particles in the waste packages. In addition, because the fuel assemblies would be dried before waste package loading, and the DOE-owned spent nuclear fuel would be dried before being loaded into canisters and the waste packages would be backfilled with helium, there would be insufficient oxygen to combine pyrophorically with zirconium. The geology of the Yucca Mountain site has been extensively studied, and the location of the repository is in a geologically stable area with no active faults intersecting the location of the emplacement drifts. The effects of large earthquakes have been evaluated in Section H.2.1.3 (preclosure) and in Chapter 5 (postclosure) of the EIS and the impacts of such events have been estimated.

7 (13172)

Comment - 010243 / 0019

The Fuel Blending process mentioned in the SDEIS is not discussed in detail in either the DEIS nor in the SDEIS. The SDEIS should contain a full description of the proposed fuel blending process. This description should include a complete estimate of the NEPA cognizable impacts that will occur as a result of the proposal. This information is not contained in the SDEIS. Clark County has two specific concerns with regard to the fuel blending facility. The first is impact related. The second is perceptual.

The fuel handling facility necessary to implement the action proposed by the SDEIS is itself a significant impact that is not assessed in the SDEIS. There are numerous unanswered questions about the facility. These questions should have been addressed in the SDEIS.

- How many rods will the facility handle at a time?
- What operations are performed on the rods?
  - Inspection
  - Removal from packaging
  - Characterization
- Replacement into packaging
- How many people are employed?
- What is the size of the budget for the facility?
- How long did it take to construct? License? Etc...
- What special emergency management precautions are provided to surrounding communities?

Response

The level of discussion in the EIS is similar to the description of the other operational characteristics of the waste handling process. DOE based its preparation of the Draft EIS, the Supplement to the Draft EIS, and the Final EIS on the Viability Assessment (DIRS 101779-DOE 1998), Science and Engineering Report (DIRS 153849-DOE 2001), and Preliminary Site Suitability Evaluation (DIRS 155734-DOE 2001), which provide more detailed engineering descriptions. These and the other references cited in this EIS provide more detail about blending and other detail aspects of the design. Further information on blending strategy and proposed facilities are in the Science and Engineering Report (DIRS 153849-DOE 2001). Chapter 4 of the Final EIS includes a full evaluation on potential impacts related to the fuel blending process. DOE believes that the level of detail is consistent with the National Environmental Policy Act and provides information sufficient to support the Secretary of Energy's determination whether to recommend the Yucca Mountain site for development of a repository.

7 (13175)

Comment - 010243 / 0022

The handling of highly radioactive HLW in the pool building will create additional opportunities for accidents. Releases of radioactive materials from accidents may or may not be contained in the pool storage and blending area. The mixing of SNF assemblies of different sizes and different radiological characteristics, from different fuel batches and/or reactors, will create numerous opportunities for errors (e.g. insertion of incorrect assembly in disposal canister, insertion of assembly in incorrect disposal canister cell, etc).

Response

Blending would involve some additional handling of the commercial spent nuclear fuel, which is the only waste form to be blended. Blending would consist of the selective loading of disposal containers to control waste package temperature. Accidental assembly drops during handling and loading operations are evaluated in Appendix H of the EIS and impacts from such accidents are discussed in Section H.2.1.5. Releases of radioactive materials from dropped assemblies in the pool would be mitigated by retention of the materials in the pool water; accidents within the confines of the Waste Handling Building would be mitigated by the ventilation system, which would control the flow of any radioactive release and filters any airborne discharge to the atmosphere. An error during loading of a waste package could occur, and such events could result in excessive temperatures. The possibility of such events has been considered, and it is expected that procedures for loading containers would be developed based on thermal analyses of the various waste package configurations such that sufficient margin would be available to ensure that temperature criterion would not be violated if a loading error occurred (DIRS 150198-CRWMS M&O 2000).

7 (13184)

Comment - 010243 / 0031

The fuel-blending proposal may not be feasible because of the standard contracts with utilities that describe the order in which the DOE must accept the SNF [spent nuclear fuel] from the utilities. It is entirely possible that the fuel-handling facilities will have to be significantly different than described in the SDEIS in order to accommodate a wide range of significantly different types of fuel necessary to make fuel-blending possible. The SDEIS should have carefully described how the NPA [new proposed action] will avoid these problems.

Response
The current design for the repository allows flexibility in the types of commercial spent nuclear fuel that DOE would receive. However, the estimated receipts are based on DOE projections of actions that utilities would take to deliver spent nuclear fuel for disposal and are independent of the repository design. Rather, they are based on the terms of DOE's Standard Contract for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste contained in 10 CFR Part 961 and the generation and storage characteristics of each generator site (see discussion of CALVIN computer program in Section J.1.1.1 of the EIS). Therefore, DOE believes that the flexible design, including the blending facility, would accommodate fuel that would be shipped to a Yucca Mountain repository based on the terms of the Standard Contract.

7 (13259)
Comment - 010274 / 0001
From the very beginning, my major concern were [are] the containers, (casks), this high level nuclear material will be stored in. What will be the constant temperature without attempts to neutralize it? How much heat will Gamma Ray; [Alpha} Rays; [neutrons]; [protons]; radioactivity; Fission products and continual radiation-generated heat; will there be?!!

Your office has not disclosed the tremendous heat that will be generated within each container.

Response
The designs of the waste packages and repository consider the heat output from all sources of radiation in the spent nuclear fuel. Surface aging, fuel blending, ventilation, waste package sizes, and waste package spacing are some of the methods that might be used to control the temperature within the repository. In addition, a recent assessment determined that the peak temperature of the outer surface of the waste package [from 369º to 454ºC (696º to 849ºF)] would not occur until 15 years after a ventilation loss that takes place immediately after emplacement (DIRS 154278-CRWMS M&O 2001). Thus, ample time would be available to restore ventilation prior to any significant waste package degradation from overheating. Furthermore, current plans include provisions for a high-efficiency particulate filtration system that can be used to filter the ventilation flow and eliminate most of the radionuclide particulate release to the atmosphere if any radionuclide releases were to occur in the underground.

7 (13306)
Comment - 010157 / 0003
Now they want to put in a dry storage pad up there of 200 acres of cement. Well, they decided not to use concrete underneath the containers inside the mountain because of the alkalinity, and yet they want to store these dry fuel pods for 50 years on 200 acres of alkaline concrete sitting out in the hot Nevada sun where the ground temperature gets to something like 150° for 50 years. I don't think that makes much sense.

I asked about that storage pool -- and I hadn't planned on this foolish speaking tonight. I just wanted to stay home and be comfortable but sometimes one gets a bur under one's saddle. I asked about the storage pool, and I was told 5,000 metric tons, and that is for blending. Well, now, this blending business puts me in my kitchen. And if I want to make some warm water, maybe I want to make some bread and get the yeast right, you know. Oh, I forgot I had to answer the phone. The water boiled. Well, I want to cool the water, so I put some cold water in it.

Now, they want to blend the hot nuke waste above boiling point with the colder nuke waste to get -- I don't know what they want to get, but they never done it and they don't know what the heck is going to happen when they do it.

When the first atomic particles were being experimented upon there was a meeting somewhere or other, I don't remember, I don't know what that was all about, but they had some of these cute little pellets. They didn't hold them in their hand but they did lay them down on the table. And these little pellets started jumping towards each other and all those scientists just about had to go home and change their clothes because they were going -- they were scared to death that these cute little pellets were either going to fission or fusion, and they didn't know what. And now we want to mix hot rods with cold rods. No, I don't think so. That doesn't make sense.

The gentleman told us 5,000 metric tons. This thing says 12,000 fuel assemblies as an inventory for fuel blending. Well, there's a difference between 12,000 and 5,000. I asked how big was this pool to be. Oh, about the size of this room. Well, they looked it up and it's 160 feet by 37 feet by 50 feet deep.

Now, from the front of this stage to the front of the kitchen there is 80 feet. Now, twice that length. That's the length of it. The interior of this room is about 44 feet wide. And it's to be 37 feet wide. So it's going to be twice as long as the room and almost as wide. It's going to be 50 feet deep. You know that's five stories? And they have no idea how much water that's going to hold. They told me to multiply it out and figure it for myself.

They don't have a source for the water. It's in litigation they told me. This is going to be -- these rods are going to be held in there for 50 years. And I would sure like to see some plans for this and see, find out who's going to bid on building these storage pools.

In fact, there's going to be four of them side by side. I didn't ask them then is this going to be one pool with bars in between like four attached pools or are they going to be four separate pools. I don't know, but I don't think it makes much differences. The whole thing is foolish.

Response
Dry storage on concrete pads would occur for the relatively short period of 50 years. During the 50-year period DOE would monitor the dry storage facility to ensure that the facility was safe. Concrete was removed from the emplacement drift design to reduce the chance of waste package and spent nuclear fuel corrosion due to alkalinity concerns over 10,000 years.

The processes planned for the blending pool are the same as those being used successfully at nuclear plants throughout United States. The considerations mentioned in the comment regarding match heat output to balance temperatures are implemented, in a manner similar to those proposed for thermal blending at the proposed repository, at the nuclear facilities. The Science and Engineering Report contains more information on blending strategy and proposed facilities (DIRS 153849-DOE 2001).

DOE filed suits on March 2, 2000, in the U.S. District Court for the District of Nevada, and on March 3, 2000, in Nevada's Fifth Judicial District Court for injunctive relief to overturn the Nevada State Engineer's Ruling No. 4848, dated February 2, 2000, denying DOE's water-appropriation request for 530,000 cubic meters (430 acre-feet) per year for repository construction and operation. The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest.

On September 21, 2000, the U.S. District Court Judge granted the State's motions to dismiss the DOE lawsuit. DOE appealed the ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE suit. The case is pending.

DOE has not developed any other plans to acquire water for the proposed repository. Depending on the final ruling, DOE might consider other options to carry out its responsibilities under the NWPA.

The proposed Yucca Mountain design continues to plan on the use of water from Nevada Test Site water wells. DOE will review this plan and determine what necessary cause of action is required based upon future court rulings.

7 (13472)
Comment - 010372 / 0002
Page 2-l indicates that DOE may include as many as 6,000 more canisters under the proposed action in the Supplement as compared to the proposals in the Draft Environmental Impact Statement, an almost 50 percent increase. With respect to the additional canisters, there appears to be no discussion or analysis related to the expanded repository size (105,000 metric tones [sic]), total acreage needed, and the prospects for increased juvenile canister failures.

Response
As discussed in Section 2.1 of the Supplement to the Draft EIS, under the Proposed Action DOE would permanently place approximately 11,000 to 17,000 waste packages containing no more than 70,000 metric tons of heavy metal (MTHM) of spent nuclear fuel and high-level radioactive waste in a repository at Yucca Mountain.

The number of waste packages now estimated to be needed to accommodate the material has a larger range than the 10,000-to-11,000-package design described in the Draft EIS due to the potential use of smaller commercial spent nuclear fuel waste package designs (to reduce the heat output per waste package) and to changes to the waste package designs for DOE spent nuclear fuel and high-level radioactive waste. Appendix A of the EIS contains additional information on the inventory and characteristics of spent nuclear fuel, high-level radioactive waste, and other materials that DOE could emplace in the proposed repository.

Under the Nuclear Waste Policy Act of 1982, the repository is limited to 70,000 MTHM and the EIS evaluates the flexible design scenarios that support 70,000 MTHM. Based on public comments during EIS scoping hearings, the EIS evaluates a possible total projected inventory of commercial spent nuclear fuel and DOE spent nuclear fuel and high-level radioactive waste (Inventory Module 1) and the of that total inventory plus the inventories of commercial Greater-than-Class-C waste and DOE Special-Performance-Assessment-Required waste (Inventory Module 2) (see EIS Chapter 8). That inventory projection has not changed since the Draft EIS was published. The impacts have been updated to reflect the flexible design. The EIS does not contemplate inventory greater than those of Modules 1 and 2.

7 (13473)
Comment - 010372 / 0003
Page 2-8 indicates that DOE would consider aging as much as 40,000 MTHM of commercial spent nuclear fuel during a 50-year period. The surface aging proposal appears to be a significant change in basic proposals for the repository. More than half of the total waste would be held above ground in effect creating an interim storage facility. This change probably requires additional environmental analysis beyond this supplement. There is very limited analysis in the Supplement as it relates to the surface aging requirement. Coincidentally, the amount of waste considered for aging is similar to the amount proposed for the Skull Valley interim site. DOE should incorporate the possibility of a Skull Valley site into any future waste management system. It appears that the surface aging facility for maintaining this inventory at the Yucca Mountain site is nothing more than a thinly disguised monitored retrievable (MRS) or interim storage facility. The co-location of a repository and an MRS is specifically prohibited by the Nuclear Waste Policy Act.

Response
Although the flexible design described in the Supplement to the Draft EIS includes a surface aging facility for storage of as much as 40,000 metric tons of heavy metal over 50 years, this facility has been proposed as a repository operational option that could provide a cost-effective method of achieving a lower-temperature repository. DOE does not agree that the siting limitations for interim storage facilities contained in the NWPA constrain the operational flexibility of the repository or ultimately the long-term performance of the repository. Therefore, DOE believes that the surface aging facility option constitutes a potential operational element of a proposed repository.

The purpose of the EIS is to provide a reasonable estimate of environmental impacts that could result from the proposed action to construct, operate and monitor, and close a geologic repository at Yucca Mountain. As such, the Final EIS has included the impact estimates for the Proposed Action, which include both higher- and lower-temperature operating modes. DOE believes that the range of impacts presented for these operating modes, which include impacts resulting from construction, operation, and decommissioning of a surface aging facility (for the lower-temperature operating mode) provide adequate information to inform the decisionmaking process.

Since DOE published the Draft EIS, the Nuclear Regulatory Commission has published the Draft Environmental Impact Statement for the Construction and Operation of an Independent Spent Nuclear Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah (DIRS 152001-NRC 2000). That EIS evaluates the potential construction and operation of an interim storage facility that would be licensed by the Nuclear Regulatory Commission for storage of commercial spent nuclear fuel. Because of the similar size and function, impacts from this facility are likely to be similar to those of a surface aging facility at the proposed repository.

7 (13495)
Comment - 010288 / 0009
The process of mixing fuel assemblies of different temperatures to lower a waste package temperature is inadequately discussed in the Supplement. To blend fuels safely, the exact history of each fuel assembly must be known. Any mistakes in record-keeping would lead to mistakes in packaging, and more uncertainties in the

repository performance. The Supplement fails to discuss any specific plans or mechanics for fuel blending, and makes no mention of possible impacts of incorrect record keeping.

Response
The processes planned for the blending commercial spent nuclear fuel are the same that are being used successfully for fuel management at nuclear plants through out United States. The considerations mentioned in the comment regarding record keeping are routinely and safely done at the nuclear facilities.

Further information on blending strategy and proposed facilities can be found the Science and Engineering Report (DIRS 153849-DOE 2001).

7 (13514)
Comment - 010367 / 0005
"Blending" of various temperatures is untested, timing and results unknown.

Response
An error during loading of a waste package could occur, and such events could result in excessive temperatures. The possibility of such events has been considered, and it is expected that disposal container loading procedures will be developed based on thermal analyses of the various waste package configurations such that sufficient margin will be available to ensure that temperature criterion will not be violated if a loading error occurred (DIRS 150198-CRWMS M&O 2000). Further information on blending strategy and proposed facilities can be found the Science and Engineering Report (DIRS 153849-DOE 2001).

7.1 Repository Design

7.1 (31)
Comment - 6 comments summarized
Commenters said that the design of the waste package is preliminary and conceptual. Others said the design described in the Draft EIS is no longer the operative design concept and it is likely to change again as more is learned about the materials and their interaction with near-field environmental conditions at selected thermal load conditions. Some noted that the most current design of the waste package has the two layers flipped; the Alloy-22 is now on the outside of the canister with the carbon steel on the inside, and the thicknesses have changed.

Commenters state that because the waste package is so central to repository performance, and to the amplification or attenuation of impacts from the repository, the EIS should contain a complete and final description of the waste package chosen by DOE to ensure waste containment. It would also be appropriate for the EIS to comprehensively evaluate alternative waste package designs and select the preferred design for use in a Yucca Mountain repository. Without a preferred design, it is impossible to evaluate the environmental and human health impacts of the repository.

Commenters were concerned that many aspects of the waste package are conceptual. Examples included statements in Chapter 2 that the waste packages would be loaded with fissile material and neutron absorbers "if needed." Commenters wanted to know when and how these decisions would be made. Others said that DOE could not conduct detailed reliability analyses on a conceptual design for the waste package.

Response
In the Draft EIS, DOE evaluated a preliminary design based on the Viability Assessment of a Repository at Yucca Mountain (DIRS 101779-DOE 1998) that focused on the amount of spent nuclear fuel (and associated thermal output) that DOE would emplace per unit area of the repository (called areal mass loading). Areal mass loading was represented for analytical purposes in the Draft EIS by three thermal load scenarios: a high thermal load of 85 metric tons of heavy metal (MTHM) per acre, an intermediate thermal load of 60 MTHM per acre, and a low thermal load of 25 MTHM per acre. These scenarios were not intended to place a limit on the choices among alternative designs because, as stated in the Draft EIS, DOE expected the repository design to continue to evolve in response to ongoing site characterization and design-related evaluations. Rather, DOE selected these analytical scenarios to represent the

repository performance. The Supplement fails to discuss any specific plans or mechanics for fuel blending, and makes no mention of possible impacts of incorrect record keeping.

Response
The processes planned for the blending commercial spent nuclear fuel are the same that are being used successfully for fuel management at nuclear plants through out United States. The considerations mentioned in the comment regarding record keeping are routinely and safely done at the nuclear facilities.

Further information on blending strategy and proposed facilities can be found the Science and Engineering Report (DIRS 153849-DOE 2001).

7 (13514)
Comment - 010367 / 0005
"Blending" of various temperatures is untested, timing and results unknown.

Response
An error during loading of a waste package could occur, and such events could result in excessive temperatures. The possibility of such events has been considered, and it is expected that disposal container loading procedures will be developed based on thermal analyses of the various waste package configurations such that sufficient margin will be available to ensure that temperature criterion will not be violated if a loading error occurred (DIRS 150198-CRWMS M&O 2000). Further information on blending strategy and proposed facilities can be found the Science and Engineering Report (DIRS 153849-DOE 2001).

7.1 Repository Design

7.1 (31)
Comment - 6 comments summarized
Commenters said that the design of the waste package is preliminary and conceptual. Others said the design described in the Draft EIS is no longer the operative design concept and it is likely to change again as more is learned about the materials and their interaction with near-field environmental conditions at selected thermal load conditions. Some noted that the most current design of the waste package has the two layers flipped; the Alloy-22 is now on the outside of the canister with the carbon steel on the inside, and the thicknesses have changed.

Commenters state that because the waste package is so central to repository performance, and to the amplification or attenuation of impacts from the repository, the EIS should contain a complete and final description of the waste package chosen by DOE to ensure waste containment. It would also be appropriate for the EIS to comprehensively evaluate alternative waste package designs and select the preferred design for use in a Yucca Mountain repository. Without a preferred design, it is impossible to evaluate the environmental and human health impacts of the repository.

Commenters were concerned that many aspects of the waste package are conceptual. Examples included statements in Chapter 2 that the waste packages would be loaded with fissile material and neutron absorbers "if needed." Commenters wanted to know when and how these decisions would be made. Others said that DOE could not conduct detailed reliability analyses on a conceptual design for the waste package.

Response
In the Draft EIS, DOE evaluated a preliminary design based on the Viability Assessment of a Repository at Yucca Mountain (DIRS 101779-DOE 1998) that focused on the amount of spent nuclear fuel (and associated thermal output) that DOE would emplace per unit area of the repository (called areal mass loading). Areal mass loading was represented for analytical purposes in the Draft EIS by three thermal load scenarios: a high thermal load of 85 metric tons of heavy metal (MTHM) per acre, an intermediate thermal load of 60 MTHM per acre, and a low thermal load of 25 MTHM per acre. These scenarios were not intended to place a limit on the choices among alternative designs because, as stated in the Draft EIS, DOE expected the repository design to continue to evolve in response to ongoing site characterization and design-related evaluations. Rather, DOE selected these analytical scenarios to represent the

range of foreseeable design features and operating modes, and to ensure that it considered the associated range of potential environmental impacts.

Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties or improve long-term repository performance, and improve operational safety and efficiency. The result of the design evolution process was the development of the flexible design. This design focuses on controlling the temperature of the rock between the waste emplacement drifts (as opposed to areal mass loading), but the basic elements of the Proposed Action to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain remain unchanged. DOE evaluated the flexible design in a Supplement to the Draft EIS, which was released for public review and comment in May 2001.

As described in the Supplement to the Draft EIS, DOE has redesigned the waste package to include a thick outer shell of a corrosion-resistant high-nickel alloy (Alloy-22) and a thick inner shell of stainless steel for strength. This newer design would resist corrosion far better than the design described in the Draft EIS, and has improved the predicted performance of the repository and reduced uncertainties associated with that performance. Section 2.1.2.2.4 of the Final EIS describes the flexible design waste package.

The type and amount of neutron absorber necessary for a specific waste package design would be determined by DOE prior to receipt of a license from the Nuclear Regulatory Commission to receive and posses spent nuclear fuel and high-level radioactive waste. This would have to be done consistent with a criticality analysis methodology that had been accepted by the Nuclear Regulatory Commission. The specifics of that methodology are presented in "Disposal Criticality Analysis Methodology Topical Report" (DIRS 101095-CRWMS M&O 1998), which DOE submitted to the Nuclear Regulatory Commission in January 1999.

DOE has determined how many waste packages with neutron absorbers would be necessary for the alternatives evaluated. DOE accounted for different types and quantities of neutron absorbers in the "baseline" design for the Draft EIS (see Appendix I) to determine the quantity of toxic materials originating from the waste package materials. The updated flexible design did not affect this baseline. The presence of neutron absorbers would not affect degradation behavior of the waste packages.

The Final EIS addresses all aspects of the Proposed Action, including the flexible design. DOE acknowledges in the EIS that the flexible design could be further modified or refined during the license application process, if the site is approved for development. DOE believes that the information on the potential environmental impacts that could result from either the Proposed Action or the No-Action Alternative complies with the Nuclear Waste Policy Act requirements for a Final EIS to accompany any recommendation by the Secretary of Energy to the President to approve Yucca Mountain for development as a repository. This belief is based on the level of information and analysis, the analytical methods and approaches used to represent conservatively the reasonably foreseeable impacts that could occur, and the use of bounding assumptions where information is incomplete or unavailable or where uncertainties exist.

7.1 (33)
<u>Comment</u> - 10 comments summarized
Commenters said that storage casks at some commercial reactor sites have prematurely failed. Problems experienced with storage casks such as the Ventilated Storage Cask, Model 24 system used at the Palisades site and the Transtor system used at the Trojan site suggest that problems with waste package at the repository are inevitable. Commenters stated that the cask design for Plant Hatch is flawed; the process used to design and certify cask designs is not standard, promotes using cheap materials, allows easy changes to designs; and cask design and operations are not tested correctly, vent holes are too small, coatings create flammable hydrogen, ground down welds are too thin, designs are changed for every reactor site, and coatings are painted on rather than baked on, causing turbidity problems in pools.

<u>Response</u>
The issues noted by the commenters are widely documented in bulletins of the Nuclear Regulatory Commission, inspection reports, letters, and other public documents. Many of these issues resulted from a failure of the licensee to adequately implement the required quality assurance and quality control programs; however, they are important because lessons were learned that can be applied to existing and future storage system technologies.

Spent nuclear fuel storage systems, like the one used at Palisades, are designed and licensed to the requirements of 10 CFR Part 72; spent nuclear fuel transportation systems are designed to the requirements of 10 CFR Part 71; and disposal systems are designed to the requirements of 10 CFR Part 60. The storage systems designed only to 10 CFR Part 72, like the Model 24, would not be used for transportation or disposal. As discussed in this EIS, the spent nuclear fuel located at the 72 commercial and 5 DOE sites would be transported to the repository in casks licensed to the requirements in 10 CFR Part 71.

DOE acknowledges the difficulties in design and implementation of effective quality assurance programs. However, much has been learned over the past decades related to fabrication, installation, and maintenance of components important to nuclear safety. As part of the waste package performance analysis, DOE conducted a comprehensive evaluation of fabrication processes that indicated that, for the current design and with a strong quality assurance program, the Department anticipates only a small number of early failures. The updated analysis in the Final EIS projects the very unlikely event of between zero and five packages failing due to manufacturing defects. A strong quality assurance program would ensure proper fabrication, stress relief, and testing of the waste packages before emplacement.

7.1 (191)

Comment - 20 comments summarized

Commenters stated they were not convinced that the technology exists to design and fabricate a waste package that would last for thousands of years. Others were not convinced that DOE has the ability to confidently predict the performance of waste casks far into the future. Some said that the waste casks must last for 10,000 to 250,000 years without leaking and that this was impossible. Others said that the casks would deteriorate after 100 years. Some noted that the EIS even admits that some waste casks would fail within the next thousand years; after 10,000 years all the canisters may degrade and release radioactivity into the water and air. Still others wanted to know how DOE could conclude that the waste packages would last so long when the design of these packages has yet to be finalized, and could still change substantially during the licensing process. Some said that up to 95 percent of waste containment may be achieved with the waste package, yet very little information about its long-term performance capabilities has been developed, including the testing of full size waste packages for extended periods of time and to the point of failure.

Response

The waste packages and waste handling facilities are being designed and fabricated to meet the applicable Federal regulations, which include rigorous testing requirements. Section 2.1.2.1.1 of the EIS summarized the process by which waste packages would be loaded and sealed. All unloading of waste from transportation casks and loading and sealing of waste packages would be performed remotely in a manner similar to the way casks and canisters are loaded today for transportation and storage. DOE has extensive experience in designing, fabricating, testing, and implementing use of nuclear components. Over the past 30 years, there have been more than 2,700 U.S. spent nuclear fuel shipments in transportation casks with no releases.

DOE acknowledges that it cannot build a waste package that can be guaranteed to provide perfect containment forever. The EIS provides DOE's best estimate of the impacts that could occur when the containment system inevitably degrades. The Environmental Protection Agency, in promulgating the Yucca Mountain environmental protection standards (40 CFR Part 197), also recognized that with the current state of technology, it is impossible to provide a reasonable expectation that there will be "zero" releases over 10,000 years or for a longer period. Therefore, the Environmental Protection Agency has established standards that would protect human health and safety. These standards do not require complete isolation of the wastes over the compliance period (that is, 10,000 years) or the period of geologic stability (taken to be 1 million years). The goal of a performance assessment for Yucca Mountain supporting the site recommendation decision and later licensing (if the site was recommended) is to evaluate whether the repository is likely to meet these standards. The goal of this EIS is to project possible impacts using similar modeling technology. Chapter 5 of the EIS presents the results of these efforts, which show that releases under the Proposed Action would not exceed environmental protection standards (40 CFR Part 197) within 10,000 years of repository closure.

The design of the waste package, including its construction materials, has evolved from that used for the Viability Assessment reference design to the flexible design. While both use a two-layer waste package, the flexible design places the corrosion-resistant material on the outside rather than the inside the package to provide long-term protection to the more corrosion-susceptible structural material. The current waste package design includes a thick and very corrosion-resistant nickel-based alloy (Alloy-22) as the outer barrier, over a thick stainless-steel inner liner. Data on the corrosion performance of the waste package materials (including the internal structure) have been collected from DOE tests and from research literature. Testing would continue during waste emplacement and preclosure to collect long-term data under conditions prototypical of those expected at Yucca Mountain. The data generated would continue to be used by the scientists and engineers to determine the long-term performance of the materials as a part of the determination of total system performance in compliance with regulatory standards.

DOE based the development of models that predict the performance of corrosion-resistant, nickel-based Alloy-22 in the repository on data from research literature and testing. The Department performs long-term tests under expected repository conditions (months to years), and short-term tests (days to weeks) under expected repository conditions and conditions much more aggressive than those expected in the repository environment to provide confidence in the long-term performance of the materials. The American Society for Testing and Materials codified this approach (DIRS 105725-ASTM 1998). Analyses of the tests use a suite of tools, including standard microstructural evaluation and atomic force microscopy, which permits the examination of surface films in such great detail that DOE can evaluate even very slow degradation rates. DOE intends to continue to test samples of Alloy-22 (and other alloys that would be exposed in the repository) in the laboratory for decades to confirm the results collected to date. In addition, DOE would explore analogs of Alloy-22 to provide confidence in its performance.

DOE based the materials selection on the input of recognized subject-matter experts and laboratory tests, and from material performance observed in full-size industry applications. The corrosion tests involve Alloy-22 and other candidate waste package materials subjected to environments that are at least as aggressive as any expected inside Yucca Mountain. DOE would continue these tests during waste emplacement operations to confirm the expected waste package performance.

If the Secretary recommended the site to the President and the site was approved for further development, DOE would initiate testing as part of the performance confirmation program, elements of which would address the engineered barrier system. The purpose of this program would be to evaluate the adequacy of the information used to demonstrate compliance with performance objectives. The performance confirmation program, which would continue through closure of the repository (possibly more than 300 years after the end of waste emplacement), would monitor conditions at the waste packages in emplacement drifts and other systems important to performance, thereby reducing uncertainties.

7.1 (831)
Comment - EIS000160 / 0002
The Department is clear that the Yucca Mountain site cannot be depended upon to contain the waste. But rather than abandon the site, it is set out to design the undesignable: a container that can guarantee it will isolate the waste for as long as it remains hazardous. It is impossible for the Department -- regardless of what new technology or alloy may be invented -- to certify that an engineered container will hold up over the hundreds of thousands of years necessary to protect the environment and the public from releases from the site.

If we now accept that we must rely upon engineered barriers to contain the waste, then this program needs to be scrapped and redesigned from the bottom up. Yucca Mountain could not be said to have any distinct geologic advantage over any other site. There is a real possibility that no proposed geologic site in the United States would be able to meet the fundamental requirements for waste containment.

Response
DOE acknowledges that it cannot build a containment system that can be guaranteed to provide perfect containment forever. The EIS provides DOE's best estimate of the impacts that would occur when the containment system inevitably degrades. DOE does confirm in the EIS that the Proposed Action would be likely to result in release of radioactive contamination to the environment beginning as early as a few thousand years after repository closure. However, the EIS also shows that these releases under the Proposed Action would be far below environmental protection standards (40 CFR Part 197) within the 10,000-year compliance period for the repository, standards specifically enacted to ensure the safety of future generations.

The current approach by DOE is consistent with the NWPA, which recognizes the use of engineered features especially for defense-in-depth as noted in the following words from the Act:

"Such criteria shall provide for the use of a system of multiple barriers in the design of the repository…" [42 U.S.C. 10141(b)(1)(B)].

In addition, environmental standards recently issued by the Environmental Protection Agency for Yucca Mountain (40 CFR Part 197) as well as those issued by the Nuclear Regulatory Commission (10 CFR Part 63), require that DOE provide a reasonable expectation that the system (natural plus engineered barriers) would meet the performance objectives for the period after permanent closure. The analysis in the EIS suggests that these standards can be met by the total repository system (see Section 5.4.2).

To reduce the uncertainty inherent in long-term predictions of complex engineered and natural systems and improve the confidence in the system's ability to ensure safety at Yucca Mountain, DOE made physical changes to the engineered system (for example, more robust and corrosion-resistant waste packages). The improved design and modeling approaches represented by the flexible design in the Final EIS show peak doses that would be much smaller than the values published in the Draft EIS at the most populous locations (see Section 5.4.2).

However, not all of this reduction is due to improved engineered systems. A substantial reduction would be due to more realistic models that better account for factors in the natural system. Part of the compliance strategy is a defense-in-depth approach under which various components of the engineered and natural system would supply independent attenuation of dose impacts.

7.1 (1220)
Comment - EIS000296 / 0006
We're very concerned about some of the technical reviews that have taken place in the last couple of years about the Department of Energy's work on containers. Alloy C-22, for example, under certain conditions, can be not passive and so can actually have penetration and a loss of integrity in only a few tens of years. So relying on containers is just not going to be workable, and pretending that there is a solution to the waste management problem is a grave danger because there are real problems to high-level nuclear waste. And pretending that there's a solution just creates the incentive on the part of industry to extend their life, like Duke at Oconee 1, 2 and 3, and as nuclear utilities across the country are going to the NRC [Nuclear Regulatory Commission] to do right now. So pretending that you've got a solution causes a much bigger problem.

Response
DOE recognizes that any man-made material will fail under very adverse conditions given enough time. However, the potential for such adverse conditions to exist at Yucca Mountain is extremely low. Based on technical data to date, DOE is confident that the Alloy-22 of the outer waste package would be stable for extremely long periods. To further increase confidence in the long-term performance of Alloy-22, DOE is performing very-long-term testing under actual conditions and somewhat adverse conditions. In addition, DOE would examine waste packages remotely for several decades prior to closure of the repository for performance confirmation.

7.1 (2647)
Comment - EIS000409 / 0005
Plans for the Canisters: Is there any metal or metallic compound that can withstand temperatures of 300° - 360°C? The Nelson limits were created by observation of catastrophic failure whenever metallurgy was not appropriate to contain a variety of elements under harsh conditions. At the NRC [Nuclear Regulatory Commission] & DOE meetings 1 out of 100 canisters would blow. Is this the reason for the 12 mile buffer zone in the EIS?

MC I (my bugs) will enjoy eating the canisters (as proved by the tests performed by Livermore Labs at YM [Yucca Mountain] and the bugs will add even more poison into the water in the leaky mountain. Liability for on site accidents is also unknown.

Response
The EIS analyses did not reveal any instances where waste package temperatures would exceed 300ºC (570ºF). Such temperatures would only be possible from an igneous intrusion, which is an exceedingly unlikely disruptive

event. Maximum waste package temperatures would be less than 300ºC at all times. Both stainless steel and Alloy-22, the principal waste package materials evaluated for the flexible design in the Final EIS, are routinely subjected to higher temperatures in industrial applications. DOE is performing tests to examine the properties of Alloy-22 at elevated temperatures over extended periods.

The Nelson limits (Nelson curve) mentioned by the commenter is mainly applicable to embrittlement of carbon steels exposed to high (for example, greater than 100 pounds per square inch) partial pressures of hydrogen gas at high temperature [300º to 360ºC (570º to 680ºF)]. However, these limits do not apply to the waste packages because very little hydrogen gas is present and, for the updated flexible design, carbon steel is no longer used as one of the barriers. DOE has investigated hydrogen embrittlement for the waste packages and determined it not to be an important failure mechanism.

DOE disagrees with the assertion that the waste packages would rupture due to temperature induced internal pressures. Pressures of sufficient level to cause package rupture could only occur with temperatures far higher than those expected in the repository.

With regard to the 20-kilometer (12-mile) buffer zone [revised to 18 kilometers (11 miles) for the Final EIS based on recently finalized 40 CFR Part 197 regulations], for purposes of analysis, the extent of a land withdrawal area is important to understanding the impacts of the Proposed Action. For example, the magnitude of impacts to a member of the public from an accident at an operating repository would be determined in part by the proximity of the land withdrawal area to the repository operations areas. However, the withdrawal area is only in effect while there is active institutional control. For the Final EIS, the approximately 18-kilometer location prescribed by the regulators (40 CFR 197.21) for calculating potential doses to the reasonably maximally exposed individual was not based on the proposed land withdrawal boundary. This receptor location was based on the likely future location of a small community of persons and farms, given the physical setting of the potentially affected area, and the depth to water in that setting.

DOE acknowledges that certain microbes can survive on metallic surfaces under the right conditions (based on tests conducted at Lawrence Livermore National Laboratory on microbiologically influenced corrosion (DIRS 110016-Horn et al. 1998). However, the microbes do not eat the metal. The microbes may secrete substances that can alter the corrosion environment on the waste package. Studies of corrosion of the titanium drip shields indicate that the effect of microbial growth on the corrosion potential is not significant and the initiation of crevice corrosion under biological films formed on titanium has never been observed. Therefore, the drip shield material would not be affected by microbially influenced corrosion. Studies indicate that the Alloy-22 can be subject to this effect if the humidity exceeds 90 percent and sufficient nutrients exist. In the analysis used for the Final EIS, microbially influenced corrosion of Alloy-22 is represented by a corrosion enhancement factor represented in the probabilistic sampling of the analysis of long-term performance by a uniform distribution between 1.0 and 2.0.

7.1 (3482)
Comment - EIS001185 / 0001
What is the construction of the containers that will contain the nuclear waste? Will the waste be encased in an inert material such as glass? What assurance do we have for our children and grandchildren that there will be no leakage before the material is inactive? Are the final burial containers the same as those used for transport?

Response
As described in the Supplement to the Draft EIS (issued for public review in May 2001) and the Final EIS, the waste package would be a cylindrical container with a thick outer wall of high-nickel alloy (Alloy-22) and a thick inner wall of stainless steel. DOE selected the high-nickel material for corrosion resistance and the stainless steel, which is also corrosion resistant, for structural strength. The engineered barrier system, which would include the waste package as a key element, would preclude releases that represented a risk to populations for 10,000 years after repository closure.

The waste packages that DOE would place in the repository would be very different from the shipping casks used to transport the waste to the repository. The shipping casks would be large containers designed for transport by railcars or trucks. The shipping cask would be designed to protect people from exposure to radiation and to contain the waste in the event of a severe transportation accident. The Nuclear Regulatory Commission would license the container designs for waste transport, but not for disposal in the repository.

Sections 5.2.2 and I.2.4 of the Final EIS contain more information on the design and expected lifetime of the waste package.

7.1 (4872)
<u>Comment</u> - EIS000337 / 0010
Pg. 2-57: The three bullets indicate that DOE will continue to study design improvements. Why can't these studies be used in the No-Action Alternative and thus improve the storage life at the various sites?

<u>Response</u>
The Nuclear Regulatory Commission, the Electric Power Research Institute, and DOE are currently sponsoring a program to examine fuel that has been in dry storage for 15 years. These studies might result in improved designs for onsite storage facilities. However, under the NWPA, DOE is responsible for determining the suitability of the Yucca Mountain site for a geologic repository. The determination of site suitability will be based on the expected long-term performance of the natural and engineered barriers. The engineered barriers include the waste package. It is prudent, therefore, that DOE continue to investigate improvements to the design of the waste package that could further reduce the eventual release of radioactive materials from the repository.

Future improvements in dry storage technology could reduce the environmental consequences of the No-Action Alternative. However, DOE has no control over the storage of commercial spent nuclear fuel at utility sites. Therefore, it would not be justified for DOE to take credit in the EIS for reductions in the projected environmental consequences of the No-Action Alternative from unspecified, future dry storage technology.

7.1 (5368)
<u>Comment</u> - EIS001887 / 0085
Page 2-32; Section 2.1.2.2.2 - Waste Package Design

The current design of the waste package has the two layers flipped. The Alloy-22 is now on the outside of the canister with the carbon steel on the inside.

<u>Response</u>
The current waste package design utilizes a thick outer barrier of a corrosion-resistant nickel-based alloy over a thick inner structural liner of stainless steel. This is a change from the early design in the Draft EIS. This newer design has expected superior corrosion performance, so that the Draft EIS results are conservative in regard to waste package lifetime. The Final EIS includes the current waste package design.

7.1 (5369)
<u>Comment</u> - EIS001887 / 0086
Page 2-32, Section 2.1.2.2.2 - Waste Package Design

Issues of criticality are addressed by stating that neutron absorbers (if needed) would be placed within the waste package so that no criticality could take place "even if the package somehow became full of water." There is no discussion of the resultant possible steam explosion that could occur if water made contact with the waste form. A steam explosion could be almost as bad as a criticality incident. Any kind of explosion inside an emplacement drift could be detrimental to the entire repository block.

<u>Response</u>
The potential for a steam explosion, or any other kind of explosion, inside a waste package or within an emplacement drift is not credible. Rapid expansion of water to create a "steam explosion" would require an appreciable amount of water being dumped on the waste form while temperatures are well in excess of 100°C (212°F). As discussed in Section I.4.3.3 of the Draft EIS, penetration of the outer barrier of the waste package would not be expected before 800 years. Penetration of the inner barrier would only be expected in a very small fraction of the emplaced waste packages within 10,000 years. Such failures would be the earliest opportunities for water to contact the waste form. By this time, waste temperatures would be well below 100°C. For the flexible

design evaluated in the Final EIS, package failures would be expected to occur later than with the Draft EIS design because of improved waste package design and the addition of titanium drip shields.

7.1 (5370)
<u>Comment</u> - EIS001887 / 0087
Page 2-34; Figure 2-21 - Conceptual design of waste package in emplacement drift.

The current conceptual design of the emplacement drift does not include a concrete liner. The current conceptual design of the emplacement drifts should be described in Section 2.1.2.2.3, Waste Package Emplacement Operations.

<u>Response</u>
DOE believes that ongoing site characterization and design-related evaluations would demonstrate a continued improvement in repository performance and a reduction in associated uncertainties. However, DOE also recognizes that since publication of the Draft EIS, certain key aspects of the design (for example, waste package design and use of drip shields) have changed in ways that are important to repository performance and reduction in uncertainties. For this reason, DOE published the May 2001 Supplement to the Draft EIS, which focuses on the most recent base design, including various thermal management strategies. DOE believes that the level of information provided for each element (for example, waste handling facilities, heat management scenarios, and transportation alternatives and scenarios) of the Proposed Action is sufficient to provide a meaningful assessment of environmental impacts for review by the public and the decisionmakers, and thus the timing of the EIS is appropriate.

7.1 (6422)
<u>Comment</u> - EIS001632 / 0010
Page 2-32: The second paragraph contains a general description of the waste package used for the performance assessment. The description of the waste package must be updated in the Final EIS.

<u>Response</u>
As described in the Supplement to the Draft EIS and incorporated into the Final EIS, the waste package has been redesigned to include a thick outer shell of a corrosion-resistant high-nickel alloy (Alloy-22) and a thick inner shell of stainless steel for strength. This newer design would resist corrosion far better than the design described in the Draft EIS, and would improve the predicted performance of the repository and reduced uncertainties associated with that performance. Section 2.1.2.2.4 of the EIS describes the waste package design.

7.1 (6481)
<u>Comment</u> - EIS001774 / 0003
There is not a shred of evidence to support that thermally hot, highly radioactive fuel rods will stay intact at any site. We're supposed to comment on non-existent and untested technology at an inappropriate site. According to DOE document DE-AC04-84A-25747, "These wastes have a potential for causing great harm." They are thermally hot, 250,000 BTUs per hour and highly radioactive. A ruptured cask either in transport or in the dump itself would be a major environmental disaster that could contaminate a large area. The recent small disaster in Japan would be nothing compared to a breach of containment.

<u>Response</u>
The waste that DOE would place in the repository would be mainly commercial spent nuclear fuel and DOE high-level radioactive waste. The spent nuclear fuel would be clad in an alloy of zirconium containing small alloying additions. It would be very resistant to corrosion, and the chemical industry has used it for more than 50 years to contain very aggressive chemical solutions. The cladding has operated at high temperatures and pressures in commercial nuclear reactors for as long as 3 years before removal and storage at the reactor site. Only a very small fraction of this cladding, less than 1 percent, has failed in service, and failure rates have decreased with improvements in fuel-rod design. Through modeling, DOE evaluated the degradation of this cladding in the repository and found that it would remain intact for thousands of years.

As described in the Supplement to the Draft EIS and the Final EIS, the waste package has been redesigned to include a thick outer shell of a corrosion-resistant high-nickel alloy (Alloy-22) and a thick inner shell of stainless steel for strength. DOE has evaluated the waste package design for resistance to chemical and mechanical degradation and evidence suggests that waste packages would survive intact for tens of thousands of years. DOE's confidence in the corrosion resistance of Alloy-22 is bolstered by years of industry experience, input from independent experts, ongoing lab tests that would continue well into the repository operations period, and a fabrication program that is examining the impact of fabrication and welding on material performance.

DOE recognizes that accidents could occur during the transportation of spent nuclear fuel and high-level radioactive waste. For this reason, the EIS evaluates risks and impacts to the public from accident scenarios that are highly unlikely but that would have severe consequences (called maximum reasonably foreseeable accident scenarios). For the maximum reasonably foreseeable accident scenarios, the analysis selected the accident scenario from the 32 possible combinations of weather conditions, population zones, and transportation mode that would have a likelihood greater than 1 in 10 million per year and would have the greatest consequences. Table 6-12 lists the impacts from such an accident.

In a similar manner, DOE has evaluated potential impacts from accidents that could occur at the repository that could result in a cask rupture. The results of these accident scenarios are presented in Section 4.1.8 of the EIS.

7.1 (6576)
Comment - EIS000817 / 0001
The history of dry cask storage of the VSC-24 cask, which was a complete fiasco, is a foretelling of the future of cask behavior at Yucca Mountain.

Response
Waste would be emplaced in waste packages, not casks. The materials used to construct the waste packages would be thoroughly tested throughout the decades-long period prior to closure of the repository. The waste packages themselves would be subject to thorough nondestructive testing. In addition, prototype waste packages would be tested to confirm that they would withstand design-basis accidents.

7.1 (7049)
Comment - EIS001337 / 0011
Lincoln County and the City of Caliente encouraged DOE to consider alternatives for accomplishing the waste emplacement phase of the repository within the DEIS. The County and City noted that perhaps most important would be the evaluation of various candidate materials from which waste packages might be fabricated. Options suggested by the County and City which DOE might consider include those characterized as corrosion resistant, corrosion allowance, and moderately corrosion resistant. Each option was noted as performing differently under alternative thermal and geochemical environments. The County and City recommended that each alternative considered in the DEIS be characterized by varying contributions to risk management, cost and uncertainty. The County and City recommended that a similar evaluation be included for alternative materials for fabrication of waste package baskets. The DEIS does consider alternative design concepts and design features intended to limit release and transport of radionuclides. The DEIS does not provide an assessment of the relative contributions to risk management, cost and uncertainty associated with each alternative considered. The information in the DEIS is therefor of limited value for decision-support.

Response
As encouraged by Lincoln County and the City of Caliente, DOE has considered, and continues to consider, enhanced or improved methods of implementing waste emplacement, including waste package materials and repository design.

As a result of the evaluations in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) and concerns such as those of the Total System Performance Assessment Review Panel, DOE modified the waste package design and added a drip shield over the waste packages. The waste package would have Alloy-22 as the outside layer with stainless steel on the inside. The titanium drip shield would add further defense-in-depth to the design.

DOE based the waste package corrosion model in the Final EIS on the corrosion experiments on Alloy-22 at Lawrence Livermore National Laboratory. Those experiments showed that Alloy-22 is very corrosion-resistant and, even accounting for uncertainty, would be unlikely to fail for many thousands of years.

Because of these evolving design changes, DOE issued a Supplement to the Draft EIS in May 2001. The information in the Supplement, which DOE has incorporated to the Final EIS, describes the potential impacts associated with the design modifications. In the case of the Alloy-22 package material, DOE considered its thermal, mechanical, and chemical performance (corrosivity), ease of fabrication, costs, and compatibility with other materials.

7.1 (7376)

Comment - EIS001614 / 0002

I would like to comment on why I believe Yucca Mountain will fail to isolate waste. DOE's own data shows that Yucca Mountain site will fail to contain nuclear waste. Radioactive gases will be released and radioactive waste will be washed into the groundwater a short time after the first containers fail.

Containers do fail. About 70 dry storage casks are in use at reactors. There is already one juvenile failure, a cask with a faulty weld in less than 20 years. Repository casks will be made of different material, but the manufacturing will be subject to the same problems. There will be more than 10,000 repository casks, and so likely hundreds of early cask failures.

Response

DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. The EIS provides the Department's best estimate of the impacts that could occur when the containment system inevitably degraded. The EIS confirms that the Proposed Action would be likely to result in release of radioactive contamination to the environment after repository closure. However, the EIS shows that these releases under the Proposed Action would not exceed environmental protection standards (40 CFR Part 197) within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed in accordance with 40 CFR Part 197 to gain insight into the long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower that background levels (see Chapter 5 of the EIS for details).

The Yucca Mountain Repository, as described in the Supplement to the Draft EIS, would include a robust engineered barrier system designed specifically to work with the favorable natural barrier system at Yucca Mountain. The waste package would not be the only engineered barrier. The engineered barrier system design has evolved since the publication of the Draft EIS and will continue to evolve. The current design includes a more robust and corrosion-resistant waste package and a titanium drip shield above each waste package for defense-in-depth against corrosion. In addition, the structural steel material used for ground support in the drifts and the titanium drip shields would protect the waste packages against rockfalls.

DOE understands the concern about the use of dry storage casks. However, the Department would not use such casks for disposal in the repository. The problem cited in the comment has been widely documented in Nuclear Regulatory Commission bulletins, inspection reports, letters, and other public documents; it was attributed in large part to the failure of the licensee to implement the required quality-assurance and quality-control standards. However, no measurable consequences have resulted from weld defects, and this type of storage cask is still safely in use.

The longevity of the waste package is a principal factor in the EIS safety case. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of an inner shell of stainless steel and a thick, corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). The updated analysis in the Final EIS projects the possibility of between zero and five packages failing due to manufacturing defects.

7.1 (7576)
Comment - EIS001912 / 0069
Almost 95 percent of waste containment is now being attributed to the waste package. DOE must include a discussion of information about waste packaging materials, which supports a level of performance capable of meeting the regulatory standard.

Response
The engineered barrier system, of which the waste package is a key part, would prevent the annual dose to an average individual living 18 kilometers (11 miles) from the repository from exceeding 15 millirem total effective dose from all pathways and all radionuclides in the first 10,000 years after closure, as prescribed in 40 CFR Part 197. As described in the Supplement to the Draft EIS and in the Final EIS, the long-term performance calculations were based on a waste package with a thick outer wall of high-nickel alloy (Alloy-22), which is highly corrosion-resistant, and a thick inner layer of stainless steel, which is also corrosion-resistant, and which would provide structural strength. This design includes a support structure for the waste package of Alloy-22 and a drip shield of titanium.

7.1 (7611)
Comment - EIS002027 / 0002
When it's stored will the containers open or crack because the molecules are expanding?

Response
DOE anticipates that most of the waste packages would not open or crack for any reason for at least 10,000 years. The materials used to fabricate the waste packages would be stable alloys. The fabrication welds in the waste packages would be annealed and thoroughly inspected to prevent the initiation of any type of failure as a result of fabrication defects. Increases in internal pressure due to high temperatures would not be sufficient to cause a waste package to rupture. In addition, DOE would monitor the waste packages for as long as practicable up to the time of permanent closure to verify performance.

7.1 (7927)
Comment - EIS000817 / 0040
And the sodium and aluminum salts in HLW need close evaluation as to [their] eventual interaction with cask materials (as things break down in a repository).

Response
Corrosion of the waste packages in the repository, given enough time, is inevitable. Before the start of site characterization, there was a general belief that thin-walled stainless-steel waste packages would be sufficient. The evolving design of the repository, as described in the Supplement to the Draft EIS and the Final EIS, now includes a more robust waste package and titanium drip shields to delay by more than 10,000 years the release of radionuclides from the repository.

DOE's understanding of corrosion is based on research literature and long- and short-term testing of the waste packages. These tests are conducted under conditions that are expected in the repository, as well as very aggressive conditions. The American Society for Testing and Materials codified this approach in *Standard Practice for Prediction of the Long-Term Behavior of Materials, Including Waste Forms, Used in Engineered Barrier Systems (EBS) for Geological Disposal of High-Level Radioactive Waste* (DIRS 105725-ASTM 1998). The tests use standard microstructural evaluation and atomic-force microscopy to examine surface films in such detail that DOE can evaluate extremely slow rates of degradation. DOE would continue to test samples of Alloy-22 (the waste package material) and other materials for many decades to confirm the results that have been collected to date.

7.1 (7931)
Comment - EIS002005 / 0001
My class is studying on the nuclear waste and I was just wondering what it's like down there.

Where does the waste go every month? Do you burn everything that's trash and what time do you leave from the nuclear waste?

Response
At present there is no radioactive waste disposal taking place at Yucca Mountain. This EIS evaluates potential impacts for the proposed repository if the site is approved. DOE scientists at Yucca Mountain are studying the inside of the mountain via an 8.9-kilometer (5.5-mile) long tunnel bored through the rock into the mountain. Inside the tunnel, it is mostly dry and fairly warm throughout the year.

Spent nuclear fuel and high-level radioactive waste cannot be treated by burning, and DOE has no plans to burn any types of waste at the proposed repository. If the site was approved, the waste transported there would be emplaced in the mountain. DOE plans to dispose of low-level waste from repository operations at a low-level waste disposal facility at the Nevada Test Site.

7.1 (8000)
Comment - EIS000817 / 0055
You talk about neutron absorbers. You don't know how long they will maintain their integrity. That is a big question here. It is not time tested for dry cask storage yet.

Response
The most important function of the neutron absorber would be to absorb neutrons and reduce the potential for criticality. The absorber material is typically an additive material (for example, stainless steel alloyed with a boron compound). The carrier material with the added neutron absorber would be part of the internal structure in the waste package. Corrosion behavior would be important in keeping the absorber material in place and effective in controlling criticality long after emplacement. Therefore, DOE used chemical performance in a variety of environments as an important selection criterion. In addition, the Department used mechanical performance as an evaluation factor because the internal components must be able to sustain mechanical loads due to handling, emplacement and, if necessary, retrieval. The analysis considered compatibility with other materials because the neutron absorber components must not degrade the waste form. These components provide an important path for conducting heat from the fuel to the waste package layers, so the analysis considered thermal performance. The material of choice for the neutron absorber is Neutronit A978. DOE based this selection on the corrosion performance of this material in comparison to other candidate materials and available boron concentration (DIRS 138192-CRWMS M&O 2000). The composition of Neutronit is similar to that of American Society for Testing and Materials standard Type 316, but with 1.6 percent boron. Based on the selection process used and the performance of similar material, there is no reason to expect untimely failure of the neutron absorbers.

7.1 (8004)
Comment - EIS000817 / 0059
So many unexpected problems have developed already. Nobody expected coating reactions or that they would have to UT [ultrasonically test] the seal welds. There are too many unknowns in dry cask storage to already think of disposal casks that will really work as planned. All you have is a "preliminary conceptual" design. I read the full transcript of the Nuclear Waste Technical Review Board meeting on this cask design and if shrink fitting is still an option, I think it's a mistake. Not enough experience with this.

Response
DOE understands the commenter's concern about the use of dry storage casks. However, DOE would not use such casks for disposal in the repository. As described in the Supplement to the Draft EIS (released for public review in May 2001) and in the Final EIS, the design of the repository now includes a more robust waste package and titanium drip shields. This design would delay by more than 10,000 years the release of radionuclides from the repository.

The unexpected problems mentioned by the commenter presumably refer to use of the Ventilated Storage Cask, Model 24 (VSC-24) storage system. These problems are widely documented in bulletins of the Nuclear Regulatory Commission, inspection reports, letters, and other public documents. The VSC-24 storage system uses a mostly carbon-steel fuel basket (internals and shell) with anti-corrosion coatings. The majority of the spent-fuel storage technologies use stainless steel and no or limited amounts of anti-corrosion coatings. Many of the problems of the VSC-24 system resulted from a failure of the licensee to adequately implement the required quality-assurance and quality control programs. Several problems were associated with the anti-corrosion coatings and hydrogen-induced weld cracking. The weld defects were detected using the inspection and testing procedures approved by the Nuclear Regulatory Commission that are intended for this process and resulted in no release of radioactive material. The

Nuclear Regulatory Commission used its regulatory authority to formally address each of these problems, including halting the use of this particular system until the issues were addressed and resolutions implemented. Resolutions included design and procedural changes and development of alternate inspection techniques.

The VSC-24 problems are important in that lessons have been learned that can be applied to existing and future storage-system technologies. However, the problems that occurred with one system do not support the claim that dry-storage-cask systems approved by the Nuclear Regulatory Commission would not work. DOE believes that dry storage and transportation technologies that have been approved by the Nuclear Regulatory Commission are sound and viable. In support of this view are the thousands of shipments of spent nuclear fuel that have been transported safely over the past several decades.

7.1 (8029)
Comment - EIS000817 / 0073
Fuel rods in dry storage are likely to be environmentally secure for long periods -- you state this as if you have some evidence -- what, I'd like to know? The "generic" (so-called -- but each one gets so many changes, it ends up "site-specific" anyway) casks NRC [Nuclear Regulatory Commission] is certifying are new designs -- never built or tested in full scale -- with real fuel over time -- never unloaded. You have no real evidence from fuel stored in any of these cask designs to prove this "likelihood" you refer to. I'd like to see each cask design unloaded after 5, 10, 15 years and an inspection of assemblies inside and full evaluation of impacts of unloading on the cladding and pellets. All your computer analysis will not tell us the real thing any more than all the computer analysis for the VSC-24 [Ventilated Storage Cask, Model 24] told us that a coating would cause a hydrogen explosion. If nobody enters the right data, nobody knows about uncertainties, right? There are too many uncertainties. Test the real thing. Unload casks. This has to be done. I've been requesting it for years and years.

Response
Both Canada and Germany have evaluated spent nuclear fuel in dry storage. The United States has not performed any analysis until recently on the behavior of spent nuclear fuel in long-term dry storage. As part of a cooperative program among DOE, the Nuclear Regulatory Commission, and the Electric Power Research Institute, spent nuclear fuel in dry storage is now being examined. Recently, a dry storage cask that has been located on a concrete pad at the Idaho National Environmental and Engineering Laboratory for more than 13 years was opened and the 17 assemblies of Surry fuel have been examined remotely using a video camera. No changes were observed. One assembly was chosen, and selected rods were removed for further nondestructive and destructive analysis. The nondestructive analysis is in progress.

The temperature of the spent nuclear fuel in the repository, and the rate of its degradation, would decrease over time. Thus, there is little benefit to evaluate the condition of spent nuclear fuel rods or assemblies after about 10 years of disposal. However, testing samples of spent nuclear fuel would continue in order to confirm predictions of alteration and release mechanisms.

7.1 (8032)
Comment - EIS000817 / 0076
You say here that most utilities and DOE have not constructed ISFSIs [independent spent fuel storage installations] -- right! Dry cask storage is in its infancy, yet your whole plan is based on it working as predicted. Why is your EIS based on horizontal modules rather than vertical? Horizontal, such as Nuhoms, have to rest on a pedestal. Is that the best way? Why? Is a stainless steel outer shell the best (better than carbon steel)? -- I would think it is. But why have you chosen this cask design above others certified by now? Where is your comparison of descriptions of all casks on the market? Are these casks really safe in an airplane crash as you insinuate? With a fuel fire from the plane?

Response
About one-third of the commercial utility sites have constructed, or are planning to construct, independent installations to store spent nuclear fuel. The function and design of these installations are substantially different than the function and design of the waste packages that DOE would place in a repository at Yucca Mountain. Independent spent fuel storage installations are for above-ground interim storage of spent nuclear fuel that DOE would ultimately ship to the repository. Most of the five DOE sites evaluated in the EIS have some dry-fuel-storage capability.

Chapter 7 of the EIS evaluates the likelihood and effects of an airplane crash into dry-vault storage facilities at reactor sites. The consequences of such an accident would not pose undue risks to the health and safety of the public. Airplane crashes into emplacement areas at the repository for waste packages that have been emplaced are not an issue because the waste packages would be far underground. Aside from activities in the Waste Handling Building, spent nuclear fuel would be at the surface only if postemplacement retrieval was required or if DOE implemented surface aging prior to emplacement in support of lower-temperature operating mode thermal management objectives (see Section 2.1.2.1.1.2 of the EIS).

Any design concepts for such a surface aging facility are preliminary, but it would be licensed in compliance with Nuclear Regulatory Commission requirements (10 CFR Part 72). These requirements specify that storage modules must be able to withstand credible accidents. If the repository was approved for development and if a lower-temperature operating mode was selected that required surface aging, DOE would incorporate the latest dry storage technologies into the design, including lessons learned from independent spent fuel storage installations.

DOE evaluated the consequences of an aircraft (both military and large commercial jet) crash into surface facilities at the proposed repository, including into a potential surface aging facility. It was determined that a large commercial jet aircraft would not penetrate the surface aging storage modules.

7.1 (8056)
Comment - EIS002026 / 0002
I think the tests on the containment casks are a waste of time. They're minimal at the best.

Response
The Yucca Mountain repository design includes a robust engineered barrier system and takes advantage of the natural barrier system (dry environment and geologic features). The waste package would not be the sole engineered barrier. The engineered barrier system design has evolved since the publication of the Draft EIS and will continue to evolve. The current design includes a more robust and corrosion-resistant waste package, in addition to a titanium drip shield above each waste package for defense-in-depth against waste package corrosion. Structural steel material used for ground support in the drifts and the titanium drip shields would provide protection to the waste package against rockfall.

DOE has completed extensive evaluations of the best materials for the containment function of the waste package. The Department performed material analysis by selecting weighting criteria and establishing grading scales. Weighting criteria included mechanical performance, chemical performance (corrosion), predictability of performance, compatibility with other materials, ease of fabrication, cost, previous experience, thermal performance, and neutronic performance. Data on the performance of the materials of the engineered barrier have been collected from tests conducted by DOE and from literature based on extensive industry experience in fabrication and use of these materials. Testing would continue during waste emplacement and preclosure to collect long-term data under conditions prototypical of those expected at Yucca Mountain. The data generated would continue to go to analysts who would determine the long-term performance of the materials as a part of the determination of total system performance in compliance with regulatory standards. In addition, DOE will implement fabrication testing of full-diameter waste package mockups.

DOE would design and build waste packages to meet applicable Federal regulations, which include rigorous testing requirements. The Department has extensive experience in designing, fabricating, testing, and implementing nuclear components. Over the past 30 years, there have been more than 2,700 U.S. spent nuclear fuel shipments in transportation casks with no releases.

7.1 (8283)
Comment - EIS001615 / 0001
I would like to ask a question of the materials engineers concerning their design of the final encasement of the products.

They're encasing these centered fuel elements in a multi -- an engineered multilevel metal container, and they have already said that they are producing radioactive gases inside this system that is leakproof. It will also produce helium gas as part of the radioactive decay processes.

I anticipate that there will be a significant increase in the pressure inside these vessels and the radiation that is produced from the decay of these products, both beta decay and alpha decay, will cause embrittlement internally. And because they are alpha emitters, the material will undergo alpha creep through the fractures and the gas will enhance the fracturing process over several years.

My question to the DOE is, what is the overpressuring that will develop inside these vessels, and with cooling, will that produce the possibility of the fracturing process? And since they are not vented, is there a possibility of helium gas causing the fissioning of the uranium and plutonium that are inside these fuel pellets?

Response
The radiolytic gases produced from decay of the waste would be a small fraction of the total pressure of the system. Also, this decay would not generate significant radiation damage to the waste packages. The integrated dose over tens of thousands of years would be less than the threshold for damage for the materials selected for the waste package. The helium generated would not cause fissioning of the nuclear material.

7.1 (8294)
Comment - EIS000817 / 0106
P. 4-88 Disposal Containers -- do not use carbon steel. Will you UT [ultrasonic test] the top welded closures? 16 different containers -- sounds like a real mess in figuring interactions when they all degrade!

Response
The waste package design analyzed in the Supplement to the Draft EIS (released for public review in May 2001) and in the Final EIS, includes a corrosion-resistant nickel-base alloy (Alloy-22) as the outer barrier material. The closure weld would be performed remotely. Inspection would include both visual and ultrasonic (test cut) methods. All of the waste packages would be made from the same materials (Alloy-22 on the outside; stainless steel on the inside) and take on the same basic shape. Thus, corrosion chemistries would be identical for all of the waste packages.

7.1 (8299)
Comment - EIS000817 / 0108
"Polypropylene sheath"? What is the fire hazard here?

Response
DOE would use the polypropylene sheath discussed in Section 4.1.15.3 of the EIS to provide neutron shielding for the transportation cask. The Department does not believe there would be an undue fire hazard. Polypropylene and related materials are in use today for neutron shielding for transportation casks and other container systems certified by the Nuclear Regulatory Commission.

7.1 (8569)
Comment - EIS000817 / 0177
P. 9-16. What do you mean, "waste package self shielding"? Like what?

Response
The concept of self-shielding for waste packages as presented on page 9-16 of the Draft EIS refers to an additional barrier around the waste package. This barrier would not necessarily provide additional corrosion resistance. This barrier would have to be sufficiently thick to reduce radiation levels to the point where limited human access in the emplacement drift would be possible provided air temperatures inside are low enough. The concept of self shielding is not currently under active consideration by DOE (see Section E.2.2.10 of the EIS).

7.1 (8577)
Comment - EIS000817 / 0183
P. E-20. Self shielding sounds like a good idea.

Response
The concept of waste package self-shielding referred to in Sections 9.2.10 and E.2.2.10 of the EIS is one of several design features that DOE examined to assess how the design could evolve in the future and how this evolution would relate to the assessment of environmental impacts.

The concept of self-shielding for waste packages refers to adding a shielding material around the waste package. This barrier would not necessarily provide additional corrosion resistance. This barrier would have to be sufficiently thick to reduce radiation levels to the point where limited human access in the emplacement drift would be possible, provided air temperatures inside were low enough.

Potential drawbacks to self-shielding could include increases in the size, weight, or quantity of waste packages and increased drift excavation, thus posing additional industrial safety risks. Shielded waste packages could also be more difficult to monitor since the barriers relied upon for protection against corrosion would not be visible. Shielded waste packages could also make it more difficult to maintain peak cladding temperatures below 350°C (660°F) to protect the integrity of the cladding.

7.1 (8658)
Comment - EIS000817 / 0198
Be very careful to evaluate the manufacturers' sheets on any neutron shield material. The RX277 in the shield lid of the VSC-24 [Ventilated Storage Cask, Model 24], for example, was supposed to be baked to 350° and then moisture was driven out -- and gases formed. The sheet, which I don't remember in detail, said something about how high the temperature should be allowed to go in casks and also that it could require moisture under situations. But the main thing about any enclosed poured material like this is that it has to be completely enclosed. This material, and material in the transfer cask wall, got wet at some locations when in the pool as all paths to the material were not welded shut. This could be a big concern in disposal casks as some materials actually attract moisture, and if trapped moisture is inside a cask to begin with, you have problems. Also Boral and Boral panels -- will it have continued efficiency? And is any type of poured neutron shield really safe? -- Uncontrolled voids can cause real problems. Also is helium in the cask dry? Really dry? Are weld areas preheated, and are welds done so that they are as strong as the parent metal? Are they UT [ultrasonically] tested? What is the basis for the critical flaw size acceptance? Are bolted casks better than welded ones? Is an inflatable annulus seal acceptable? Some neutron shield material is a plastic sort of stuff and flammable. What are the highest cladding temperatures for the cask design? How does it affect the Zircaloy? Watch for radiation streaming areas. (A lot of things to consider in dry casks.)

Well again I do think that materials interactions in cask materials and in all materials in the repository are your biggest unknown and your biggest problem.

Response
The current design of the waste package, as described in the Supplement to the Draft EIS, does not include any Boral as a neutron absorber. The neutron absorber material is typically in the form of an additive material (for example, stainless steel alloyed with a boron compound). The design of the waste package incorporates the neutron-absorber within the internal component structure in the waste package, when needed for criticality control. Corrosion behavior is important in keeping the neutron absorber material in place and effective in controlling criticality long after emplacement. Therefore, chemical performance in a variety of environments was used as an important selection criterion. Mechanical performance, compatibility with other materials, and thermal performance were also considered. The current design uses Neutronit A978.

This comment referred to the plastic sheath that is used as an outside cover for shipping casks to serve as a neutron shield (Section 4.1.15.3 of the EIS). The design of the transportation casks must include the capability to survive significant fire events. Moreover, Nuclear Regulatory Commission requirements for cask licensing do not permit the use of materials that would increase the risk of fire. The waste packages do not use plastic or any other flammable materials.

The current design of the disposal container (called a *waste package* upon emplacement) includes five welded closure lids. All of the welds in the disposal container would be subjected to thorough inspection. Welds are the choice for disposal container closure due to their ability to provide a long-term leak-resistant environment for the waste. A bolted/gasketed or inflatable seal closure is not included in the disposal container design because it cannot ensure adequate sealing capability in the long term without periodic replacement of deteriorated gasket or seal components. To the maximum extent practicable, disposal containers would be fabricated and inspected in accordance with the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (DIRS 141257-ASME 1995). The specified weld inspections and acceptance criteria (that is, flaw size) are based on the requirements of that Code for ensuring an adequate closure seal.

Radiation streaming, if any, will be considered in the design of the remote handling and emplacement systems. A shielded transporter and remote handling accomplish radiation protection during emplacement. Shielding analysis has been analyzed for streaming in the emplacement and handling equipment designs.

The interior of the disposal containers would be dry; they would be dried by pulling a very low vacuum and refilled with inert gas. The maximum cladding temperature permitted in the waste package would be 350ºC (660ºF). This temperature is based on test data that identified the maximum temperature at which cladding is not susceptible to creep rupture. Actual cladding temperatures probably would be much lower.

7.1 (8777)
Comment - EIS001907 / 0017
A Multi-purpose canister (MPC) seems to make the most sense---why move the assemblies around more than necessary, right? To date however, no MPC has undergone full-scale testing and under current NRC [Nuclear Regulatory Commission] regulations, none ever will. The DOE is relying on computer models, and scale testing (though the scale testing doesn't seem to be needed by law). There is a program going on at the test site right now, called Stockpile Stewardship and Management, which claims that computer models aren't enough to test the reliability of aging nuclear weapons in the stockpile, yet computer models are all we, the citizens have to protect us against nuclear waste moving on our roads and rails??

Response
DOE remains receptive to the idea of using multipurpose canisters to load spent nuclear fuel assemblies at utilities, transport them to Yucca Mountain, and emplace them in the repository. DOE agrees that multipurpose canisters can reduce the number of times fuel assemblies have to be handled. Any multipurpose canister to be used in transportation and emplacement would have to comply with the Nuclear Regulatory Commission regulations for transportation casks (10 CFR Part 71) and regulations governing disposal of high-level radioactive wastes in a repository at Yucca Mountain (10 CFR Part 63).

The Stockpile Stewardship and Management Program deals with the reliability of nuclear weapons. The assertion that computer models are not sufficient to characterize the condition of nuclear weapons as they age is based on the fact that minute changes in the isotopic composition and dimensions of the weapon can dramatically alter expected behavior. Confidence in computer models available to evaluate the mechanical stress, radiation shielding, and heat transfer behavior of multipurpose canisters is based on how well such models have predicted the behavior of similar containers and other objects in the past. While full scale testing of a multipurpose canister is not explicitly required by the Nuclear Regulatory Commission, there is no guarantee that the Nuclear Regulatory Commission would be willing to rely solely on scale testing and computer analysis of a multipurpose canister to demonstrate compliance.

7.1 (8935)
Comment - EIS001922 / 0007
The containment of radiation is based on integrity of the casks. When the DEIS estimates accident scenarios, it underestimates the risks posed by groundwater flowing directly from the site to the agricultural community in Amargosa Valley. It is impossible and fallacious to develop the assumption that the casks will not leak during transportation and emplacement when the casks have not been designed yet. We feel that, at the very least, the containers should be determined and subjected to full-scale testing. The DEIS should be revised to reflect new container information.

Response
This comment is correct that the various accident scenarios evaluated for the repository (see Chapter 4 of the EIS) and transportation (see Chapter 6) did not include an evaluation of possible groundwater impacts. This is because

even if these accidents occurred, the consequences would be mitigated to the extent necessary to preclude long-term impacts to groundwater.

DOE agrees that casks could develop leaks during transportation. For this reason, the Nuclear Regulatory Commission would require and DOE would implement a rigorous quality assurance program that would include testing and inspection of equipment and waste containers during every step of the transportation, handling, and emplacement activities. DOE believes that successful implementation of an effective quality assurance program would provide the ability to detect and repair damaged or leaking casks prior to emplacement in the repository.

Transportation casks licensed by the Nuclear Regulatory Commission (10 CFR Part 71) are very different from the waste disposal packages designed for the proposed repository. The Commission has certified a number of tests on casks. Required tests on the structural integrity of transportation casks require that they not release their contents after a drop of 9 meters (30 feet) onto an unyielding surface. Transportation casks have been safely used in more than 2,700 shipments of spent nuclear fuel in the United States. See Section M.4 of the EIS for additional information on cask safety and testing.

DOE is designing containers for the permanent disposal of spent nuclear fuel, which the EIS refers to as waste packages. Samples of candidate metals for waste packages are undergoing laboratory tests. Full-diameter, one-third-length mockups of different waste packages have been built to demonstrate techniques for welding lids to packages. Full-scale prototype testing of waste packages may also be necessary.

The Draft EIS evaluated the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for repository surface facilities, and disposal containers (waste packages). It also evaluated the plans for the construction, operation and monitoring, and closure of the repository. DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review of the repository by the Nuclear Regulatory Commission. The design evolution was evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement incorporated new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements.

Although the waste package and repository designs will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies, DOE believes the designs have progressed to a point that they provide a reasonable basis for estimating the range of potential short- and long- term impacts that would likely result from any final designs. Furthermore, it not unusual for an agency to assess design alternatives that are in the conceptual phase under the National Environmental Policy Act. The consideration of only a final design could, on the other hand, preclude or bias an agency's flexibility to structure a Proposed Action that could be less intrusive on the environment.

The design of the waste package, including its construction materials, has evolved from the Draft EIS design to the current flexible design. While both use a two-layer waste package, the flexible design places the corrosion-resistant material on the outside rather than the inside of the package to provide long-term protection to the more corrosion-susceptible structural material. The current waste package design includes a thick and very corrosion-resistant nickel-base alloy (Alloy-22) as the outer barrier over a thick stainless-steel inner liner. Data on the corrosion performance of the waste package materials (including the internal structure) have been collected from DOE tests and from research literature. Testing would continue during waste emplacement and preclosure to collect long-term data under conditions prototypical of those expected at Yucca Mountain. The data generated will continue to go to the analysts who determine the long-term performance of the materials as a part of the determination of total system performance in compliance with regulatory standards.

DOE based the development of models that predict the performance of corrosion-resistant, nickel-based Alloy-22 in the repository on data from research literature and testing (including long- and short-term tests). DOE performs long-term tests under expected repository conditions, and short-term tests under expected repository conditions and very aggressive conditions. The American Society for Testing and Materials codified this approach in a standard procedure (DIRS 105725-ASTM 1998). Analyses of the tests use a suite of tools, including standard microstructural evaluation and atomic force microscopy, which permits the examination of surface films in such great detail that

DOE can evaluate even very slow degradation rates. DOE will continue to test samples of Alloy-22 and other alloys that would be exposed in the repository and in the laboratory for decades to confirm the results collected to date. In addition, DOE will explore analogs of Alloy-22 to provide confidence in its performance.

DOE based the materials selection on the input of independent experts and laboratory tests, and from material performance observed in full-size industry applications. The corrosion tests involve Alloy-22 and other candidate waste package materials subjected to environments that are at least as aggressive as any expected inside Yucca Mountain. These tests would continue during waste emplacement operations to confirm the expected waste package performance.

DOE acknowledges that it cannot build a waste package that can be guaranteed to provide perfect containment forever. The EIS provides DOE's best estimate of the impacts that would occur when the containment system degraded. The Environmental Protection Agency, in promulgating the Yucca Mountain environmental protection standards (40 CFR Part 197), recognized that with the current state of technology it is impossible to provide a reasonable expectation that there will be "zero" releases over 10,000 years or longer time frame. Therefore, the Agency promulgated standards that it believes would protect human health and safety. These standards do not require complete isolation of the wastes over the compliance period (10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment for Yucca Mountain supporting the site recommendation decision and later licensing (if the site was recommended and approved) is to evaluate whether the repository would be likely to meet these standards. The goal of this EIS is to project possible impacts using similar modeling technology. The results of these efforts, as described in Chapter 5 of the EIS, show that releases under the Proposed Action would not exceed environmental protection standards (40 CFR Part 197) within the 10,000-year compliance period for the repository.

7.1 (10574)
Comment - EIS002131 / 0003
And there has been some talk about how good dry cask technology is. Here's the New York Times article. It says: "To maximize the chance that they will stay intact for thousands of years, the stainless steel is handled only by machines or by gloved hands because the chemists say that even the salt on sweaty palms would begin to corrode the stainless steel, which is three-eighths of an inch thick," and this is supposed to last a half a million years, and just it will corrode from the salt on your hand.

Response
The proposed repository, as described in the Supplement to the Draft EIS, would include a robust engineered barrier system designed specifically to work with the favorable natural barrier system at Yucca Mountain. The current design includes a robust and corrosion-resistant waste package and a titanium drip shield above each waste package for defense-in-depth against corrosion. Structural steel used for ground support in the drifts and the titanium drip shields would protect the waste packages against rockfalls.

The design of the waste package described in the Supplement and carried forward to the Final EIS includes a very corrosion-resistant, nickel-base alloy (Alloy-22) as the outer barrier over a stainless-steel inner structural liner. The purpose of the stainless-steel wall is to provide structural strength and resistance to corrosion. For added conservatism, the long-term performance assessment models assumed no barrier credit for stainless-steel components.

DOE conducted an extensive process to identify suitable materials for the waste package; this selection process continues to evolve. Material selection involved evaluating each waste package component and function, selecting commonly available materials that have characteristics that meet the functional requirements, rating materials, and testing materials. DOE completed the analysis by selecting weighting criteria and establishing grading scales. Weighting criteria included mechanical performance, chemical performance (corrosion), predictability of performance, compatibility with other materials, ease of fabrication, cost, previous industrial experience, thermal performance, and neutronic performance. Testing would continue during waste emplacement and preclosure to collect data under conditions expected at the repository. The data generated would continue to be analyzed to determine the long-term performance of the materials.

The container cited in the comment is built of thin-walled stainless steel. This is very different from the robust design of the waste package, which would have a thick nickel alloy outer wall in addition to a stainless-steel inner wall. Section I.5.1 of the Final EIS describes the results of computer analyses of the behavior of the waste package under a range of environmental conditions.

7.1 (11115)

Comment - EIS001207 / 0004

Has the Yucca Mountain Site Characterization Office determined the package design (can in canisters filled with borosilicate glass containing intensely radioactive high-level waste) to be acceptable/suitable for disposal? Has this technology been deemed to meet performance standards? How and when were performance/can-in-canister design standards tested and approved? During what time period of the Yucca Mountain Site operations are there can-in-canisters anticipated to fail/leak?

Response

Waste package designs evaluated in the Draft EIS were summarized in Section 2.1.2.2.2 and shown in Figure 2-20 of the Draft EIS. One or two high-level radioactive waste canisters containing immobilized plutonium, the so-called "can in canister," would be placed along with other glass high-level radioactive waste canisters inside a waste package such that five high-level radioactive waste canisters are arranged as a ring inside the waste package. A canister of DOE-owned spent nuclear fuel can be placed in the center of the ring. The walls of the waste package analyzed in the Draft EIS would consist of a thick carbon-steel barrier surrounding a thick barrier of Alloy-22, a highly corrosion-resistant nickel-chromium-molybdenum alloy.

The design of the waste package, including its construction materials, has evolved from that used for the Draft EIS design to the current flexible design. While both use a two-layer waste package, the flexible design places the corrosion-resistant material on the outside rather than the inside of the package to provide long-term protection to the more corrosion-susceptible structural material. The current waste package design includes a very corrosion-resistant nickel-based alloy (Alloy-22) as the outer barrier over a thick stainless-steel inner liner. Data on the corrosion performance of the waste package materials (including the internal structure) have been collected from DOE tests and from research literature. Testing would continue during waste emplacement and preclosure to collect long-term data under conditions prototypical of those expected at Yucca Mountain. The data generated will continue to go to the scientists and engineers who determine the long-term performance of the materials as a part of the determination of total system performance in compliance with regulatory standards.

To determine the long-term performance of the repository, a modeling system called Total System Performance Assessment was used. The Total System Performance Assessment is a simulation of the performance of the entire repository system after closure. The Total System Performance Assessment is a probabilistic simulation; that is, it directly incorporates ranges of uncertainty in parameters and reports the possible range of results. The mean value of the range is what is used to determine compliance with environmental protection standards. In the case of waste package degradation, a very conservative wide range (several orders of magnitude) of possible degradation rates (centered on values obtained from testing as described above but also including some much higher pessimistic values) are simulated in the analysis which includes up to 300 trials during which the full range of possible values is sampled. The results of these simulations for the flexible design, described in Chapter 5 of the Final EIS, indicate that penetration of high-level radioactive waste canisters containing immobilized plutonium would not occur until after the waste package had been breached. Failures would be unlikely during the first 10,000 years.

7.1 (11919)

Comment - EIS002303 / 0004

For very long term storage of unusually hazardous materials, why not use containers with a geologically relevant lifespan? Glass has a potential lifespan of MILLIONS of years, comparable to the hazard life plutonium and related waste represent. Recycled glass, as compared to quartz or ceramic, is cheap, plentiful and easy to work with. Higher grade materials could be used, but a multi-layer, mechanically isolating design should be adequate.

Intruding groundwaters will not corrode steel barrels, if they are encapsulated with a Long Life Chemically Resistant Toxics Container.

Kevlar woven glass is tough and chemically resistant, and can encapsulate the waste for the geologically relevant time frame required. Glass provides long term mechanical isolation for the inner layer(s). More than two solid glass layers could be used. An inner PTFE (Teflon) coating provides a reserve seal.

<u>Response</u>
Selection of materials for the waste package is based on several factors, not just corrosion resistance. The waste package must be able to withstand significant static loads and shocks (dynamic loads). It must have good thermal conductivity to transmit the heat generated by the nuclear waste. When the waste package was loaded with waste, the final seal would have to be just as strong, ductile, and corrosion-resistant as the rest of the waste package.

Glasses are inferior for nuclear waste containment compared to corrosion-resistant metal alloys for the following reasons: (1) poor fracture toughness and ductility, (2) low thermal conductivity, (3) difficulties associated with fabrication and sealing of large waste packages, and (4) lack of thermodynamic stability to retain the material composition and microstructure. In addition, the ability of glass to withstand elevated temperatures and intense gamma radiation is not as well understood as that of many metal alloys.

DOE continues to research the ability of different materials to contribute to the isolation of nuclear waste. Alloy-22, the waste package material currently considered most suitable for the repository, offers excellent resistance to corrosion, is relatively easy to manufacture, is able to transfer heat effectively, and is able to survive handling and hypothetical accidents.

7.1 (12744)
<u>Comment</u> - EIS001888 / 0431
[Clark County summary of comments it has received from the public.]

Commenters wanted the EIS to address the abilities of the waste packages to contain SNF and HLRW (for thousands of years, forever, until full decay has occurred, how long?) given thermal dissipation requirements, radioactive bombardment, photo disintegration, nuclide release rates, failure under earthquake-induced stress, and other natural hazards. A commenter requested that the EIS select manmade and natural materials that will retard the movement of radionuclides for placement in the near-field around the waste packages.

These materials were requested to reduce uncertainties associated with the retardation potential of the host rock and to be consistent with DOE's suitability guidelines and the U.S. Nuclear Regulatory Commission's regulations, both of which call for "multi barrier" concepts. Another commenter requested that the EIS provide a description of engineered features that would provide adequate containment of C12 for 10,000 years, without reliance on natural barriers. One commenter requested a discussion of the measures that would ensure the integrity of repository seals, as well as any other barriers to permanently separate the waste from the environment.

<u>Response</u>
The purpose of any design scenario would be to delay or disrupt the potential release of radioactivity. The objective of the repository (both engineered and natural barriers) would be to minimize dose at the accessible environment. The repository would rely on delaying and restricting releases to achieve this objective. The design scenarios DOE has considered would reduce dose rates at the accessible environment by retarding the migration of radionuclides or by delaying the earliest time at which they could migrate, thereby allowing most of the radioisotopes to decay to stable elements.

Carbon-12 is a stable isotope of carbon. Carbon-14 is a radioactive isotope present in spent nuclear fuel. Carbon-14 has a half-life of approximately 5,700 years, meaning half of a given inventory of carbon-14 decays to stable nitrogen-14 within 5,700 years. The waste packages are expected to outlive most of the carbon-14. DOE also expects that most of the fuel rods in the waste packages would have intact cladding, which would further delay the release of carbon-14 and therefore provide additional time for carbon-14 to continue to decay.

Various aspects of the natural system would retard the migration of radionuclides and delay the earliest time at which radionuclides could migrate. The analyses in the EIS do not identify potential impacts that would be a basis for not proceeding with the development of Yucca Mountain as a repository.

While the Nuclear Waste Policy Act of 1982 mentions waste isolation, because of the long periods involved (10,000 years or more), permanent, complete isolation of the waste from the habitable environment is not realistic for any site. However, the Nation still must address the disposal of existing radioactive waste. Therefore, the EIS discusses this goal in achievable terms of limiting the release rate and transport of radionuclides to the environment. Reliance on the natural barriers provided by the rock, dry climate, and remoteness of the site, as well as the additional engineered barriers, would minimize the potential dose rate to the accessible environment to within regulatory guidelines defined by the Environmental Protection Agency and the Nuclear Regulatory Commission. The purpose of the regulations prepared by the Agency (49 CFR Part 197) and the Commission (10 CFR Part 63) is to implement the policy stated in the Nuclear Waste Policy Act, and both regulations recognize the validity of this approach.

The *Viability Assessment for a Repository at Yucca Mountain* discusses sealing materials and placement methods for closure and sealing of shaft, ramps, and boreholes (DIRS 101779-DOE 1998). DOE does not plan to backfill the emplacement drifts, but has not precluded it as a potential future design option.

7.1 (13290)
Comment - 010068 / 0002
The corrosion of the proposed alloys in recent news seems to have been missed in the DEIS. The attractiveness of certain alloys is not factored into the human intrusion scenarios. Expensive alloys used to protect the waste would be a lure for human intrusion. Titanium can increase in cost and attractiveness to human intrusion. Titanium is used in drip shields.

Response
The behavior of Alloy-22 and the titanium alloy has been studied extensively for the project and very recent experimental data have been incorporated into the waste package and drip shield degradation models. Additional information can be found in Appendix I of the Final EIS and various supporting documents referenced therein.

Under the advice of the National Research Council of the National Academy of Sciences, the Environmental Protection Agency elected to exclude considerations of deliberate human intrusion from the final repository performance standard (40 CFR Part 197). This is because it is impossible to characterize with any degree of certainty the range of deliberate acts of humans in the future and also because of the long period of administrative control. Therefore, such considerations as the value of materials of construction in the repository are not within the scope of the long-term performance analyses.

However, consistent with requirements, DOE evaluated the potential impacts of an inadvertent human intrusion; the results are summarized in Section 5.7.1 of the EIS.

7.1.1 DRAFT EIS REPOSITORY DESIGN

7.1.1 (73)
Comment - 3 comments summarized
Commenters were concerned that DOE did not know what type of ground support would be used in the emplacement drifts. Some wanted to know if any supports had been tested. Others noted that steel, concrete, rockbolts, and mesh all have problems, and suggested that other materials be examined.

Response
The ground support methods and materials are based on many years of experience and testing in the mining industry. Additional specific experience has been gained through testing of ground supports conducted at Yucca Mountain for many years in the Exploratory Studies Facility (see Section 2.1.2.2.4.2 of the EIS for more information on ground supports). The reference design of the subsurface facilities on which DOE based the Draft EIS analyses has evolved. The current design includes an all-steel ground support system (welded wire, tie rods, steel sets) rather than concrete liners. The Final EIS evaluates and explains the rationale for design enhancements. To provide updated information to the public, DOE published a Supplement to the Draft EIS that focused on the most recent design enhancements.

The subsurface facility design is still evolving under the direction of DOE. The Department would ensure that the facility and equipment designs, including the drift lining, meet all design requirements, receive the necessary peer reviews, and receive Nuclear Regulatory Commission review and approval prior to licensing of the proposed repository.

7.1.1 (74)
Comment - 6 comments summarized
Commenters were concerned that the waste packages would not be retrievable after being emplaced in the drifts. Some said that retrieval equipment would fail and block further retrieval efforts. Others questioned whether it was accurate for the EIS the consider retrieval to be simply the reverse of emplacement. Commenters suggested that a few waste packages should be retrieved each year to ensure that retrieval, if required, could be accomplished. Commenters pointed to problems with the Ventilated Storage Cask, Model 24 in current use for dry storage and said similar problems could occur at the repository. Commenters also noted several other possible problems including weld problems, unexpected emissions, stuck shims in the lid, overhead trolley problems, and the movement of casks over other casks in the emplacement drift. Some commenters said that detailed procedures for retrieval should be developed.

Response
Current conceptual designs assume the equipment used for retrieval would be the same equipment used for emplacement. As a consequence, maintenance and operation of this equipment during emplacement would provide extensive experience before any retrieval. The current concept would not involve lifting one waste package over another; retrieval would be accomplished by moving one waste package at a time starting at the end of the drift and moving toward the center. Empty drifts would provide staging for waste packages that did not need to be retrieved but only moved. The reliability of the retrieval process is based on having the capability to retrieve from either end of a drift and having multiple gantry vehicles available at either drift entrance to retrieve waste packages. Based on many years of experience in mines, small rockfalls would not preclude operation of the gantry for retrieval; the ground support system would protect against large rockfalls. However, in the event that a drift became blocked during retrieval, the operation could be continued through the other drift entrance with other equipment.

DOE is evaluating periodic removal of emplaced waste packages for performance evaluation in the design.

The subsurface facility design is still evolving under the direction of the DOE. The Department will ensure that the facility and equipment designs meet all design requirements (including development of adequate maintenance programs) and receive the necessary peer reviews. In addition, the Nuclear Regulatory Commission must review and approve all repository design and operational plans prior to licensing of the proposed repository.

7.1.1 (430)
Comment - EIS000080 / 0001
Nye County is a proponent of alternative repository design, including natural ventilation. We believe that that will lead to a safer repository, and a safer repository is Nye County's number one concern.

Response
DOE has considered alternative design concepts in the EIS, including natural ventilation. Sections 2.1.4.1 and E.2.2.5 of the EIS provide more information on this topic.

The latest repository design described in the Supplement to the Draft (released for public review in May 2001) and the Final EIS has the flexibility to accommodate and take advantage of new information that might improve performance or reduce long-term uncertainties.

7.1.1 (431)
Comment - EIS000080 / 0002
Nye County is a proponent of active groundwater controls. We don't see any concept being put forth by DOE to go in and improve the suitability of the site.

We routinely go in and [de-water mines in] the State of Nevada because of the water below the ore piles. No one's talking about going in and decreasing the water level underneath Yucca Mountain. We see that as a viable mitigating measure that increases the distance between the waste and the water resources.

<u>Response</u>
Groundwater pumping to lower the water table can be a viable means for dealing with short-term contamination issues at mines. However, it is not a viable option for a geologic repository that would have to meet regulatory compliance limits for 10,000 years. Before closure, the waste packages would remain intact and there would be no radioactive releases. So lowering the water table to increase the travel time from the waste emplacement areas to the saturated zone would not be an issue. After closure, the passive components of the system, comprised of engineered and natural barriers, have been designed to provide long-term protection to people and the environment by demonstrating compliance with both Environmental Protection Agency and Nuclear Regulatory Commission environmental protection standards.

7.1.1 (754)
<u>Comment</u> - EIS001337 / 0081
Page 2-65 Section 2.2.2.2. The assumption of 10,000 years of institutional control seems inconsistent with NRC [Nuclear Regulatory Commission] licensing guidance which encourage licensees to not assume institutional control beyond 300 years. This scenario should be revised to assume institutional control for 300 years (which is also consistent with the Preferred Alternative for Yucca Mountain).

Page 2-66 Section 2.2.2.3. The assumption of loss of institutional control after 100 years is not consistent with NRC licensing guidelines nor with assumptions associated with the Preferred Alternative (institutional controls at Yucca Mountain for 300 years). No-Action Scenario 2 should be deleted from the DEIS.

<u>Response</u>
Because the future course of action taken by the Nation and by commercial utilities would be uncertain if Yucca Mountain was not recommended as a repository site, the No-Action Alternative evaluated two hypothetical scenarios with different assumptions about institutional control to provide a range of impacts that could occur and to provide a basis for comparison to the Proposed Action.

The assumption for Scenario 1 is that DOE and commercial utilities would maintain institutional control of the storage facilities to ensure minimal releases of contaminants to the environment for at least 10,000 years. Although both the Nuclear Regulatory Commission and the Environmental Protection Agency encourage the maintenance of monitoring and physical oversight for as long as possible, they have recognized that projecting society's willingness and ability to provide such a function for more than 100 years into the future is not reasonable. For this reason, Scenario 2 assumes no effective institutional control after approximately 100 years. DOE based the choice of 100 years on a review of Environmental Protection Agency regulations for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain (40 CFR Part 191), Nuclear Regulatory Commission regulations for the disposal of low-level radioactive material (10 CFR Part 61), and the National Research Council report on standards for the proposed Yucca Mountain Repository (DIRS 100018-National Research Council 1995), which generally discount the consideration of institutional control for longer periods in performance assessments for geologic repositories. Assuming no effective institutional control after 100 years provides a consistent analytical basis for comparing the No-Action Alternative and the Proposed Action.

7.1.1 (2648)
<u>Comment</u> - EIS000409 / 0006
Designs for the Repository itself: There are no concrete plans for one much less two repositories. The application of real or artificial barrier systems are still in the conversational stages. Where & how would the canisters be stored (hot, hot) temporarily until the cave is burrowed out? The International Nuclear Industry is waiting and watching carefully to see how fast we can succeed in blowing ourselves up. All of the extrapolations done by our famous DOE physicists will mean nothing because there is no DOE policy on how long the mountain would remain open or how many years it would take to fill (1 or 2). The law says you cannot close the mountain until it is filled.

Again the only answer is transmutation and recycling by our business trained trillionaires. Projected cost for 1 repository $35 billion.

<u>Response</u>
Until a repository is licensed and prepared to receive spent nuclear fuel and high-level radioactive waste, the Department believes that these materials will continue to be stored at the generator sites. However, other options

have been evaluated, including a proposed interim storage facility in Utah (DIRS 152001-NRC 2000). In addition, the updated flexible design includes provisions for aged storage at Yucca Mountain for up to 40,000 metric tons heavy metal of commercial spent nuclear fuel to support the low-operating temperature operating mode. However, onsite storage of spent nuclear fuel at the Yucca Mountain site would not be allowed until after the Nuclear Regulatory Commission issued an operating license, which would not be expected before the year 2010.

The scope of the EIS is limited by the NWPA to the consequences of a single repository at Yucca Mountain (the Proposed Action) compared to the consequences of storing the waste indefinitely at commercial and DOE sites around the country (the No-Action Alternative). The amount of waste that DOE could place in the repository is restricted by the NWPA to 70,000 metric tons of heavy metal until a second repository is in operation. DOE is not scheduled to report to Congress on the need for a second repository until 2007.

DOE believes that the design of the engineered barrier system described in the Supplement to the Draft EIS (released for public review in May 2001) is sufficiently developed to allow DOE to estimate the long-term environmental consequences of the repository. As discussed in Section 2.1.2.1.1 of the Final EIS, waste would be unloaded from transportation casks and repackaged in waste packages for emplacement in the repository; storage at the surface would not extend over long periods.

Section 122 of the NWPA requires retrievability at a high-level radioactive waste repository. Federal regulations (10 CFR Part 63) require that the repository be designed to preserve the option of waste retrieval on a reasonable schedule for as long as 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the Yucca Mountain repository provides for a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving the waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly as long as 300 years or more in the event of a decision to retrieve the waste either to protect the public health and safety or the environment or to recover resources from spent nuclear fuel. DOE examined closure dates ranging from 50 to 300 years after initial emplacement and has determined that any closure date within this range would not significantly affect the environmental consequences of the repository, especially when comparing the Proposed Action to the No-Action Alternative.

There is no law stipulating that the repository must remain open until it is “filled,” only restrictions on the maximum amount of waste that can be emplaced and the minimum duration for the retrieval period.

With regard to transmuting or recycling nuclear waste, DOE acknowledges that new technologies for waste management could be developed in the future. In fact, at the direction of Congress, DOE is studying accelerator transmutation of radioactive waste. The process involves state-of-the-art principles, some of which are not yet proven. However, even if accelerator transmutation becomes a feasible technology, a repository is an essential element of the nuclear fuel cycle because significant quantities of highly radioactive, long-lived materials would remain. Therefore, DOE does not recommend abandoning the Nation’s current waste management strategies.

7.1.1 (4166)

Comment - 010034 / 0001

It is obvious that there is little or no attention being given to accidents, electrical or mechanical malfunctions. In the event of these unforeseen incidents there very well might be a short isolation period followed by a fast, uncontrolled release. This could be caused by a seismic event or an electrical failure shutting down the ventilation now required to lower the temperature and dissipate the unexpected humidity and moisture. This same humidity moisture is corrosive, containing brine and microorganisms.

Would human beings be able to enter the tunnel to retrieve these waste packages in the event the train and/or gantry malfunctioned? How can the DOE depend on robotics when there has been little attention given to accidents and malfunctions? If there is backup power to the project is there enough to fully operate all electrical machines and other equipment? It was mentioned that brine and microorganisms would degrade the waste packages made up of titanium and stainless steel. What attention has been given to the corrosive effects on the electrical and mechanical systems? For example, rails, switches, circuit breakers, wire connections or metal less able to resist corrosion than titanium or stainless steel?

It is obvious that since the tunnels will be open for 300 years to assure retrievability of the waste packages, that an accident or malfunction will make this impossible.

Response
Humans would not be able to enter an emplacement drift once it has been loaded with waste packages without the use of thermal and radiation shielding. DOE has developed plans for waste package retrieval for normal and off-normal conditions. Waste package retrieval under normal conditions would use the same subsurface equipment and facilities as emplacement, but in reverse order. This would provide a built-in capability for retrieval that could be readily implemented. Individual waste package removal for inspection, testing, and maintenance reasons would not be retrieval; however, waste package removal for these purposes, if needed, would involve the same equipment and operational steps. Alternative waste package equipment and processes have been identified for off-normal conditions when normal retrieval procedures could be different or impossible to execute. In addition, support equipment (equipment to remove obstacles, prepare surfaces, or install temporary ground supports) that could be used in retrieval operations under off-normal conditions has been identified. The equipment and processes would support various scenarios such as repair of the railing system, repositioning the emplacement pallet and waste package, or cleaning or removal of debris. All retrieval scenarios include establishment of radiation and temperature controls and other administrative controls, as needed, to conduct a safe retrieval operation (DIRS 153849-DOE 2001). During the preclosure period, which could last up to more than 300 years, the repository will be open and subject to inspection and maintenance. Should problems with corrosion of rails, switches, etc. be detected, repairs and/or replacements would be made.

7.1.1 (4266)
Comment - EIS001521 / 0025
Page 3-30, first paragraph--In this paragraph, fault displacements are related to the layout design of the central block of the repository. It does not appear that the same consideration was given to the design of the l-t-l expansion blocks (especially the westward extension). If it was, it should be mentioned in the text.

Response
There are little site characterization data available for a potential expansion zone west of Solitario Canyon. DOE would not have to expand into that area until the central repository block was full or if space was needed to accommodate more than 70,000 metric tons of heavy metal. There would be ample time (30 to 40 years) to characterize the expansion area in detail before it was needed. An expansion of storage capacity to accommodate more than the 70,000 metric tons of heavy metal authorized in the NWPA would require the operation of a second repository or a Congressional amendment to the Act.

7.1.1 (4564)
Comment - EIS001521 / 0078
Page 4-99, Figure 4-5--Where is the location of the waste-retrieval and storage area with reference to Midway Valley? The referenced page 3-34, Figure 3-12, shows the location of Midway Valley (sort of) but the actual location of the waste retrieval and storage area is still unknown.

Response
One of the alternative sites for the Retrieval Facility is in Midway Valley near the repository site. DOE has not yet determined the design of this facility or its exact location. The Department believes that the information in the EIS is adequate for determining representative environmental impacts of using this site for waste retrieval.

7.1.1 (4968)
Comment - EIS001326 / 0002
I also recommend telling the U.S. what measures you are taking to be positive that the nuclear waste you are disposing of will not leak into the environment.

Response
The repository would include an engineered barrier system designed specifically to work with the natural geologic and hydrologic barriers at the site. The engineered barrier system is described in the Supplement to the Draft EIS (released for public review in May 2001) and the Final EIS. This system includes a robust and corrosion-resistant waste package and a titanium drip shield above each waste package for defense-in-depth against corrosion.

Structural steel used for ground support in the drifts and the drip shields would protect the waste packages against rock fall. Based on analyses in Chapter 5 of the EIS, the engineered and natural barriers at the site would provide waste isolation in compliance with the standards in 40 CFR Part 197. These analyses show that the waste would be isolated for tens of thousands of years. Confirmatory testing would continue during the emplacement and preclosure periods to collect long-term data under conditions typical of those expected at Yucca Mountain after closure.

7.1.1 (5356)
Comment - EIS001887 / 0077
Page 2-16; Section 2.1.2.1.1 - North Portal Operations Area

It should be pointed out that the design of this part of the repository surface facility, including the buildings and operations in the restricted area, is preliminary and, at best, conceptual. DOE has not even finally decided (contrary to information in the Draft EIS) whether the Waste Handling Building will employ the use of waste transfer pools or use hot cells exclusively.

The Draft EIS fails to adequately describe and evaluate impacts of specific types of facilities needed to receive, package, and handle spent fuel and high-level waste for disposal. The Draft EIS attempts to avoid specific analyses by indicating that the nature of such operations would depend on how the spent fuel is packaged for transport. Nevada contends that the information currently exists for DOE to clearly identify specific operational requirements and to discriminate among alternatives for operations at the North Portal facilities. However, this requires a more adequate, substantive, and site-specific analysis of spent fuel and HLW at reactor and generator facilities and the specific modes to be used for shipment from each site. Such an assessment is clearly within the technical capabilities of DOE and within the appropriate scope of the Draft EIS. DOE should be able to identify, with considerable certainty, the type of package that would be received at the North Portal from each reactor/generator site. With that information, DOE can then specify, in considerable detail, the actual facilities and activities required at the North Portal area. Such a detailed description is needed in order to conduct an adequate assessment of risks and impacts.

Such an analysis would also help to clarify the differential risks and attendant mitigation associated with various handling scenarios. For example, if the analysis showed that a large percentage of the waste would arrive at the North Portal operations area as uncanistered spent fuel (as is very likely, given the market-driven transport system being planned by DOE and commercial utilities), the North Portal Operations Area and facility needs would be considerably different than they would be if most of the waste arrived in dual or multi-purpose canisters.

Response
Because of the evolving nature of the design of the repository, DOE issued a Supplement to the Draft EIS in May 2001 for public review. This Supplement describes the impacts of the repository based on the most recent repository design. This design information was carried forward to the Final EIS. DOE believes that these impact analyses would adequately bound the impacts from any additional changes in the design of the repository.

DOE is developing waste acceptance criteria for the repository. Some shipments could contain failed fuel and radioactive nonfuel components in special packages. A variety of defense waste forms include spent nuclear fuel and defense high-level radioactive waste shipped in canisters that can be directly placed in disposable waste packages at the repository.

The waste handling systems at the repository would be able to handle a diversity of casks, canisters, and waste forms; open casks and canisters; and package the waste for disposal. The systems would concurrently handle waste in disposable canisters and bare fuel (the assembly transfer and canister transfer systems). The systems and facilities would also handle abnormal and damaged waste forms, damaged waste packages (the waste package remediation system), and a facility for maintaining shipping casks to license requirements.

DOE made full use of the waste form characteristics, and the system and facility designs previously described to ensure that it considered the range of environmental impacts of the monitored geologic repository, as described in Section 4.1. Also included are the environmental impacts for three additional scenarios, the all legal-weight truck scenario, the mostly disposable canister scenario (canisters designed for direct insertion into a waste package), and the mostly dual-purpose canister scenario. Facility and system designs have not been developed for these cases. However, the monitored geologic repository facility, site staffing, and waste form were factors that were included in the analysis of the potential environmental impacts. The same detail of information is provided in the Supplement to the Draft EIS for the latest changes in the design of the repository. This updated design information is carried forward to the Final EIS.

DOE performed an analysis to classify the various systems for their importance to safety. The Department is performing preliminary hazard and design-basis event analyses to determine the hazards associated with equipment failures and events that would be used to determine if additional design and safety features are required.

7.1.1 (5361)
Comment - EIS001887 / 0079
Page 2-21; Sections 2.1.2.1.3 and .4 - Ventilation Shaft Operations Area

The Draft EIS does not describe the method to be used for ventilation shaft construction and does not appear to describe the environmental impacts specific to shaft construction. Section 4., Section 2.1.2.2.1, Subsurface Facility Design and Construction, implies that the shafts are not planned to be constructed by drill-and-blast. This should be clarified.

Response
The Final EIS has been revised to state that the vertical ventilation shafts would be excavated by mechanical means (for example, vertical mole, drilling, and raised boring) or by drill-and-blast techniques (DIRS 153849-DOE 2001). Additional information related to various excavation techniques may be found in DOE (DIRS 153849-2001).

The impacts to air quality from this and other construction activities are addressed in Section 4.1.2 and in the Supplement.

7.1.1 (5364)
Comment - EIS001887 / 0082
Page 2-27; Section 2.1.2.2.1 - Subsurface Facility Design and Construction

Concrete liners are no longer part of the repository design. An accurate, current description of the repository design should be included in the Draft EIS.

Under what circumstances and in what manner would waste packages be moved over other waste packages? Does the technology exist at this time to do this? Have scenarios where waste packages are dropped on other waste packages been evaluated? The Draft EIS should include a discussion of this aspect.

Response
Because of the evolving nature of the design of the repository, DOE issued the Supplement to the Draft EIS in May 2001 for public review. The current design for the emplacement drifts includes an all-steel ground support system (welded wire, tie rods, steel sets, rock bolts), rather than concrete liners. The Supplement evaluates and explains the rationale for these design enhancements and this information was carried forward to the Final EIS. The current design, as well as the design examined in the Draft EIS, does not include the lifting of a filled waste package over other waste packages.

7.1.1 (5365)
Comment - EIS001887 / 0083
Page 2-31; Section 2.1.2.2.1 - Subsurface Facility Design and Construction

Water usage during site characterization and the construction of the ESF was not adequately monitored, evidenced by the multiple quality assurance findings and nonconformance reports written about the tracking of water usage. What other controls would DOE use to ensure that water used during construction of the repository would not affect repository performance?

Response
During construction of the Exploratory Studies Facility, it was very important to monitor and limit the use of water because scientists did not want to disturb the natural environment of the mountain before they could measure the natural ambient conditions. Water use during construction of the repository for such things as dust suppression would not be as critical because the site characterization work would have been completed.

Potential impacts to surface water from construction, operations, maintenance, monitoring, and closure of the repository are discussed in Section 4.1.3.2 of the EIS. Water used in the subsurface areas during construction would be pumped to a lined evaporation pond at the South Portal Operations Area. Water collected from the emplacement areas, if any, would be pumped to a lined evaporation pond at the North Portal Operations Area.

7.1.1 (5413)
Comment - EIS001887 / 0116
Page 2-57; Section 2.1.4.1 - Design Features and Alternatives to Limit Release and Transport of Radionuclides

Of the five design features listed in the category "Barriers to limit release and transport of radionuclides" in Table 2-4, only one -- additives and fillers -actually serves to limit release and transport of radionuclides. The remaining four, drip shields, backfill, waste package corrosion-resistant barrier, and ground support options serve only to delay releases and do not eliminate or substantially reduce releases of radionuclides, the true measure of repository performance. The ideal goal of repository performance is to eliminate the potential for release of emplaced radionuclides. The realistic objective is to limit releases, at whatever time they occur, to acceptable levels. The Draft EIS analysis indicates that a Yucca Mountain repository cannot meet this objective, relative to expected peak doses resulting from released radionuclides after the short period of time (300 to 1,000 years) during which the major fission products decay. Juvenile failure of components of the engineered barrier system could result in radionuclide releases prior to the time major fission products have decayed to very low levels.

Many of the features and alternatives discussed in this section and elsewhere in the Draft EIS are actually part of DOE's current design for a Yucca Mountain repository. As such, the impacts of these features and alternatives should have been fully addressed in the Draft EIS. For example, the current repository conceptual design (not the design described in the Draft EIS) calls for the waste packages to be covered by a continuous titanium drip shield. The Draft EIS should examine the impact on the national (and perhaps international) titanium resource from the increased demand caused by the use of titanium drip shields in up to 100 miles of repository tunnels.

Response
DOE recognizes that some radionuclides and potentially toxic chemicals would, after more than 10,000 years, enter the environment outside the repository. The design alternatives described in the EIS would delay the potential release of radioactive contaminants from the repository. As noted in Section 5.4.1 of the EIS, DOE expects the rate of early failures of waste packages to be very low; too low to have meaningful consequences on the long-term performance of the repository. Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, DOE believes that a repository at Yucca Mountain would operate in compliance with the radiation protection standards in 40 CFR Part 197.

Because of the evolving nature of the design of the repository, DOE issued a Supplement to the Draft EIS in May 2001 for public review. The enhanced design discussed in the Supplement would improve long-term repository performance and reduce some of the uncertainties associated with this performance. Enhancements include a more corrosion-resistant waste package and titanium drip shields over each waste package. The Supplement describes the impacts of the repository based on the most recent repository design. DOE believes that the impact analyses in the Supplement would adequately bound additional impacts that could result from further enhancements in the design of the repository.

As described in Section 4.1.15 of the EIS, the annual requirement for titanium for drip shields ranges from about 4,300 to 6,500 metric tons (4,700 to 7,200 tons) depending on the operating mode and packaging scenario. The magnitude of the comparison is the result of low U.S. production of the basic raw material, because the United States imports most of the titanium raw material. Although the annual U.S. production of titanium raw material is only 21,600 metric tons (23,800 tons), the annual U.S. capacity to produce titanium ingots is 78,200 metric tons (86,200 tons) (DIRS 152457-Gambogi 1997). The maximum annual program need is a little more than 8 percent of the current annual U.S. ingot production. Titanium is classified as a Federal Strategic and Critical Inventory material and is the ninth most common element in the Earth's crust (DIRS 107031-U.S. Bureau of Mines 1995). Because the drip shields would not be needed until repository closure, there would be adequate time (more than 100 years) to expand the production of titanium raw material or to import additional raw material before the need to reduce impact on markets.

7.1.1 (5485)
Comment - EIS001887 / 0155
Page 3-24; Section 3.1.3.1 - Physiography (Characteristic Landforms): Selection of Repository Host Rock

The discussion on the repository host rock should indicate that, during construction of the ESF, more significant ground support methods than originally expected were required to achieve "stable openings."

Response
During construction of the Exploratory Studies Facility, portions of the North and South Ramps needed ground support. However, ground support at the repository level (where the waste would be emplaced) was minimal; the openings were very stable. DOE believes that the existing text is adequate.

7.1.1 (5584)
Comment - EIS001887 / 0209
Page 4-3; Section 4.1 - Short-Term Environmental Impacts of Performance Confirmation, Construction, Operation and Monitoring, and Closure of a Repository

The text states that closure would include "Potentially backfilling the main drifts, access ramps, ventilation shafts, and connecting openings." This is not fully consistent with the description of closure in Section 2.1.2.3, Repository Closure. That section states closure would include, "filling of the main drifts, access ramps, and ventilation shafts; and sealing of openings, including ventilation shafts, access ramps, and boreholes." These two statements must be reconciled, and the commitment to backfilling and sealing must be maintained.

Response
DOE has modified the text in Section 4.1 of the Final EIS to be consistent with the text in Section 2.1.2.4 (formerly Section 2.1.2.3) with regard to backfilling and sealing.

7.1.1 (5588)
Comment - EIS001887 / 0213
Page 4-6; Section 4.1.1.2 - Impacts to Land Use and Ownership from Construction, Operation and Monitoring, and Closure

This section precludes backfill of the emplacement drifts. This is inconsistent with the design features and alternatives that are being held open to bound the impacts of the different thermal load alternatives and is inconsistent with the current design approach.

Response
The current design, described in the Supplement to the Draft EIS and carried forward to the Final EIS, and the design described in the Draft EIS do not include backfilling of the emplacement drifts.

DOE based the statement in Section 4.1.1.2 of the Draft EIS—that it would exclude the emplacement drifts from backfilling—on the Viability Assessment (DIRS 101779-DOE 1998). The current design assumes that the emplacement drifts would not contain backfill; the Supplement describes the consequences of this design.

7.1.1 (5624)
Comment - EIS001887 / 0249
Page 4-72; Section 4.1.11.2 - Impacts to Utilities, Energy, Materials, and Site Services from Construction, Operation and Monitoring, and Closure

Construction Material: The Draft EIS fails to evaluate the impact on titanium resources from the planned use of titanium drip shields in 100 miles or more of emplacement tunnels. The current repository design calls for the use of such drip shields as an integral part of the waste isolation system. The Draft EIS, however, addresses only the use of concrete, steel, and copper as the primary construction materials. The impact of extraordinarily large amounts of titanium for waste package protection should be addressed.

Response
As described in Section 4.1.15 of the Final EIS, the annual requirement for titanium for drip shields ranges from about 4,300 to 6,500 metric tons, depending on the operating mode and packaging scenario. The magnitude of the comparison is the result of low U.S. production of the basic raw material, because the United States imports most of the titanium raw material. Although the annual U.S. production of titanium raw material is only 21,600 metric tons, the annual U.S. capacity to produce titanium ingots is 78,200 metric tons (DIRS 152457-Gambogi 1997). The maximum annual program need is a little more than 8 percent of the current annual U.S. ingot production. Titanium is classified as a Federal Strategic and Critical Inventory material and is the ninth most common element in the Earth's crust (DIRS 107031-U.S. Bureau of Mines 1995). Because the drip shields would not be needed until repository closure, there would be adequate time (more than 100 years) to expand production of titanium raw material or to import additional raw material in advance of the need to reduce impact on markets.

7.1.1 (5630)
Comment - EIS001887 / 0257
Page 4-99; Section 4.2.1.1 - Retrieval Activities

The figure on this page gives inadequate detail as to the exact location of the proposed waste retrieval and storage area, even when combined with Figure 3-12. The figure on this page should give more detail as to the exact location of the storage area.

Response
One of the alternative sites for the Retrieval Facility is in Midway Valley near the repository site. DOE has not yet determined the design of this facility or its exact location. However, the Department believes that the information in the EIS is adequate for estimating the representative environmental impacts from using this site for waste retrieval.

7.1.1 (5665)
Comment - EIS001887 / 0284
Page 5-28; Section 5.4.1 - Consequences from the Groundwater Exposure Pathway for the High Thermal Load Scenario

The discussion of the waste package lifetime should be rewritten to indicate the new configuration of the waste package, i.e., the Alloy-22 on the outside.

Response
Since publication of the Draft EIS, the waste package design has evolved into a more robust and corrosion resistant design with an outside layer of Alloy-22. The appropriate sections of the Final EIS (including Section 5.2.2) now reflect this updated design.

7.1.1 (5673)
Comment - EIS001887 / 0292
Page 5-39; Section 5.6 - Consequences from Chemically Toxic Materials

Would there be any changes to the discussion in this section based on the change in the waste package design? If so, the Draft EIS should indicate these changes.

Response
Because of the evolving nature of the design of the repository, DOE issued a Supplement to the Draft EIS in May 2001 for public review. As indicated in the Supplement, the waste package has been re-designed. This new waste package design information was carried forward to the Final EIS. The conclusions reached in Section 5.6 with regard to chemically toxic materials are still valid for the new design.

7.1.1 (5720)
Comment - 010073 / 0009
Page 1-2 - The SDEIS does not consider the potential for Yucca Mountain to accommodate spent fuel in amounts beyond that considered within the DEIS due to the closer spacing to be achieved through the flexible design. The SDEIS should provide a new estimate of the total potential spent fuel and other high-level radioactive waste that could be emplaced in Yucca Mountain.

Response
Under the NWPA, the repository would be limited to 70,000 metric tons of heavy metal (MTHM); therefore, the EIS evaluates the flexible design scenarios that support 70,000 MTHM. Based on public comments during EIS scoping hearings, the EIS also evaluates the impacts of emplacing more than 70,000 MTHM in a repository (Inventory Modules 1 and 2) (see EIS Sections 8.2 and 8.3.2 for a discussion of the inventories considered and the associated impacts). These inventory projections have not changed since the Draft EIS was published, but the impacts have been updated to reflect the flexible design. The EIS does not evaluate inventories greater than those of Modules 1 and 2.

7.1.1 (5948)
Comment - EIS001622 / 0052
The Department could not find any detailed description of the repository closure including the sealing of shafts and ramps, etc. This element of the project should also be discussed in more detail.

Response
Supporting documents to the EIS such as the *Monitored Geologic Repository Project Description Document* (DIRS 151853-CRWMS M&O 2000), and other referenced supporting documents, discuss such issues as shaft seal design. It has been established that the current technology for shaft sealing will provide for sufficient integrity of these sealed openings that they will behave as well as the host rock in long-term performance. The EIS relies on all of these supporting documents, including the Science and Engineering Report, to provide discussions of such supporting details.

7.1.1 (6417)
Comment - EIS001632 / 0007
Page 2-17, Figure 2-10 does not identify the proposed locations for the cask maintenance facility and landfill. Locations of these need to be identified in order to assess their potential impacts.

Response
DOE has considered onsite and offsite locations for the Cask Maintenance Facility. A site for the landfill has not yet been identified. DOE would identify an appropriately sized landfill at the repository site for nonhazardous and nonradiological construction and sanitary solid waste, and for similar waste generated during operation, monitoring, and closure of the repository. Although the Cask Maintenance Facility may not be located at the Yucca Mountain site (therefore not depicted on current site drawings), the EIS analysis assumed the landfill and the Cask Maintenance Facility would be located at the repository. By doing so, the environmental impacts of these facilities were considered in the EIS. DOE believes that the amount of information in the EIS on these facilities is adequate to determine representative environmental impacts.

7.1.1 (6418)
Comment - EIS001632 / 0008
Page 2-21, 2.1.2.1.5: The second paragraph mentions “water used for cooling tower operations.” We found no other description or reference to a cooling tower. The final EIS should explain the purpose of this operation and any possible radiological or chemical contamination from the cooling tower.

Response
Figure 2-10 shows the location of the cooling tower at the North Portal Operations Area. DOE would use the cooling tower exclusively for air conditioning of surface facilities at the repository. The tower would not be a source of chemical contamination or radiological emissions. The Final EIS has been revised to state that the cooling tower is not a source of chemical or radiological emissions or contamination.

7.1.1 (6996)

Comment - EIS000817 / 0006

Once underground, you expect these casks to be retrievable. You think you can return the waste to the surface. How? Who will do it? How hot will the tunnels be? 400° or more? What if the remote equipment breaks down, a tunnel caves in, or there is an earthquake? What if the cask welds or seals go before you expected them to? These are the “achilles heels” of these casks. The weaknesses in fabrication will cause problems. How are you going to unload all those transport or storage casks at Yucca Mountain? How are you going to repackage all that spent fuel and HLW at Yucca Mountain before you even consider putting it underground? What condition will that fuel really be in after storage, transport, storage, transport? How many times? What happens to fuel in the wet-to-dry process repeatedly? It is wet in the reactor and pool, dry in casks at the plant, wet in unloading again, dry in transport, wet in unloading again? Dry in interim storage, wet or dry transfer to a disposal cask? Dry in the mountain at first, and wet again at the end? Think of a rock in a stream encrusted with moss, etc. Take it out, dry it in the sun--what happens? Stuff gets hard and brittle and falls off--especially if you transport the dry rock in your pocket (like fuel in a cask). Then what happens if you put the rock in water again--say water full of chemicals like a reactor pool? Stuff reacts--falls off--forms gases--not steam what? Remember spent fuel has pinhole leaks and hairline cracks in cladding--any amount is acceptable to NRC [the Nuclear Regulatory Commission]. And rods may be depressurized. Crud falls off. Blisters fall off and expose holes. Then what?

Response

The flexible design described in the Supplement to the Draft EIS and the Final EIS includes the ability to operate the repository in a range of operating modes that address higher and lower temperatures and associated humidity conditions. Higher-temperature means that at least a portion of the emplacement drift rock wall would have a maximum temperature above the boiling point of water at the elevation of the repository [96ºC (205ºF)]. The lower-temperature operating mode ranges include conditions under which the drift rock wall temperatures would be below the boiling point of water, and conditions under which the waste package surface temperature would not exceed 85ºC (185ºF). To bound the impact analysis, DOE considered conditions under which the rock wall temperatures would be above the boiling point of water, and conditions under which waste package surface temperatures would not exceed 85ºC.

The design of the subsurface facilities includes equipment and facilities for retrieving waste packages prior to closure of the repository. It is true that humans would not be able to enter an emplacement drift once it has been loaded with waste packages without the use of thermal and radiation shielding. Human entry is not planned should retrieval be required. However, provisions have been considered for recovering from accidents or malfunctions. See, for example, the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001).

Even though DOE would not expect to retrieve the waste, the impacts of such an action are examined in Section 4.2 of the EIS. Based on the current design, DOE would use the same equipment for retrieval that would be used for emplacement. Therefore, the Department would gain experience in operating and maintaining the equipment should retrieval of the waste become necessary. Design of the repository includes equipment that would be appropriate for the high temperatures and radiation fields in the emplacement drifts. The design criteria include effects from natural phenomena that could result in cave-in or other problems. In addition, Section 122 of the NWPA and the Nuclear Regulatory Commission require the repository to maintain the ability to retrieve emplaced waste for at least 50 years after the start of emplacement.

Design of the subsurface facility is still evolving. DOE would ensure that facilities and equipment meet all design requirements and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design of the retrieval equipment before licensing the repository.

The commenter is correct in asserting that the surface facilities would receive a variety of casks certified by the Nuclear Regulatory Commission. The design of the facilities upon which DOE based the analyses in the EIS includes appropriate facilities to handle transportation casks containing disposable canisters, dual-purpose canisters, or bare fuel assemblies. Section 2.1.2.1 of the EIS describes these facilities. Although several spent nuclear fuel storage technologies are in use at various commercial and DOE sites, DOE would ship spent nuclear fuel to the repository in disposable canisters in a transportation cask, dual-purpose canisters in a transportation cask, or as individual assemblies in transportation casks. Design of the Waste Handling building would accommodate the unloading of all three types of canisters. As for loading the various types of fuel and canisters into disposal containers, there are 10 designs for disposal containers to provide all the repacking options needed. Five of the designs would be for spent nuclear fuel from commercial nuclear plants and five would be for DOE spent nuclear fuel.

The conditions to which spent nuclear fuel is subjected after removal from the reactor to the time when it would be emplaced in the repository are much less severe than the conditions under which the fuel operates in service. Therefore, degradation of the fuel would be unlikely during the transition from in-service to disposal. A small amount of radioactive crud could be dislodged during handling but DOE has designed all of the facilities to deal routinely with the resulting contamination. In addition, DOE has incorporated into the design a system to deal with the small number (less than 1 percent) of damaged fuel assemblies. The operating experience in handling spent nuclear fuel at commercial nuclear plants is substantial, and DOE has used this experience to ensure that the facilities supporting Yucca Mountain would work as designed.

7.1.1 (7045)
Comment - EIS001337 / 0008
In DEIS scoping comments, the County [Lincoln] and City [Caliente] noted that the disposal of radioactive waste in a deep geologic repository at Yucca Mountain is characterized by both real and perceived risk. The risk of exposure to radiation from atmospheric pathways was noted an important issue to residents of Lincoln County. Volcanism and criticality control were presented as two issues which the County believes every aspect of repository development and operation must be evaluated against. The County and City recommended that the DEIS include a comparative evaluation of the extent to which alternatives for accomplishing construction, emplacement, closure, and post-closure phases of the facility achieve containment of radioisotopes during volcanic eruption and loss of criticality control. The DEIS does not provide a comparative evaluation of the extent to which alternatives for construction, emplacement, closure and post-closure achieve containment of radioisotopes during volcanic eruption or loss of criticality control. The FEIS should include such a comparative evaluation.

Response
DOE has evaluated the long-term geologic stability of Yucca Mountain, including the potential for volcanoes. Volcanic activity has been waning in the recent geologic past; the probability of a volcano that could disturb the repository is very low (see Section 3.1.3.1 of the EIS). Sections 5.7.2 and 5.8 of the EIS summarize potential impacts to repository performance from volcanic disturbances and from criticalities, respectively. DOE analyzed the effects of both a volcanic eruption, which could release volcanic ash and entrained wastes into the atmosphere, and the intrusion of magma into the emplacement drifts, which could damage waste packages and contaminate the underlying aquifer. DOE estimated potential impacts on the nearest population to the south, conservatively assuming wind in that direction, and determined that the resulting radiation dose would be small. DOE believes that it is not reasonable to rank one concept for a repository ahead of another in terms of their resistance to the effects of volcanism or criticality because such events would be very unlikely.

7.1.1 (7173)
Comment - EIS001337 / 0064
Page 1-17 3rd paragraph. It is not clear in reviewing the DEIS whether DOE has made a finding as to whether the repository is capable of accommodating all of the various waste volumes potentially needing disposal at the Yucca Mountain site. Can the Yucca Mountain site handle all of the waste described in this paragraph?

Response
The EIS describes the environmental impacts from the disposal of up to 70,000 metric tons of heavy metal of spent nuclear fuel and high-level radioactive waste. The NWPA restricts the first repository to 70,000 metric tons of heavy metal. DOE has determined that there is sufficient space within Yucca Mountain for this amount of waste. Chapter 8 describes the cumulative impacts from the Proposed Action along with additional amounts and types of waste that could be disposed of in the repository, providing that Congress authorized such an action. DOE has determined that there is sufficient space within Yucca Mountain for this additional waste.

7.1.1 (7297)
Comment - EIS001832 / 0031
DOE should increase the size of the early receipt facility in case lag storage needs increase due to delays or to accommodate future evolutions in repository and waste package design.

The DEIS considers the possibility of early receipt of spent fuel at the proposed Yucca Mountain repository. The early receipt facility would be capable of storing as much as 10,000 MTU of spent nuclear fuel and high-level radioactive waste in concrete storage modules. Possible changes under consideration for the repository and waste package design may result in the need for lower heat-load waste packages being emplaced in the repository. DOE should consider including an analysis of the impacts associated with a larger capacity early receipt facility in order to provide adding cooling of spent fuel to meet the needs of possible repository design evolutions.

Response
The flexible design presented in the Supplement to the Draft EIS includes provisions for surface aging of up to 40,000 metric tons of heavy metal to support the low-operating temperature operating mode of the repository. DOE believes the impact analyses of the high- and low-temperature operating modes presented in the Supplement to the Draft EIS (Chapter 3) and the Final EIS (Chapter 4) adequately reflect the range of possible impacts.

7.1.1 (7425)
Comment - EIS001912 / 0017
If the subsurface design and performance is uncertain which leads to uncertainties about surface facility design scenarios, how can DOE select among one of its packaging scenarios?

Response
DOE presented a range of packaging scenarios in the Draft EIS to define the range of consequences associated with the Proposed Action. The surface and subsurface systems described in the Draft EIS and in the Supplement to the Draft EIS, and carried forward to the Final EIS, are not tightly coupled; the only interface between the surface and subsurface systems is the transporter that takes sealed waste packages from the waste handling building to the emplacement drifts. A significant change in either the surface or subsurface system would not necessarily lead to substantial changes in the other system.

7.1.1 (7463)
Comment - EIS000817 / 0009
The waste handling facility at Yucca will be receiving a huge jumble of so-called “generic” cask designs -- mostly new, just NRC [Nuclear Regulatory Commission]-certified -- (not time tested or ever even built for prototype testing before use at reactors). Dry cask storage is still in its infancy. But NRC keeps certifying cask after cask and utilities change the designs for the facility needs -- meaning they all end up really being site-specific designs. All the spent fuel will be in different containers, having different past histories by the time they get to Yucca handling. How on earth can you have one facility appropriate to unload all of these different designs and assemblies? The specifics here are not being looked at and they need to be evaluated -- in detail! How are you going to unload and repackage all these casks? What are costs and doses here? We need to know this first before any repository is ever considered.

Response
The commenter is correct in that the repository would receive a variety of casks that have been certified by the Nuclear Regulatory Commission. The design of the surface facilities at the repository, upon which DOE based the analyses in the EIS, includes facilities to handle transportation casks containing disposable canisters, dual-purpose canisters, and bare fuel assemblies. Section 2.1.2.1 of the EIS describes these facilities. Even though there are several spent nuclear fuel storage technologies licensed and in use at commercial and DOE sites, the Department would ship all spent nuclear fuel to the repository in disposable canisters in a transportation cask, dual-purpose canisters in a transportation cask, or as individual assemblies in transportation casks. Design of the Waste Handling building would accommodate the unloading of all three canister types. As for loading the various types of fuel and canisters into disposal containers, the repository design now includes 10 specific designs for disposal containers to provide all repacking options needed. Five of the designs would be for spent nuclear fuel from commercial nuclear plants and five would be for DOE spent nuclear fuel.

Design of the surface facilities is evolving. DOE would ensure that these facilities and equipment at the repository would meet all design requirements and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

With regard to the costs for unloading casks at the surface facilities and radiation exposure, Chapter 4 of the EIS includes detailed impact analyses (including costs and exposure to workers and the public) of unloading operations.

7.1.1 (7471)
Comment - EIS000817 / 0012
Problem after problem after problem. So don't expect a person like me, well versed in the real history of dry cask storage, to blithely accept your plan to unload and load casks at Yucca Mountain in a handling facility. There will be more unexpected problems there. And don't expect me to believe retrieval is as easy as you make it sound on paper -- without the detailed analysis necessary for this EIS. You have got to look at the track record of dry cask storage so far, and evaluate what the utilities are doing now and how the casks they use and what they are allowing will affect handling at the repository in the future. It all starts with spent fuel behavior in casks at reactors. That affects your system and has got to get more attention. It is part of your concern.

Response
DOE would not use dry storage casks like those at commercial and DOE sites for disposal at the repository. Spent nuclear fuel at the 77 commercial and DOE sites would be transported to the repository in casks licensed according to 10 CFR Part 71. For disposal, the spent nuclear fuel would be removed from the transportation casks and loaded into disposal containers. There exist systems that are dual-purpose and multi-purpose, with components that meet the rigorous requirements for storage and transport, or storage, transport, and disposal. Section 2.1.1.1 of the EIS discusses the various packaging scenarios. As described in Section 4.2 of the EIS, the design of the repository includes equipment and facilities for retrieving the waste, even though retrieval is not part of the Proposed Action.

DOE would ensure that the design of surface facilities and equipment would meet all requirements and peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7.1.1 (7814)
Comment - EIS001653 / 0015
Is the surface facility design dependent upon transportation activities? If so please explain the relationship, which exists between the surface design scenarios and the selected transportation scenarios.

Response
The transportation and subsurface emplacement scenarios would influence the design of the surface facilities at the repository. Changes in the design of cask, containers, and waste packages, and the schedule for the receipt and emplacement of waste, would affect the design of the surface facility. For example, if most of the waste shipments arrived in permanently sealed multi-purpose canisters (canisters designed for shipment, surface storage, and emplacement in the repository), DOE could put the canisters directly in disposal containers. If most spent nuclear fuel assemblies arrived in shipping casks or in dual-purpose canisters, DOE would configure the surface facilities and equipment with a greater capacity to remove individual assemblies from the casks or canisters and stage them before packaging them individually in disposal containers. The surface facilities would not be very dependent on transportation routes.

7.1.1 (7982)
Comment - EIS000817 / 0045
On p. 2-16 you realize everything also depends on how the waste arriving is packaged. You blithely say you will test interior gases of these casks, vent and cool them, and remove their lids as if it is just a common practice. Well, it has never been done with any of the present cask designs up for certification holding 21-24 etc. assemblies. You don't know how this will work at all. Especially with the lack of standardization and integration of the many cask designs utilities are loading -- with any total waste system DOE has in mind. Your p. 2-19 is a fantasy at this point. And so is p. 2-20 -- so you have a pool to empty the dual purpose canisters -- every design? How? What chemicals in the pool? How [are] gases released? How [are] filters cleaned? What reactions [are] possible with cask materials and pool water? The casks affect the pool and the pool affects the casks -- and over time how dirty will that pool become? Can you really do this?

Response
The assertion that testing and venting of interior gases from waste casks has never been done is inaccurate. The spent nuclear fuel at the 77 commercial and DOE sites would be transported to the repository in casks licensed according to 10 CFR Part 71. DOE has more than twenty years of experience using these transportation casks, including initial cask-unloading operations that check the cask for contamination, sample interior gases, vent the interior gases through filtration, and unbolt the lid. All transportation casks used to ship spent nuclear fuel would comply with 10 CFR Part 71 and include features to accomplish these initial cask-unloading operations.

DOE has extensive experience with pools for spent-fuel loading and unloading operations. The design of the spent nuclear fuel pools to be used for unloading in the Waste Handling Building is similar to the design of pools used at DOE and commercial facilities. The design includes systems to continually treat the pool water for removal of radioactive contamination by pumping the pool water through particulate filtration, ion exchange, and sterilization systems. Vacuum systems and leak-detection systems are also included.

7.1.1 (7986)
Comment - EIS000817 / 0047
You talk about maintaining pressure differentials to ensure an air flow for ventilation. Depending on anything not passive is risky. Fans can break. Then what? How contaminated would a fan be? How long to replace a defective one or broken one with the standby one? If that one has problems, how long before you have a problem heat up in the repository? What are risks here?

Response
Ventilation will be active to help remove heat from the emplacement shafts during the preclosure period. In the event of a ventilation failure, a very slow build up of heat would begin in the repository. There would be no adverse consequences from this heat. For example, other repository designs were evaluated without active ventilation and repository performance was acceptable. The forced-air ventilation system has been added as a conservative defense-in-depth feature to maintain a lower drift-wall temperature (described in the Supplement to the Draft EIS that was released for public review in May 2001 and the Final EIS). If a fan failed, it could be repaired or replaced within a couple of weeks; this would not cause any detectable impacts.

The exhaust system is designed to prohibit the exhaust of radioactively contaminated air. Design of the repository ventilation system includes air monitoring for radioactivity and a feature to avert exhaust through high-efficiency particulate air filtration prior to exhausting if any radioactivity is detected.

The design of the repository ventilation system is still evolving. DOE would ensure that the final design meets all requirements (including development of adequate maintenance and inspection programs) and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7.1.1 (7988)
Comment - EIS000817 / 0048
P. 21 -- What is the “cooling tower”? You say water from it will be put in ponds lined with “heavy plastic sheets”? How long will these last? And how contaminated will that area become long term? -- Can wastewater leak at seams of sheets? No plastic sheet lasts very long.

Response
The design of the repository includes cooling towers adjacent to the utility building to support heat rejection from the utility building chiller systems. Water from the cooling tower, among other industrial streams from the water-softening and deionized water systems would be collected in an evaporation pond located in the North Portal Operations Area. The purpose of this pond would simply be to collect and evaporate the collected wastewater. Water from these industrial streams would not contain any hazardous materials.

The design of the repository is still evolving. DOE would ensure that the industrial wastewater-evaporation system meets all applicable design requirements (including development of adequate maintenance and inspection programs) and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7.1.1 (8001)
Comment - EIS000817 / 0056
I am very interested in the support for the casks. Why are they designed this way? I gather the cask sits horizontally on a “V” of steel. What kind of steel? This is a crucial area of metal on metal and needs as much corrosion resistance as possible, for water could collect or condense there later on and rust these two metal surfaces together and prevent retrieval. This is a real concern. It was with [the] VSC-24 canister sitting on [the] metal liner of the concrete outer shell. NRC [Nuclear Regulatory Commission] demanded a different design and ceramic tiles were the accepted solution between these metal-to-metal surfaces so they wouldn’t corrode together and prevent retrieval there. But -- handling procedures had to be very carefully directed not to set the inner canister down too hard on the tiles and crack them. Are they now cracked in loaded VSC-24s? Nobody knows. None has ever been unloaded. What is DOE’s evaluation of corrosion rusting the support and the cask together over time? Has this been done? It needs to be done.

Response
The waste package support evaluated in the Draft EIS was a steel “V” type; it would be made of the same material that would be used to fabricate the waste package. The design of both the waste package and support were updated in the Supplement to the Draft EIS that was issued for public review in May 2001. The updated design would place the waste package on an emplacement pallet during the transfer of the package to the subsurface. Both the outer barrier of the waste package and pallet would be made of Alloy-22. If waste retrieval were required, the waste package and pallet would remain together and transferred to the surface.

The design of the subsurface facility is still evolving. DOE would ensure that the design of these facilities and equipment meet all requirements and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7.1.1 (8003)
Comment - EIS000817 / 0058
If you reuse the railcar and the shielded transporter, how contaminated will they be over time? How will that affect the outer surface of waste packages -- and eventual doses at retrieval? P. 2-32 sounds like playing with a train set -- and you expect this all really to work as expected over all that time? I sure don’t. What are doses if somebody has to get in there and fix that gantry or locomotive system? You know it’s like these outer space landers -- one little screw or something loose and the whole thing goes “Kaflooey.” All that money lost! I predict problem after problem with your system that will cost the public plenty. There is too much that can go wrong here.

Response
The current design of the repository specifies that loaded waste packages are remotely decontaminated to specified activity levels prior to loading into the waste package transporters. A waste package would also be welded shut, inspected, and leak tested to ensure no leakage of radioactive contamination. Thus, contamination of the rail car and transporter would be minimized such that dose rates resulting from such incidental contamination would be negligible and would have no discernible effect on the dose rates from the spent nuclear fuel in the waste package.

The design of the subsurface facility is still evolving. DOE would ensure that the facility and equipment designs (including necessary radiological surveys and decontamination of the transporter) meet all design requirements and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7.1.1 (8018)
Comment - EIS000817 / 0069
P. 2-57 -- You need drip shields -- but will they work? How have they been tested? What ceramic coating has been tested? If rockfall could crack it, it may exacerbate corrosion in the cracks; have you thought of that? Water will collect in cracks in ceramic and rust there. What “additions” and “fillers”? What “getters” under waste packages? Anything -- any other materials -- chemicals especially -- need to be evaluated for final repository conditions when everything in there becomes mushed together in a “radioactive soup.” -- What will be the interactions of materials then? And interactions of new materials formed from interactions? This is crucial to your plan and must be evaluated in detail.

<u>Response</u>
As described in the Supplement to the Draft EIS (released for public review in May 2001) and in the Final EIS, titanium drip shield would be installed over each waste package just prior to repository closure. The drip shields would be an additional barrier to corrosion by diverting any water away from the waste packages. The drip shields would survive rockfalls.

Since DOE issued the Draft EIS, the design of the waste package has evolved for the reasons mentioned in the comment (cracks in ceramic coatings). Therefore, the design no longer has these coatings. The waste package design now consists of a highly corrosion-resistant outer barrier of Alloy-22 with an inner structural liner of stainless steel.

The design of the repository is still evolving. DOE would ensure that the final design of facilities and equipment (including compatibility of all subsurface materials, including fuel and engineered and natural barriers) would meet all requirements and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

"Getters" and "fillers" are yet-to-be-identified materials that could be added beneath and inside the waste package to further retard the migration of radionuclides. If DOE decided to include such features in the repository design, it would have to evaluate them fully to determine their impacts on the drift environment. At present, these features are not part of the design of the repository.

7.1.1 (8312)
<u>Comment</u> - EIS000817 / 0110
Figure 4-6. Where did this "typical" concrete storage module design come from? I've never seen one like it. How can there be an air inlet and an air outlet at the top of the cask? All the casks I know have inlets at the bottom and outlets at the top, and NRC [Nuclear Regulatory Commission] has stated that if all inlets on the bottom are blocked, the outlets at the top will not act as inlets. Please explain your design. What are the locking plates for? Is this a 2-piece thing, or what? If so, why? You have only a shield lid on top -- isn't a double welded closure demanded by NRC? Also, I don't understand the steel liner -- why isn't it under the waste package too? And if there is metal-to-metal contact at the base of the waste package and the liner, you need to prevent corrosion there with ceramic tiles or something. Moisture can condense on the flat surface of the bottom of the waste package.

<u>Response</u>
Conceptual, rather than typical, could be a more appropriate title for Figure 4-6. The figure is based on preliminary design work for the Multi-Purpose Cask System (see DIRS 101775-DOE 1994); this system is not currently licensed or in use. The conceptual design was used to estimate such things as crane capacities, pad sizes, and material quantities, but should not be used for evaluating detailed features such as cask ventilation. The final design would have to be approved by the Nuclear Regulatory Commission prior to use if retrieval was necessary.

The locking plates shown in Figure 4-6 simply provide the means to assemble a multi-piece unit, which can be more economically shipped and handled at the repository. From the figure it can be seen that at the locking plate location, the thick steel components of the locking plates provide shielding equivalent to the concrete cross-section.

The steel liner in the typical unit is simply a heat barrier for the concrete wall and as depicted in Figure 4-6; the bottom of the waste package is not exposed to concrete.

The shield lid of the storage unit provides no sealing to the spent nuclear fuel. The double seal required for storage by 10 CFR Part 72 is accomplished by the waste package itself, which becomes part of the storage system when it is placed in the typical storage unit.

The design of the repository is still evolving. DOE would ensure that the design of the facility would meet all requirements and receive necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

7.1.1 (8567)
Comment - EIS000817 / 0175
P. 9-15 Access to Waste Packages -- All these fillers, etc. -- how would you get this all out to get at the cask? "Modified waste emplacement" -- this sounds more feasible -- a main tunnel for access and casks in alcoves or short side tunnels -- The idea of a track getting clogged by a rock fall or something, and not usable, would certainly be easier to "unclog" if casks weren't in the way. Keep the main tunnel for personnel movement and use alcoves for waste -- easier to monitor and repair and replace. Also less chance of one problem causing a mess with the whole tunnel. This paragraph is full of some good creative thinking here. Work out all possibilities and test them. Take your time. Do this the best way possible if you are going to do it at all. Keep your mind free to all possibilities. Maybe nobody has thought of the best way to do this yet. Keep some people just at the job of brainstorming or have brainstorming sessions for personnel together periodically. The best document I've read is when NWTRB [the Nuclear Waste Technical Review Board] had that creative meeting on waste package ideas. It was great! I read the transcript. People interacting who are experts -- saying what comes to mind as workable and then discarding it, but at least not "bogged down" in one old idea that won't work.

Response
DOE has considered alternate configurations for the main tunnels and emplacement drifts at several stages during the design of the repository. DOE considers the current design, which incorporates parallel emplacement drifts connected to main drifts, to be the most appropriate arrangement for construction, handling, and operation.

7.1.1 (8568)
Comment - EIS000817 / 0176
P. 7-16 Rod Consolidation -- I've read a lot about this in the past and it "sounds" good, but the end fittings create a problem. I guess it costs more and the utilities won't do it anyway. It would save space. But no cask designs are out there for this that I know. They were interested in this years ago and discarded the idea.

Response
Section E.2.2.6 of the EIS considered rod consolidation in conjunction with a wide range of design options and alternatives. Rod consolidation is not included in the current design for the Yucca Mountain repository.

7.1.1 (8570)
Comment - EIS000817 / 0178
P. 9-16. 2-level repository -- would help retrieval, but could one above the other allow for more avenues of seepage eventually?

Response
As this comment suggests, a multilevel design could provide a quicker pathway for seepage to reach certain waste packages. However, the updated flexible design evaluated in the Final EIS does not include a consideration for waste packages being emplaced in multiple layers.

7.1.1 (8580)
Comment - EIS000817 / 0184
P. H-5. 4 PWR assemblies in a basket? I had no idea that's all you planned to put in there. A suspended basket should not be allowed to go above another basket -- redesign this. NRC [the Nuclear Regulatory Commission] doesn't allow a cask of fuel to be carried over other assemblies in the pool -- and for good reason.

Response
The baskets used for transferring assemblies of spent nuclear fuel are designed to hold four pressurized-water reactor assemblies or eight boiling-water reactor assemblies. During all basket transfers, the operations would be conducted to avoid moving one basket over another. However, in that part of the operation where the basket would be placed in the assembly drying station, the assemblies would be close enough together so that it would not be possible to ensure that a failure that caused the suspended basket to drop would not result in the dropped basket contacting another basket. If a release of radionuclides occurred as a result of the basket drop, a corresponding coincident failure (within 24 hours) of the high-efficiency particulate air filtration system would be required before workers or the public could be exposed to any significant radioactivity. For the design described in the Supplement

to the Draft EIS and the Final EIS, coincident failures of the basket transfer system and the high-efficiency particulate air filtration system are not considered to be credible.

7.1.1 (10453)
Comment - EIS001337 / 0013
The County [Lincoln] and City [Caliente] recommended that the DEIS assess alternative materials which might be used to achieve closure for their relative contribution to risk management, retrievability and cost. The DEIS does not appear to consider the risk management, retrievability and cost attributes of alternative materials which might be used to achieve repository closure. Absent such information, closure decisions cannot be supported by the document.

Response
As a result of the evaluation of the "Viability Assessment of a Repository at Yucca Mountain" (DIRS 101779-DOE 1998) and concerns such as those of the Total System Performance Assessment Review Panel, DOE modified the waste package design and added a drip shield over the waste packages. The waste package would have Alloy-22 as the outside layer with stainless steel on the inside. The titanium drip shield would add further defense-in-depth to the design.

Because of these evolving design changes, DOE issued a Supplement to the Draft EIS in May 2001. The information provided in the Supplement, and incorporated into the Final EIS, describes the potential impacts associated with the design modifications, which took into consideration thermal, mechanical, and chemical performance, ease of fabrication, costs, and compatibility with other materials.

While DOE believes the design enhancements will improve the proposed repository's chances of complying with regulatory requirements over the long term, it would maintain flexibility with regard to when it would ultimately close the repository and under what conditions it would retrieve the waste material. To maintain flexibility and an ability to respond to changing conditions and technologies, Section 122 of the NWPA requires retrievability at a high-level radioactive waste repository. Federal regulations (10 CFR Part 63) require that the repository be designed to preserve the option of waste retrieval on a reasonable schedule for as long as 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the Yucca Mountain Repository provides for a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly as long as 300 years in the event of a decision to retrieve the waste, either to protect the public health and safety or the environment, or to recover resources from spent nuclear fuel. During this period, the repository would remain accessible for scientists to continue testing and monitoring while providing more flexibility for future generations of scientists and engineers to determine the timing and methods of repository closure.

Once the repository is closed, a postclosure monitoring program would be implemented pursuant to 10 CFR Part 63. This program would include monitoring activities around the repository after the facility had been closed and sealed. The program would include continued oversight to prevent barriers of increasing the radiation beyond allowable limits. The details of this program would be defined during the processing of the license amendments for permanent closure.

7.1.1 (11436)
Comment - EIS001888 / 0355
[Clark County summary of comments it has received from the public.]

Commenters requested that the EIS justify the selection of the alternatives, and that the alternatives and options be sufficiently defined to comprehensively describe the affected environment, and to allow an equivalent analysis (between alternatives) of potential positive and negative impacts to human health and the environment (e.g., groundwater, air, socioeconomics) from routine operations and accidents during construction, operation, and closure. The types of detail identified include: construction methods, facilities, used at Yucca Mountain, subsurface attributes [to] ensure that SNF and HLW can be contained, surface and subsurface operations (e.g., handling, packaging, emplacement, secondary waste handling, mitigations), anticipated waste package characteristics (e.g., fuel age, heat, size), retrieval scenarios.

Response
The Proposed Action is to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain. The only alternative to the Proposed Action considered in the EIS is the No-Action Alternative. Under the Proposed Action, DOE examined several transportation modes and routes and various design alternatives. Many aspects of the design and operation of the repository are based on conservative assumptions or covered by a range of possibilities. This approach allows DOE to continue to refine and improve the design before settling on final design and operational specifics. DOE believes that the level of detail presented in the EIS is sufficient to analyze and compare the various alternatives and design options. During any licensing process with the Nuclear Regulatory Commission, DOE would evaluate the design alternatives and options in greater detail, as necessary, to demonstrate compliance with applicable requirements.

7.1.1 (11437)
Comment - EIS001888 / 0514
[Clark County summary of comments it has received from the public.]

Commenters requested that the EIS justify the selection of the alternatives, and that the alternatives and options be sufficiently defined to comprehensively describe the affected environment, and to allow an equivalent analysis (between alternatives) of potential positive and negative impacts to human health and the environment (e.g., groundwater, air, socioeconomics) from routine operations and accidents during construction, operation, and closure. The types of detail identified include: pre- and post-closure monitoring programs, and institutional controls.

Response
The Proposed Action is to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain. The only alternative to the Proposed Action considered in the EIS is the No-Action Alternative. Under the Proposed Action, DOE has defined several transportation modes and routes and various design alternatives. Many aspects of the design and operation of the repository are based on conservative assumptions or covered by a range of possibilities. This approach allows DOE to continue to refine and improve the design before settling on final design and operational specifics. DOE believes that the level of detail presented in the EIS is sufficient to analyze and compare the various alternatives and design options. During any licensing process with the Nuclear Regulatory Commission, DOE would evaluate the design alternatives and options in greater detail, as necessary, to demonstrate compliance with applicable requirements. DOE expects that the environmental consequences of the final design would be adequately bounded by the consequences of the design analyzed in the EIS.

As described in Section 4.1 of the EIS, DOE would conduct testing and performance confirmation activities during all the phases of the repository project prior to closure to evaluate the adequacy of the information it used to demonstrate compliance with the performance objectives.

DOE would also design and implement a postclosure monitoring program in compliance with the Nuclear Regulatory Commission regulations (at 10 CFR Part 63). Prior to closure, DOE would submit a license amendment to the Commission for review and approval. The license amendment application would include among several items, an update of the assessment of the performance of the repository for the period after closure; a description of the postclosure monitoring program; a detailed description of the measures to be employed to regulate or prevent activities that could impair the long-term isolation of the waste; and methods to preserve relevant information for use by future generations.

The application also would describe DOE's proposal for continued oversight to prevent any activity at the site that would pose an unreasonable risk of breaching the repository's engineered barriers, or increase the exposure of individual members of the public to radiation beyond allowable limits. DOE has modified the EIS to include the types of monitoring and other institutional controls that would be contemplated. The details of this program, however, would be defined during the processing of the license amendment for closure. This would allow DOE to take advantage of new technological information, as appropriate.

As described in Section 2.1 of the EIS, the Proposed Action would use two types of institutional controls—active and passive. Active institutional controls (monitored and enforced limitations on site access; inspection and maintenance of waste packages, facilities, equipment, etc.) would be used through closure. Passive institutional controls (markers, engineered barriers, etc., that are not monitored or maintained) would be put in place during closure and used to minimize inadvertent exposures to members of the public in the future.

7.1.1 (11703)
<u>Comment</u> - EIS002312 / 0001
Why not use soda ash (refined) to plug the walls of the storage repository! Soda ash will let out heat, keep out water, keep in radioactive waste. Soda ash will not break down over long periods of time.

<u>Response</u>
The evolving design of the repository, as described in the Supplement to the Draft EIS and carried forward to the Final EIS, now includes a more robust waste package to delay by more than 10,000 years the release of radionuclides from the repository. The design also includes a titanium drip shield over each waste package to limit and moisture that could otherwise contact the waste packages. DOE also considered backfilling the emplacement drifts, but eliminated this concept because of its adverse impact on the cladding temperature of spent nuclear fuel. The design of the liner has evolved from an all-concrete liner to a combination of steel inverts with steel sets and welded-wire fabric with grouted rockbolts (see the Supplement to the Draft EIS and the Final EIS). DOE abandoned the all-concrete concept due to concerns about the long-term impacts of the concrete on the alkalinity of the drift environment, and the potential for corrosion of the engineered barrier and waste package components. In addition, DOE considered near-field treatment of rock in the repository design, as discussed in Section E.2.2.17 of the EIS. The rock treatment would inject a low-permeability grout into cracks in the rock above each emplacement drift to limit the amount of water that could seep into the drift.

The use of soda ash for plugging the walls of the repository, whether as a backfill or a rock treatment material, would raise the alkalinity of the repository environment. In addition, the use of soda ash as a backfill would have an adverse effect on heat removal and cladding temperatures. DOE would continue to refine the design of the engineered barrier system to reduce the creation of preferential pathways for water to contact the waste packages and to reduce the migration of radionuclides through existing pathways.

7.1.1 (12380)
<u>Comment</u> - 010073 / 0005
Table S-2 - The SDEIS offers no explanation of the need for up to 4 times as much electrical energy and 5 times as much waste generation for the lower temperature alternative than the DEIS design.

<u>Response</u>
Both the higher-temperature and lower-temperature operating modes of the flexible design use electrically powered fans for forced-flow air cooling to the emplacement drifts. The number of fans operating would gradually increase from the start of emplacement to the completion of emplacement when all fans had been placed in operation. The fans would continue to operate during monitoring for up to 300 years, depending on the specific scenario. The Draft EIS scenarios included much smaller fans for ventilation only, and did not include the operation of fans to cool the emplacement drifts. The substantially increased capacity of the fans, and the operation of the fans for up to 300 years, are the reasons that the use of electrical power for the flexible design scenarios is greater than the electrical use for the design in the Draft EIS.

The commenter refers to the upper range of construction and demolition debris generated under the lower-temperature operating mode; 810,000 cubic meters compared to 150,000 cubic meters under the Draft EIS thermal load scenarios. Section 3.1.12 of the Supplement to the Draft EIS discusses waste generation, as does Section 4.1.12 of the Final EIS. This section explains that the largest waste volumes would result from the lower-temperature operating mode with surface aging of waste. Additional waste would be generated from the construction and demolition of the surface aging facility and 4,500 dry storage vaults.

7.1.1 (12432)
<u>Comment</u> - EIS000817 / 0075
"Dry storage units are simpler and easier to maintain." What is the basis for this statement? You mean than aging pools? Are they really? Do you realize the huge number of problems with dry cask so far? At least in a pool you can see the assemblies. You know what is happening with them and with the water. You have access to them to

change situations. This idea that once in a cask, everything is fine, is based on nothing -- just predictions. You don't really know.

Response
Dry storage casks such as those in use at commercial facilities would not be used at the repository. In the unlikely event that the waste would be retrieved from the repository, the Alloy-22 waste packages would be brought to the surface and stored in dry storage units.

The Nuclear Regulatory Commission has concluded that above-ground dry storage is a viable option at commercial plants. Dry storage units are described as "simpler and easier to maintain" than pool storage because they provide passive cooling of spent nuclear fuel, as well as shielding. Unlike spent nuclear fuel pools, dry cask storage requires no treatment equipment to keep the pool water clean, involves no filtration, and generates no radioactive waste while maintaining shielding and allowing the spent nuclear fuel to cool.

The problems referred to by the commenter are widely documented in Nuclear Regulatory Commission bulletins, inspection reports, letters, and other public documents. The problems involve the use of a storage technology that uses a mostly carbon-steel fuel basket (internals and shell) with anti-corrosion coatings. The majority of the spent-fuel-storage technologies use stainless steel and either no or limited amounts of anti-corrosion coatings. Many of the problems cited resulted from a failure of the licensee to adequately implement the required quality assurance and quality control programs.

7.1.1 (12606)
Comment - EIS000817 / 0033
Your term "incident free" sounds like a sale -- nothing is really "free" -- expect "incidents" -- there will be some, and I expect faulty fabrication of casks and poor designs and handling procedures for casks to provide the biggest doses to workers and the public. These designs are new, vendors are new, subcontractors are not used to nuclear QA criteria, etc. -- a perfect setup for problems. And we already have a lot in dry cask storage at plants. The track record is bad already!

Response
The design, fabrication, and handling of waste packages are subject to the same level of peer review, public review, and regulatory review as the rest of the repository program. The waste packages would be fabricated under the American Society of Mechanical Engineer's Section III nuclear codes (DIRS 145103-ASME 1998). This approach has been successfully used in the past to ensure high-quality components. Dry cask storage at commercial plants is designed for interim (about 100 years) storage above ground, not for underground disposal. The waste package that would be used at the repository would far exceed the performance and reliability of waste containers currently used for dry cask storage at commercial sites.

7.1.1 (13373)
Comment - 010182 / 0016
The SDEIS states that titanium drip shields will be constructed on site and placed over the waste packages after emplacement. It states that titanium is extremely corrosion resistant; however, on Page 3-19, para. 3.1.15 "Offsite Manufacturing," it states that titanium is "somewhat difficult to refine into metal." The installation of drip shields at the time of repository closure may result in transportation of shields to the site over a relatively short period of time rather than during emplacement; and the cost of drip shields will be deferred. This does not seem to be consistent with protecting the waste packages and ultimately protecting the public and environment from potential escape of radionuclides during emplacement. If the drip shields are emplaced during waste package emplacement, will funds be available when needed? The SDEIS should consider:

a. An analysis, now, on the ability for the DOE to mass produce the drip shields presently, and on the cost to produce and install the drip shields at time of waste package emplacement;

b. The transportation accident and fatality risk associated with a short-duration campaign to ship drip shields to the site; and

c. A mitigation measure to include installation of drip shields at time of waste package emplacement.

Response

DOE believes that Congress, having directed the Government to embark on this project, will continue to fund it adequately to protect the public health and welfare. As reported in *Nuclear Waste Fund Fee Adequacy: An Assessment* (DIRS 153257-DOE 2001), the Nuclear Waste Fund investments had a market value of $8.5 billion as of September 30, 1999. The report found that the current fee of 1 mil per kilowatt-hour charged to generators of commercial spent nuclear fuel was adequate to cover projected disposal expenses (including costs associated with packaging and transportation and updated to include a variety of operating modes and closure modes, including drip shields, and schedules for the flexible design) and recommended that the fee remain unchanged.

Response to comment subparts:

a. Section 2.15 of the EIS describes the results of the estimates to produce, deliver, and install the drip shields. The report *Life Cycle Cost Analysis for Repository Flexible Design Concepts* (DIRS 156900-DOE 2001) is based on the TSLCC and contains cost estimates for the 70,000 MTHM Proposed Action. Section 2.4.4 of the Science and Engineering Report (DIRS 153849-DOE 2001) describes the feasibility of using drip shields.

b. The transportation accident and fatality risk associated with transporting drip shields to the repository has been added to the Final EIS transportation analysis. See Section 6.1.3 of the EIS for more information.

c. During the preclosure period the repository is ventilated. Also the newly emplaced packages are at their highest heat output. During this preclosure period there is no dripping from infiltrating water due to the de-watering effect of the heat output and the ventilation. Under these conditions only humid air corrosion would take place. The drip shields' only purpose is to prevent liquid water from dripping on the waste packages so that liquid water corrosion effects are prevented. Prior to closure there is no dripping and therefore no need for the drip shields.

7.1.2 SUPPLEMENT TO THE DRAFT EIS FLEXIBLE DESIGN

7.1.2 (2249)

Comment - 010212 / 0005

One of the changes from the DEIS design is to have one canister transfer line instead of two, based on "further waste stream requirements analysis," and a reduction from three to two assembly transfer lines. We have not read the reference for those changes but we are curious about reducing redundancy to account for maintenance or equipment malfunction. We recommend that redundancy of equipment be a design parameter, as we understand it is one of the hallmarks of the nuclear industry's excellent safety record.

Response

Operation, preventive maintenance, and the repair of malfunctions at the repository would be part of the detailed engineering process during License Application, if the Yucca Mountain site was designated for the repository. The difference in the number of processing lines between the Draft EIS and Final EIS was based on the planned level of operation and the rate at which the flexible design would handle the waste stream. If it was determined that malfunctions in the transfer lines would be likely to impair the ability to meet processing requirements successfully, design alternatives, including redundant capability, would be considered.

7.1.2 (12362)

Comment - 010491 / 0002

The use of titanium as a roof over the waste inside the repository only makes the repository more attractive commercially to tomb robbers.

Response

Under the advice of the National Research Council of the National Academy of Sciences, the Environmental Protection Agency elected to exclude considerations of deliberate human intrusion from the final repository performance standard (40 CFR Part 197). This is primarily because it is impossible to characterize any range of deliberate acts of humans in the future and also because of the long period of administrative control. However, DOE did evaluate potential impacts of an inadvertent human intrusion in a manner required by the Environmental Protection Agency's recent *Public Health and Environmental Radiation Protection Standards for Yucca Mountain,* *Nevada* (40 CFR Part 197) to gain insight into the robustness of the repository design. The result reported in the Draft EIS was one-fifteenth of the standard set by the Environmental Protection Agency. The Final EIS includes an updated version of this analysis.

7.1.2 (12654)
Comment - 010099 / 0004
It is not clear that the "S&ER flexible design" discussed in the SDEIS is the same as that used in the TSLCC document which uses a "Reference System Design" ("capable of emplacing 97,000 MTHM") from a "Project Description Document" not made available to the public. The FEIS should clarify this.

Response
The commenter is correct in noting that the flexible design is not the same as the reference design referred to in *Analysis of the Total System Life-Cycle Cost of the Civilian Radioactive Waste Management Program* (DIRS 153255-DOE 2001). The flexible design includes the reference design as the higher-temperature operating mode. The other operating modes of the flexible design, referred to as lower-temperature operating modes, were discussed generally in Chapter 8 of DOE (DIRS 153255-2001). The *Life Cycle Cost Analysis for Repository Flexible Design Concepts* (DIRS 156900-DOE 2001) is an update to the information provided in the May 2001 report and is for the full range of the flexible design for 70,000 MTHM. The estimated costs associated with the Proposed Action have been updated in the EIS (see Section 2.1.5).

7.1.2 (12690)
Comment - 010480 / 0002

The retrievability-
To maintain waste package retrievability. The drip shields would be placed over the waste packages just before repository closure.

What happens if the drip shield [gets] dripped on and becomes contaminated and possible melt down effect occurs? How can you retrieve them?

Response
Drip shields would be emplaced just prior to permanent closure of the repository. Therefore, their emplacement would occur only after satisfactory completion of the performance confirmation program which, under certain implementation options, could extend for more than 300 years after final emplacement of the waste packages. The purpose of the performance confirmation program is to ensure that the engineered barriers and the geologic setting are performing as predicted by the long-term performance models thus ensuring compliance with the Environmental Protection Agency's Human Health and Environmental Protection Standards (40 CFR Part 197) as well as the Nuclear Regulatory Commission's licensing criteria (10 CFR Part 63). Once the determination has been made that the repository is in compliance with the long-term performance standards, a license amendment would be prepared and submitted to the Nuclear Regulatory Commission requesting approval for permanent closure of the repository (possibly more than 300 years in the future). The drip shields would not be emplaced until approval to close the repository was received from the Nuclear Regulatory Commission.

The repository design allows for maintenance of systems and structures such that retrieval of the waste packages would be possible up to the time of permanent closure. After emplacement of the drip shields and closure of the repository, retrieval of the waste packages would not be expected or planned.

For a period after closure, the intrinsic heat of the waste packages would be sufficient to drive liquid moisture away from the waste packages and the drip shields. At some time in the future, the waste packages would cool to a point that allowed infiltrating liquid water to drip onto the drip shields. The purpose of the drip shields would be to prevent liquid water from dripping on the waste packages, which could increase corrosion rates and shorten the life of the waste packages. However, studies have determined that use of drip shields probably would ensure the integrity of the vast majority of the waste packages for more than 10,000 years.

With regard to drip shields becoming contaminated and undergoing a meltdown, DOE is not aware of any scenario related to dripping water that could produce such an effect.

7.1.2 (12959)
Comment - 010249 / 0013
Clarify the appropriateness of DOE's "criteria for repository area selection"

In Section 2.3.3 of the SDEIS, DOE introduces a set of criteria that are constraints on the location of the below ground repository (type of rock formation, proximity to faults, distance from the surface, and distance from the water table). It is not entirely clear that these criteria are necessary at this time. DOE should either remove these constraints from the FEIS or better explain the reason for imposing them.

Response
The criteria mentioned are part of the assumptions for the design basis for the flexible design. The criteria are imposed by the Yucca Mountain Project, not the EIS. The criteria for location of the repository are detailed in the Subsurface Facility Design Description Document that was referenced in the Supplement to the Draft EIS where the criteria in question were stated. The criteria are based primarily on requirements set forth in the Nuclear Regulatory Commission regulation for high-level waste disposal (10 CFR Part 63) which are then further detailed in DOE's Mined Geologic Repository Requirements Document. The repository must meet the requirements of this regulation in order to be licensed by the Nuclear Regulatory Commission. Further information on development of these criteria can be found in the design description document. The relationship of each of the criteria to the regulation and related rationale are as follows:

Location in the Topopah Spring Formation:
10 CFR 63.113(b) requires the repository to be within the TSw2 geologic unit. This is primarily because the rock in this unit has general properties favorable to containment and isolation.

Avoid major faults:
10 CFR 63.113(a) requires the geologic repository to include a natural barrier. Major faults represent potential preferential pathways and therefore are potential breaches of the natural barrier. Therefore a standoff distance is established between the repository openings and Type I faults to ensure the presence of a natural barrier.

Locate at least 200 meters below the surface:
This is related to 10 CFR 63.113(b) and stems from a requirement in the Mined Geologic Repository Requirements Document (Section 3.3.C) which states specifically that there will be an overburden of 200 meters for the perimeters of the drifts at the emplacement level. The rationale for this is primarily to maintain sufficient distance from human influence and the surface environment.

Locate at least 160 meters above the existing water table:
This is also related to 10 CFR 63.113(a) requiring natural barriers. This leads to the need for sufficient separation from the water table to avoid future climate conditions causing the water table to reach the level of the repository and sufficient separation from faults. Several lines of evidence point to a past waster table elevation at Yucca Mountain of at most 115 meters above the present-day level. It was also determined that better repository performance would be ensured if the water table remained below the farthest extent of boiling influence from the heat generated by the waste. Consideration of all these factors led to the 160-meter criteria.

7.1.2 (12960)
Comment - 010249 / 0014
Correctly reflect storage cask design standards

In Section 3.1.15 of the SDEIS, DOE makes the following statement regarding the carbon-steel shells in dry storage casks (in the 4th paragraph on p 3-19); "The shell... manufactured to less demanding procedures and specifications." This statement is not accurate. While the procedures and specifications are different, they are not necessarily "less demanding". In accordance with NRC [Nuclear Regulatory Commission] licensing requirements, these components are designed to withstand seismic events, provide natural convection cooling, and otherwise meet rigorous standards. This statement should be revised so as not to provide misleading information about the adequacy of the design.

Response
The statement has been revised in the Final EIS.

7.1.2 (13100)
Comment - 010227 / 0018
There are many questions that arise from the DOE study of the drip shields, as with much of this project, you don't really get any answers to your questions, just more questions. One of these questions that were not addressed in the SDEIS is where the drip shields would divert moisture? The images shown in the document show a slight railing along the shields, which would seem to be a gutter of sorts, yet there is no description of where this moisture would go -- possibly between the drift walls? Possibly back into fissures in the rock? It could potentially evaporate right off the drip shields depending on how hot those would be (but that information isn't in the SDEIS either); there is no clear answer to how these would really work to protect the environment from the waste.

Response
Section 2.3.4.3 "Emplacement Pallets" of the Supplement to the Draft EIS has a very brief discussion on drip shields with conceptual figures. For more details, see the Science and Engineering Report (DIRS 153849-DOE 2001). Figure 2-71 in that section illustrates the "ballast" support of the drip shield. This ballast would be engineered granular material that would absorb any dripping water. The runoff water would then be evaporated or trickle into the rock invert and its matrix of pores and fractures.

7.1.2 (13101)
Comment - 010227 / 0019
The SDEIS states that the drip shields would not be put into place until the repository closes -- what happens if that is more than 300 years away? The drip shields are designed to protect waste packages from possibly corrosion. If the waste packages are in place for 300 years before the drip shields are placed, that allows for 300 years of rainfall to corrode these packages. If the higher-temperature scenario becomes a part of the final design then there will still be 50 years before the drip shields go into place. According to the SDEIS 2.3.4.1 (p. 2-25) if the drip shields aren't in place water will drip onto the waste packages increasing the likelihood of corrosion. SDEIS does not adequately describe a method for preventing that corrosion until the drip shields can be put into place.

Response
During the preclosure period the repository would be ventilated. In addition, the newly emplaced waste packages would produce their highest heat output. During this period there would be no dripping from infiltrating water due to the dewatering effect of the waste-generated heat and from ventilation. Under these conditions only corrosion from humid air would take place. The purpose of the drip shields would be to prevent liquid water from dripping on the waste packages. Prior to closure there would be no dripping and, therefore, no need for the drip shields.

7.1.2 (13218)
Comment - 010244 / 0017
The SDEIS does not consider the potential for the Yucca Mountain geologic formation to accommodate spent fuel in amounts beyond that considered within the DEIS due to the closer spacing to be achieved through flexible design. The SDEIS should provide a new estimate of the total potential spent fuel and other high level radioactive waste that could be emplaced at Yucca Mountain.

Response
Under the NWPA, the repository is limited to 70,000 metric tons of heavy metal (MTHM) and the EIS evaluates the flexible design scenarios that support 70,000 MTHM. Based upon public comments during EIS scoping hearings, the EIS also evaluates the impacts of emplacing more than 70,000 MTHM in the repository (Inventory Modules 1 and 2) (see EIS Chapter 8 for a discussion of the inventories considered and the associated impacts). These inventory projections have not changed since the Draft EIS was published, but the impacts have been updated in the Final EIS to reflect the flexible design. The EIS does not contemplate inventories greater than those of Modules 1 and 2.

7.1.2 (13224)
<u>Comment</u> - 010244 / 0023
The SDEIS does not address the fact that the Drip Shields will not be employed until repository closure leaving the waste packages unprotected for up to 300 years under the lower temperature repository scenario.

<u>Response</u>
During the preclosure period the repository would be ventilated. During this time the waste packages are at their highest heat output (under all operating modes). During this preclosure period there would be no dripping from infiltrating water due to the de-watering effect of the heat output and the ventilation. Under these conditions only humid air corrosion would take place. The drip shields' only purpose is to prevent liquid water from dripping on the waste packages so that corrosion is prevented. Prior to closure, there is no dripping and, therefore, no need for the drip shields.

7.1.2 (13236)
<u>Comment</u> - 010244 / 0035
The repository would have two evaporation ponds for wastewater, one at each portal. In both ponds it is suggested that heavy plastic liners would prevent water migration into the soil. The North Portal Area would also include a 32-acre storm water retention pond. Increases of roughly 10% for the S&ER design is projected due to additional blow down and water for the 5,000 MTHM cooling pool. The supplement [provides] no proof that the plastic liners would survive during the 300 years it would take to close the lower-temperature repository design, which could possibly cause the release of radionuclides.

<u>Response</u>
Neither of the evaporation ponds would be needed or operated during the entire preclosure period. The evaporation pond at the South Portal would be used for excess water returned to the surface during subsurface excavation. This excavation would take place during the 5-year construction phase and for the first 22 years of the operation and monitoring phase, which includes simultaneous development (emplacement- and access-drift construction) and emplacement. That is, the South Portal evaporation pond would be used for a total of about 27 years. The evaporation pond at the North Portal would be used only during that portion of the operation and monitoring phase when waste was being emplaced in the repository and surface facilities were needed to support those actions. For most operating scenarios, emplacement would completed in 24 years. The exception would be if a surface aging facility were included; in such a case, it would be another 26 years before all of the waste was put into the subsurface repository. Maintenance (including replacement, as appropriate) could be necessary to keep these liners intact during their operational life, but they would not be expected to be in use during the caretaker and monitoring period, which could be as long as 300 years under several of the lower-temperature operating modes.

7.1.2 (13272)
<u>Comment</u> - 010231 / 0006
Page 2-13, Figure 2-4. The "potential commercial spent nuclear fuel aging area" is inside the RCA but apparently outside the security station. What security controls will there be for this area?

<u>Response</u>
To avoid compromise, details of physical security plans are typically not made available to the public. However, DOE believes that security for the spent nuclear fuel surface aging facility would be similar to that required for existing commercial Independent Spent Nuclear Storage Facilities currently licensed by the Nuclear Regulatory Commission. At a minimum, security controls would include positive control on ingress and egress at the facility, as well as periodic surveillance by security personnel. Detailed security requirements for all areas of the proposed repository, including the fuel aging facility, would be included in the construction and operating license approved and issued by the Nuclear Regulatory Commission.

7.1.2 (13274)
<u>Comment</u> - 010231 / 0008
Page 2-31, Section 2.4. The last two sentences of the fourth paragraph state: "The effect of drift spacing on these related parameters would be less than the effect of waste package spacing in the analytical scenarios presented in this Supplement. Therefore, DOE did not perform a quantitative evaluation of the environmental impacts of variable drift spacing." EPA questions the basis for this statement and conclusion. What about interactions? The

distance between waste packages is an independent design factor from the distance between drifts. Therefore, there is a range of potential conditions and impacts that could occur. These impacts should be assessed or a more detailed rationale provided for the statements and conclusion.

Response
The Final EIS is based on the flexible design described in detail in the Science and Engineering Report (DIRS 153849-DOE 2001). Thermal management of the proposed repository would involve complex, nonlinear relationships among many parameters of the repository system [see the Science and Engineering Report (DIRS 153849-DOE 2001) for further discussion]. The major determinants of the peak temperatures are the age of the fuel at emplacement, the linear heat load along each drift, and the ventilation period after emplacement. By keeping the drift spacing constant, the overall feasibility of the various repository operating modes can be evaluated. The analysis presented in the Science and Engineering Report supports the environmental impact conclusions in the EIS. The Science and Engineering Report recognizes that the thermal load or areal mass loading can be varied also by the liner thermal load (which was done in the Science and Engineering Report), the drift spacing (which was not done in the Science and Engineering Report), or both. By varying the fuel age, waste package spacing, and ventilation, DOE has considered the major factors that would affect temperature variations in the repository. As noted in both the Science and Engineering Report and the Supplement to the Draft EIS, future studies could include variations in drift spacing. At present, DOE does not expect the conclusions drawn from the analysis in the Final EIS to change substantially as a result of variations in drift spacing versus waste package spacing.

7.1.2 (13275)
Comment - 010231 / 0009
Page 2-31, Section 2.4. The first sentence of the final paragraph identifies "Uncertainties in future funding profiles or the order of...waste shipments" could affect the construction of the repository. The next sentence states that this approach could "potentially increase confidence in meeting the schedule for waste receipt and emplacement." DOE should explain how uncertainties in funding can result in increased confidence for meeting the schedule.

Response
As mentioned in Section 2.4 of the Supplement to the Draft EIS, uncertainties in future funding or the order of waste shipments might require the repository to be developed in a sequential manner, such as constructing the surface and subsurface facilities in portions or "modules." This approach would incorporate "lessons learned" from initial work into subsequent modules, reduce the initial construction costs and investment risk, and potentially increase confidence in meeting the schedule for waste receipt and emplacement. The intent of this discussion was not to imply that uncertain funding would increase confidence.

7.1.2 (13329)
Comment - 010317 / 0009
The DEIS-S mentions the use of back-fill material but [it's] not clear what material will be chosen. The recommendation of the Yucca Mountain site should not be made until firm decisions have been made about … what back-fill materials will go where.

Response
Section 2.3.6 of the Supplement to the Draft EIS discusses using excavated rock from the storage area or another source. At present, the backfilling of emplacement drifts is not considered beneficial. Because only the ramps, shafts, mains, and miscellaneous openings are designated for backfill, only processed mined rock (welded tuff) has been selected for backfill material.

7.1.2 (13345)
Comment - 010296 / 0005
It is erroneous to assume that lowering operating temperature of the repository automatically eliminates corrosion problems. Operating-temperature management of individual canisters will be required to reduce corrosion problems.

Response
The management of waste package temperature to achieve thermal goals would be based on the established thermal blending requirements. This comment is correct in stating that each package would have to be "managed" or loaded

with a mixture of spent nuclear fuel that met the requirements. The performance of the repository system under a lower-temperature operating mode is discussed in detail in Section 2.1.5 of the Science and Engineering Report (DIRS 153849-DOE 2001). One tradeoff regarding thermal loads is the estimation of rockfall. At lower temperatures, the overall amount of rockfall probably would be lower, but the localized amounts of rockfall could be greater due to nonuniform temperatures along the drift. Another result of lower temperatures would be lower corrosion susceptibility and reduced uncertainty. However, aqueous processes would be initiated sooner. Each of the degradation mechanisms utilized to predict the performance of the waste package includes temperature as a variable. Thus, the response of the waste package to a set of thermal conditions is built into the models.

Although a range of thermal loads was investigated for the repository, waste package performance as evaluated by the expected maximum dose to the public would not vary greatly with thermal loading. See the *FY 01 Supplemental Science Performance Analyses* (DIRS 155950-BSC 2001) for further detail.

7.1.2 (13387)
Comment - 010296 / 0020
As Nye County understands it, people (workers, operators) would drive the waste packages along a railroad from the waste handling building down to the appropriate point in the main drifts. Then “the operators would leave” (back to the surface?) and remote controls (operated at the surface?) would:

a) Open the door to the intended emplacement drift;
b) Use the locomotive to push the waste package and its pallet into the drift;
c) Close the door (maybe);
d) Remove (by gantry) the loaded waste package from the transporter and onto the metal ground support;
e) Pull the locomotive and transporter out of the emplacement drift, and close the door behind;
f) Then the workers return and drive the locomotive and transporter back to the surface.

The details of these operations must be disclosed in the FEIS (or its supporting documentation) in order to fully evaluate the DOE’s assessment of risk.

Response
A technical report entitled *Concept of Operations for Waste Transport, Emplacement, and Retrieval* (DIRS 155732-BSC 2001) was prepared in July 2001. One of the objectives of this technical report was to discuss the base case concepts of waste transport, emplacement, and retrieval operations and evaluate these operations relative to a lower-temperature repository design. Detailed discussions of all operations necessary to emplace the waste packages were presented.

7.1.2 (13392)
Comment - 010296 / 0021
Further, Nye County notes that there is no explanation of how contingencies in remote handling would be met and at what cost in time, money and risk. For example, what happens when:

- A chunk of rock gets lodged in the gantry equipment, or in the emplacement drift door?
- The locomotive dies during gantry operation;
- The gantry sets the package one foot forward or backward, or one foot to the side of where it should be;
- The above contingency is not discovered until emplacement of a subsequent package.
- Again, information regarding how contingencies in remote handling would be met must be included in the FEIS or its supporting documentation.

Response
Accidents are addressed in Section 3.1.8 of the Supplement to the Draft EIS and Section 4.1.8 of the Draft and Final EIS.

The Supplement to the Draft EIS addresses proposed changes to the concepts contained in the Draft EIS. The waste emplacement operations applied to the revised flexible operating mode are fundamentally the same as those described in the Draft EIS (see Section 2.1.2.2.3 “Waste Package Emplacement Operations”).

These types of off-normal events will be addressed as final design of the gantry is developed. Also, refer to “Broad Based Risk Analysis Subsurface Facilities” (DIRS 102707-CRWMS M&O 1998).

The isolation door control system will be equipped with redundant switches to indicate full open or closed position. Should the door not operate properly, the conditions would be investigated and appropriate mitigation strategies will be developed and initiated. Refer to “Emplacement Drift Isolation Door Control System” (DIRS 131504-CRWMS M&O 1998).

The locomotive and gantry are totally separate pieces of equipment that operate independently of each other. One failing will have no effect on the other.

Final Waste Package placement within the emplacement drift (waste package spacing) is a very important parameter. This separation distance between waste packages will be verified by two or more remote measuring technologies to ensure accurate package placement. Refer to “Gantry Structural/Control System Analysis” (DIRS 154553-BSC 2001).

7.1.2 (13397)

Comment - 010296 / 0022

Figure 2.2 (p.2-5): This is an artist’s conception of the nuclear waste repository rather than a scientist’s perception. The high temperature version of this figure (top) gives no indication where silica might precipitate relative to emplacement drifts, nor where dissolution of minerals caused by condensing steam (in refluxing zones) might occur. The precipitation of silica is important because it can control the flow of water (and gases) around and near the emplacement drifts. Silica precipitation could form a “gap” over the drift deflecting water around it, or it could precipitate between drifts causing flow into the drifts. If drifts are spaced too closely together, the silica caps could merge with adjacent drifts; low spots between drifts could accumulate infiltrated water causing a perched zone. Upon cooling, the blanket of silica precipitate could fracture and the perched water could then flow into the repository. Depending on the velocity of this flow into drift(s), steam explosions are possible. Nye County finds this overly simplistic “artist’s” conception of the repository to be inaccurate and misleading. The FEIS should identify all the natural processes that might occur within the repository and explain the potential consequences of these processes on repository performance.

Response

As indicated by Figure 2-2 of the Supplement to the Draft EIS, during the period of high heat output from the waste packages, expected water flow conditions for the higher- and lower-temperature repository operating modes would be dominated by the thermal effects of the waste packages. After the waste packages cooled, more complex thermal-hydrological-chemical interactions would affect the water in the drifts. This comment is correct to point out that those interactions are complex. Figure 2-2 is based on Figures 2-71 and 4-38 from the Science and Engineering Report (DIRS 153849-DOE 2001), which show the expected waste package emplacement and drift scale thermal-hydrologic flow and transport processes, respectively.

The overall long-term performance of the higher- and lower-temperature repository operating modes is described in Chapter 5 of the EIS. Long-term performance results include simulations of thermal-hydraulic-chemical processes in the Total System Performance model, which include coupling between heat, water, and vapor flow; aqueous and gaseous species transport; kinetic and equilibrium mineral-water reactions; and feedback of mineral precipitation or dissolution on porosity, permeability, and capillary pressure (hydrologic properties) for a dual-permeability (fracture-matrix) system (DIRS 155950-BSC 2001).

7.1.2 (13398)

Comment - 010296 / 0023

As stated in the DSEIS [Supplement to the Draft EIS], the drip shield provides an independent corrosion resistant barrier. Independent barriers provide confidence against unforeseen processes and failure modes that cannot be included in PA [performance assessment] calculations. However, the quantitative performance improvement provided by the drip shields is unclear. Because the bottom is not sealed, moisture can theoretically enter below the drip shields. Under some sets of conditions, this can lead to condensation forming on the inside of the drip shield. The drip shields would reduce, but not clearly eliminate, dripping on the waste package and waste. The waste package would still be exposed to deposits of dirt and salt prior to closure. This would allow corrosion of the Alloy-22 to begin prior to the failure of the drip shields.

Response

The current modeling of waste package degradation includes the processes cited in this comment. These are expected processes that are accounted for in the modeling of package degradation. Corrosion would proceed prior to failure of drip shields, but would be greatly retarded by their presence. Thus, while the drip shields would not be an absolute containment, like the waste package, they would provide protection for the waste package containment by greatly reducing corrosion processes and protecting packages from rockfalls as drifts deteriorated. DOE has taken a conservative approach to assessing drip shield and waste package performance. The analysis assumed that dripping water contacting the drip shields or waste packages would be concentrated in its contained salts due to evaporation and condensation processes or by the presence of deliquescent salts brought in by the ventilation system. Two types of water were evaluated (DIRS 153849-DOE 2001). These include J-13 well water, a bicarbonate water, and rock pore water, a chloride-sulfate water. Once a water film was present, the degradation model was activated for the outer surfaces of the drip shield and the waste package. Water that condensed on the underside of the drip shield was assumed to be relatively pure. Such condensation on the drip shield would be possible but it was not observed in pilot-scale testing at thermal conditions similar to those of the repository. See Section 4.2.5.1 of the Science and Engineering Report (DIRS 153849-DOE 2001).

Sensitivity analyses were performed for each of the barriers [see Section 4.5.3 of the Science and Engineering Report (DIRS 153849-DOE 2001)]. The drip shield would provide some defense-in-depth for the case of a degraded waste package. Mean dose rates would increase by about a factor of 10; however, mean dose rates at the 10,000-year regulatory period would still be low.

7.1.2 (13399)

Comment - 010296 / 0024

Alloy-22 “feet” are to go on the drip shields purportedly to prevent galvanic coupling with the underlying steel members. While this may reduce the potential for galvanic coupling and hydrogen accumulation, it will not prevent it.

Response

DOE agrees that the use of Alloy-22 feet on the drip shield would not entirely eliminate galvanic coupling. This could accelerate the generation of insoluble ferric oxides or oxyhydroxides. However, Alloy-22 and Titanium Grade 7 have very similar corrosion potentials in repository-relevant solutions (compare DIRS 144971-CRWMS M&O 2000, Table 4, to DIRS 144229-CRWMS M&O 2000, Table 4). Therefore, galvanic coupling between Alloy-22 and Titanium Grade 7 would be of little consequence to degradation characteristics.

Hydrogen can evolve when passive alloys such as titanium are galvanically coupled to more active metals such as carbon steel. A consequence of hydrogen evolution could be hydrogen induced-cracking of repository materials. In the current repository design (including features such as the Alloy-22 feet), the titanium drip shield would not be in contact with any more active metals intentionally. Hydrogen embrittlement of alloys such as the Titanium Grade 7 drip shield occur when three general conditions occur simultaneously:

- A mechanism for generating hydrogen on a titanium surface
- Metal temperature above approximately 80°C (175°F)
- Solution pH less than 3 or greater than 12, or impressed potentials more negative than -0.7 V (SCE)

In the current repository design a mechanism for generating hydrogen could occur through galvanic coupling between the titanium drip shield and steel structural components (rockbolts, etc.) that could fall on the drip shield. In addition, conditions two and three would be met at certain repository locations where temperatures were high [80°C (175°F)] and concentrated groundwater was present. If all three conditions were present at the same time, local hydrided “hot spots” could form.

Despite the potential for local hydrided hot spots, significant hydrogen embrittlement of Titanium Grade 7 would be unlikely. The drip shield would have a large "tolerance" for hydrogen; that is, substantial concentrations would have to be achieved before any degradation in fracture toughness was observed. The critical hydrogen concentration level has been suggested to be at least 400 micrograms per gram and is likely to be well in excess of 1000 micrograms per gram (DIRS 154666-CRWMS M&O 2000). The estimated hydrogen concentration in the drip shield from passive corrosion 10,000 years after emplacement would be about 257 microgram per gram from a conservative estimate and 58 micrograms per gram from a best estimate (DIRS 151599-CRWMS M&O 2000). This would be well below the threshold concentration, and would not result in any noticeable hydrogen embrittlement or degradation of fracture toughness.

7.1.2 (13400)
<u>Comment</u> - 010296 / 0025
Alloy-22 should increase the time to first penetration of the waste package in comparison with the Draft EIS design. It is unclear whether DOE has sufficient data or theoretical models to justify taking performance credit for the material.

<u>Response</u>
The commenter is referred to Section 4.2.4 of the Science and Engineering Report (DIRS 153849-DOE 2001), Section 7 of the *FY 01 Supplemental Science and Performance Analyses* (DIRS 155950- and 154659-BSC 2001) and several other supporting documents referenced in the EIS for extensive detail concerning data and models used to forecast the behavior of Alloy-22. In particular, Section 7 of the Supplemental Science and Performance Analyses examines the uncertainties in extensive detail. Sensitivity analyses provide estimates of the importance of this uncertainty to the overall performance forecast. The information supports considerable confidence that while the range of possible behavior is great, use of this material supports a range of outcomes in performance in which all values lie well below accepted performance standards.

7.1.2 (13401)
<u>Comment</u> - 010296 / 0026
Placement of the drip shields is scheduled far in the future (at time of closure). Given the proclivity of Congress to play games with federal programs, what confidence can one have that the shields will ever be placed? Corrosion of the drip shields occurs in parallel with Alloy-22, rather than in series. Why not affix the titanium so that it is present from the start, corrodes in series with the waste package, and protects the waste package from initial dirt and salt deposits?

<u>Response</u>
During the preclosure period, the repository would be ventilated. Also, the newly emplaced waste packages would be at their highest heat output. During this preclosure period, there would be no dripping from infiltrating water because of the dewatering effect of the heat output and repository ventilation. The air would be low in relative humidity, assisted through the use of active ventilation. The drip shields' only purpose at that point would be to prevent liquid water from dripping on the waste packages, thus preventing liquid-water corrosion effects. Before closure, there would be no dripping. During the preclosure period, the corrosion of the waste packages is very low; they withstand rockfall without failure. (See Section 4.2.3.2.5 of the Science and Engineering Report for further information.) Therefore, installing the drip shields early would have no technical benefit and would result in an early, but unnecessary, expenditure. The drip shields would provide defense-in-depth during the postclosure period.

7.1.2 (13402)
<u>Comment</u> - 010296 / 0027
As discussed in Section 2.3.4, Engineered Barrier Design, the switch from Alloy-22 inside to the outside of the canister, with stainless steel inside for structural support was justified by its greater performance. Once the outer shell of Alloy-22 is breached, the rusting of the inner stainless steel shell with accompanying volume increase of iron oxides will quickly destroy the remainder of the outer shell by deformation and cracking. Since at least 90 percent of the performance of the repository is based on the canister, and ongoing experiments on canister materials are not completed (specifically, the effects of trace elements such as lead), it seems premature to justify changes of this sort on performance assessment.

Response

The analysis took no credit for the stainless-steel sleeve, which it considered only as a structural reinforcement prior to a breach of the Alloy-22. Until the Alloy-22 was breached, the interface would be unwetted and not exposed to oxygen. Therefore, any damage to the passive layer would be of no consequence. After the Alloy-22 was breached, corrosion would proceed from the inside and such things as the presence of iron oxides would be accounted for.

The Final EIS contains a new analysis of non-nuclear toxic materials based on the new design of the repository and waste packages. The analyses show that even under very conservative and bounding assumptions, toxic materials would have no significant impacts during the compliance period. Further details are in Sections I.6 and 5.6 of the EIS. The purpose of the current research is to support a possible decision to construct and operate the repository with postclosure forecasts only for making a reasonably informed decision that a postclosure mode would be feasible. The operation of the repository would include contingency planning for continued performance monitoring, which could extend for up to 300 years after emplacement. During this period, research would continue, including tests of the materials of construction and refinement of forecasting techniques. DOE believes that by the time of closure there would be sufficient knowledge of canister integrity and other pertinent items to support the case for safe closure or some alternative action. However, DOE also believes that current research on these materials is sufficient to provide a level of confidence and understanding to inform a site recommendation decision. See Section 4.2.4.3 of the Science and Engineering Report (DIRS 153849-DOE 2001) for more information.

7.1.2 (13403)

Comment - 010296 / 0028

The DOE has not identified any potential problems with respect to engineered barrier materials. Specifically, Nye County is referring to the potential effects of trace elements on the canister material alloy, ALLOY-22. Tests being conducted by DOE are beginning with low temperature conditions (70°C) and working up to higher temperature conditions. Given that temperature increases reaction rates exponentially as temperature increases, DOE will not see any significant effect of trace elements until and unless they experiments are performed at sufficiently high temperatures (120°C and above). A better approach would be to look for an effect at high temperatures and work down to see at what temperature the effect is not observable. The FEIS should address the potential effects of trace elements on barrier material performance in the presence of high temperature conditions. Given that the first canister failures are currently projected to occur just after the 10,000-year regulatory period, the potential complications that might result from the presence of trace elements in the canister material under high temperature conditions should be addressed in the FEIS.

Response

The purpose of the current research is to support a suitability decision for the Yucca Mountain site, with postclosure forecasts only for making a reasonably informed decision regarding long-term performance and regulatory compliance. As required by 10 CFR Part 63, the operation of the repository would include performance confirmation activities that would continue until repository closure. During this period, research would continue, including tests of the materials of construction and refinement of forecasting techniques.

Dripping water could contact the waste packages after the repository radionuclides decayed. The water could become concentrated in dissolved salts due to evaporation of the water film, as on the waste package surface. The chemistry of the water is described in the Science and Engineering Report (DIRS 153849-DOE 2001, Section 4.2.4.2.4). Two types of water were identified: J-13 well bicarbonate water that becomes alkaline near saturation and a pore-type chloride-sulfate water that remains near neutral near saturation. Long-term corrosion tests and short-term electrochemical potential tests have been conducted with the J-13 well water. In the latter tests, predicted concentrations of trace elements were added. No significant differences in corrosion rate were observed in these tests. Testing with the pore water is planned.

DOE believes that by the time of closure there would be sufficient knowledge of canister integrity and all other pertinent items to fully support the case for safe closure or for some alternative action. However, DOE also believes that the current research on these materials is sufficient to provide a level of confidence and understanding to adequately inform the site recommendation decision.

7.1.2 (13404)
Comment - 010296 / 0029
Rock bolts, as identified in Section 2.3.4.2, Ground Structures, may focus water flow onto the drip shields, and ultimately the canisters, as a result of their radial style of emplacement. What is the effect of grout on the chemistry of any dripping water? What is its trace element content? The FEIS must address these questions or indicate that DOE is uncertain of how these factors might affect performance.

Response
The in-drift environments are defined based on many processes including interaction of seepage water with rock bolts and grout material. The modeling of in-drift environments is discussed in the EIS in Section I.2.3, and in various referenced supporting documents. The ground control system is described in the Science and Engineering Report, Section 2.3.4. The system includes steel sets with welded-wire fabric and fully grouted rock bolts. This system would degrade with time. The steel would form oxides or oxyhydroxides, which would not be deleterious to the drip shield or waste package, while the grout would slightly modify the water dripping through it. However, the testing of drip-shield and waste-package material has included a broad range of water chemistries, including concrete modified water. Water chemistries are described in Section 4.2.4.2 of the Science and Engineering Report. Essentially no differences were seen in the rates of corrosion for any of the water chemistries evaluated.

7.1.2 (13448)
Comment - 010296 / 0033
With respect to Cask Maintenance (page 2-13), the DSEIS states that "the DElS assumed that there would be a CMF...at the YM site." In nearly two years, DOE hasn't located such a facility. Its function, Nye County assumes, is to clean and repair DOE-owned casks as delivered by private carriers. Such a facility would likely generate additional volumes of hazardous wastes (spent solvents, metal cuttings, etc.). It not clear whether the impacts from the CMF have been included in either the DEIS or the DSEIS.

Response
To transport spent nuclear fuel and high-level radioactive waste to the repository, DOE would use existing or new shipping casks that met Nuclear Regulatory Commission regulations (10 CFR Part 71). One or more qualified companies that provide specialized metal structures, tanks, and other heavy equipment would manufacture new shipping casks. The number and type of shipping casks required would depend on the predominant mode of transportation.

DOE would remove casks from service periodically for maintenance and inspection. These activities would occur at a cask maintenance facility(s) where cask functions and components would be checked and inspected in compliance with Nuclear Regulatory Commission requirements and preventive maintenance procedures. The major operations involved in cask maintenance would include decontamination, replacement of limited-life components such as O-rings, and verification of radiation shielding integrity, structural integrity, and heat transfer efficiency.

The large number of repository shipments would require new facilities for cask maintenance. DOE has not decided where in the United States it would locate a cask maintenance facility(s), but this EIS assumes that such a facility would be at the repository inside the Restricted Area at the North Portal on approximately 0.01 square kilometer (2.5 acres). Minor cask maintenance activities could occur at commercial or DOE sites.

7.1.2.1 Higher- and Lower-Temperature Operating Modes

7.1.2.1 (13086)
Comment - 010227 / 0004
In the higher temperature scenarios which were described in the SDEIS, drifts would be 81 meters apart, this is so that water moving through fast pathways would not pool above all of the drifts, and would instead find its way through the spaces between the drifts. The SDEIS seems to be telling people that there is no way to keep water from moving close to the waste packages (even with the fancy titanium drip shields) and that there are indeed fast pathways which can move water more quickly to the water table.

Response
The existence of fast pathways and the possible contact of water with the waste packages are all considered in the long-term performance models. The drip shields would keep dripping water from the waste packages for more than 10,000 years, which would greatly improve long-term performance. All of the concerns expressed in this comment are accounted for in the models used.

7.1.2.1 (13138)
Comment - 010237 / 0007
The S&ER flexible design allows for a degree of operator error if the wrong operating mode is selected.

Response
For the analyses performed for the Supplement to the Draft EIS, DOE developed analytical scenarios to estimate the range of potential environmental impacts that could result from the Proposed Action. These analytical scenarios include the low, intermediate, and high thermal load scenarios presented in the Draft EIS, as well as the higher-temperature and lower-temperature repository operating modes of the Reference Design. Section 2.2.1 of the Supplement summarizes the operational parameters for the three thermal load scenarios analyzed in the Draft EIS and the two repository operating modes analyzed in the Supplement. Section 2.2.2.2 describes the operational parameters for the higher- and lower-temperature repository operating modes. DOE developed these scenarios and operating modes to accommodate and maintain flexibility for the potential future evolution of the design of the repository. So as not to underestimate the impacts that could result from future design evolution, these scenarios and operating modes incorporate conservative assumptions. Sections 2.2.1 and 2.2.2 of the Supplement discuss the design and operational evolution, respectively, which was carried forward to the Final EIS.

7.1.2.2 Ventilation

7.1.2.2 (12717)
Comment - 010073 / 0021
Page 2-21 - The SDEIS estimates that as much as 145 times as much air will be moved through the S&ER flexible design. Why is the risk associated with ventilation related exposure pathways not 145 times greater? There appears to be an inconsistency in the analyses.

Response
Although a greater amount of air would be moved through the repository with the increased ventilation for some flexible design operating modes, the source of pollutants does not increase proportionally. The source remains approximately the same, slightly larger, between the low ventilation rate (0.1 cubic meter per second) and the higher ventilation rate [15 cubic meters per second (32,000 cubic feet per minute)]. As a result, the risk only increases a small amount.

7.1.2.2 (12935)
Comment - 010257 / 0001
The idea that ventilation shafts and fans can be operated and maintained for hundreds of years implies long-term social and political stability that has never been demonstrated before.

Response
DOE recognizes that an underlying assumption of the extended emplacement period is that institutional controls would have to be maintained for at least 300 years into the future and that these controls could only be administered by a government that possessed the resources and the desire to do so. The Department also recognizes that if a political upheaval, such as the one that recently occurred in the former Soviet Union, was to occur in the United States, the government could have difficulty protecting and maintaining the storage facilities. However, the analyses in the EIS have followed the general guidance for the prediction of the evolution of society provided by the National Research Council in *Technical Bases for Yucca Mountain Standards* (DIRS 100018-National Research Council 1995), in which the Committee on Technical Bases for Yucca Mountain Standards concluded that there is no scientific basis for predicting future human behavior. The study recommends policy decisions that specify the use of default (or reference) scenarios to incorporate future human behaviors into compliance assessment calculations. The analyses in the EIS followed this approach, based on societal conditions, as they exist today. In doing so, the analysis assumed that ventilation and other repository systems could operate for very long periods with

regular maintenance. The Department believes that these assumptions are appropriate when estimating impacts because of the inherent inability to accurately predict the future of social behavior.

7.1.2.2 (13097)
Comment - 010227 / 0015
The SDEIS indicates a huge increase in the need for ventilation, and increases the proposed number of ventilation shafts -- how will more shafts impact the drip shields? How will they impact the structural integrity of the overall repository design? These are issues that were not adequately addressed in the SDEIS.

Response
All ventilation shafts are located in access drifts separated from emplacement drifts by solid rock 20 meters (66 feet) or more in thickness. In addition, the drip shields would not be emplaced until the repository is ready for and been approved for closure. Therefore, there would be no relationship between shafts and drip shields. In addition, ventilation shafts are spaced 300 meters (980 feet) or more apart. Therefore, weakening of the overall integrity of the repository would be highly unlikely.

Supporting documents to the EIS such as the *Monitored Geologic Repository Project Description Document* (DIRS 151853-CRWMS M&O 2000), and other referenced supporting documents discuss such issues as shaft seal design. It has been established that the current technology for shaft sealing will provide for sufficient integrity of these sealed openings that they will behave as well as the host rock in long-term performance. The EIS relies on all of these supporting documents, including the Science and Engineering Report, to provide discussions of such supporting details.

7.1.2.2 (13219)
Comment - 010244 / 0018
The SDEIS should consider the extent to which increased ventilation results in an enhanced exposure pathway.

Response
Increased ventilation was considered in Section 3.1.2 of the Supplement to the Draft EIS. The Final EIS addresses the environmental impacts due to increased ventilation [15 cubic meters per second (32,00 cubic feet per minute)] in greater detail in Section 4.1.2.3 of the EIS.

7.1.2.2 (13234)
Comment - 010244 / 0033
DOE claims that it can reduce the maximum temperature in the host rock by extending the drift ventilation period with either active of passive ventilation. This process alone could require ventilation periods as long as 300 years after emplacement to ensure post closure temperatures. The Supplement provided no substantiated proof that such a system would last 300 years.

Response
Ventilation systems can be maintained for very long periods as demonstrated by deep mining operations and underground traffic tunnels. The proposed flexible design would include the maintenance, operational, and equipment-replacement features needed to continue operations for the period of operation needed.

7.1.2.2 (13260)
Comment - 010274 / 0002
If the drift rock is maintained at 205° [Fahrenheit]; and the ventilation fans are removing 70% of the heat; it means that the high level nuclear material is sustaining 30% more heat in the containers; with the ventilation system in full operation; which means that each container is generating 266.5° [Fahrenheit].

Any high school student can tell you that water boils at 212° [Fahrenheit].

So, if the ventilation system or another coolant system fails to operate; that means the containers can add an additional temperature of 70% to 266.5° [Fahrenheit]; comes to 1,865.5° [Fahrenheit].

So, if all the coolant and ventilation systems fail, a chain reaction will develop and each of the 11,000 to 17,000 containers can melt-down and explode.

Response
If the ventilation systems were not operating, the drift wall and waste package temperatures would increase. This event is discussed in the *Yucca Mountain Science and Engineering Report*, which discusses the impact of a ventilation shutdown for the lower-temperature repository operating mode (DIRS 153849-DOE 2001). It would take 2 to 3 weeks for the maximum drift wall temperature [96ºC (205°F)] to be exceeded. However, even assuming no ventilation for 15 years, the peak temperature of the waste package is analyzed in the Science and Engineering Report to be less than 460ºC (896°F). Because the waste package has been analyzed to not fail prior to 600ºC (1,112°F), waste packages would not release gases or material due to fans failing for at least 15 years, thus providing ample time to repair the ventilation system or retrieve the waste packages.

7.1.2.2 (13263)
Comment - 010274 / 0004
There are no oceans, lakes, rivers, or any other above ground means to provide coolant to the Yucca Mountain area. The major source is underground drinking water. That in itself should disqualify this site.

I was always of the opinion that the high level nuclear material inside the containers, will have to be vented (open the containers in order to release the (buildup) pressure; in order to keep them from exploding.

Response
The treatment of water from the fuel pools is discussed in Section 2.2.4.3.1 of the Science and Engineering Report (DIRS 153849-DOE 2001). As discussed in that section, liquid low-level radioactive waste would be treated, recycled, or stabilized for offsite disposal.

The design of the repository includes a cooling tower adjacent to the utility building to support heat rejection from the utility building systems, such as the building chillers. Water from the cooling tower, among other industrial streams such as water collected from dust control operations, would be collected in one of two evaporation ponds. The ponds would evaporate excess water from dust-control operations at the South Portal and wastewater from water treatment and cooling systems at North Portal surface facilities. Water from these industrial streams would not contain any radioactive or hazardous materials.

The design of the repository is still evolving. DOE would ensure that the industrial wastewater-evaporation system met all applicable design requirements (including development of adequate maintenance and inspection programs) and received necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing the repository.

Based on requirements for shipping casks and waste packages, no water would be permitted inside the containers. Thus, generation and buildup of hydrogen from radiolytic decomposition of water would not occur. In addition, the greatly reduced radiation fields from fuel that must be cooled 5 years prior to shipment would limit the generation of hydrogen even if water was present. The radiolytic gases produced from decay of the waste would be a small fraction of the total pressure of the system. This decay would not generate significant radiation damage to the waste packages. Even in the event of a ventilation system failure, the peak temperature of the waste packages would only rise to something less than 460°C (820°F). Because the waste package has been analyzed to not fail prior to 600°C (1,112°F), the waste packages would not have the potential to release gases or material due to fans failing for at least 15 years, thus providing ample time to repair the ventilation system or retrieve the waste packages. Thus, once emplaced, the waste packages would need to be vented to reduce internal pressures.

7.1.2.2 (13273)
Comment - 010231 / 0007
Page 2-21, Section 2.3.3.2. The second paragraph states that “this low ventilation rate [0.l cubic meter per second] would permit monitoring of the air stream exhausting from the drifts for leaks of radioactive material, but would not contribute significantly to removal of heat from the emplacement drifts.” This is followed by a discussion of the higher ventilation rate [15 cubic meters per second (32,000 cubic feet per minute)] under the new flexible design, but there is no mention of monitoring. Does this mean that the flexible design does not allow for monitoring of the

exhaust air? If so, this raises public health and on-site safety concerns. The final design must include effective monitoring and a system to divert the air into high-efficiency filtering systems in case releases are detected.

Response
The flexible design does include monitoring of the exhaust air and the ability to filter the exhaust stream if radioactive contamination was detected. The design would comply with applicable health and safety requirements.

7.1.2.2 (13344)
Comment - 010296 / 0004
The footprint of the underground facility will need to be expanded considerably from 4.7 for HTOM to 10.1 for LTOM (Table S-1 of SEIS). Although these area requirements are less than those of the DEIS cases, Nye County believes that managing and designing a better ventilation system could reduce the area requirements substantially. Larger area of the footprint means more excavation, material used, and energy consumed. Therefore, increased repository size equals increased environmental impacts. Although Nye County believes that lower-temperature operating modes would enhance the long-term safety of the repository, the increased size and its environmental impacts in the short term are of significant concern.

Response
The commenter is correct in pointing out the trade off of repository size versus ventilation needs to achieve LTOM. If the Yucca Mountain site is recommended, these tradeoffs and others will be considered in detail to select the flexible design operating modes for the license application.

7.1.2.2 (13348)
Comment - 010296 / 0008
DOE needs to evaluate other design configurations where natural ventilation can be used. Nye County believes that with the heat of the nuclear waste and modification of the design, most of the ventilation can be provided by natural ventilation. Only a few areas of underground facility may need to have supplemental forced ventilation as needed for workers and operational safety reasons.

Response
The amount of air that will flow in the repository due to natural ventilation depends on the difference in elevation between the intake and exhaust openings, the resistance of the subsurface excavations to airflow and the difference in temperature between the atmosphere and the subsurface repository. The difference in temperature between atmosphere and the subsurface repository depends on the operating mode. A higher-temperature repository would result in the greatest temperature differential and would produce a more reliable, higher natural airflow. A lower-temperature repository design would produce less temperature differential and a less reliable, lower natural airflow. Because the use of preclosure ventilation is a means toward meeting thermal goals, the choice of a hot or cooler mode of operation will influence the amount of natural airflow that will occur. The resistance of the excavation to airflow is low because the excavations are large in diameter. There are no designed restrictions in the system that would preclude natural ventilation.

DOE recognizes that postemplacement natural ventilation could be used to reduce long-term repository temperatures as discussed in Section 2.1.4 of the Science and Engineering Report (DIRS 153859-DOE 2001). As a consequence, natural ventilation has been proposed in several lower-temperature operating scenarios for the repository. By extending the time during which loaded emplacement drifts are ventilated (both forced and naturally), the repository could be operated at lower temperatures with minimal increases in the disposal area. The latest repository design including the concept of natural ventilation has the flexibility to accommodate and take advantage of new information that might improve performance or reduce long-term uncertainties.

The design of the repository ventilation system is still evolving and the concept of natural ventilation is a design detail that may be further developed for license application. The DOE will design the ventilation system in accordance with all requirements and peer reviews will be performed as necessary. In addition, the Nuclear Regulatory Commission will review the final design before licensing the repository and ensure the design meets all requirements.

7.1.2.2 (13352)
Comment - 010296 / 0011
Overall ventilation will tend to dry out the repository horizon. However one can postulate several scenarios leading to condensate formation in the ventilation shafts. Transient condensate could theoretically enter fractures prior to drying out. Example 1: The initial thermal pulse would increase the partial pressure of water vapor in the circulating air. As the air rises it contacts cooler rock and expands as pressure drops in the shaft. Both processes cool the air, potentially leading to condensate formation. Example 2: During a summer thunderstorm the ambient relative humidity rises. Humid air is pulled into the ventilation system and contacts cooler rock, leading to condensation. Because the fans are located at the shaft exits (negative pressure system) the air expands as it enters the ventilation system, leading to additional cooling. Note that since preclosure ventilation is stated to be under positive pressure, which lowers the likelihood of condensation, current experience may not be a reliable guide to future performance. Has the potential for condensate formation in the ventilation system been fully evaluated?

Response
The potential for condensation formation is considered in the ventilation system. The design for the repository intake and exhaust shafts includes a collection sump at each shaft bottom. The sump provides a collection area for water entering the Subsurface Facility (including any potential shaft condensation) to collect for subsequent pumping to the surface.

Even though a thunderstorm may increase the ambient relative humidity, it will remain below 100 percent, a level necessary to begin condensation at a given temperature (dew point). The Subsurface Facility natural wall rock temperature exceeds the average dew point temperatures for Southern Nevada, therefore, wall rock condensation would not likely occur.

7.1.2.2 (13355)
Comment - 010296 / 0012
On page 3-4 it is stated that, "The use of natural ventilation rather than forced-air ventilation for some portion of the preclosure period would result in less than half of the radon released to the offsite public for that portion of the period." This is the main reason that DOE needs to continue to strongly evaluate the potential of a naturally ventilated repository.

Response
DOE recognizes that postemplacement natural ventilation could be used to reduce long-term repository temperatures as discussed in the Science and Engineering Report (DIRS 153849-DOE 2001). As a consequence, natural ventilation has been proposed for some lower-temperature operating mode scenarios. By extending the time during which loaded emplacement drifts were ventilated (both forced-air and naturally), the repository could be operated at lower temperatures with minimal increases in the disposal area. The latest repository design, including the concept of natural ventilation, has the flexibility to accommodate and take advantage of new information that could improve performance or reduce long-term uncertainties.

The design of the repository ventilation system is still evolving, and the concept of natural ventilation is a design detail that could be developed further for license application. DOE will design the ventilation system in accordance with all requirements, and peer reviews will be performed as necessary. In addition, the Nuclear Regulatory Commission will review the final design before licensing the repository and will ensure that the design meets all requirements.

7.1.2.3 Spent Nuclear Fuel Aging

7.1.2.3 (13134)
Comment - 010237 / 0003
Surface aging will increase the release of radiation to the environment and should not be used.

Response
Onsite aging would increase direct radiation exposures slightly at the repository; these exposures have been included in the Final EIS (see Table 4-25). However, because of the lower population density (public) and the larger distance between the surface aging facility and workers (both involved and noninvolved), the net collective dose from the

surface aging facility at the proposed repository over the 50-year aging period would be less than leaving the spent nuclear fuel at the generator sites for the same period (see Chapter 7, Table 7-6).

7.1.2.4 Waste Package Spacing

7.1.2.4 (13099)
Comment - 010227 / 0017
Where to put the waste packages -- this seems to be a question plaguing not only DOE, but most of the nuclear power industry as well. The SDEIS looks at a number of options for how to space the waste packages to keep temperatures within range, yet there is no mention of how those either closely spaced or widely spaced packages might create more of a hazard. There was no mention in the SDEIS of how waste package spacing could be impacted by accidental bombings from Nellis bombing range (the air force has a history like DOE -- and doesn't always get exactly what it's aiming for), or terrorist activity.

Response
Waste package spacing would be unrelated to the repository hazard as long as drift temperatures were controlled within acceptable limits. Accidental bombings from Nellis Air Force Base operations would not impact the waste packages because of the approximately 1,000-foot-thick rock overburden.

7.1.3 WASTE PACKAGE DESIGN

7.1.3 (717)
Comment - EIS000211 / 0002
The DEIS fails to address the fact that the number of shipments and the amount of radioactive material that will be shipped is unprecedented in world history. About 90% of the volume would be spent fuel from nuclear power plants, and virtually none of this type of material has ever been shipped before. Not only is it not known what type of container would be used to transport nuclear waste, but also these containers have been neither constructed nor tested -- therefore, the impact statement is incomplete.

Response
DOE does not agree that shipping large quantities of radioactive material is unprecedented. More than 2,700 shipments of spent nuclear fuel have been transported over about 2.6 million kilometers (1.6 million miles) of U.S. highways and railways without a breach of a shipping cask.

The Nuclear Regulatory Commission requires that the design of transportation casks for spent nuclear fuel and high-level radioactive waste meet very stringent standards (10 CFR Part 71). Casks must be able to survive, among other things, a drop of 9 meters (30 feet) onto an unyielding surface. See Section M.4 of the EIS for additional information on cask testing. Post-test analyses have found that, had the casks been filled with waste, they would not have released their contents. Many of the cask tests greatly exceed the test requirements of the Nuclear Regulatory Commission.

7.1.3 (3609)
Comment - EIS001031 / 0015
Do any fool-proof fuel containers exist for the storage, shipment or the permanent disposal of the wastes? Have these containers had full-scale tests? If radioactive gas leaks out, wouldn't it go around the world?

Response
Containers for the storage and transportation of spent nuclear fuel are in use in the United States and many other countries. Storage systems, regulated by the Nuclear Regulatory Commission (10 CFR Part 72), have been in use for about 10 years. Several commercial utilities have placed spent nuclear fuel in such systems. Transportation casks, also regulated by the Nuclear Regulatory Commission (10 CFR Part 71), have been used in more than 2,700 shipments of spent nuclear fuel. The Nuclear Regulatory Commission has certified a number of tests on casks. See Section M.4 of the EIS for additional information on cask testing.

DOE is designing containers for the permanent disposal of spent nuclear fuel, which the EIS refers to as waste packages. Samples of candidate metals for waste packages are undergoing laboratory tests. Full-diameter, one-third-length mockups of different waste packages have been built to demonstrate techniques for welding lids to packages. Full-scale prototype testing of waste packages could also be necessary.

To DOE's knowledge, there has been no leakage from the storage casks and transportation casks currently in use. If a cask's seal was breached, virtually all of the radioactive material (with the exception of noble gases) would remain in the cask. In theory, when noble gases are released to the atmosphere, they remain there indefinitely because of their nonreactive nature. However, the small quantities of these gases that could be released from failed or damaged waste packages would be quickly diluted in the atmosphere to concentrations well below those likely to result in adverse human health impacts.

7.1.3 (4209)
Comment - EIS001160 / 0023
The DEIS does not adequately address issues raised and substantiated by White Pine County during the scoping process. For example:

The repository EIS must include a comparative evaluation of the extent to which alternatives for accomplishing construction, emplacement, closure, and post-closure phases of the facility achieve containment of radioisotopes during volcanic eruption, earthquakes, and loss of criticality control. The comparative evaluation of alternatives for repository design, construction and operation should consider the full spectrum of uncertainty attendant to such options. In this way, the EIS should facilitate decision-making under conditions of uncertainty. The DEIS does not provide a comparative analysis in a useful summary form of the extent to which construction design and operational alternatives provide containment of radioisotopes from the accessible environment. It is not easy to conclude from the information in the document which design and operational alternative is preferred.

Beyond construction of the repository, alternative methods for conducting waste emplacement operations should be considered. Critical issues include candidate materials from which waste packages might be fabricated and alternative materials for fabrication of waste package baskets. The DEIS does not appear to consider technology alternatives or material choice in construction of waste packages.

Response
The EIS examines the impacts of the Proposed Action (to construct, operate and monitor, and eventually close a repository at Yucca Mountain), and the No-Action Alternative (maintain the wastes at existing generator and storage sites). The EIS does not provide, nor was it intended to provide, the basis for deciding on a final repository design (see Section 2.1.1.5 of the EIS). Rather, the EIS provides a range of design alternatives that DOE believes reflect a range of environmental impacts that could reasonably be expected to occur from any combination of design alternatives. Since publication of the Draft EIS, several enhancements have been included in the design of the repository to improve performance and reduce uncertainties. These enhancements include a more robust waste package, a titanium drip shield that would cover each waste package, and various ways to manage heat. This evolving design was described in a Supplement to the Draft EIS that was released for public review in May 2001.

If Yucca Mountain was recommended for further development as a geologic repository, the Nuclear Regulatory Commission would review the design concepts and performance predictions before granting DOE a license to begin construction. The final design would be described in the License Application. Environmental impacts associated with that design would be addressed as part of the License Application for construction authorization. During the licensing process, DOE would evaluate design alternatives and options in greater detail, as necessary, to demonstrate compliance with requirements of the Nuclear Regulatory Commission. The expected environmental consequences of the final design would have to have been adequately bounded by the consequences described in the Final EIS.

The Final EIS includes updated models for seismic events including those that could result in cladding damage. Nevertheless, modeling indicates that waste package failure would not increase greatly. The most likely results of seismic shaking are rocks falling from the ceilings of the emplacement rooms that could breach the waste packages. The updated analysis of seismic-induced rockfall for the flexible design indicates that during the first 10,000 years, the titanium drip shields covering each waste package would be expected to provide adequate protection from rockfall. After 10,000 years, the collapse of tunnels would preclude rocks from falling because the ceilings would rest on or near the drip shields and waste packages. In conclusion, damage to waste packages from seismic shaking would be unlikely. Potential impacts associated with other disruptive events, such as volcanic eruptions and human intrusion, have been updated for the flexible design and are presented in Chapter 5 of the EIS.

Consistent with National Academy of Science observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. DOE confidence in the disposal techniques is based on defense-in-depth that, for example, places drip shields over waste packages to account for uncertainties. DOE adopted an assessment approach that explicitly considered the spatial and temporal variability and inherent uncertainties in geologic and biological components. The bases of the approach are summarized as follows:

- Site description is based on extensive underground exploratory studies and investigations of the surface environment.
- Reference design is based on laboratory investigations and conceptual engineering studies.
- Features, events, and processes that could effect the long-term safety of the repository are identified.
- Evaluation of a wide range of exposure scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical, and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.
- Development of alternative conceptual and numerical models to represent the features, events, and processes of a particular scenario and to simulate system performance for that scenario.
- Parameter distributions to represent the possible change of the system over the long term and use of conservative assessments that lead to overestimating of impacts when there is insufficient information for use of a probability distribution.
- Performance of sensitivity analyses.
- Extensive peer review and oversight.

DOE believes this process resulted in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios, including the preferred alternative. The Department continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as the system-level of modeling. A task force has been organized to review and outline further work to be completed on uncertainties before the time of license application, should the repository be recommended as a suitable site.

7.1.4 WASTE PACKAGE MANUFACTURING

7.1.4 (2190)
Comment - EIS000765 / 0005
My suggestion involves the disposition of some 6000 tons of DOE-owned radioactively-contaminated scrap nickel which was removed from DOE's uranium enrichment plants. DOE has decided not to release this nickel to the market for recycle. My suggestion is that DOE earmark this nickel for the fabrication of the corrosion-resistant inner layer of the disposable waste packages to be placed in the waste repository. In that manner DOE uses a resource that it already owns, the contaminated nickel is managed safely, and the issue of contaminated scrap metal getting into the public sector is totally avoided.

Response
Surplus nickel has been recovered, and is still being recovered, from DOE uranium-enrichment plants. While the Department has not released this material for unrestricted recycling, it has not decided on a final course of action for ultimate disposition of the nickel. After initial evaluation, DOE has determined that a suitable application for the

nickel could involve the fabrication of waste containers or related components for a high-level radioactive waste repository or some other disposal facility.

7.1.4 (9391)
Comment - EIS001888 / 0096
DOE's selections of corrosion rate values for the waste-package Corrosion Allowance Material (A516 10,01 carbon steel) may not adequately represent the corrosion-rate potential because they do not account for the effects of drip velocity, and formation of salts and chlorides. Similarly, the corrosion rates for the 7.0 Corrosion Resistant Material, Alloy 22, may not adequately account for adverse crevice-corrosion conditions. Corrosion rates are discussed in Attachment B.

Response
The evolving design of the engineered-barrier system, as described in the Supplement to the Draft EIS (released for public review in May 2001) and carried forward to the Final EIS, now includes a more robust and corrosion-resistant waste package with a nickel-based alloy (Alloy-22) as the corrosion-resistant barrier over a stainless-steel structural inner liner. In addition, the engineered barrier now includes a titanium drip shield above each waste package for defense-in-depth against corrosion.

The Supplement evaluates the enhanced waste package and explains the rationale for the changes. The degradation model used for predicting long-term performance of the waste packages includes corrosion rates that address salt and chloride formation and adverse crevice corrosion. DOE does not view drip velocity as a meaningful parameter in the long-term performance calculations because the titanium drip shield would prevent dripping on the waste package in the near term and because the analysis assumed that the drift would collapse over time. The EIS degradation model evaluated both drip and no-drip models, as discussed in Appendix I and its referenced sources.

7.1.4 (10279)
Comment - EIS000993 / 0003
I'd like to touch on an issue that is often cited as a failure of spent fuel management performance and NRC [Nuclear Regulatory Commission] oversight. It is the issue of the flawed cask loaded and in operation at Palisades during my tenure. Although we found and reported this partial through wall flaw on a storage container, the NRC demanded that we demonstrate that the cask met all design conditions including the worst case postulated accidents. We were able to demonstrate that it did to the NRC's satisfaction and the cask has been in operation cooling and shielding the spent fuel since 1994 with no abnormal radiation, contamination or any other performance issues. If you don't believe my statement here, I invite anyone to come to MI [Michigan] to stand with me next to the flawed cask and observe for yourself the actual performance and review our historical records. The NRC demanded the cask meet requirements or it could not have been allowed to stay in operation. All future spent nuclear fuel storage and transportation activities must and will meet the same type of standard or they will not be allowed to occur.

Response
The casks that DOE would use to transport and dispose of spent nuclear fuel and high-level radioactive waste at a repository at Yucca Mountain would meet all applicable standards.

7.1.5 DISPOSAL

7.1.5 (1547)
Comment - EIS000357 / 0006
Page 1-6. 1.2.2. The text reads, Cladding. If it is not damaged or corroded, has the capability to isolate the spent nuclear fuel and delay the release of radionuclides to the environment for long periods. What is a "long period"? This is not quantified.

Response
The purpose of this statement is to provide a general sense that the zirconium alloy cladding that encases most of the commercial spent nuclear fuel would provide an isolation barrier for thousands of years. The improved cladding degradation models used for the analyses in the Final EIS indicate that less than 10 percent of the cladding would be perforated at 50,000 years, and that about 15 percent would be perforated after 100,000 years (DIRS 157307-BSC 2001).

7.1.5 (4873)

Comment - EIS000337 / 0011

Pg. 2-61, Section 2.2.2.1: Storage Packages and Facilities at Commercial and DOE Sites, 4th par.: "Figure 2-38 shows a typical dry storage canister,...." Are these canisters the same as what will be used in the proposed action? If not, why not?

Response

The dry storage canister depicted in Figure 2-34 of the EIS is typical of canisters in use today to store spent nuclear fuel in a dry configuration at commercial nuclear reactor sites and some DOE facilities. Canisters of spent nuclear fuel that utilities store on site in a dry storage cask would resemble the canister shown in Figure 2-34. The decision to place fuel in such a configuration, however, is made by the utilities, not DOE.

The Proposed Action includes removing the spent nuclear fuel from these commercial and DOE sites and transporting it to Yucca Mountain for emplacement in a repository. At Yucca Mountain the spent nuclear fuel and high-level radioactive waste would be placed in specially designed waste packages for emplacement in the repository. The function of the waste package would change over the lifetime of the repository. During the operation and monitoring phase, the waste packages would function as the vessels for safely handling, emplacing, and retrieving (if necessary) their contents. After closure, the waste packages would be the primary engineered barrier to inhibit the release of radioactive material to the environment.

The function of the repository's waste packages is similar to the function of short-term dry storage canisters used at utilities. However, the repository's waste packages are also designed specifically for the long-term needs of permanent disposal.

7.1.5 (4882)

Comment - EIS000337 / 0022

Pg. 5-28, 1st par, last sentence: Until now DOE has stated that it is difficult to obtain precise values. This section discussed juvenile failures and made the ambiguous statement that they would be very low. DOE proceeded to say that if there were no failures the mean consequences would decrease by 2%. They have not proven that anything in this DEIS is accurate to 2%.

Response

For the purposes of analysis in the Draft EIS, DOE assumed that 1 of every 10,000 waste packages would fail completely, exposing all its contents 1,000 years after closure of the repository. This rate was based on industrial experience of manufacturing and handling (DIRS 101779-DOE 1998). The statement that the mean consequences would decrease by 2 percent in the event of zero juvenile failures means that the repository system would still provide excellent isolation of the waste, even in the event of juvenile failures.

As part of the waste package performance analysis performed for the updated package design for the flexible design, DOE conducted a comprehensive evaluation of fabrication processes. The results of the analysis indicated that improper heat treatment could result in early failure of some packages. The results showed that the probability of an improperly heat-treated waste package in the proposed repository was 20.2 percent. Corresponding probabilities for two and three improperly heat-treated packages were 2.6 percent and 0.2 percent, respectively. (DIRS 155950-BSC 2001). The Total System Performance Assessment Model was run with these probabilities sampled, so that a little more than 20 percent of the simulations show a very small release prior to 10,000 years as a result of these early failures. The resultant annual doses are many thousand times smaller than the limit in the Environmental Protection Agency standard. A strong quality assurance program would ensure proper fabrication, stress relief, and testing of the waste packages before emplacement.

In addition, the updated waste package modeling and life expectancies for the flexible design evaluated in the Final EIS are based on experiments and analyses documented in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000) and the *FY 01 Supplemental Science and Performance Analyses Report* (DIRS 154659- and 155950-BSC 2001). These studies identify and discuss each potential waste package degradation mode. The degradation model includes those modes that analyses did not screen out as highly improbable.

Obviously, there is uncertainty associated with the extrapolation of experimental results for such long periods. DOE selected the design analyzed in the Final EIS to mitigate the uncertainties by adding features (such as the drip shield) to provide defense-in-depth. This provides greater assurance that the repository would meet its performance standards in the face of uncertainty.

7.1.5 (7291)
Comment - EIS001683 / 0002
There are so many reasons why nuclear waste should not be stored at Yucca Mountain. The casks are not able to contain the waste. Bacteria found at the site can corrode them.

Response
The Yucca Mountain repository, as described in the May 2001 Supplement to the Draft EIS, includes a robust engineered barrier system designed specifically to work with the favorable natural-barrier system at Yucca Mountain. The container in which DOE would place nuclear waste in the repository would not be the sole engineered barrier. The current design includes a robust waste package with a nickel-base alloy (Alloy-22) as the outer corrosion-resistant barrier over a stainless-steel structural inner liner.

DOE is evaluating waste package materials, including Alloy-22, for reaction to an attack by microbes under conditions expected at Yucca Mountain. To date, this evaluation has identified no bacteria-related concerns for Alloy-22. However, for conservatism, DOE added a microbial attack factor to the assessment of the long-term performance of Alloy-22. Information in the Supplement, carried forward to the Final EIS, evaluates the new design and materials for waste packages and explains the rationale for the enhancements.

7.2 Repository Operational Plans

7.2 (1704)
Comment - EIS000624 / 0002
I have been told by many of them people there, if [an] accident ever happens out there, we're going to get the robots out here from back east, two of the robots. They are going to handle it. I think that's under no agreement, or I don't know what you call it. Let's all think about it. What are we going to do if accident ever happens?

Response
Section 4.1.8 of the EIS describes potential accident scenarios. In the event of a radiological accident, DOE would use remotely controlled equipment such as inclined plane haulers, load-haul-dumps, and other special equipment to recover from such accidents. This equipment exists today. DOE has identified and developed the methods for retrieval and the equipment and procedures it would use for retrieval under both normal and abnormal conditions. The Department would not rely on "robots" or any other technology strictly from one source or location.

Tables 2-7 of the EIS compares the potential accident consequences for the Proposed Action and No-Action Alternative. Appendix H contains a more detailed discussion.

7.2 (5327)
Comment - EIS001887 / 0055
Page 1-17; Section 1.4.2 - Proposed Disposal Approach

The third sentence of the first full paragraph indicates that "(t)he waste packages would be moved underground by rail." This is also described elsewhere in the document (Section 2.1.2.2.1 Subsurface Facility Design and Construction, Page 2-27 through 2-31). However, nowhere does the Draft EIS indicate what level of inspection will be performed on the rail/trolley system, as well as other infrastructure in place at the site. Inasmuch as a transportation or emplacement related accident at the site could have catastrophic and long-term impacts to Nevada, quality control, inspection by qualified outside expertise, and a comprehensive maintenance and inspection program for the transportation activities and infrastructure within the site are critical to program safety. The Draft EIS fails to address this important component of long-term site safety.

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DOE can contract for such services from the private sector, utilize existing contractors, hire DOE expertise in these areas, or provide resources so that other State or federal agencies conduct inspections. Additional resources for affected federal or state agencies would need to be quantified and funded accordingly.

Response
Prior to construction and operation of a repository, the Nuclear Regulatory Commission would first have to issue a license under the provisions of 10 CFR Part 63. The Commission has always required a strong quality assurance program for licensed nuclear facilities. DOE expects that the license provisions for an in-depth quality assurance program at a deep geologic repository would be no less stringent than those required for other nuclear facilities. Required elements of an effective quality assurance program would include inspection by independent experts as well as a comprehensive maintenance program. However, although DOE is committed to funding an effective quality assurance program, estimating the resources required at this time would be too speculative to provide meaningful information to the decisionmaking process. Therefore, this information has not been included in the EIS.

DOE agrees that even with the best approach to operations and maintenance, accidents could occur. Therefore, a number of accident scenarios have been evaluated both at the repository and during transportation. Impacts from these accident scenarios are described in Chapter 4 of the EIS.

7.2 (5352)
Comment - EIS001887 / 0073
Page 2-11; Section 2.1.2 - Repository Facilities and Operations

The statement is made that "...spent nuclear fuel and high-level radioactive waste would be handled remotely with workers shielded from exposure to radiation using design and operations practices in use at licensed nuclear facilities to the maximum extent practicable" (emphasis added). Since the Yucca Mountain facility is required to be licensed by the NRC [Nuclear Regulatory Commission] and all facility operations would be carried out under NRC regulations, it is inaccurate to assume that practicability would dictate which regulations would be followed and which would not be. The statement that practices used in other licensed facilities would be implemented at Yucca Mountain only to the extent practicable is indicative of the assumption throughout the document and the entire DOE program that regulations and requirements can be changed, modified, or suspended to meet the dictates of the project.

Response
DOE agrees that all facility operations would be conducted in accordance with license requirements issued by the Nuclear Regulatory Commission. In addition, repository designs and operating procedures must satisfy Commission regulations, or DOE would not receive a license to build and operate the facility. However, the Department does have the ability to decide which design features and procedures it feels will best satisfy those regulations. Many functions of the repository, such as cask handling and fuel storage, would be identical to those at existing nuclear facilities. Therefore, DOE has many examples from which to choose to satisfy the regulations.

7.2 (5372)
Comment - EIS001887 / 0089
Page 2-37; Section 2.1.2.4 - Performance Confirmation Program

As part of performance confirmation and prior to initiation of waste emplacement, DOE should commit to a demonstration of a full drift emplacement-retrieval cycle as a proof of operational capability.

Response
As part of routine pre-operational testing, DOE would test the waste package transporter, emplacement gantry, and emplacement operations before such operations began, which would not be before 2010. The retrieval operation would use essentially the same equipment and operations as emplacement (in reverse order), so the tests would be relevant to demonstrating the capability for retrieval.

7.2 (5373)
Comment - EIS001887 / 0090
Page 2-38; Section 2.1.3.1 - Loading Activities at Commercial and DOE Sites

The text states "..the EIS assumes that at the time of shipment the spent nuclear fuel and high-level radioactive waste would be in a form that met approved acceptance and disposal criteria for the repository." In the case of commercial spent fuel, there is no basis for making such an assumption. Given the market-driven, [laissez] faire approach planned for transporting spent fuel from reactor sites to Yucca Mountain, the form of the spent fuel to be shipped will be determined by the type of transport canister used and the shipment mode selected. Both of these factors will be determined largely by economic factors and by conditions and infrastructure at each reactor location. DOE will likely deal with widely diverse spent fuel configurations, including different shipping cask configurations, different shipment loads and weights, different conditions of fuel elements, etc. The overly optimistic assumption that spent fuel and HLW received at the repository surface facilities will be in standard forms and require little or no remediation or special handling is erroneous and understates the difficulties associated with the waste acceptance and handling operations at the repository.

The level of effort required at a repository waste acceptance, handling, and processing facility will be one that is unprecedented in volume, diversity of waste forms, and duration. The handling of spent fuel is currently done only on a very limited scale, usually one or two fuel assemblies at a time, at reactor locations. There is no experience with the scale and complexity of operations that would be required to process hundreds of thousands of spent fuel elements (both at points of departure and at the repository surface facilities) over a sustained period of 30 years or more. The Draft EIS completely ignores the unprecedented nature of this effort and, instead, treats it as if it were a routine industrial activity.

Response
The Waste Handling Building would be able to handle a variety of waste forms consistent with known waste acceptance and transportation requirements. DOE is developing detailed waste acceptance and interface criteria documents with which the waste generators would have to comply and that will identify the characteristics of acceptable waste forms for the repository. These documents will contain the details of the standard waste forms that the repository would be able to accept and would be part of its licensing basis. The waste forms would include commercial spent nuclear fuel packaged in different truck and rail casks, and in dual-purpose canisters. Some of the shipments would contain failed fuel or radioactive nonfuel components. In addition, a variety of defense nuclear waste forms including DOE spent nuclear fuel and high-level radioactive waste would be shipped in canisters that could be placed directly in disposal containers (waste packages). The repository's waste handling systems would include the variety of tooling required to handle the diversity of shipments, open and handle them, and package the various waste forms for disposal.

DOE disagrees with that part of the comment that contends that the loading and transportation of commercial and DOE spent nuclear fuel would be market driven. Waste transport would be governed by strict safety requirements mandated by the Nuclear Regulatory Commission for commercial facilities and by DOE for its sites. Over the past 30 years there have been thousands of shipments of commercial spent nuclear fuel in the United States without notable radiological releases or incidents of exposure, which is evidence that such loading can occur safely. Section 6.2.2 of the EIS contains more information.

System and facility designs can accommodate the handling of abnormal and damaged waste forms. These include systems for handling a damaged waste package (the Waste Package Remediation System). Shipments of commercial spent nuclear fuel would be licensed in accordance with the provisions of 10 CFR Part 71, which provided much of the information for the Waste Handling Building related to such spent nuclear fuel.

Although the waste handling operations would be a significant undertaking, DOE would use proven techniques, technology, and practices to develop the design. Such operations are not unprecedented. All of the waste to be handled at the repository would have been moved at least once to a facility or storage system before being transported. Commercial reactor sites have received, stored, and loaded nuclear fuel for decades, and have provided packaging, shipping, and surface storage of spent nuclear fuel. Computer modeling verified that current preliminary designs could meet the conservative (maximum expected) waste receiving, handling, and packaging rates with some margin. In addition, the model used realistic reliability and maintainability data to account for equipment outages during the model runs.

7.2 (5424)
<u>Comment</u> - EIS001887 / 0124
Page 2-60; Section 2.2.1 - Yucca Mountain Site Decommissioning and Reclamation

If Yucca Mountain is not used as a repository under the No-Action Alternative, all openings should be sealed, not just gated. Under the NWPA [Nuclear Waste Policy Act], the site would be permanently removed from consideration as a repository.

DOE should state that the activities discussed in this section will be carried out according to federal and State requirements and as required by BLM [the Bureau of Land Management] in the applicable right-of-way grants that are, and have been, in place throughout Yucca Mountain site investigations.

This section provides no detail about reclamation procedures, their application, and their chances for success.

<u>Response</u>
Chapter 7 of the EIS describes the impacts if the Yucca Mountain site was found unsuitable or otherwise dropped from consideration as a repository and the specific actions that DOE would take. Section 7.1.4 describes the reclamation activities that would occur at Yucca Mountain, and the "Reclamation Implementation Plan" (DIRS 102188-YMP 1995) describes the procedures for those activities. The Bureau of Land Management developed reclamation procedures in accordance with stipulations agreed to when it granted rights-of-way for site characterization to DOE. Section 3.1.1.2 contains information on these rights-of-way.

DOE would gate, rather than seal, the North and South Portals at Yucca Mountain. Backfilling and sealing of the Exploratory Studies Facility would create environmental impacts that would outweigh the environmental and cost benefits of gating these portals.

7.2 (5598)
<u>Comment</u> - EIS001887 / 0224
Page 4-20; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure

What methods would be established to control water application amounts for surface and subsurface dust suppression? DOE's track record for controlling and tracking water usage during site characterization is weak, at best.

<u>Response</u>
DOE has not selected exact methods for controlling surface dust. Section 4.1.3.2 of the EIS states that DOE would establish controls as necessary to ensure that water application for subsurface and surface control of dust did not affect repository performance or cause substantial impacts. Tables 4-9 and 4-10 include the estimated water use required for surface facility dust control during construction in the total water use.

7.2 (5599)
<u>Comment</u> - EIS001887 / 0225
Page 4-22; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure
The Draft EIS should provide actual details of the plan for managing spills and radiological contaminant leaks, not just give a reference as an "example" of what might be done.

<u>Response</u>
The purpose of the EIS is to evaluate the environmental impacts of the Proposed Action and alternatives. Detailed plans for managing spills and radiological contaminant leaks would be prepared as part of the licensing process, if the repository was approved for development by the President and Congress, if necessary, and would not contribute in a meaningful way to discriminating between design scenarios. However, DOE believes that environmental consequences of spills and radiological contaminant leaks during construction, operation and monitoring, and closure would be minor and manageable.

7.2 (5600)
Comment - EIS001887 / 0226
Page 4-23; Section 4.1.3.2 - Impacts to Surface Water from Construction, Operation and Monitoring, and Closure

The Draft EIS should provide the actual surface environmental monitoring plan.

Response
DOE would develop a surface-water monitoring plan during the License Application phase. The purpose of the EIS is to determine the environmental consequences of the Proposed Action and the No-Action Alternative. Inclusion of a surface-water monitoring plan in the EIS would add unnecessary bulk.

As described in Section 4.1.3.2 of the EIS, DOE contends that the environmental consequences to surface water from construction, operation and monitoring, and closure would be minor and manageable. High- and low-level radioactive waste would be handled under fully contained and controlled conditions. The facilities and systems would be designed for confinement and safety. Use of hazardous materials would be subject to administrative controls, and nonhazardous material substitutes would be used to the maximum extent possible. Spills of hazardous materials, should they occur, would be handled in accordance with all applicable Federal and state regulations.

7.2 (6420)
Comment - EIS001632 / 0009
Page 2-31: The third full paragraph describes removing materials from the repository during the subsurface construction that occurs simultaneously with waste emplacement. What plans does the Department have for monitoring the water and other material being removed during waste emplacement operations? Monitoring should ascertain that no radioactive contamination is being removed. While it is not likely that such contamination will occur, there is always the possibility of contaminants adhering to the surface of waste packages and getting into the water or material being removed, or of an accident occurring.

Response
DOE would emplace waste packages in underground tunnels at the same time it was constructing additional tunnels. However, the two areas of operation would be isolated from one another. Section 4.1.3.2 of the EIS discusses potential impacts to surface water from repository construction, operations, maintenance, monitoring, and closure. As stated in that section, DOE would pump water from subsurface construction areas to a lined evaporation pond at the South Portal Operations Area. It would pump water from the emplacement areas, if any, to a lined evaporation pond at the North Portal Operations Area, but only after verifying that it was not contaminated.

DOE would remove solid materials through mining operations, but only from the development area. Bulkheads would isolate this area from the emplacement side, and the ventilation system would ensure that air leaks would be from the development side to the emplacement side (because it would maintain a lower pressure on the emplacement side).

7.2 (6862)
Comment - EIS001466 / 0007
Another interesting experience was being on top of the mountain, and in one single spot, because you have a view, a lot of this equipment was nearby. I found it really interesting that all the weather monitoring equipment, the seismographs and other machines up there were solar powered. I really liked that. I thought that was great. And one of the proposals for ventilating Yucca Mountain, because the heat is going to be so intense from the waste is -- or was, I'm not sure if it's still a project proposal, but a solar powered -- the whole mountainside has solar power panels to drive the ventilation system at Yucca Mountain. So it's the world's first solar powered nuclear waste dump.

Response
As described in the Supplement to the Draft EIS (released for public review in May 2001) and carried forward to the Final EIS, DOE would construct a 3-megawatt solar power generating facility which would operate in conjunction with commercial power to meet the power needs of the repository.

7.2 (7224)

Comment - EIS001337 / 0103

Page 4-3 4th full paragraph. This section should describe what factors will be used to determine whether a 50 or 300 year performance confirmation period will be utilized. The length has implications for PETT [Payments-Equal-to-Taxes] payments and timing of possible retrieval and related transportation activities.

Response

Testing and performance confirmation activities would extend until the beginning of repository closure. DOE would decide on the exact date in concurrence with the Nuclear Regulatory Commission and any laws and regulations that exist at that time. For analysis purposes, the Draft EIS evaluated closure starting 100 years after the start of emplacement, but also assessed impacts for closure starting 50 and 300 years after the end of emplacement. The updated flexible design presented in the Supplement to the EIS includes a lower-temperature operating mode with ventilation extended for 300 years after final emplacement. The impacts related to this and other operating modes for the flexible design are presented in Chapter 4 of the Final EIS.

Waste shipments to the repository would not be influenced by a date for starting closure. Payment-Equal-to-Taxes is required under the NWPA, and is not a discriminating factor in the decisionmaking process. DOE has not estimated Payment-Equal-to-Taxes beyond 2003 and, therefore, has not included long-term Payment-Equal-to-Taxes estimates in the EIS.

DOE agrees that the final closure date could affect the timing of any retrieval that might be required. However, the impacts of such contingency action would be relatively insensitive to timing and such an evaluation would produce little meaningful information for the decisionmaking process. For this reason, DOE has not included this evaluation in the EIS.

7.2 (7542)

Comment - EIS001912 / 0061

Pg. 4-2 How long will it take to construct the repository including all the emplacement tunnels? What is the total estimated cost of construction?

Pg 4-4 Repository design is not conceptual-it is unproven. DOE at this point cannot prove that any of the design alternatives can meet licensing standards. DOE cannot even demonstrate with models or otherwise that their design alternatives can work.

Response

The estimated time to construct the surface facilities, main drifts, ventilation systems, and initial emplacement drifts is five years. Construction of emplacement drifts would continue through about 2032. Section 2.1.5 of the EIS presents updated cost estimates for the proposed repository. Total system life-cycle costs would range from $42.8 billion to $57.4 billion, depending on the repository operating mode.

The purpose of the EIS is to evaluate the consequences of the Proposed Action and the No-Action Alternative. The intent is not to demonstrate compliance with a regulatory licensing requirement. EISs are often based on conceptual designs. The evolution of the design of the repository has included a comprehensive evaluation of alternative features and concepts prior to the selection of the design upon which DOE based the Draft EIS. Since publication of the initial Draft EIS in July 1999, the design of the repository has continued to evolve. This evolved design was described in a Supplement to the Draft EIS that was released for public review in May of 2001 and was carried forward to the Final EIS. The evolved design includes the flexibility to operate the repository in either a higher- or lower-temperature mode after closure. The evolved design includes more robust waste packages and titanium drip shields over each waste package to protect the waste packages from moisture and rockfalls.

DOE recognizes that absolute proof of long-term performance of the repository is not possible. The Environmental Protection Agency, in promulgating the Yucca Mountain environmental protection standards (codified at 40 CFR Part 197), recognized that, with the current state of technology, it is impossible to provide a reasonable expectation that there will be "zero" releases over 10,000 years or over a longer period. Therefore, the Agency promulgated standards that it believes provide comparable protection to those of other activities related to radioactive and nonradioactive wastes. These standards do not require complete isolation of the wastes over the compliance period

(10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment for Yucca Mountain supporting the site recommendation decision and later licensing (if the site is recommended), is to evaluate whether the repository is likely to meet these standards. The goal of this EIS is to project possible impacts using similar modeling technology.

Therefore, as directed by the NWPA and consistent with Environmental Protection Agency and Nuclear Regulatory Commission guidelines, DOE will continue the characterization effort at the Yucca Mountain site. If this effort determined the site was suitable, and if a recommendation by the Secretary was accepted by the President and Congress, if necessary, the Department would continue detail design and licensing efforts necessary for construction, operation and maintenance, monitoring, and eventual closure of the repository. These efforts would use the best science and construction techniques available at the time to provide a reasonable expectation that the repository would meet the environmental protection standards of 40 CFR Part 197, as well as the site suitability standards of 10 CFR Part 63, thus ensuring the long-term protection of the general public and the environment.

7.2 (7572)
Comment - EIS001912 / 0067
Pg. 4-98. Describes short-term impacts from the [of] a retrieval contingency yet the proposed action does not include such action. Why? The contingency action needs to be completed and described in the proposed action.

To be consistent with the no-action alternative (scenario 2), the DEIS must describe impacts from the loss of institutional control. The analysis of the contingency must also describe the costs to manage waste in this form indefinitely and who would be responsible for the cost. Maintaining waste on-site at Yucca Mountain would be similar to the no-action alternative-deep geologic storage would be the preferred option.

Response
Section 122 of the NWPA requires DOE to maintain the ability to retrieve the materials emplaced in the repository in the event of a decision to retrieve them to protect public health and safety or the environment or to recover constituent parts of spent nuclear fuel. This retrieval requirement is reflected in the Nuclear Regulatory Commission's disposal regulations [10 CFR 63.111(e)]. Although DOE does not anticipate that retrieval would be necessary, it would utilize the repository design to maintain the ability for future generations to retrieve these materials for at least 100 years and possibly for as long as 300 years after emplacement operations began (see Section 4.2 of the EIS). The Federal Government, therefore, would maintain stewardship of the repository site for generations to come. These stewardship activities would entail site protection, confirmatory scientific work and a postclosure monitoring program required by Nuclear Regulatory Commission rules governing the disposal of high-level radioactive wastes in a geologic repository (10 CFR 63.51). The decision to close the repository (and thus give up active control) would come after the approval of a license amendment supported by what would be new and more advanced analyses utilizing future data and modeling tools.

Although it is not part of the Proposed Action, DOE has considered the impacts of retrieving spent nuclear fuel from the repository as a contingency action and describes the potential impacts if it was to occur (see Section 4.2 of the EIS). The Department evaluated only those actions that it could predict with any certainty (that is, removal of the emplaced waste materials and subsequent onsite storage). Because any future actions regarding the management and disposal of these materials following retrieval would be at the direction of Congress, and because they are highly speculative and unnecessary to support current decisionmaking, DOE believes it is inappropriate to attempt to evaluate impacts that could result from these actions.

Under Nuclear Regulatory Commission regulations (10 CFR Part 63), the required "description of plans" for retrieval operations is not the same as that required for the designs and plans associated with fuel receipt, handling, and emplacement. The Commission would have to approve a decision to retrieve the waste (separate from the Proposed Action), at which time it would review detailed retrieval plans and facility designs.

A loss of institutional control under retrieval circumstances is not a feasible occurrence. Nuclear Regulatory Commission regulations (10 CFR Part 63) require that DOE institute active and passive institutional controls, so the repository design contains such controls. The controls would reduce, for as long as possible, the potential that human activity could degrade long-term repository performance. Scenario 1 of the No-Action Alternative includes an analysis of impacts under effective institutional controls for at least 10,000 years and is consistent with the portion of the analysis of the Proposed Action that includes an analysis of effective institutional controls for the first 100 years after closure. Scenario 1 assumes that the spent nuclear fuel and high-level radioactive waste would be stored in a configuration that would allow retrieval at any time in the future; therefore, long-term retrievability is not an issue. The Scenario 2 analysis of the No-Action Alternative does not consider institutional controls after approximately 100 years and is parallel to the portion of the Proposed Action analysis in which long-term performance after 100 years does not include institutional controls.

Concerning economics, the costs associated with the Proposed Action would be greater during the first 100 years; the ongoing costs associated with continued storage under the institutional control scenario would be far greater. Most of the funding for site characterization and ultimately development of a repository, should the project proceed to that stage, comes from ratepayers who benefit directly from the use of nuclear power. Continued storage of spent nuclear fuel at generator sites would also be ratepayer-funded. The analysis assumed that continued storage facilities would require replacement every 100 years, and there would be a major facility repair halfway through the first 100-year cycle. Under Scenario 2, loss of institutional control, the projected economic impacts would be the same as those for Scenario 1 for the first 100 years, but after that approximately 800 jobs would be lost.

Cost estimates of the No-Action Alternative are presented in Section 2.2.3 of the EIS and estimates of the Proposed Action are presented in Section 2.1.5. However, a specific cost/benefit analysis has not been performed because it is not necessary to support current decisionmaking. It is DOE's opinion that sufficient information about potential impacts to the public health, safety, and the environment is provided in the EIS to support current decisionmaking.

7.2 (7989)
Comment - EIS000817 / 0049
If you are cooling and venting casks as you unload them, I assume gases and water released will be highly contaminated.

Response
DOE has extensive experience with the unloading of transportation casks. Experience has shown that cask gases and interior surfaces are sometimes contaminated from dislodging crud from spent-fuel-element surfaces during transportation. Normal cask-unloading operations include checking the cask exterior for contamination, sampling the cask gases, and venting the interior gases through filtration. Before using the cask again, the external surfaces are checked for contamination and decontaminated, producing small amounts of low-level waste. Nuclear facilities routinely conduct loading and unloading operations using methods and equipment designed to accommodate contamination to ensure that no contaminated gases or radioactivity from cask surfaces are released. The equipment designed for Yucca Mountain incorporates features developed over several decades of safe handling of spent nuclear fuel at U.S. nuclear facilities.

7.2 (8233)
Comment - EIS001873 / 0027
P. 2-13. The discussion of closure scenarios must identify any conditions that might affect the ability of the DOE to carry out this fifteen year project 300 years from now.

Response
Section 2.1.2.4 of the EIS discusses the steps DOE would take to close the Yucca Mountain Repository. Since the publication of the Draft EIS, the Department has modified the repository design to include drip shields over the waste packages and forced ventilation during the operation and monitoring phase. The drip shields would be placed over the waste packages immediately before closure. The forced ventilation would end when DOE closed the repository. The current design does not involve the placement of backfill over waste packages. The Final EIS discusses these design changes and the steps DOE would take to close the repository.

The flexible design includes operating scenarios that would require the repository to remain open for at least 300 years after the end of emplacement. During this period, the repository would remain accessible for scientists to continue testing and monitoring while providing more flexibility for future generations of scientists and engineers who will conduct repository performance confirmation and ultimately determine the timing and methods of repository closure. However, DOE believes that that the conceptual information contained in Section 2.1.2.4 of the

Final EIS provides an adequate basis for estimating closure impacts for purposes of informing the decisionmaking process.

7.2 (8327)
Comment - EIS000817 / 0111
Now here -- here at this giant ISFSI in Nevada -- after retrieval -- here is where you could have the big degradation of casks that you describe could happen at reactors. The reason it could happen here is that there are just too many casks in one place to recask them all if need be in 20-40 years, etc. What is the plan for storage monitoring and upkeep of casks, if the whole repository load is actually retrieved? What are doses to workers and the public if all these casks need future unloading and recasking? Plan for that!!

Response
Section 4.2 of the EIS examines the potential impacts from retrieving the waste. Retrieval is not part of the Proposed Action, but rather a contingency required by Section 122 of the Nuclear Waste Policy Act. DOE would maintain the ability to retrieve the waste for at least 100 years and possibly as long as 300 years. Management of these materials following retrieval would be in accordance with license conditions approved by the Nuclear Regulatory Commission. If the material were to be deemed unsuitable for re-emplacement into the repository, alternate disposal options would be at the direction of Congress. However, in the event the materials were determined to be unsuitable for re-emplacement into the repository, some period of surface storage would be required.

Since publication of the Draft EIS, a more detailed study of the retrieval contingency action has been completed for the flexible design [see Section 2.3.4.6 of the Science and Engineering Report (DIRS 152985-DOE 2001)]. This study includes considerations for normal and off-normal operations including handling and repackaging damaged waste packages. However, because of the low probability that the retrieval contingency would be implemented and the uncertainties related to the possible condition and integrity of the retrieved packages, DOE believes the impacts estimates for such action would be too speculative to provide meaningful information for the decisionmakers. For this reason, potential impacts of the retrieval contingency have not been provided in the EIS.

7.2 (8330)
Comment - EIS000817 / 0112
You are better off leaving small ISFSIs [independent spent fuel storage installations] at the reactors where they are now and can be taken care of. Why are you expecting only to put the waste package in a concrete module? Some fuel may have to be unloaded. And modules may have to be replaced too. Think of this large retrieval ISFSI long into the future. What will have to be done? Long term? Just remember, all the movement of the cask handling will result in some problems. I doubt that your statement p.4-107 “the waste packages would not be opened” will prove to be the case.

Response
Section 4.2 of the EIS examines the potential impacts from retrieving the waste. Retrieval is not part of the Proposed Action, but rather a contingency required by Section 122 of the Nuclear Waste Policy Act. DOE would maintain the ability to retrieve the waste for at least 100 years and possibly as long as 300 years. If retrieval were required, surface storage would be in compliance with regulations that exist at that time.

Since publication of the Draft EIS, a more detailed study of the retrieval contingency action has been completed for the flexible design [see Section 2.3.4.6 of the Science and Engineering Report (DIRS 152985-DOE 2001)]. This study includes considerations for normal and off-normal operations including handling and repackaging damaged waste packages. However, because of the low probability that the retrieval contingency would be implemented and the uncertainties related to the possible condition and integrity of the retrieved packages, DOE believes the impacts estimates for such action would be too speculative to provide meaningful information for the decisionmakers. For this reason, potential impacts of the retrieval contingency have not been provided in the EIS.

7.2 (8369)
Comment - EIS001873 / 0054
P. 4-86. Impacts from cask maintenance should be included.

Response
Although it could be located either onsite or offsite, the environmental impacts from Cask Maintenance Facility are included in the impact analyses for the entire repository. See the various subsections under Section 4.1 of the EIS.

7.2 (9591)
Comment - EIS001888 / 0265
Service and Maintenance Support

This refers to the "personnel, facilities, equipment, materials, and system for transportation cask system equipment maintenance, inspection, repair inventory, regulatory compliance, and decommissioning." Will the waste packages be opened and the waste inspected before it is disposed? Will the waste be shipped in a single container with multiple uses, or will waste be transferred from a shipping container to a disposal container? If so, where will the facility to perform such an operation be located? When will it be built? By whom?

Response
The May 2001 Supplement to the Draft EIS and Section 2.1.2 of the Final EIS describe the design and operation of the repository. The transportation casks that would be used to transport the waste to the repository would be opened and the waste forms removed and inspected. Some commercial spent nuclear fuel could arrive at the repository in canisters that could be moved from the transportation cask to the waste package without being opened. In such cases the canister itself would be inspected. Commercial spent nuclear fuel could also arrive at the repository as individual assemblies that would unloaded and placed into the spent nuclear fuel blending inventory pools. When a fuel assembly was relocated from the fuel blending pool for packaging, it would be prepared for and loaded into a waste package one by one. All DOE waste forms would arrive in canisters that would be taken from transportation cask to waste package without being opened. Waste forms packaged in canisters prior to shipment to the repository would be inspected before the canister was sealed. The canisters themselves would be inspected at the repository, but not opened. See Section 2.1.2.1.1.1 and 2.1.2.1.1.2 for a more detailed description and also Science and Engineering Report, Section 2.2.4.2.1.

The receipt and unloading of transportation casks, and the loading and sealing of waste packages, would be done at the surface facilities at the North Portal Area on the east slope of Yucca Mountain. The EIS analysis assumes that construction of these facilities would start around 2005 and that operations would begin in 2010. There has been no decision as to who would construct these facilities.

7.2 (9788)
Comment - EIS001888 / 0374
[Clark County summary of a comment it received from a member of the public.]

One commenter requested that the EIS evaluate the potential for spills to penetrate into the ground.

Response
As described in Section 4.1.3.2, DOE believes that the environmental consequences to surface water from construction, operation and monitoring, and closure of the repository would be minor and manageable. High- and low-level radioactive waste would be handled under fully contained and controlled conditions. The facilities and systems are designed for confinement and safety. Use of hazardous materials would be subject to administrative controls, and nonhazardous substitute materials would be used to the maximum extent possible. Spills of hazardous materials, should they occur, would be handled in accordance with all applicable Federal and state regulations.

DOE would develop operational plans for managing spills during the License Application phase, as the preliminary design progresses.

7.2 (10394)
Comment - EIS002192 / 0004
Now I've been around the horn a few times and I can only say they cannot say how long the repository will be opened 50, 100, 300 years, and this is again a very ambiguous attitude of DOE, DOD [Department of Defense], EPA [Environmental Protection Agency] and NRC [Nuclear Regulatory Commission], and I'm sure people don't realize how dangerous this is.

Response
As stated in Section 2.1.2 of the EIS, the design of the repository maintains the capability to close as early as 50 years or as late as 300 years after the start of emplacement operations. The purpose for this approach is to provide future decision makers with sufficient flexibility in determining when the repository should be closed.

The earlier closure time, 50 years after emplacement would begin, stems from the requirement by the Nuclear Regulatory Commission that waste retrieval be possible at least 50 years after the start of emplacement operations (10 CFR Part 63). For analysis purposes, Chapter 4 of the EIS assumes that closure would begin between 100 and 324 years after the start of emplacement.

7.2 (10415)
Comment - EIS002205 / 0001
All the water, and it's pumped into Yucca Mountain through pipes, every bit of its on a meter. This is recorded, and any wastewater -- we use water. The dust is the problem because there's no water in the mountain. It's all powder river, it's all lava rock, and they're digging with alpine miners or blasting or whatever, you spray the dust and it's brought on a conveyor system.

The conveyor system has foggers on it that spray onto the rocks and the dirt so they won't have to keep the dust down, and what you saw as far as the ten down, that's for the wipers on the conveyor system that cleans off any of the excess after the head roll and it falls down into tanks, but all this water is collected in tanks and it's pumped back into another pipe that is metered and goes back outside, and they can compare their meter readings on how much water was used and how much was pumped back in and they -- the difference is how much was left in the ground, and they have criteria where you can only have so much water or waste so much, but it's -- they're not trying to hide anything, and water does not pour out of that mountain, trust me.

Now, you got into that when that tunnel boring machine came through that south portal. It's spraying water all over. Well, on the tunnel boring machine, you spray water on that to keep the dust down. Otherwise, I mean, you've got men working in there. They're in respirators, but the dust gets so thick, you can't even see, so you have to control the dust as best you can, and that's why use of water, but all that water is still measured back into sumps, pumped back out -- outside, but it's all recorded.

Response
Section 4.1.3.2 of the EIS addresses the impacts to surface water from repository construction, operation and monitoring, and closure. The EIS also discusses the potential for treatment and/or recycling of water throughout the preclosure period.

DOE has concluded that any impacts to surface water from construction, operation and monitoring, and closure of the repository would be minor and manageable.

7.2 (10913)
Comment - EIS001293 / 0001
I wish I could endorse and support the Yucca Flats project. The United States and the World needs a viable method for storage and permanent disposal of high-level nuclear waste. However, I cannot endorse this project for reasons that I will get to in a moment.

The concept of underground storage presumes that high-level wastes generate relatively small amounts of heat that can be dissipated in the rock. On the contrary, heat generation is sufficiently large and prolonged that heat must be continuously transferred to the environment in order to keep the wastes immobile.

Assume that spent fuel is allowed to decay in storage pools for 30 years after removal from the reactor. By this time 98% of the remaining radioactive decay and heat generation is accounted for by two isotopes, strontium-90 and cesium 137. It can be calculated that the heat generation from 15,000 metric tons of spent fuel (the present U.S. inventory) is approximately 19,000 kW. One hundred seventy years later (200 years after removal from the reactor) the wastes will generate 300 kW of heat.

These heat generation rates can be compared with the normal heat flow from Earth of approximately 0.215 kW per acre. This heat is transferred to the surface with a temperature gradient of about 9ºC per thousand feet. Assume that the waste canisters are distributed under 1000 acres of the Yucca Mountain repository. This gives an initial heat flow of 19 kW per acre, which is 90 times normal heat flow. In theory, the waste-containing strata will rise in temperature until long-term equilibrium is reached and heat generation equals heat flow to the surface. In practice, the wastes will soon reach melting and volatilization temperatures and begin to migrate from the repository depths. Groundwater that comes into contact with the molten wastes will form steam, which will speed up waste migration.

These calculations, which I made from information in published government and nuclear industry sources, help explain why repeated attempts to plan and build underground high-level radioactive waste repositories have come to naught. I predict Yucca Mountain will be another exercise in futility, and the ever-increasing waste inventory will continue to burden our future.

Response
The waste in the repository would generate a large amount of heat, which would decrease with time. DOE has conducted detailed tests of the effects of heat on the rock at Yucca Mountain, and developed computer models that predict the results of these tests within reasonable limits. Based on these computer models, the temperatures of the waste inside the waste packages would remain below the melting point. Therefore, DOE predicts no volatilization of wastes, either before or after closure of the repository.

Although there would be heat in the emplacement drifts during preclosure operations, ventilation systems would keep the temperatures below the boiling point.

Because of the evolving nature of the design of the repository, DOE issued a Supplement to the Draft EIS in May 2001 for public review. This Supplement and the Final EIS describe the impacts of the repository based on the most recent repository design. The repository design has evolved to include the flexibility to operate in either a higher- or a lower-temperature mode after closure. Higher-temperature means that at least a portion of the rock wall in the emplacement drift would have a maximum temperature above the boiling point of water. Operations in the lower-temperature mode would ensure that the rock wall would remain at a temperature below the boiling point of water and would keep the average maximum surface temperature of the waste packages below 85°C (185°F) to avoid conditions that could increase the rate of waste package corrosion. DOE believes that ongoing site characterization and design-related evaluations will continue to improve projected repository performance and reduce associated uncertainties.

7.2 (12187)
Comment - 010073 / 0015
Page 2-9 - The SDEIS does not consider the potential for an extended fuel-aging process to also extend the transportation campaign.

Response
The commenter is correct. Under any of the flexible design operating modes, DOE would receive commercial and DOE spent nuclear fuel and high level radioactive waste over a 24-year period. Differences in the flexible design modes would not directly affect transportation to the repository. DOE intends to maintain the transportation schedule described in the Draft EIS.

7.2 (12780)
Comment - 010212 / 0004
Footnote d to Table S-l refers to an assumption for the lower-temperature operating mode over a 50-year period ending in 2060. We understand the purpose for the additional aging before emplacement is to reduce thermal loading in the drifts. Does that affect the waste acceptance rates for commercial spent fuel or does it mean that the fuel will be stored at the fuel aging area that is part of this operating mode alternative?

Spent nuclear fuel from commercial nuclear plants was supposed to have begin acceptance by DOE in January 1998, according to the mandate of Nuclear Waste Policy Act and under terms of the contracts DOE required plant operators to enter into in 1983. The earliest that DOE indicates spent fuel would be accepted is 2010, on the presumption of the proposed action that Yucca Mountain is found suitable for the repository and that a license authorizing construction is issued sometime in 2005.

The nuclear utilities have been placed in a bind by the delay in waste acceptance. Many have already had to make investments to expand reactor site storage that should not have been necessary if DOE had met the 1998 milestone or had taken other steps to move spent fuel per the waste acceptance schedule to other DOE-managed sites on a temporary basis. As a consequence, many utilities expanded their on-site storage capacity and others will need to before waste acceptance begins in 2010 or later. Many utilities have entered into litigation seeking waste removal and cost recovery for damages from DOE's breach of contract.

We raise this question in the context of the need to move the spent fuel from reactor sites in a timely fashion as move spent fuel accumulates. This must be a priority regardless of whether the lower or higher temperature-operating mode is the one selected. Therefore, the aging facility needs to be sized accordingly if the lower-temperature mode is adopted.

Response
As discussed in Section 2.2.2.2.2 of the Supplement to the Draft EIS, commercial spent nuclear fuel would be the major contributor of heat in the repository. It would have a wide range of thermal outputs. The thermal output of the waste packages could, however, be reduced by varying waste package loading. Commercial spent nuclear fuel waste package loading could be varied by (1) placing low-heat-output (older) fuel with high-heat-output (younger) fuel in the same waste package (fuel blending), (2) limiting the number of spent nuclear fuel assemblies to less than the waste package design capacity (derating), (3) using smaller waste packages, or (4) placing younger fuel in a surface aging area to allow its heat output to dissipate so it could meet thermal goals for later emplacement. Section 2.3.2.1 of the Supplement to the Draft EIS describes the fuel blending process further. Reducing the thermal output of the waste package through any of these means would achieve lower waste package and drift wall temperatures. DOE would consider aging as much as 40,000 metric tons of heavy metal of commercial spent nuclear fuel during a 50-year period.

The flexible design for the repository allows flexibility in the types of commercial spent nuclear fuel that DOE would be receive. However, the estimated receipts are based on DOE projections of actions that would be taken by utilities to deliver spent nuclear fuel for disposal and are independent of the repository design. Instead, they are based on the terms of DOE's Standard Contract for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste contained in 10 CFR Part 961 and the generation and storage characteristics of each generator site (see discussion of CALVIN computer code in Section J.1.1.1 of the EIS). Therefore, DOE believes that the flexible design, including the blending facility, would accommodate fuel that would be shipped to a Yucca Mountain repository based on the terms of the Standard Contract.

7.3 Repository Long-Term Performance

7.3 (7)
Comment - 24 comments summarized
Commenters said that Total System Performance Assessment evaluations are close to the status required for licensing reviews. However, improvements needed for licensing would include revision or refinement of model details, revision of parameter values as a result of data additions, and improvement of quality assurance basis for models, computer codes, and data. One commenter said that the long-term consequences in the Draft EIS suffer from the shortcomings that they are a snapshot in an evolutionary process. Commenters felt that the Viability Assessment provided only a limited description of the methodology, assumptions, and use of information in the Total System Performance Assessment (DIRS 101779-DOE 1998).

Response
DOE has continued technical development of the Total System Performance Assessment since publication of the Draft EIS, including further site characterization, improvements to the engineered system design, system performance assessment calculations, and quality assurance and validation of results. Chapter 5 and Appendix I of the Final EIS reports on the modified assumptions and methodologies utilized. DOE agrees that the process requires continual refinement and improvement.

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The nuclear utilities have been placed in a bind by the delay in waste acceptance. Many have already had to make investments to expand reactor site storage that should not have been necessary if DOE had met the 1998 milestone or had taken other steps to move spent fuel per the waste acceptance schedule to other DOE-managed sites on a temporary basis. As a consequence, many utilities expanded their on-site storage capacity and others will need to before waste acceptance begins in 2010 or later. Many utilities have entered into litigation seeking waste removal and cost recovery for damages from DOE's breach of contract.

We raise this question in the context of the need to move the spent fuel from reactor sites in a timely fashion as move spent fuel accumulates. This must be a priority regardless of whether the lower or higher temperature-operating mode is the one selected. Therefore, the aging facility needs to be sized accordingly if the lower-temperature mode is adopted.

Response
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Response
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A peer review of the Total System Performance Assessment noted: "For cases in which it is feasible to improve either the component models or their underlying data, the Panel recommends that primary attention be directed to those changes that will affect the overall assessment of the proposed repository. Where conservative bounding analyses do not result in an unduly pessimistic estimate of total system performance, it may not be cost-effective to refine the assessment in an attempt to make it more realistic. For those systems and events for which, by virtue of their complexity, it is not feasible to produce realistic models supported by data, the Panel recommends that, if possible, a combination of bounding analyses and design changes be applied." (DIRS 102726-Budnitz et al. 1999). DOE concurs with these approaches. They are consistent with the Department's strategy for developing a preclosure safety case for the potential Site Recommendation and License Application, with the ongoing design selection process, and with its efforts to prioritize future work for the Site Recommendation and License Application.

With regard to the statements about Total System Performance Assessment sufficiency and the fact it is evolutionary, DOE did not intend for the assessment to provide a precise projection of the probable behavior of the repository system. Rather, the Total System Performance Assessment provides the probable behavior within the range of results given the available information and analyses.

DOE continues to evaluate the sufficiency of its approach to uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should Yucca Mountain be recommended as a suitable site for a geologic repository.

7.3 (71)
<u>Comment</u> - 4 comments summarized
Several commenters questioned the location of the maximally exposed individual, indicating that there is no rationale provided in the EIS for the location and that the location is not conservative. Other commenters suggested the individual should be an age- and gender-weighted subsistence farmer located at the repository operations area boundary.

One commenter noted that the definition of the maximally exposed individual in the EIS is not the same as the reasonably maximally exposed individual used by the Environmental Protection Agency.

<u>Response</u>
Environmental Protection Agency rules (40 CFR Part 197) and Nuclear Regulatory Commission rules (10 CFR Part 63) specify protection of the reasonably maximally exposed individual as the standard of safety for the proposed Yucca Mountain Repository.

DOE accepts the definition of the Reasonably Maximally Exposed Individual (RMEI) at 40 CFR 197.21, which defines the individual as a hypothetical person who could meet the following criteria:

1. Has a diet and living style representative of the people who are now residing in the Town of Amargosa Valley, Nevada. DOE must use the most accurate projections, which might be based upon surveys of the people residing in the Town of Amargosa Valley, Nevada, to determine their current diets and living styles and use the mean values in the assessments conducted for 40 CFR 197.20 and 197.25.

2. Drinks 2 liters (0.5 gallon) of water per day from wells drilled into the groundwater at the location where the RMEI lives.

The location of the RMEI described in 40 CFR Part 197 would be where the predominant groundwater flowpath crosses the southern boundary of the Nevada Test Site, which coincides with the southern boundary of the controlled area as defined in the regulation. This point is approximately 18 kilometers (11 miles) from the proposed repository. DOE has concluded that it is not necessary to analyze in the Final EIS a hypothetical individual at locations closer than approximately 18 kilometers (11 miles) to the repository because it is unreasonable to assume that anyone would reside in this area, for these reasons:

- An individual would need to install and operate a water well in volcanic rock more than 360 meters (1,200 feet) deep to reach the water table, at costs significantly (and likely prohibitively) above those that would be incurred several kilometers farther south of the repository where the water tables lies less than 60 meters (200 feet) beneath the surface through sand and gravel.

- Locations closer than 18 kilometers (11 miles) are within the controlled area defined in the Environmental Protection Agency individual protection standard (40 CFR 197.20) for a Yucca Mountain Repository and, therefore, not in the postclosure accessible environment defined by the Agency.

The updated analysis in the Final EIS estimates potential impacts to a member of the public reported for the location prescribed in 40 CFR 197.21 [approximately 18 kilometers (11 miles) from the proposed repository]. As part of a comprehensive presentation of impacts, this EIS is charged with providing groundwater impacts for two other important downgradient locations. These are 30 kilometers (18 miles), where most of the current population in the groundwater path is located, and 60 kilometers (37 miles) where the aquifer discharges to the surface (this location is also known as Franklin Lake Playa). The doses for these other locations were assessed for an individual with the same characteristics as the RMEI with the exception of the location. This analysis indicates that for the first 10,000 years there would be only very limited releases, attributable to a small number of early waste package failures (zero to three, and possibly as many as five) due to waste package manufacturing defects, with very small radiological consequences (see Table 5-6). For the first 10,000 years after repository closure, the mean peak annual individual dose would be thousands of times less than the Environmental Protection Agency individual protection standard (40 CFR 197.20), which allows up to 15-millirem-per-year dose rates during the first 10,000 years. The peaks would be even smaller at greater distances.

DOE has revised the definitions of the maximally exposed individual and RMEI in the Final EIS. Chapters 4, 6, and 7 now use the term "maximally exposed individual," and Chapter 5 uses "individual" for distances other than 18 kilometers (11 miles). The "individual" is the same as the "reasonably maximally exposed individual" defined in 40 CFR Part 197 with the exception of the location.

7.3 (94)

Comment - 10 comments summarized

Several commenters cited or referred to a report by two DOE scientists at the Los Alamos National Laboratory, Drs. Bowman and Venneri, which concluded that an explosive nuclear criticality was credible and suggested that the impacts of such an event should be analyzed in the EIS. Commenters also suggested that these analyses should be quantitative in nature and that all assumptions and results should be in the Final EIS. One commenter wanted to know why impacts from an external criticality event could not be determined by experiment.

One commenter suggested that enhanced material migration resulting from natural (earthquake, volcanism) or manmade (intrusion) external events could increase the likelihood of a criticality event. Other commenters were concerned about the lack of any consensus among DOE's own scientists on the subject. One commenter stated that the Nuclear Regulatory Commission position is that DOE does not have sufficient data to support the conclusion that criticality is not a significant issue.

One commenter noted that "there is no chance" of criticality accident, with the words in quotes taken from the Draft EIS. Another commenter stated that regardless of the conclusion that an explosive criticality is not credible, the DOE must show the impacts of such an event because it is considered credible by some critics of Yucca Mountain.

Response

To evaluate criticality safety, DOE analyzed a comprehensive collection of all features, events, and processes that could conceivably affect the potential for criticality, including those postulated by Drs. Bowman and Venneri in their report, *Underground Autocatalytic Criticality from Plutonium and Other Fissile Materials* (DIRS 152123-Bowman and Venneri 1995), as well as those postulated to occur as a result of natural (earthquake, volcanism) or manmade (intrusion) external events. In addition, DOE updated the analysis to consider the flexible design repository and waste package designs.

In performing the analysis, DOE used the most current information on the facility design and site properties, known physical processes regarding nuclear criticality, and industry-accepted methods to evaluate nuclear criticality scenarios. In addition, the Department believes there is adequate experimental data available from operating commercial and research reactors as well as empirical data gathered from natural analogs (for example, the Oklo natural reactors in Gabon, Africa) to predict the likely behavior of these systems without the need for conducting additional criticality experiments.

These exhaustive, quantitative analyses demonstrate that nuclear criticality is not likely at the Yucca Mountain Repository. While a highly unlikely criticality within a waste package could occur, it would result in an inconsequential increase in heat load and radioactivity. It would not result in mechanical disruption of the engineered systems. Criticalities outside a waste package were deemed not credible. Therefore, an explosive nuclear criticality is not considered a reasonably foreseeable event. The Draft EIS references the source of the information supporting the conclusions (DIRS 101779-DOE 1998) and the Final EIS references sources of information supporting similar conclusions for the enhanced design (DIRS 153849-DOE 2001).

Information related to the criticality analyses performed for the Final EIS waste package designs has been provided in Chapter 5 and Appendix I of the Final EIS. Because of space considerations, it would have been impractical to include all the information from supporting documents. Therefore, the information is summarized with appropriate reference citations. Supporting information including the scientific bases regarding nuclear criticality can be found in the Science and Engineering Report (DIRS 153849-DOE 2001) and referenced supporting documents. DOE has made information about these and more than 600 other Final EIS reference documents available to the public on the Internet (*www.ymp.gov*) and at reading rooms across the Nation (see Appendix D.)

DOE continues to provide the results of updated criticality analyses and other requested information to the Nuclear Regulatory Commission as part of an ongoing technical exchange. This information exchange will continue as the repository design evolves, and the Department expects to be able to address adequately any issues that might arise in the future.

The comment noting that "there is no chance" of a criticality is taken out of context. The complete phrase from the Draft EIS is "...there is no chance that a criticality would cause a mechanical disruption of the waste package and engineered barrier system." A reference is provided for that conclusion. The comment that DOE must show the impacts of an explosive criticality event regardless of the probability of the event is incorrect. Consistent with Council of Environmental Quality regulations (40 CFR 1502.22) for implementing the National Environmental Policy Act, DOE analyzes reasonably foreseeable significant adverse impacts, including impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason. However, as explained above, DOE has taken a hard look at this issue and has determined that an explosive nuclear criticality is not a credible event (that is, not reasonably foreseeable). Thus, DOE believes that analysis of the impacts of such an event is not required under the National Environmental Policy Act and would not provide useful information to decisionmakers.

7.3 (110)
<u>Comment</u> - 6 comments summarized
Commenters questioned DOE's reliance on computer modeling, in lieu of actual testing and use of real data, to demonstrate the safety of a Yucca Mountain Repository. Several commenters pointed out that the Department does not accept modeling as an accurate predictor of the behavior of nuclear weapons and questioned why such modeling should be considered acceptable for the proposed repository.

<u>Response</u>
A much larger amount of nuclear weapons testing would have been necessary had there not been good models for prediction of weapons effects. Modeling in support of weapons testing has been very highly developed. The significant difference between modeling the behavior of nuclear weapons and a geologic repository is that it is possible to test a weapon that operates over a period of fractions of a second with data gathering, interpretation, and analysis over a few months. In the case of a geologic repository the test duration would be at least 10,000 years. In the case of weapons, the testing provided a much higher degree of certainty in the results of modeling of weapons effects.

For the proposed repository, DOE does not have the option of a 10,000-year test and must accept some uncertainty in predictions of long-term repository performance. DOE deals with this uncertainty in two ways. First, where it is necessary to make assumptions, either due to uncertainty or to make mathematical modeling practicable, DOE chooses conservative assumptions that tend to result in overestimates of impacts. Second, models are used to simulate behavior statistically using large ranges of values for parameters about which there is uncertainty. In addition, note that it is expected that the final decision to close the repository would not be made for at least 50 years and possibly up to 300 years after final emplacement. The sophistication of modeling tools probably would have advanced significantly during the intervening years and DOE would have obtained much more comprehensive data on repository during construction, operation, and associated investigations and monitoring. Thus, the final decision to close the repository would benefit from more analyses than are possible now.

The Federal Government, therefore, would maintain stewardship of the repository site for generations to come, if the site is selected for a repository. These stewardship activities will entail site protection, confirmatory scientific work, and a postclosure monitoring program, as required by Nuclear Regulatory Commission rules governing the disposal of high-level radioactive waste in a geologic repository (10 CFR 63.51). The decision to close the repository (and thus give up active control) would come after the approval of a license amendment supported by what will be new and likely more advanced analyses utilizing future data and modeling tools.

7.3 (206)
Comment - 20 comments summarized
Commenters generally expressed concern about the repository site conditions and consequences to future generations or societies. One commenter suggested that "both should be projected at least several thousand years into the future." Other commenters acknowledged that "predicting societal change over the long term was impossible" but that there was still a need to assess the long-term socioeconomic and health impacts. Another commenter suggested that the biosphere would change and, therefore, the human population and pathways of potential importance would change over 10,000 years as the climate changed. There also was worry expressed over the legacy left to future generations.

Commenters stated that nuclear waste would be with us for an extremely long time, and one commenter asked what would happen if some future society had a change in language and could not read warnings we might post or no longer retain the knowledge of radiation. Another commenter asked what would happen if a few hundred years from now someone somehow "taps into" the repository. One commenter said that there would be no institutional controls that last as long as the waste is toxic. Similarly, a concern was expressed that there would be no accountability, the engineering errors of this time would not require an accounting because of failure until long after the current generations are gone.

Several commenters expressed concern over long-term consequences. Commenters expressed concern over the ability of the Federal Government to maintain support in terms of oversight and funding for the required number of decades.

Response
As described in Chapter 1 of the EIS, Congress has determined through the passage of the Nuclear Waste Policy Act of 1982 that the Federal Government has the responsibility to permanently dispose of spent nuclear fuel and high-level radioactive waste to protect the public health and safety and the environment. The Act states that the Federal Government needs to take precautions to ensure that these materials do not adversely affect this and future generations. DOE believes that our elected representatives, having directed the Federal Government to embark on this project, would continue to fund it adequately to protect the public's health and welfare.

Given the current state of technology, it is virtually impossible to design and construct a geologic repository that would provide a reasonable expectation that there would never be any releases of radioactive materials. DOE would design, construct, operate and monitor, and eventually close a repository that would meet public health and safety radiation protection standards and criteria established by the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC). Congress, in the Energy Policy Act of 1992, directed the EPA to develop public health and safety standards for the protection of the public from releases of radioactive materials stored or disposed of in a repository at the Yucca Mountain site. Congress also directed the NRC to publish criteria for licensing the repository that would be consistent with the radiation protection standards established by the EPA. In part, the EPA standards (40 CFR Part 197) and NRC criteria (10 CFR Part 63) prescribe radiation exposure limits that the repository, based on a performance assessment, must be designed not to exceed during a 10,000-year period after closure.

In the EIS, DOE has evaluated the ability of the natural and engineered barrier system to isolate radioactive materials from the environment for thousands of years. As a result of this evaluation, DOE would not expect the repository to exceed the prescribed radiation exposure limits during the 10,000-year period after closure. Further, DOE estimates that the average peak dose to a hypothetical individual from the repository would be less than the dose received from natural background radiation.

DOE recognizes, as one commenter noted, that predicting societal change over the long term is not credible. As a consequence, the Department has structured conservative assumptions and scenarios taking into account the regulatory guidance provided by the EPA and NRC, as well as other scientific authorities that have provided reviews. These assumptions and scenarios attempt to reasonably accommodate the inherent uncertainties with estimating long-term repository performance.

DOE confidence in the robustness of its analyses is enhanced by the safety margin and the defense-in-depth provided by the multiple natural and engineered barriers at Yucca Mountain. Nevertheless, the EPA, NRC, and DOE have all recognized that some uncertainty about repository performance would remain. As a consequence, DOE has established performance, monitoring, and site stewardship programs that would accomplish multiple goals related to DOE's obligation to protect the public health and safety and the environment (DIRS 153849-DOE 2001).

After closure, DOE would be responsible for maintaining institutional control over the proposed repository, as required by the Energy Policy Act of 1992. Neither the extent nor the length of this regulatory requirement is well defined at present. However, DOE would maintain appropriate institutional control for as long as required (DIRS 153849-DOE 2001).

To maintain flexibility and an ability to respond to changing conditions and technologies, Section 122 of the NWPA requires retrievability at a geologic repository. Federal regulations (10 CFR Part 63) require that the repository design preserve the option of retrieval on a reasonable schedule for as long as 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the Yucca Mountain Repository allows the flexibility to preserve options for modifying emplacement and retrieving waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly more than 300 years, in the event of a decision to retrieve the waste either to protect the public health and safety or the environment, or to recover resources from spent nuclear fuel. During this period, the repository would remain accessible for continued testing and monitoring while providing flexibility to future generations, who would ultimately determine the timing and methods of repository closure.

Once the repository was closed, DOE would implement a postclosure monitoring program pursuant to 10 CFR Part 63. This program would include monitoring activities around the repository after the facility was closed and sealed. The program would include continued oversight to prevent any activity at the site that would pose an unreasonable risk of breaching the repository's geologic or engineered barriers or increasing the radiation beyond allowable limits, as discussed in Section 2.1.2.3 of the EIS. The details of this program would be defined during the processing of the license amendment for closure.

While DOE cannot speculate on future society's ability to read today's warnings or on its retention of knowledge about nuclear materials, it would have an obligation to notify future potential intruders that the repository exists. As a consequence, monuments designed and fabricated to be as permanent as practicable would identify the repository. The monuments would allow intruders the option to make informed decisions regarding the use of the surface and subsurface areas for habitation or other activities.

DOE has considered questions about human intrusion and acknowledged this as an important issue because the future behaviors of humans cannot be predicted. The NRC and the EPA have specified the way to analyze human intrusion in their respective regulations for Yucca Mountain. The regulations describe a stylized calculation that attempts to address why humans would intrude into the proposed repository. DOE also incorporated the advice provided by the National Academy of Sciences, through a National Research Council report requested by Congress on the *Technical Bases for Yucca Mountain Standards* (DIRS 100018-National Research Council 1995).

7.3 (208)

Comment - 11 comments summarized

Commenters cited a report issued by the Peer Review Panel (the Panel) that was, in the view of the commenters, critical of the scientific work underlying the Total System Performance Assessment. The report was offered as an indication that DOE cannot sufficiently assess the long-term performance of the repository because the assessment is based upon approaches that are “fraught” with uncertainty and “flanked” by lack of data. For example, several commenters cited the final report of the Panel, which states “…the panel finds that at the present time an assessment of the future probable behavior of the proposed repository may be beyond the analytical capabilities of any scientific and engineering team. This is due to the complexity of the system and the nature of the data that now exists or that could be obtained within a reasonable time and at a reasonable cost.”

One commenter questioned the meaning of the term “reasonable assurance.” Another noted that DOE indicates in Chapter 5 of the EIS general agreement with the Panel’s advice. However, the commenter wants to know what DOE does not agree with and why.

Response

DOE welcomed the reviews and suggestions provided by the Peer Review Panel (DIRS 102726-Budnitz et al. 1999). The panel was formed to provide a formal, independent evaluation and critique of Total System Performance Assessment carried out for the Viability Assessment (DIRS 101779-DOE 1998). The objectives of the panel are to describe the technical strengths and weaknesses of the Total System Performance Assessment and to provide suggestions for its improvement.

DOE acknowledges the difficulties associated with assessing the performance of the repository over the long periods involved. Section 5.2.4 of the EIS discusses uncertainty in the assessment process. The Peer Review Panel recognized the complexity of the system and nature of the data that now exist or that could be obtained within a reasonable time and at a reasonable cost. The Panel’s concerns are provided within that context. The Panel also noted that while serious questions remain as to the adequacy and acceptability of some portions of the analysis, parts of the study were well done. In addition, the Panel noted that the overall performance assessment framework and the approach used in developing the assessment were sound and followed accepted methods.

As presented in the Supplement to the Draft EIS and in the Final EIS, DOE modified its performance assessment in several key areas in response to the Peer Review Panel’s critique. Two of the more notable examples are:

1. In the Draft EIS, DOE based cladding failure rates on expert judgment. The Final EIS based cladding failure rates on experimental data.

2. The Panel expressed concern that a hot repository introduced too many uncertainties to model the reasonable long-term performance of the repository, given the current state of knowledge. Major concerns are associated with the ability to model complex coupled processes with the rock in a higher-temperature (above-boiling) state. As a consequence, DOE evaluated a lower-temperature operating mode in the Final EIS. This lower-temperature operating mode would result in lower repository operating temperatures over the long-term life of the repository.

The assessments presented in the Draft EIS were not meant to be definitive predictions of probable repository behavior as used in the Peer Review Report. Work continues to address the higher-priority issues identified in the report and would continue if a decision was made to recommend the site. The purpose of the ongoing work is to ensure that as future decisions need to be made, the basis for the performance calculations will be more and more complete where possible and where important to demonstrate long-term performance.

In its review, the Peer Review Panel does not imply that implementing all their recommendations would result in the ability to calculate probable behavior. The Panel’s position is that the recommendations could result in a determination of “whether it can be shown with reasonable assurance that the repository will comply with the applicable regulatory limits.”

"Reasonable assurance" is the standard applied in the licensing of commercial nuclear facilities. DOE believes it can perform projections of long-term behavior that are consistent with the regulatory goals of providing reasonable expectation of compliance with dose-based standards.

With regard to the request for an accounting of what DOE did not agree with in the Peer Review Report, the Department does not agree with the Panel's position that "it is unlikely that the [Total System Performance Assessment-Viability Assessment], taken as a whole, describes the long-term probable behavior of the proposed repository (DIRS 102726-Budnitz et al. 1999). The DOE responses to the Peer Review Report are in CRWMS M&O (DIRS 153111-1999).

7.3 (209)
Comment - 26 comments summarized
The term "isolation" was interpreted by many commenters to mean "absolute containment forever". Based on this interpretation, the commenters stated that the Proposed Action would not meet the criteria of "isolation." One commenter added that the concept of "disposal" is not possible because this would require the same idea of absolute containment forever.

Response
The goal of geologic disposal is to concentrate and isolate spent nuclear fuel and high-level radioactive waste in a relatively small area for a very long time. DOE intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. It is also likely that eventual release of some material is inevitable because all systems will degrade given sufficient time.

The Environmental Protection Agency standards (40 CFR Part 197) recognize that, with the current state of technology, it is impossible to provide a reasonable expectation that there would be no releases over a 10,000-year or longer time frame. Therefore, the Agency has established public health protection standards that the Agency believes would protect human health and safety. These standards do not require complete isolation of the wastes over the compliance period (that is, 10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment for Yucca Mountain is to evaluate whether the repository would be likely to meet these standards and thus provide protection of human safety and the environment.

7.3 (210)
Comment - 16 comments summarized
Many comments expressed concern about designing a system that would operate for 10,000 years and longer. Commenters cited the short experience of engineering practices compared to these time frames, along with comparisons between recorded history and the necessary period of performance. One commenter expressed concern about the potential for early cask failures due to manufacturing defects.

Response
DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. The EIS provides the Department's best estimate of the impacts that could occur when the containment system inevitably degraded. The EIS confirms that the Proposed Action would be likely to result in release of radioactive contamination to the environment after repository closure. However, the EIS also shows that these releases under the Proposed Action would not exceed environmental protection standards (40 CFR Part 197) within the 10,000-year compliance period for the repository, standards specifically enacted to ensure the safety of future generations.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed consistent with 40 CFR Part 197 to gain insight into the long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than background levels (see Section 5.4.2 for details).

With regard to the potential for manufacturing defects, as part of the waste package performance analysis DOE conducted a comprehensive evaluation of fabrication processes that indicated that, for the current design and with a strong quality assurance program, the Department anticipates a very small number of early failures. The DOE long-term performance model represents the number of early package failures statistically as a probability distribution of between zero and five failures. The results show releases during the first 10,000 years that are more than 100,000 times less than the 40 CFR Part 197 individual protection standard of 15 millirem per year. A strong quality assurance program would ensure proper fabrication, stress relief, and testing of the waste packages before emplacement.

7.3 (220)

<u>Comment</u> - 32 comments summarized

A number of comments reflected worry or fear over the potential for catastrophic repository failure from earth motion and volcanism. Several commenters suggested the containers would be vulnerable to earthquake motion, and especially to a penetrating volcanic dike. Among the concerns were: that damage could consist of ready access to the waste, as well as accelerated waste package failures and releases to the water table and the environment; that earthquake damage calculations in the Draft EIS did not include an uncertainty discussion or impacts on downgradient springs; and whether any of the impact analyses would change with the new design that was forecast in the Draft EIS. Potential impacts were said to be missing from a volcanic intrusion with an eruption, and the potential impacts as far away as White Pine County were requested. The adequacy of the rockfall analysis was questioned.

One commenter questioned the impact of a future generation not being able to predict earthquakes, while another questioned the inability to provide a correct future response in case of a disaster. Two commenters questioned the wisdom of siting a repository where there was even the remotest chance of a severe earthquake or a volcanic event. One of those suggested there was a political consideration in the siting process that overruled what would have been an obviously bad choice to an engineer.

<u>Response</u>

The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probabilities and effects of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

One change in the Final EIS is that now there is an aerial pathway release from an eruptive scenario that is analyzed. The dose rates for this scenario are reported in Section 5.7.2 and are well below the 40 CFR Part 197 individual protection standard of 15 millirem per year.

For probabilistic analyses such as that performed to evaluate potential impacts from igneous disruption events in the EIS, a Monte Carlo method was used whereby a number of realizations using different sets of input parameters are added together to give the total probability-weighted dose. For the Final EIS, 5,000 realizations were completed and the results are provided graphically in the Section 5.7.2. The results are presented as a group of curves that display probability-weighted annual dose rates calculated using different sets of statistically sampled values for uncertain input parameters in the model. The range of results shown by these individual curves displays the uncertainty in the calculated dose history resulting from uncertainty in parameter values.

The dose history for the igneous activity scenario in Figure 5-7 of the Final EIS is presented as a probability-weighted annual dose resulting from events occurring at uncertain times throughout the period of simulation. This approach to calculating and displaying the probability-weighted annual doses is consistent with the approach specified by 40 CFR Part 197 and is required for determination of the overall expected annual dose. However, displays of the probability-weighted annual dose do not allow direct interpretation of the conditional annual dose, which is the annual dose an individual would receive if a volcanic event occurred at a specified time. For conditional analyses, the probability of the event is set equal to one, and the time of the event is specified. Conditional results do not provide a meaningful estimate of the overall risk associated with igneous activity at Yucca Mountain, but they provide insights into the magnitude of possible consequences for specific sets of assumptions. A sensitivity calculation was performed to provide results for this conditional case, and conditional mean annual dose histories were calculated for eruptive events at 100, 500, 1,000, and 5,000 years. The conditional mean dose in the first year after an eruptive event at 100 years after repository closure is approximately 13 rem. The conditional dose in the first year after an eruption decreases to approximately one-half this level for an eruption 500 years after closure, and is approximately 10 percent of this value for an eruption 5,000 years after closure. This calculation was made with a previous TSPA model that has some differences from the model used elsewhere in this EIS for long-term performance. The differences that affect the analysis described above are that dose factors were revised to conform to 40 CFR Part 197 and the distance analyzed is 18 kilometers (11 miles) rather than 20 kilometers (12 miles) from the repository. These changes would be expected to increase the dose values at 100 years and 500 years by a factor of between 2 and 3. The results at the later times would increase by about 20 percent.

As discussed in Section 5.2.3.5 of the Draft EIS, the major effect of an earthquake at Yucca Mountain would be ground motion (shaking) rather than direct offset along a fault. The *Disruptive Events Process Model Report* (DIRS 151968-CRWMS M&O 2000) discusses the effect of offset along a fault. Past movement has been along existing faults, and the probability of new faults forming is low. DOE would not emplace waste packages near existing faults, so the probability of shearing a waste package would be very low.

The rockfall analysis discussed in the *Waste Package Degradation Process Model Report* (DIRS 138396-CRWMS M&O 2000) that supports the Total System Performance Assessment (DIRS 151968-CRWMS M&O 2000) and the Final EIS is much more detailed than that in the Draft EIS. DOE based the analysis of the probability of rocks of various sizes falling and damaging waste packages on the rock properties in the repository. Analyses of this new design (DIRS 114171-CRWMS M&O 1999), which includes a drip shield, show that the waste package could withstand the largest potential rockfall. Adding strong drip shields above the waste packages provides a very robust design that would be able to withstand any credible rockfall. Therefore, the effects of rockfall are not part of the Total System Performance Assessment calculations for the Final EIS.

The analysis for the million-year period extended the screening of seismic damage to waste packages throughout that time. This was an analytical assumption based on using the best data and models available for the Final EIS. No quantitative analysis was performed to determine when a waste package might degrade to the point where it could be damaged by a seismic event. However, it is reasonable to expect that peak dose estimates would likely have been higher (by an unknown amount) if the analysis accounted for potential seismic damage of degraded waste packages hundreds of thousands of years in the future.

Computer technology is being used to assess the impacts on the environment and human population that would result from seismic and volcanic activity, but not to predict the occurrence and magnitude of these natural events. Computer simulation allows the integration of scientific knowledge about earthquakes and volcanism frequencies, and their effects, together with repository design and other data to predict what damage could result from volcanic events. These are the type of results reported in the Final EIS.

Seismic occurrences around Goldfield, Nevada, are similar to those expected for much of the Yucca Mountain setting and earthquakes of the general magnitude and frequency experienced in the Goldfield vicinity are a part of what analysts have termed the “expected case” for Yucca Mountain for purposes of calculating long-term performance assessment for the proposed repository at Yucca Mountain. The 10,000-year results in the Final EIS were obtained using models that were updated with this new information.

DOE has evaluated the long-term geologic stability of Yucca Mountain, including the potential for volcanoes. Volcanic activity has been waning in the recent geologic past; the probability of a volcano that could disturb the repository is very low (see EIS Section 3.1.3.1). Nevertheless, DOE presents an analysis of the effects of both a volcanic eruption, which could release volcanic ash and entrained wastes into the atmosphere, and the intrusion of magma into the emplacement drifts, which could damage waste packages and contaminate the underlying aquifer. DOE estimated potential impacts on the nearest population to the south, conservatively assuming wind in that direction. Impacts in White Pine County would be a small fraction of nearby impacts such as those calculated. Sensitivity studies for the Total System Performance Assessment suggest that the probability-adjusted dose from a volcanic, eruptive event at 20 kilometers (12 miles) in the direction of wind transport of an ash plume peaks at a few hundredth of a millirem per year. Therefore, given that White Pine County is considerably farther from the source, doses would be much lower than the very small doses calculated at 20 kilometers.

DOE's analyses also continue to include water pathways in its analyses of health risks of the proposed repository. The people of Amargosa Valley are most at risk because groundwater in the saturated zone beneath Yucca Mountain flows in a generally southerly direction. They use water acquired primarily from local wells for household purposes, agriculture, dairy and catfish farms, horticulture, and animal husbandry.

With respect to comments regarding potential impacts on Death Valley, the DOE acknowledges in Chapter 3 of the EIS that a small amount of groundwater may move beyond the primary groundwater discharge point at Alkali Flat (Franklin Lake Playa) and continue toward Death Valley through the areas of Tecopa and Shoshone. Some of the groundwater in the Amargosa Desert might move through the southeastern end of the Funeral Mountains toward springs in the Furnace Creek area of Death Valley. However, even if this were the case, any impacts on the Furnace Creek area would be even less than the low impacts shown in Chapter 5 of the EIS for the discharge location (Franklin Lake Playa) because the impacts would decline with distance from the repository.

7.3 (221)
Comment - 5 comments summarized
Commenters were dissatisfied that only nine "dominant" radionuclides (carbon-14, selenium-79, technetium-99, iodine-129, protactinium-231, uranium-234, neptunium-237, and plutonium-239 and -242) were selected for the detailed analysis of repository performance. Commenters requested revisions to provide specific information on why a number of long half-lived radionuclides present in the wastes were excluded from the evaluation. The commenters questioned the method used to account for ingrowth of decay products. One commenter also questioned if classified radionuclides had been included in the analysis.

Response
DOE agrees with the concerns raised in these comments. As a consequence, DOE has reevaluated and enhanced the radionuclide screening analysis and inventory abstraction for the analysis of long-term performance for the Final EIS. It should be noted that information provided in the Final EIS is summary in nature because of space limitations. However, the reference documents cited in Final EIS Chapter 5 and Appendix I provide the detailed information necessary to trace important information and to independently verify the results.

The radionuclide screening analyses now encompass the nominal release scenario, disruptive event and human intrusion scenarios, and time periods of 100 to 10,000 years and 1 million years after repository closure. The radionuclide inventory abstraction includes commercial, defense, and naval spent nuclear fuel; defense high-level radioactive waste; and DOE plutonium waste (DIRS 152218-CRWMS M&O 2000). The screening procedure considered factors such as relative contribution to annual dose, radionuclide longevity (that is, decay and production), elemental solubility, transport affinity, release scenario, and containment time (for example, 10,000 years and 1 million years). This screening procedure produced an initial list of radionuclides that was then augmented to account for ingrowth of the actinide decay chains (DIRS 153246-CRWMS M&O 2000). The combined list of radionuclides for the three waste allocation categories was screened to identify the specific ones that could make significant contributions to the calculation of expected annual dose. The results of the radionuclide screening identified the following important radionuclides for various scenarios and time periods:

- Nominal Scenario (and Indirect Release for Volcanism Scenario), 10,000 Years–actinium-227; americium-241 and -243; carbon-14, iodine-129; neptunium-237; protactinium-231; lead-210; plutonium-238, -239, and -240; radium-228; technetium-99; thorium-229 and -232; and uranium-232, -233, -234, -235, -236, and -238.

- Nominal Scenario (and Indirect Release for Volcanism Scenario), 1,000,000 Years–The nominal scenario set for 10,000 years, plutonium-242, radium-226, and thorium-230, less americium-241, carbon-14, plutonium-238, and uranium-232.

- Volcanism Scenario with Direct Release, 10,000 Years–actinium-227; americium-241 and -243; cesium-137, protactinium-231; lead-210; plutonium-238, -239, and -240; radium-232; strontium-90; thorium-229, and uranium-232, -233, -234, and -235.

- Volcanism Scenario with Direct Release, 1 Million Years–Volcanism scenario with direct release for 10,000 years, plus neptunium-237, plutonium-242, radium-226, thorium-230, uranium-236 and -238, less americium-241, carbon-14, plutonium-238, strontium-90, and uranium-232.

- Human Intrusion Scenario, 1 Million Years–Same as nominal scenario for 1 million years.

DOE agrees that the discussion in Section 5.1 of the Draft EIS related to allowance for ingrowth is somewhat confusing. However, the updated analysis in the Final EIS does not require the predecay of relatively short-lived radionuclides because the analysis includes a transport model for chains of radionuclides (that is, parents and their decay products). This enhanced model therefore accounts for release estimates of short-lived radionuclides in the event of early waste package failure from possible disruptive events such as inadvertent human intrusion.

With regard to the human intrusion scenario, for periods of 1 million years, uranium-235 was added to the list because it is a source for actinium-227, which was considered potentially important to dose. In addition, certain radionuclides were added because of their relevance to the groundwater protection standard (40 CFR Part 197). This standard specifies concentration limits for radium-226 and radium-228. As a consequence, radium-228 and its precursor, thorium-232, were added to the list for the case of the nominal scenario. These adjustments expanded the list to a total of 26 radionuclides.

With regard to classified radionuclides/materials in Yucca Mountain, Appendix A provides an inventory of all candidate materials and radionuclides for disposal in the repository. All waste accepted for disposal would be required to meet the repository waste acceptance criteria as well as the packaging requirements regardless of the classification of the materials. These waste form, radionuclide quantity, and packaging requirements were developed to enhance the long-term performance of the repository.

7.3 (222)
Comment - 15 comments summarized
Commenters stated that DOE is designing the repository to leak, and charged that the Department is relying on the natural environment to dilute the contamination. Commenters took the position that DOE could not stop the repository from leaking, citing past failures and leaks at DOE and commercial facilities. Some commenters were concerned that DOE is underestimating the rate at which leaks would occur.

Response
The repository performance assessment does not begin with the assumption the repository will leak. Rather, the assessment assigns probability-of-occurrence values (referred to as probability distributions) to various parameter and process features that include consideration of the uncertainty associated with that parameter or process. When multiple simulations of repository performance (realizations) are computed, the results indicate which of the various outcomes are more likely to occur (mean values). However, in addition to the most likely outcome, the distributions also show extreme cases referred to as the 5th- and 95th-percentile values, which provide a measure of the uncertainty associated with a particular outcome. In response to the observation that the analysis appears to assume, *a priori*, that the repository will leak, it should be noted that, although not likely, there were a number of realizations (outcomes of computer models) that produced no leakage for extremely long times. In the new analyses for the Final EIS, the releases in the first 10,000 years would be extremely small [more than 100,000 times less than the standard set by the Environmental Protection Agency (EPA)] and would be due to the very unlikely event of between zero and five packages failing due to manufacturing defects.

The goal of geologic disposal is to concentrate and isolate high-level radioactive wastes in a relatively small area for a very long time. The Department intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. In other words, the eventual release of some material is inevitable because all systems will degrade given sufficient time.

Given the current state of technology, it is virtually impossible to design and construct a geologic repository that would provide a reasonable expectation that there would never be any releases of radioactive materials. DOE would design, construct, operate and monitor, and eventually close a repository that would meet public health and safety radiation protection standards and criteria established by the EPA and the Nuclear Regulatory Commission (NRC). Congress, in the Energy Policy Act of 1992, directed the EPA to develop public health and safety standards for the protection of the public from releases of radioactive materials stored or disposed of in a repository at the Yucca Mountain site. Congress also directed the NRC to publish criteria for licensing the repository that would be consistent with the radiation protection standards established by the EPA. EPA standards (40 CFR Part 197) and NRC criteria (10 CFR Part 63) prescribe radiation exposure limits that the repository, based on a performance assessment, must be designed not to exceed during a 10,000-year period after closure.

In the EIS, DOE has evaluated the ability of the natural and engineered barrier system to isolate radioactive materials from the environment for thousands of years. As a result of this evaluation, DOE would not expect the repository to exceed the prescribed radiation exposure limits during the 10,000-year period after closure. Further, DOE estimates that the average peak dose to a hypothetical individual from the repository would be less than the dose received from natural background radiation.

In terms of contamination at other DOE sites, the Yucca Mountain Repository would be different from other facilities in several important aspects. The system under consideration would allow relatively little water to contact the barriers to waste migration and the materials selected for those barriers would be highly immune to degradation in the anticipated subsurface environment.

DOE believes that it has incorporated much knowledge and data from incidents at other DOE sites into the Yucca Mountain design and performance assessment. To ensure safety, DOE has used conservative (that is, pessimistic) calculations of the potential impacts of this system to estimate the risks of the repository. There has been no effort to minimize these risks.

In addition, in the last 5 years there has been considerable study by DOE, with coordination across locales and programs, of the poorly predicted or unpredicted radionuclide transport phenomena alluded to at other Department facilities. As a result, DOE now has a better understanding of transport processes and has improved its modeling ability. For example, DOE better understands the potential transport of actinides by colloid-sized mineral particles, and has incorporated conservative estimates of such actinide transport mechanisms into the modeling of the proposed Yucca Mountain Repository reported in this EIS (see Chapter 5).

7.3 (232)
Comment - 7 comments summarized
Several comments suggested that climate change should be incorporated into the long-term performance analysis. Several others acknowledged that climate change had been addressed, but not in sufficient detail to allow impacts from climate change to be properly evaluated. Commenters suggested, for example, that the increased flux in the unsaturated zone had not been properly incorporated; another suggested that extreme precipitation events had not been properly evaluated.

Response
The Draft EIS included an evaluation of climate change and its effects on long-term performance. These effects included increased infiltration, increased flux at depth, increased radioactive material transport at depth after waste package failure, and a shortened path to the water table because of changes in water table elevation.

The Draft EIS performance assessment considered three climate scenarios: present day, long-term average (wetter than the present-day climate), and superpluvial (Draft EIS Section I.4.2.4). These climate scenarios were assumed to occur at short-duration, fixed intervals on a periodic basis during the 1,000,000-year period after waste emplacement. However, the modeling of climate states was changed for the Final EIS based on the latest research of the U.S. Geological Survey and the Desert Research Institute. As a consequence of this work, pluvial states were expanded to allow short-duration states within them resembling the previously modeled superpluvial states. Superpluvial states are no longer included as separate states based on the results of this continued research.

Models of future climates caused by global warming from increased atmospheric carbon dioxide are speculative, though they are supported by some global climate modeling and the general increase in global temperature noted in the 20th Century. At Yucca Mountain the estimated effect of global warming would increase average precipitation to a level similar to the long-term average climate of the Draft EIS, which resembles the glacial-transition climate in the Final EIS. This estimate, which is based on atmospheric model input, resembles near-continuous El Niño conditions and the near doubling of the precipitation that accompanies these conditions. In other words, DOE considers global warming impacts on future climates to be within the bounds of predicted climate ranges used in the assessment of long-term performance. Chapter 5 of the Final EIS incorporates such climate impacts in the estimates of the environmental consequences of long-term repository performance. These impacts include the effects of global warming and future climate change in general.

Extreme precipitation events were mentioned in Section 3.1.2.2, but do not greatly influence the infiltration rates discussed and used for modeling purposes in Chapter 5 and Appendix I. This is because the subsurface tends to "damp" the extreme events (particularly in the Paintbrush nonwelded stratigraphic unit) to produce a nearly uniform infiltration rate with time at depth. If anything, extreme precipitation events are more closely associated with surface runoff events. Locality-based infiltration rates were used (not whole-mountain averages) to derive infiltration rates for repository zones modeled in the performance analysis. The approach to discretizing the repository (dividing it into discrete zones) for performance analysis calculations, and the areal infiltration rate applicable to each modeled zone, has been updated for the calculation results reported in the Final EIS (Section 5.4).

7.3 (238)

Comment - 2 comments summarized

Commenters stated, "The analysis is very detailed discussing the latent cancer fatalities with respect to a chosen scenario. For the undisturbed case DOE states '...that it is mostly likely that no person would die due to groundwater contamination by radiological material in the 10,000 year period....'" Commenters requested "the worst case scenario using a pregnant woman and young children to establish the dose rate, and don't use the new dose rate that you guys are trying to put into the record. Use the EPA rate."

Response

The EIS does not present a worst-case scenario for dose-to-receptor analysis and calculations because no matter what worst-case choice was presented, it would be always possible for someone to develop a worse scenario. This is consistent with the Council on Environmental Quality regulations that implement the National Environmental Policy Act. These regulations do not require a worst-case analysis. In addition, problems related to worst-case analyses were recognized as a potential issue by the Environmental Protection Agency (EPA), which settled the issue by prescribing a biosphere modeling approach and identifying the potential dose recipients to be evaluated in the analyses as part of the Yucca Mountain environmental protection standards (40 CFR Part 197).

With regard to estimating dose to special groups within the general population (for example, children, pregnant women, and the fetus), the Department recognizes that metabolic weighting factors (such as those described in ICRP (DIRS 101836-1991) are constantly under study and refinement. This research will continue. For this reason, DOE has decided to use the methodology specified by the regulatory standards for the Yucca Mountain Repository promulgated by the EPA (40 CFR Part 197) and the Nuclear Regulatory Commission (10 CFR Part 63). This method of dosimetry is fully described in ICRP (DIRS 101075-1977) and the dose conversion factors derived from this methodology and used in the EIS are provided in Federal Guidance Reports 11 and 12 (DIRS 101069-Eckerman, Wolbarst and Richardson 1988 and DIRS 107684-Eckerman and Ryman 1993, respectively). In addition, the EIS has incorporated the reasonably maximally exposed individual concept described in the preamble to 40 CFR Part 197 to project potential doses for long periods.

DOE will continue to monitor the future developments in the field of dosimetry and will refine its dose factors as necessary to ensure capture of generally accepted scientific principles, recommendations by national and international scientific advisory groups and, where appropriate, regulatory requirements.

With regard to use of the recently published EPA age-specific risk factor of 5.75 chances in 10 million per millirem for fatal cancer (DIRS 153733-EPA 2000), DOE currently uses the value of 5.0 and 4.0 chances in 10 million per millirem for fatal cancer for members of the public and workers, respectively, as recommended by the International Commission on Radiological Protection (DIRS 101836-ICRP 1991). When recommending these risk factors, the International Commission on Radiological Protection also expressed the desirability, for purposes of radiation protection, to use the same nominal risk factors for both men and women and for a representative population with wide ranges in age. The Commission stated that although there are differences between the sexes and populations of different age-specific mortality rates, these differences are not so large as to necessitate the use of different nominal risk factors. However, the higher risk factor for members of the public compared to that recommended for workers accounts for the fact that children comprise a relatively large part of the population and are more sensitive to the effects of radiation (cancer induction) than adults. Although the embryo-fetus is more radiosensitive (with a radiation risk factor about two times that for the whole population) it is protected by the body of the mother and comprises a small part of the overall population. Pregnant women are not particularly radiosensitive, especially to low levels of radiation.

Both the EPA and DOE recognize that there are large uncertainties associated with these risk factors, as expressed by the National Council on Radiation Protection and Measurements comment on the result of their uncertainty analysis in the risk coefficients that "... show a range (90 percent confidence intervals) of uncertainty values for the lifetime risk for both a population of all ages and an adult worker population from about a factor of 2.5 to 3 below and above the 50th percentile value" (DIRS 101884-NCRP 1997). DOE believes that the 15-percent difference in these risk factors is well within other uncertainties and would provide little additional information to the decisionmaking process that this document informs. In the Final EIS, DOE used risk factors recommended by the International Commission on Radiological Protection.

7.3 (239)

Comment - 13 comments summarized

Several commenters expressed concern that there was undue reliance on the integrity of the waste form to contain radioactive materials. Comments focused on the issue of whether the cladding on spent nuclear fuel would provide any containment and whether any credit should be taken for cladding containment in the long-term performance assessment. Commenters expressed concern that the high-level radioactive waste glass form would not maintain integrity over long periods and skepticism that the current models being used for neptunium solubility were appropriate for assessment of release of neptunium-237 from the waste forms. Commenters expressed concern about degradation of storage casks and waste forms while they are in dry storage.

Response

DOE has conducted considerable research on the various waste form materials. This information has been used to develop models of how these materials would perform over long periods in the repository environment. For example, models of commercial spent nuclear fuel dissolution are based on experimental tests where actual reactor fuel has been used. The models for borosilicate glass and the plutonium ceramic are also based on extensive testing. Dissolution and degradation models for borosilicate glass have been under development for over 25 years, and there has been extensive testing of plutonium ceramic degradation for several years to support the Yucca Mountain Project. While all these waste forms eventually degrade and dissolve, the process is extremely slow, being characteristic of reactions of water on glass and ceramic materials where time scales are in the hundreds of thousands of years (DIRS 153246-CRWMS M&O 2000, Section 3.5.3).

The dissolution models used in the Total System Performance Assessment are described in the Final EIS. Details about these models are contained in supporting documents referenced in Section I.2.5.

Since the publication of the Draft EIS, research has continued on solubility of neptunium, with considerable focus on formation of secondary phases. Recent data, incorporated in the analysis presented in Chapter 5 of the Final EIS, show that the lower solubility results in considerably lower peak doses than found in the analysis in the Draft EIS.

The updated zirconium alloy cladding failure models used for the Final EIS analyses include representations of cladding behavior that are extremely conservative, which resulted in highly conservative values of failure rates (DIRS 153246-CRWMS M&O 2000, Section 3.5.4). In addition, no barrier credit was taken for either stainless-steel packaging or cladding, or cladding on DOE spent nuclear fuel.

The cladding degradation model used for the Final EIS is much more rigorous than that for the Draft EIS. The model is based on empirical data and includes localized corrosion and unzipping effects. This model results in greatly reduced reliance on cladding than was the case for the Draft EIS (see Section I.2.5). The Final EIS analysis also includes seismic effects on the cladding, so the occurrence of seismic activity was modeled as damaging the cladding within the waste packages. Nevertheless, the peak doses in the Final EIS would be lower than those in the Draft EIS.

7.3 (252)
Comment - 7 comments summarized
Some commenters expressed concern that microbes could conceivably contribute significantly to degradation of materials, especially in waste packages or drip shields.

Response
Microbes would not directly attack the materials; rather they would be responsible for biofilms (layers of dead organisms and waste products) that would alter the chemistry on the surface of the material. The modeling of corrosion of the Alloy-22 includes enhancement factors for microbial-induced corrosion. Very conservative values are used to account for this possibility, even though research to date has not identified significant effects of biofilms on the material. The research indicates no tendency for the titanium drip shields to be affected in any way by such films, so no enhancement factors were used (DIRS 153246-CRWMS M&O 2000). This is also discussed in Section I.2.4 of the EIS and referenced supporting documents.

7.3 (253)
Comment - 7 comments summarized
Commenters expressed concern that deficiencies found in the DOE quality assurance program and the large number of errors identified by the Nuclear Regulatory Commission cast significant doubt on the validity of the TSPA-SR long-term performance estimates. Several commenters suggested that the deficiencies were so great that the Supplement to the Draft EIS and the Science and Engineering Report should be withdrawn and resubmitted pending resolution of all the quality assurance findings and the calculational errors.

Response
DOE has an ongoing program to address Nuclear Regulatory Commission (NRC) comments on technical issues, largely as they have been translated into its comprehensive listing of scientific modeling issues in the Commission's Issue Resolution Status Reports (see, for example, DIRS 135160-Bell 1996; DIRS 154605-NRC 2000). Not all technical issues raised by the NRC are closed, but DOE has made and will continue to make a good faith effort to address each issue to the extent practicable. As reported in the Final EIS, DOE has made a number of modifications to the design of the repository and to the Total System Performance Assessment that address NRC concerns. As of September 1, 2001, the Key Technical Issues had all been declared "Closed-Pending" by the NRC.

DOE has made a similar best effort to address the status of model validation and quality assurance findings. The Department recognizes that it needs to apply a rigorous and effective quality assurance program, and that doing so will be crucial to demonstrating the validity of findings and analyses in any License Application. In response to previous NRC comments in this area, the Department has established a schedule for achieving quality assurance goals by the time of the License Application, if Yucca Mountain is found suitable and approved for development of a repository. DOE has met interim quality assurance goals for the Site Recommendation phase.

DOE has taken action to correct the deficiencies and ensure that similar deficiencies do not recur. On September 6, 2001, DOE provided transition plans for the respective quality assurance programs that would support becoming a licensee. Implementation of these transition plans is periodically reviewed by the NRC.

DOE has also evaluated the effects of the identified deficiencies on the performance analysis performed and determined that they did not affect long term performance estimates.

7.3 (256)
Comment - 9 comments summarized
Commenters expressed concern that the human intrusion scenario was inadequate, unrealistic, or too constrained and that additional effects such as atmospheric release and direct exposure of the drilling crew should have been considered. Commenters were not satisfied with only one occurrence or with the assumed timing of the occurrence and also suggested the scenario evaluated in the EIS was inadequate because it relied on the integrity of waste packages and the continuing use of current drilling technology. Commenters stated that the risk would increase over time, because peak doses increase over time. Commenters also expressed concern with the possibility of sabotage or terrorism over the next 10,000 years. Commenters suggested that the human intrusion scenario should factor in the potential presence of mineral deposits and other natural resources as well as the potential for people to explore for

these resources in the future. Commenters expressed concern related to the statement by the State of Nevada that "drilling could occur not long after closure of the repository."

Response
The estimation of impacts from human intrusion into the repository is an analytical issue because the future behavior of humans cannot be accurately predicted. The Nuclear Regulatory Commission and Environmental Protection Agency have provided guidance to analyze human intrusion in their regulations for Yucca Mountain. The regulations describe a stylized calculation that attempts to minimize speculation as to why humans would intrude into the repository.

In formulating the regulatory approach to the human intrusion scenario, the Environmental Protection Agency and Nuclear Regulatory Commission paid attention to the advice given by *Technical Bases for Yucca Mountain Standards* (DIRS 100018-National Research Council 1995). That report suggests there are three types of intrusions: inadvertent and the intruder does not recognize that a hazard has been created, inadvertent and the driller recognizes the hazard and takes corrective action, and intentional (DIRS 100018-National Research Council 1995). The last category would include terrorists or saboteurs, but it could also include a society needing to access the material for its energy content. The members of the National Research Council committee decided to recommend that only the first category be addressed, because the second category, if corrective measures are ineffective, would have the same consequences as the first. The third category was an imponderable given the unpredictability of future human society. There is no way to absolutely ensure that if a future society wished to re-enter a repository, it would not be able to do so.

The members of the committee then assessed the types of consequences from the first category of intrusion. There would be drill cuttings brought to the surface, and these would present a hazard to the drillers and subsequent visitors to the site. It was suggested these types of consequences not be considered because they are the consequences of an intrusion that would apply no matter where the repository was located and, therefore, would not provide useful information about the safety of any particular location. The consequence recommended for evaluation was the dose to the same critical population group addressed in the long-term performance of the undisturbed repository. Therefore, the important thing is how the intrusion event affects safety by potentially degrading the engineered and natural barriers in a given location.

With regard to evaluating multiple intrusion events, the National Research Council (DIRS 100018-1995) concluded that one borehole was a good test of system resiliency, and going further was so speculative that it served no purpose useful in judging the robustness of a system. The Council also recommended the assumption of the use of current drilling technology to avoid speculation over future advances in drilling technology. The emphasis was recommended to be on the analysis of the creation of enhanced environmental transport pathways.

These conclusions and recommendations have been endorsed by the Environmental Protection Agency (40 CFR 197.26). DOE recognizes the efforts made by the National Research Council and agrees with the conclusions to which they came. The Department also recognizes that there are other viewpoints and opinions of merit, but agrees with the National Research Council and the Environmental Protection Agency that the amount of speculation required to implement other approaches to defining human intrusion consequences would make the results of such analyses arguably meaningless.

For the Draft EIS, the intrusion event was assumed to occur 10,000 years after closure of the repository. This time was chosen because it is the earliest time that waste packages (under the Draft EIS design) would have probably degraded to the extent necessary to allow penetration without the use of specialized drill bits. However, for the analysis presented in the Final EIS, DOE chose intrusion at 30,000 years to simulate an intrusion at a time when the intruder might not detect the waste package because of its weakened state. Over time, as more waste packages failed (and potential doses rose toward a peak dose from the overall system), intrusion would become less, not more, meaningful. This is because the more waste packages have failed, the less the additional waste package failure from drilling would contribute to the overall risk.

Section 5.7.1 of the Final EIS discusses the human intrusion scenario analysis and results.

As discussed in Section 3.1.3.4 of the EIS, site characterization activities have found no economic deposits of base or precious metals, industrial rocks or minerals, or energy resources based on present use, extraction technology, and economic value. The operating gold and silver mines visible from the mountain are in a different type of rock than Yucca Mountain. Those rocks formed deep in the Earth, and uplift has exposed them. Yucca Mountain was formed by ash flow and ash fall from volcanic events. Thus, DOE believes that the potential for intrusion resulting from resource recovery would be minimal.

7.3 (491)
Comment - EIS000120 / 0005
The fact that any groundwater at all comes in contact with these containers to me is not acceptable.

Response
One of the key attributes of the Yucca Mountain repository safety strategy is minimizing the amount of water that contacts the waste packages. However, this does not imply precluding such contact. The waste packages would be fabricated with a highly corrosion-resistant barrier that would result in very long waste package lifetimes even in the presence of water. In addition, DOE has modified the repository design to include a titanium drip shield with the purpose of diverting any seeping water away from the waste packages. Analyses conducted in support of the Site Recommendation process and the Final EIS include these drip shields. Such analyses also assess the effects of any water contacting the wastes in the evaluation of risk to the public and the demonstration of safety in accordance with regulatory requirements. The Final EIS documents the revised repository design and the long-term performance assessment analyses based on this design.

7.3 (600)
Comment - EIS000127 / 0017
When they do their comparisons here, they got a nice little pretty map here comparing the two no action scenarios, the one that assumes that for the 10,000 years, we're going to keep rebuilding this thing every hundred years, as least, effective institutional control for 10,000 years, and the another one that assumes that we'll lose that control in about a hundred years.

What they don't talk about is as soon as they put those things in the mountain and close the hole, they've lost institutional control. They have no way to deal with it if it's leaking, and yet that's not considered in the Environmental Impact Statement.

Response
The scientific community has long recognized that absolute confinement forever is not practical in any system. What is practical is to work to standards that can be agreed upon as providing sufficient protection of human health and the environment. The Environmental Protection Agency has set such standards (40 CFR Part 197), and the Nuclear Regulatory Commission is guiding the planning and development of the proposed repository (10 CFR Part 63).

DOE's plan for the repository includes the ability to retrieve the waste for 50 to 300 years after the start of emplacement. Part of the reason for this feature is to ensure the public health and safety and the protection of the environment should the proposed repository not perform as expected. Throughout the licensing, construction, operation, and maintenance of the repository, DOE would conduct performance confirmation activities to evaluate the adequacy of the information used to demonstrate compliance that the repository would meet long-term performance objectives. If the data determined that actual conditions differed from those predicted, the NRC would be notified and remedial measures would be undertaken to address any such condition. Nuclear Regulatory Commission regulations [10 CFR 63.51 (a)(1) and (2)] require a license amendment for permanent closure of the repository. This amendment must specifically provide an update of the assessment for the repository's performance for the period after permanent closure, which would include institutional control.

After closure, DOE would have the responsibility of maintaining institutional control over the repository, as required by the Energy Policy Act of 1992. The methods, extent, and length of this regulatory requirement are not well defined at present. However, DOE would maintain appropriate institutional control for as long as required. DOE and NRC would define the details of this program during the processing of the license amendment for permanent closure. Deferring a description of this program until closure would allow for the identification of appropriate technology, including technology that might become available in the future.

7.3 (951)
Comment - EIS000259 / 0003
On a related topic, we are concerned that all the design alternatives considered in the EIS lead, ultimately, to a repository that leaks. DOE must have as its goal complete and permanent isolation of radioactive material from humans. In our estimation, the only way to meet this goal is to have a permanently open and thoroughly monitored facility.

Backfilling and closing the repository complicates close monitoring of the waste packages for structural integrity and increases the difficulty and cost of retrieving the waste should a radioactive release occur or new findings and technologies emerge which provide for safer forms of storage or reuse of the nuclear material.

With a closed repository, groundwater contamination will not be noticed until radioactive material shows up in monitoring wells, by which time a contaminant plume is probably already well developed and beyond mitigation.

Leaving the repository open and ventilated also has the potential to drive out heat and moisture which would otherwise build up in the facility, possibly slowing or eliminating movement of water through the facility into the groundwater. The EIS should include, as a mitigation measure, a commitment to leave the repository open and ventilated indefinitely, with the decision to close the facility left up to future generations.

In closing, we believe that the project should incorporate a zero-tolerance approach to radioactive releases from the repository. The project and the EIS should not anticipate a closure date for the repository, and, in order to mitigate the many uncertainties associated with repository performance, to allow flexibility in future decision-making, and to safeguard the residents and users of Amargosa Valley and Death Valley, the facility should be kept open and monitored on an indefinite basis.

Response
The goal of geologic disposal is to concentrate and isolate high-level radioactive wastes in a relatively small area for a very long time. DOE intends to achieve isolation by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. It is also likely that eventual release of some material is inevitable because all systems will degrade given sufficient time.

The Environmental Protection Agency, in promulgating the Yucca Mountain environmental protection standards (40 CFR Part 197), recognized that with the current state of technology it is impossible to provide a reasonable expectation that there would be no releases over 10,000 years or longer. Therefore, the Agency established standards that it believes provide comparable protections to those of other activities related to radioactive and nonradioactive wastes. These standards do not require complete isolation of the wastes over the compliance period (10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment such as the *Total System Performance Assessment for the Site Recommendation* (DIRS 153246-CRWMS M&O 2000) performed for Yucca Mountain, is to evaluate whether the repository is likely to meet these standards.

A postclosure monitoring program is required by 10 CFR Part 63. This program would include the monitoring activities around the repository after the facility was closed and sealed. At 10 CFR 63.51(a)(1) and (2), the rule requires that a license amendment be submitted for permanent closure of the repository. This amendment must specifically provide an update of the assessment for the repository's performance for the period after permanent closure, as well as a description of the program for postclosure monitoring. This program would include continued oversight to prevent any activity at the site that would pose an unreasonable risk of breaching the geologic repository's engineered or geologic barriers; or increasing the exposure of individual members of the public to radiation beyond allowable limits. The details of this program would be defined during the processing of the license amendment for permanent closure. Deferring a description of this program until the closure period allows for the identification of appropriate technology including technology that might become available in the future.

Section 122 of the NWPA requires retrievability at a repository. Federal regulations (10 CFR Part 60 and 10 CFR Part 63) require that the repository be designed to preserve the option of waste retrieval on a reasonable schedule for as long as 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the proposed Yucca Mountain Repository provides for a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving the waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly more than 300 years in the event of a decision to retrieve the waste either to protect the public health and safety or the environment or to recover resources from spent nuclear fuel. During this period, the repository would remain accessible for scientists to continue testing and monitoring while providing more flexibility for future generations of scientists and engineers to continue evaluating repository performance and the methods of repository closure.

DOE recognized in the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review of the repository by the Nuclear Regulatory Commission. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS.

The Supplement to the Draft EIS and the Final EIS evaluate the environmental impacts of the higher-temperature repository operating mode, which is the design focus of Section 2.1.5 of the Science and Engineering Report (DIRS 153849-DOE 2001). In addition, the Supplement to the Draft EIS and the Final EIS evaluate the impacts for the lower-temperature repository operating mode (which embraces a range of operational parameters including 300 years of extended ventilation). The differences between these modes deal with the highest postclosure temperatures of the waste package surfaces, the temperature of the emplacement drift rock walls, and the overall temperature of the repository rock. Section 2.3 of the Supplement and Section 2.1.2.2.4 of the EIS describes the design modifications including the addition of drip shields and refined waste packages. DOE is not currently considering backfill in the emplacement drifts as part of the repository design.

7.3 (1153)
Comment - EIS001912 / 0108
Section 9.2, Groundwater -- this section has nothing to do with mitigation. None of the discussion has to do with mitigation. Some level of contingency plans should be included in this section. Appropriate mitigation should also include long-term monitoring procedures for areas aquifers. A discussion of possible adverse impacts and human health impacts should be included in the EIS.

Response
Chapter 5 of the EIS contains a full discussion of the potential for adverse long-term groundwater impacts; Section 4.1.3.3 addresses the potential for adverse impacts to groundwater anticipated from repository construction and operation. These discussions also address potential human health impacts.

DOE is considering a range of additional mitigation measures aimed at reducing the effects of the proposed repository project. These measures would complement the physical features, procedures, and safeguards already incorporated into the project plan and design to reduce environmental consequences. Chapter 9 of the EIS, which provides the Department's initial list of commitments, identifies DOE-determined impact reduction features, procedures and safeguards, and mitigation measures under consideration for inclusion in the project plan and design. Chapter 9 also identifies ongoing studies that could influence mitigation measures related to the project plan and design. For example, Section 9.2 discusses mitigation measures DOE would implement or consider to reduce potential impacts from the construction, operation and monitoring, and eventual closure of the proposed repository. Section 9.2.3.2 enumerates mitigating actions related to groundwater. Similarly, Section 9.3 discusses mitigation measures to reduce potential impacts from the national transportation of spent nuclear fuel and high-level radioactive waste.

The Proposed Action includes a lengthy program of performance monitoring and testing. Testing and performance confirmation would continue for perhaps as long as 300 years after the end of emplacement, through closure of the repository (see Section 2.1.2.3 of the EIS). It would provide data to future decisionmakers on the performance of the repository and on closing the repository or retrieving the wastes. The details of the postclosure monitoring program would be defined during the processing of the license amendment for permanent closure, but the types of monitoring that DOE would consider are discussed in Section 2.1.2.3. Deferring a description of this program until the closure period would enable the identification of appropriate technology, including technology that could become available in the future.

7.3 (1341)

Comment - EIS000424 / 0001

My first concern is about the drinking water of the surrounding communities whose water comes from Yucca Mountain. These people do not just live in Nevada, but California as well. If the nuclear waste leaked into the water system then the cancer rate would rise by dramatic levels.

If the cancer levels rose and people died due to the cancer which was caused by a project by the US government you could be looking at many large lawsuits in the future. You would be responsible for the mutation of genes in these communities and will have to put more money for more research on cancer.

Response

Prior to recommendation of the Yucca Mountain site for development of a geologic repository, DOE will have to provide reasonable expectation that the repository can meet environmental protections standards (40 CFR Part 197) developed by the Environmental Protection Agency to protect human health and the environment. The estimated dose from long-term repository performance (see Section 5.4) represents a small fraction of the environmental protection standards. Therefore, the Department believes that the occurrence of adverse health effects would be highly unlikely for all potentially exposed populations, including those in Death Valley.

7.3 (1404)

Comment - EIS000434 / 0003

I would like to know how Yucca Mountain would be evaluated and determined as a safe place to store the nuclear waste. In case of a leak in the canisters, the gases could leak, through a possible crack in the mountain.

Response

Section 5.5 of the Draft EIS evaluated the potential for release of radioactive gases (carbon-14) from the repository. The potential impacts to the surrounding population would be a very small fraction of the applicable environmental protection standards (40 CFR Part 197). Thus, DOE believes that the occurrence of adverse health effects from these releases would be highly unlikely.

The Final EIS considers (see Section I.7.3) the gas radon-222 that is formed as part of the radionuclide decay chain resulting from emplacing uranium-234 in the repository. This gas is expected to decay before reaching the ground surface because it has a half-life of about 3.8 days.

7.3 (1436)

Comment - EIS001888 / 0088

In Section 5.6, the DEIS presented consequences from chemically toxic materials. One of the elements considered in this analysis is chromium. The amount of chromium considered has been grossly underestimated since the design that the DOE is currently contemplating as the license application design uses stainless steel, instead of carbon steel as one of the barriers. In view of this, we feel DOE must consider whether RCRA [Resource Conservation and Recovery Act] regulations apply to the repository. If DOE feels that such regulations do not apply, they must provide rationale to support this position.

Response

The quantities of chromium reported in the Final EIS are accurate for the updated design. Revised evaluations for chromium have been conducted. These evaluations indicate that impacts would be lower than the Maximum Contaminant Level Goal for chromium.

Because the analysis shows extremely low levels of chromium in wells, the Resource Conservation and Recovery Act of 1976 would not apply. Furthermore, while chromium+6 is regulated as a waste under the Act, it would not be a chromium+6 solution or salt that would be placed in the repository, but rather chromium as a part of an alloy used in waste package construction. The corrosion of the chromium would lead to some soluble form, which has been very conservatively assumed to be chromium+6 (evidence indicates it would probably be chromium+3, a nontoxic, low-solubility form of chromium that is a nutrient).

7.3 (1481)

Comment - EIS001521 / 0019

Page 3-12, 3.1.2.2 Climate, first paragraph--Have these extreme precipitation events been used in determining Yucca Mountain infiltration (recharge) rates as discussed later in this chapter? Applying a range of locality-based infiltration rates would be much more realistic than using a whole-mountain average.

Response

Extreme precipitation events were mentioned in Section 3.1.2.2, but do not greatly influence the infiltration rates discussed and used for modeling purposes in Chapter 5 and Appendix I. This is because the subsurface tends to “damp” the extreme events (particularly in the Paintbrush nonwelded stratigraphic unit) to produce a nearly uniform infiltration rate with time at depth. If anything, extreme precipitation events are more closely associated with surface runoff events. Locality-based infiltration rates were used (not whole-mountain averages) to derive infiltration rates for repository zones modeled in the performance analysis. The approach to discretizing (dividing the repository into discrete zones) the repository for performance analysis calculations, and the areal infiltration rate applicable to each modeled zone, has been updated for the calculation results reported in the Final EIS (Section 5.4).

7.3 (1811)

Comment - EIS000332 / 0010

Key aspects of the risk assessments presented in the DEIS are based on estimated values rather than actual data. The NWTRB’s [Nuclear Waste Technical Review Board] experts have severely criticized the results of the models that are used as the basis for the DOE’s risk assessments. Additionally, results of the models indicate chemical toxicity may pose greater risk to Nye County residents than releases of radiation from the repository. Only now are data being collected and tests being planned to provide the information needed to do meaningful risk assessments. Coupled with inappropriate assumptions and inaccurate data, these assessments result in artificially low risk values for Nye County residents.

The evaluation of impacts associated with the performance confirmation program, as described in the EIS, does not contemplate the remedy(ies) that DOE would implement should conditions occur that suggest that repository performance could fall below those predicted. Nor does the EIS provide an analysis of the impacts that would occur should the repository not perform as predicted or planned.

Response

The EIS shows some likelihood of chemical contamination but, similar to radiological contamination, DOE must establish a reasonable expectation that the levels of contaminants where persons would be likely to use the groundwater would meet health and safety targets set by the Environmental Protection Agency.

The Nuclear Waste Technical Review Board and other reviewers have been critical of the work done for and prior to the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998). In the 2 years since DOE published the Viability Assessment, many of the criticisms received have led to activities that have improved the modeling and its bases.

In relation to underestimating potential risk to Nye County residents, DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. However, confidence in the disposal techniques is based on a defense-in-depth that, for example, would place drip shields over waste packages to account for uncertainties. DOE has adopted an analysis approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment

2. Consideration of features, events and processes that could affect repository performance over the long term

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as

changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low-probability events such as volcanoes, earthquakes, and nuclear criticality

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario

5. Parameter distributions that represent the possible change of the system over the long term

6. Use of conservative assessments that lead to an overestimation of impacts

7. Performance of sensitivity analyses

8. Use of peer review and oversight

DOE is confident that its approach to long-term performance analysis addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

DOE designed activities associated with the performance confirmation program to ensure that the repository would meet specific regulatory requirements [10 CFR 63.102(m) and 10 CFR 63 Subpart F]. As defined, the program consists of tests, experiments, and analyses to evaluate the adequacy of the information used to demonstrate compliance that the repository would meet the postclosure objective. The description of the performance confirmation program is documented in “Performance Confirmation Plan” (DIRS 146976-CRWMS M&O 2000).

The performance confirmation program would monitor and test key geologic, hydrologic, geomechanical, and other physical processes or factors (and related parameters) throughout construction, emplacement, and operation to detect significant changes from baseline conditions. DOE would use these data to confirm that subsurface conditions were consistent with the assumptions used in performance analyses and that barrier systems and components operated as expected.

Consistent with Federal regulations (10 CFR Part 963), the operational plan for the Yucca Mountain Repository provides a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving the waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly more than 300 years after the end of waste emplacement in the event of a decision to retrieve the waste to protect the public health and safety or the environment or to recover resources from spent nuclear fuel.

Because retrieval is not anticipated, DOE did not include it as part of the Proposed Action. However, the EIS evaluates retrieval as a contingency action and describes potential impacts if it occurred (see Section 4.2). DOE evaluated only actions that could be predicted with any certainty (that is, removal of the emplaced waste materials and subsequent onsite storage). Because any future actions regarding the management and disposition of these materials following retrieval would be at the direction of Congress and highly speculative, DOE believes it would be inappropriate to attempt to evaluate impacts that could result from these actions.

If the integrity of the repository was compromised, mitigation activities would be funded under the Price-Anderson Act. The Act provides liability coverage for commercial activities operating under a license from the Nuclear Regulatory Commission and for DOE activities by establishing a system of private insurance and Federal indemnification that generally ensures that as much as $9.43 billion is available to compensate for damages suffered by the public from a “nuclear incident,” regardless of who causes the damage. Payment would be from Federal funds or, if public liability arose from nuclear waste activities funded by the Nuclear Waste Fund (for example, activities at a geologic repository), from the Nuclear Waste Fund (see Section M.8).

7.3 (1880)
Comment - EIS000443 / 0012
The ground water from the site currently is used for agriculture in the regions. DEIS does not fully address consequences of contamination of the ground water and its impact on regional uses. It also incorrectly assumes

dilution will reduce the consequence of radiation and that will be an acceptable way to reduce concentration. Given the longevity of the container and the mountain barrier has not been determined, assumptions of contamination are premature at best and woefully under estimated at worst.

Response
Sections 3.1.1.1 and 3.1.4.2.1 of the Draft EIS provide information on current land and groundwater use, respectively, which includes various agricultural activities (for example, farming and dairy operations). The potential long-term (10,000-year) consequences for the three thermal load scenarios are presented in Section 5.4 of the Draft EIS and include estimated groundwater concentrations of radionuclides (Tables 5-7, 5-11, and 5-15). In addition, potential consequences (radiation dose) and human health impacts (latent cancer fatalities) resulting from of food and consumption and irrigation of feed crops are presented (Tables 5-4, 5-5, 5-8, 5-9, 5-12 and 5-13) for both reasonably maximally exposed individuals and populations for the three thermal load scenarios. These estimated consequences are a small fraction of the environmental protection standards promulgated by the Environmental Protection Agency (40 CFR Part 197) for the proposed Yucca Mountain Repository to ensure protection of the environment and human health. Therefore, DOE expects no adverse radiation-related health impacts of any kind to the population around Yucca Mountain within 10,000 years of repository closure. In addition, whereas the repository design evaluated in the Draft EIS projected small releases within the 10,000-year compliance period, the flexible design evaluated in the Final EIS projects that the Proposed Action probably would result in even smaller releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197). Therefore, DOE believes that the occurrence of adverse impacts would be highly unlikely within 10,000 years after closure with the flexible design.

With regard to the use of dilution factors, DOE does not believe that dilution, in and of itself, is an acceptable method to meet environmental protection standards. However, the Environmental Protection Agency has specified the location of the reasonably maximally exposed individual for compliance purposes (40 CFR 197.21). DOE has used the best available information and generally accepted methods, which include credit for dilution, to estimate potential impacts to this hypothetically exposed individual at this location.

With regard to uncertainties related to engineered and natural barrier protection, DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency, and Nuclear Regulatory Commission also recognize the difficulty of understanding the behavior of complex systems over long periods. In 10 CFR Part 63, the Commission acknowledged that “absolute proof is not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation.” Similarly, the Environmental Protection Agency established “reasonable expectation” as a test of compliance, with diminished “weight of evidence” with time (40 CFR Part 197). Consistent with National Academy of Science observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events.

DOE confidence in the disposal techniques is based on a defense-in-depth that, for example, places drip shields over waste packages to account for uncertainties. DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components.

DOE believes this process results in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios, including the preferred alternative.

DOE continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as at the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended as a suitable site.

7.3 (1921)
Comment - EIS000477 / 0001
My main issue is the future quality of life for southern [Nevadans] and Californians who are going to live within the nuclear waste repository impacted zone. With this storage facility located near a populated area (Las Vegas), how

can the Department of Energy guarantee that residents and visitors will not be unduly affected by radiation leakage? Presently, monitoring sites have been located in various locations of Tonopah, Rachel, and Las Vegas to measure the effects of past atomic explosions and studies have shown that local residents suffer higher rates of cancers. Is this acceptable? I don't think so. Would you want to live near this facility, raise your family, and watch your future generations die from various cancers or leukemia? Is the EIS correctly addressing the groundwater contamination concerns? Water that will eventually be consumed by the human and animal population of the region?

I wonder about possible groundwater contamination with Lake Mead/Colorado River water supplying Los Angeles, San Diego, Phoenix areas. This facility is only 100 miles away from this source and any geologic shifting from earthquakes can release harmful radioactive materials in the potable water supply.

Response

DOE can provide reasonable expectation, not a guarantee, that the proposed system of multiple engineered and natural barriers, working together, would protect public health and the natural environment for the hazardous life of the waste. In 10 CFR Part 63, the Nuclear Regulatory Commission acknowledges that "absolute proof is not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation." Similarly, in 40 CFR Part 197, the Environmental Protection Agency has proposed "reasonable expectation" as a test of compliance, with diminished "weight of evidence" over time.

In *Rethinking High-Level Radioactive Waste Disposal* (DIRS 100061-National Research Council 1990), a panel of the National Academy of Sciences observed: "Confidence in the disposal techniques must come from a combination of remoteness, engineering design, mathematical modeling, performance assessment, natural analogues and the possibility of remedial action in the event of unforeseen events". As stated in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998), DOE is taking this combined approach to provide assurance that the proposed repository would comply with regulatory requirements.

The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996) examines current and future DOE activities in southern Nevada at the Nevada Test Site, Tonopah Test Range, and sites DOE previously operated. With regard to the potential effects of past atmospheric testing at the Test Site, in 1997 the National Cancer Institute published a report entitled *Calculation of the Estimated Lifetime Risk of Radiation-Related Thyroid Cancer in the United States from the Nevada Test Site Fallout* (DIRS 152469-Institute of Medicine and National Research Council 1999, Appendix C). In 1999 the National Academy of Sciences published *Exposure of the American People to Iodine-131 from Nevada Nuclear-Bomb Tests: Review of the National Cancer Institute Report and Public Health Implications* (DIRS 152469-Institute of Medicine and National Research Council 1999). While discussion of potential health effects of the Nevada Test Site is beyond the scope of this EIS, these sources provide additional information.

The issue of radiation exposure and its relationship to cancer is very pertinent and important. DOE used risk factors recommended by the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection to estimate potential risks to the public and workers from Yucca Mountain activities. The Department is committed to protecting the public and workers from unnecessary radiation exposure and to keeping potential radiation risks as low as reasonably achievable. DOE expects no adverse radiation-related health effects from activities at the Yucca Mountain Repository.

Chapter 8 of the EIS evaluates the cumulative environmental impacts of the proposed repository and other Federal, non-Federal, and private activities, including activities at the Nevada Test Site. Estimates of health effects indicate that the number of latent cancer fatalities attributable to the Test Site is insignificant in comparison to the incidence of cancer in the general population.

Repository-related contamination of Lake Mead or the Colorado River that could affect the Los Angeles, San Diego, and Phoenix areas is not credible. DOE has conducted an extensive site characterization program, including the hydrologic conditions in the Yucca Mountain region (Section 3.1.4 of the EIS). The proposed repository would be in a closed hydrologic basin, so its surface water and groundwater would leave only by evaporation from the soil and transpiration from plants. Therefore, the watershed of the Colorado River would not be at risk.

7.3 (2003)

Comment - EIS000526 / 0004

I am also concerned about the long-term safety of the Yucca Mountain site. Page 2-37 of the EIS states, "DOE would use institutional controls, including land records and warning systems, to limit or prevent intentional and unintentional activities in and around the closed repository." It is my understanding, for example, that plutonium-239, an irradiated fuel, has a half-life of 24,400 years and that it remains dangerous for a quarter million years, or 12,000 human generations. Furthermore, as it decays, uranium-235 is generated which has a half-life of 710,000 years. Thus, the hazard of irradiated fuel will continue for millions of years. Therefore, this material must be isolated from contaminating or irradiating living things for this long. Considering the evidence provided by all of the known history of civilization, does the DOE expect the political stability of this country (which is only one issue pertaining to the long-term safe disposition of this material) to have a duration that would even remotely approach that necessary to ensure the continued application of "institutional controls" for safe disposal of this material?

Response

DOE understands that ensuring public safety requires continued stewardship and has developed components for the postclosure safety case, including site stewardship programs. These programs would include, but are not limited to, long-term monitoring of the site and maintaining the integrity and security of the repository.

After closure, DOE would have the responsibility of maintaining institutional control over the repository, as required by the Energy Policy Act of 1992. Neither the extent nor the length of this regulatory requirement is well defined at present. However, the Department would maintain appropriate institutional controls for as long as required.

A postclosure monitoring program is required by 10 CFR Part 63. This program would include monitoring activities around the repository after the facility has been closed and sealed. In addition, 10 CFR 63.51 (a) (1) and (2) require that a license amendment be submitted for permanent closure of the repository. This amendment must specifically provide an update of the assessment of repository performance for the period after closure, as well as a description of the program for postclosure monitoring. The details of this program, such as the types of active and passive controls, would be defined during the processing of the license amendment for permanent closure. Deferring a description of this program until the closure period allows for the identification of appropriate technology, including technology that might become available in the future.

For impact analysis purposes only, the EIS assumes that passive institutional controls would be applied after repository closure, as described in Section 2.1.2.3. DOE chose to analyze passive institutional controls for the postclosure period based on recommendations by the National Research Council of the National Academy of Sciences (required by the Energy Policy Act of 1992).

DOE believes that passive institutional controls (such as the land records and warning systems used for postclosure impact analysis) are commensurate with the recommendation of the National Research Council.

The last paragraph of Section 2.1.2.3 now clarifies that passive institutional controls were applied for analytical purposes, but that additional controls and monitoring could be applied if deemed necessary in the future.

7.3 (2242)

Comment - EIS000742 / 0001

First off, I am neutral toward the Yucca [Mountain] project. I believe that the US [should] be using and developing [nuclear] energy. [Fossil] fuel waste is more hazardous than [nuclear] waste ever could be. My main concern about the site is the geologic instability in the Goldfield area. [Rarely] a day goes by when a small [magnitude] quake isn't recorded in that area. Just a couple of months ago, a moderate quake hit that area (http://www.seismo.unr.edu/Catalog/fing.html).

How is it that this area can be called safe for a repository that has to remain intact for 100,000 years? It seems to me that the [decision] to place the site at Yucca [Mountain] was based more on politics than on science. As an engineer, I find that to be more than a bit unnerving.

Response
Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future earthquake activity, DOE believes that a repository at Yucca Mountain would operate safely (that is, in compliance with the Environmental Radiation Protection Standards in 40 CFR Part 197).

In addition, Section 4.1.8 describes the likely impacts from accidents caused by earthquakes during operation of the repository. As listed in Table 4-37, the maximum reasonably foreseeable accident is an earthquake-initiated event estimated to result in 0.0073 additional latent cancer fatality in the affected population.

With regard to the concern over politics possibly having more weight than science in the original decision in the NWPA to characterize only Yucca Mountain as a possible site for a geologic repository, DOE is extremely sensitive to this issue. DOE is committed to performing objective site suitability assessments based on the best science practicable given the information available. DOE's recommendation to the President and his (upon acceptance) subsequent recommendation to the U.S. Congress will be based on the site suitability investigations. The ultimate decisions will be based on a weighing and balancing of the facts by the Nation's political leaders. DOE is confident that the final decision will be in the best interest of the United States and its citizens.

7.3 (2321)
Comment - EIS000571 / 0005
Gaseous pathways for radionuclides. The volcanic tufts [tuffs] of Yucca Mountain are highly fractured and faulted already, presenting the pathway for gaseous nuclides to escape into the environment. Such fracture conductivity to the surface has already been documented at the Yucca site. So we're already finding cracks at this site and stuff. So what happens if we put these containers under the ground and they get cracked somehow and once again it gets out to the environment and it contaminates?

Response
Section 5.5 of the Draft EIS evaluated the potential impacts of atmospheric release of gas-phase radionuclides from the proposed repository. These consequences were a function of the inventory and release rate of gas-phase radionuclides (most notably carbon-14). The reported impacts to the local population from gas-phase atmospheric releases were exceedingly low (average lifetime population dose of 1.1×10^{-6} person rem over a 70-year lifetime at the peak release rate, corresponding to 5.3×10^{-10} latent cancer fatality). This represents a negligibly small risk, which was also the opinion of a National Research Council panel that reported its own investigation of this issue (DIRS 100018-National Research Council 1995). The National Research Council advised the Environmental Protection Agency not to bother controlling such a tiny potential release. The Environmental Protection Agency also calculated the risk, and agreed with the National Academy that this risk was too low to regulate.

7.3 (2527)
Comment - EIS000772 / 0005
Geological disposal was proposed in the act for waste isolation, yet the DEIS discusses facility design based on delayed release of radioactivity by means of Engineered Barriers, so the site will leak. Yet no discussion was offered stating how much leakage or when the leakage will occur.

Response
The goal of geologic disposal is to concentrate and isolate radioactive wastes in a relatively small area for a very long time. DOE intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment.

The Environmental Protection Agency recognized in its Yucca Mountain environmental protection standards (40 CFR Part 197) that with the current state of technology it is impossible to provide a reasonable expectation that there would be no releases over 10,000 years or longer. Therefore, standards have been established by the Agency that it believes provides comparable protections to those of other activities related to radioactive and nonradioactive wastes. These standards do not require complete isolation of the wastes over the compliance period (that is

10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment such as that performed for Yucca Mountain is to evaluate whether the repository is likely to meet these standards.

The EIS provides DOE's best estimate of the impacts that could occur when the containment system inevitably degrades. The updated analysis in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197) and are due to the very unlikely event of between zero and five packages failing due to manufacturing defects.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). DOE performed this evaluation, consistent with 40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that would be much lower than background levels (see Chapter 5 for details).

7.3 (2598)
Comment - EIS000802 / 0002
What about the ground water contamination has already been established and yet they build on.

Response
In 1996 DOE published the Nevada Test Site Final Environmental Impact Statement (DIRS 101811-DOE 1996). This document provides an estimate of the underground testing radionuclide source term that is the best available, unclassified, source term information. This data was used in a simplified calculation to provide a reasonable estimate of potential long-term cumulative impacts resulting from the underground testing activities at the Test Site. Because of ongoing studies and the current uncertainty surrounding groundwater transport models, DOE did not attempt to estimate actual groundwater transport characteristics for the Test Site. Rather, the estimates of potential Test Site groundwater impacts provided in Section 8.3 of the Draft EIS for Yucca Mountain were based simply on the ratio of inventories of radionuclides available for transport at the repository to the Test Site source term.

For the Final EIS, DOE has refined the Nevada Test Site groundwater impact analysis to consider not only the total inventories of radionuclides but also the relative source term radionuclide concentrations and dilution factors for the repository and the Test Site. However, because of the large uncertainties remaining, the refined analysis did not attempt to model actual groundwater transport at the Test Site. Rather, the refined analysis assumed that the radionuclide constituents in the groundwater at the Test Site would be transported in an identical manner to those from the repository (that is, the repository groundwater transport model was applied to the Test Site source term). Therefore, DOE believes that the resulting estimates of the potential cumulative impacts from underground testing activities at the Nevada Test Site represent a reasonable estimate of the maximum impacts. Section 8.3.2.1.1 describes the results.

7.3 (2619)
Comment - EIS000708 / 0002
Jessica Matthews, Senior Fellow at the Council on Foreign Relations, wrote about the Yucca Mountain Project for the Wall Street Journal that "The (DOE) plan is to dispose of nuclear wastes once and forever in a deep hole in the ground. A repository would be built, filled and sealed. This difficult, new technology must work perfectly the first time, protecting the waste for 10,000 years. There can be no pilot project, no improving of the technology, no learning curve; yet there must be public confidence that it will work."

FACT: There is NO PUBLIC CONFIDENCE that it will work. Repeatedly DOE technological discoveries about the site reveal weaknesses such as geologic instability, water penetration, heat accumulation, radioactive leakage, etc. Repeatedly the DOE response to these inherent site flaws has been to weaken the standards to accommodate the problem.

Response
DOE recognizes that that there is uncertainty in both predictive capability and in the likelihood and nature of human error. Therefore, a defense-in-depth approach is being used that, for example, places a drip shield over waste packages to account for uncertainties in the locations and rates of water seeps into the repository. DOE has adopted

this defense-in-depth design philosophy and also a performance assessment methodology that accounts for the variability inherent in natural processes, limits to our knowledge and information, differing views of experts, unpredictability of some phenomena, and uncertainty in system behavior. The methodology is widely accepted nationally and internationally. It is based on recommendations of the National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission. It conforms to international practices in other countries, including Member States of the Organisation for Economic Co-operation and Development Nuclear Energy Agency and the United Nations International Atomic Energy Agency.

In addition, because it is generally recognized that with time, our knowledge of and ability to predict future performance of both engineered and natural systems will improve, Section 122 of the NWPA and Federal regulations [10 CFR Part 60 and 10 CFR Part 63] require that the repository be designed to preserve the option of waste retrieval on a reasonable schedule starting at any time up to 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the proposed Yucca Mountain Repository provides for a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving the waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly more than 300 years in the event of a decision to retrieve the waste either to protect the public health and safety or the environment or to recover resources from spent nuclear fuel.

Section 112(a) of the Nuclear Waste Policy Act of 1982 requires the Secretary of Energy to issue general guidelines for use in recommending potential repository sites for detailed characterization. DOE issued these guidelines in 1984 (10 CFR Part 960), describing policies that were applicable to the three sequential stages of the siting process in the Act (preliminary site screening, nomination of sites, and site selection for recommendation to the President).

DOE published proposed amendments to the guidelines in 1996 to reflect the prevailing scientific view on how to evaluate the suitability of the Yucca Mountain site for the development of a nuclear waste repository (61 *FR* 66158, December 16, 1996). Because Congress had by this time required DOE to focus only on Yucca Mountain, the proposed DOE amendments dealt with provisions of the guidelines that were applicable to the site recommendation stage. In November 1999, DOE revised its 1996 proposal (64 *FR* 67054, November 30, 1999) to focus on the criteria and methodology to be used for evaluating geologic and related aspects of the Yucca Mountain site.

DOE revised its proposal for three reasons. First, in response to comments received on the 1996 proposal, DOE sought to provide more specificity in the guidelines and to expand the explanation of the factual and legal bases for them. Second, in December 1998, DOE issued the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) pursuant to Congressional direction. The Viability Assessment sets forth the bases for the site suitability criteria that DOE is proposing to use and the methodology for applying the criteria to a design for a proposed repository at the Yucca Mountain site. Third, the Nuclear Regulatory Commission proposed to issue site-specific licensing requirements for the Yucca Mountain site in February 1999. The details of this new proposal suggest the need to make conforming changes to the December 1996 DOE proposal to establish the requirements for carrying out a Total System Performance Assessment as the method for applying the site suitability criteria to the data developed during characterization of the Yucca Mountain site. DOE is not proposing to revise its guidelines due to any condition found at the Yucca Mountain site.

7.3 (2827)
Comment - EIS000955 / 0003
It is the opinion of the [Mendocino] Environment Center that shipping nuclear waste to Yucca Mountain on the Shoshone Reservation is … irresponsible in that [it] is less safe than an above ground repository.

Response
Yucca Mountain is not part of any Native American reservation, although DOE recognizes that claims exist that the location is a part of Western Shoshone land. This is an issue for Congress to consider as it decides whether to withdraw the land for the repository. In terms of transportation, while some potential routes cross Federally recognized Native American lands (see Chapter 6 of the Final EIS), DOE believes that the impacts would be small and would present no more risk to Native Americans than to any other community along those routes.

DOE does not agree with the second part of the comment. The Draft EIS, in a comparison of the Proposed Action and No-Action Alternative, suggests that although there could be little risk from above-ground storage for some time, eventually there would be either very large investments or sizable risks, some to populations and some to environmentally sensitive locales such as land adjacent to lakes, rivers, or oceans. To do nothing would be to invite disaster at some future time. To act as proposed would present some risk over a short period to those on or adjacent to transportation routes, but it would remove future risks from 77 other locales. In addition, the reduced risk of an unauthorized diversion of materials from these 77 locales, materials that could be used as tools of terrorism is important. The repository would be an important part of this Nation's commitment to nuclear nonproliferation. DOE believes the potential long-term benefits far outweigh the short-term risks from a national perspective and from the perspectives of those currently residing near spent nuclear fuel storage areas.

7.3 (2907)

Comment - EIS001009 / 0002

In the report titled "Geochemical Behavior of Long-Lived Radioactive Wastes" (ORNL-TM-4481) compiled by Ferruccio Gera for the Oak Ridge National Laboratory (1975), Gera notes in the introduction, "It is clear that these wastes will have to be contained for time periods well in excess of the recorded history of mankind." He states that it is necessary to "design a disposal facility in such a manner that it will withstand at least a few hundred thousand years of geologic change. It is known, however, that the longest-lived nuclides in the waste will present some radiological hazard for millions of years and it is not possible to absolutely guarantee that waste will be contained for such long periods of time."

To the taxpayer, the assumption made by Gera and promoted by our federal government and the nuclear power industry that the integrity of containers and the stability of the environment will permit no release of contamination for upwards of thousands of years is lunacy.

Unanticipated man-made events -- such as war or terrorist activity or environmental degradation -- or events occurring in nature -- such as geologic changes caused by earthquakes or volcanic activity or even impacts by asteroids, or the inevitable deterioration of containers -- make such long-term predictions ludicrous.

Response

The goal of geologic disposal is to concentrate and isolate spent nuclear fuel and high-level radioactive waste in a relatively small area for a very long time. DOE intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. In other words, the eventual release of some material is inevitable because all systems will degrade given sufficient time. However, based on the results in Chapter 5 of the EIS concerning long-term performance, which considered the effects of earthquakes and volcanic activity as well as the uncertainties related to future human behavior, DOE believes that the repository at Yucca Mountain would operate safely.

DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. This EIS provides DOE's best estimate of the impacts that could occur when the containment system degraded. The updated analysis in the Final EIS projects that the Proposed Action probably would result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197), which would be due to the very unlikely event of between zero and five waste packages failing due to manufacturing defects.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). DOE performed this evaluation, consistent with 40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that would be much lower than background levels (see Chapter 5 for details).

7.3 (3001)
Comment - EIS001066 / 0001
From what I have read, there are major concerns about the geologic suitability of Yucca Mountain to be a repository for nuclear waste. It is not water or air tight.

Response
Regarding the question of whether or not Yucca Mountain is "water or air tight," no natural geologic system is water or air tight because all natural geologic environments have a finite permeability to air and water. In choosing Yucca Mountain as a potential disposal site, DOE has selected a site with air and water permeability characteristics that, with the long-term climate in the area, the depth of the water table, and the robust engineering design of the proposed facility, ensures that future impacts to natural systems would be minimal.

The EIS evaluates the impacts of the proposed Yucca Mountain Repository and concludes that potential impacts to natural systems would be well within regulatory standards established by the Environmental Protection Agency and the Nuclear Regulatory Commission. Consistent with Section 122 of the NWPA and Commission regulations (10 CFR Part 63), DOE has designed the repository to maintain the capability to retrieve the waste if there were indications of unacceptable threats to public health and safety or to the environment, or to retrieve resources from spent nuclear fuel.

7.3 (3221)
Comment - EIS000957 / 0003
The risks to health and life are unacceptable due to the possible contamination of the groundwater and our environment will result in approx. 18 latent deaths a year. Any number of deaths per year related to this disposal of nuclear waste is completely unacceptable.

Response
Concerns about the risks to health and life are important and relevant to the proposed Yucca Mountain repository. The people of Amargosa Valley, the closest population center, are most at risk to groundwater contamination because the water beneath Yucca Mountain flows in a generally southerly direction.

DOE's estimate of the health risks due to the possible contamination of the groundwater does not agree with this comment. Section 5.10 of the EIS clearly indicates that no person would be likely to contract a fatal cancer from potential repository releases during the first 10,000 years after closure.

7.3 (3234)
Comment - EIS000998 / 0002
Some of this high-level nuclear waste will be toxic for 150 million years. No responsible person can assure us that any container will be designed which will contain that waste for that period of time, even under the best conditions. Further, major unanswered questions remain about the geologic predictability and long-term stability of Yucca Mountain site, raising further doubts about the safety of this proposal.

Response
DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. The Draft EIS provides the Department's best estimate of the impacts that would occur when the containment system inevitably degraded. The Draft EIS confirms that the Proposed Action would be expected to result in release of radioactive contamination to the environment beginning as early as a few thousand years after repository closure. However, the Draft EIS also shows that these releases under the Proposed Action would not exceed Environmental Protection Agency Standards (40 CFR Part 197) within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations.

The EIS contains analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probability and effect of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicate the potential risk, as reported in the EIS.

7.3 (3454)

Comment - EIS000546 / 0001

I really challenge all the scientific evidence to be looked at. There is a lot of very brilliant minds that are coming up with scientific facts and figures, but ultimately I think if you really look at it, we have to admit that it's all speculation and all hypothetical, because we really don't know what's going to happen. We don't know what's going to happen geologically in the next 500 years, in the next 50 years really. It's all speculation. Some very intelligent speculation but none all the same speculation.

We don't know what's going to happen with our environment.

Earlier, it was suggested that posing questions as comments. I'm going to reverse this and pose my question as a commenter. I'm sorry, I'm getting confused. Anyhow.

I'd really like anybody involved in the upper echelons of Yucca Mountain, I'm talking about anybody involved in the facts, the figures, in the decisions being made, whether you're a scientist, whether you are a bureaucrat, an administrator, whether you are a congressman, congresswoman. I'd like to ask you if you would live in the area? This isn't a question of aesthetics but about whether you want to live in southern Nevada, wherever Yucca Mountain happens to be. Would you want to live in the area and raise your family in that area, the next three, four generations of your family? Do you feel that the guarantees are reasonable enough and the risk is reasonable enough to want to raise your family there?

Response

DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC) also recognize the difficulty of understanding the behavior of complex systems over long periods. In 10 CFR Part 63, the NRC acknowledges that "proof that the geologic repository will conform with the objective for postclosure performance are not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation." In 40 CFR Part 197, the EPA establishes "reasonable expectation" as a test of compliance, with diminished "weight of evidence" with time. The EPA also recognizes the need for expert judgement in assigning scenario probabilities, selecting simulation models, and assigning parameter distributions. Consistent with National Academy of Science observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events. DOE continues to evaluate the sufficiency of its approach to dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended as a suitable site.

The choice of where an individual lives is a personal decision based on many factors (such as, lifestyle, cost of living, distance to work, educational opportunities, etc.). Nevertheless, the vast majority of scientists, engineers, and administrators directly involved with the Yucca Mountain project have chosen to reside within the region of influence. Before it could recommend the Yucca Mountain site for development of a geologic repository, DOE would have to provide a reasonable expectation that the repository would meet the EPA standards (40 CFR Part 197) for protecting human health and the environment. The Department believes that the occurrence of adverse health effects would be highly unlikely for all potentially exposed populations in the region of influence.

7.3 (3472)

Comment - EIS000722 / 0008

Like most power plants, Diablo Canyon lately operates with enriched fuel allowing longer stay of the fuel rods in the reactor. Since there is no empirical evidence for the rate of cladding failure in these spent fuel rods with higher burn-up, all risk assessments and analyses for accident and sabotage/terrorists scenarios are conjecture. In addition, calculations about thermal loads for casks and permanent repository may also be effected [affected]. The Draft EIS does not address this important aspect and is therefore seriously flawed.

Response
Section A.2.1.5 of the Draft EIS provides the basis for selecting "typical" pressurized-water reactor and boiling-water reactor fuel assemblies. Specifically, the typical assemblies were chosen to be representative of the average of the fuels to be received at the repository and to provide a realistic inventory and post-irradiation elemental distribution estimate for long-term performance analysis. The typical commercial assemblies specified are representative of an assembly type used in the more recently built reactors. This results in physical characteristics that are slightly higher than average (size and uranium per assembly).

In addition to the typical fuel, however, the Final EIS includes a new "representative" commercial fuel for purposes of calculating impacts of repository and transportation accidents (including accidents resulting from sabotage). The representative fuel (see Appendix A, Tables A-12 and A-13) is based on a hazard index approach that considers the relative hazard for all commercial fuel to be received at the repository. This fuel is younger and has higher burnup than the typical commercial fuels used in the Draft EIS. Use of a "most dangerous" conservative fuel (maximum burnup and minimum cooling) is not appropriate for transportation accidents because transportation casks, to ensure compliance with thermal and direct radiation exposure limits, would not be filled with such fuel. Such loading would require that casks contain fewer spent nuclear fuel assemblies than the large-capacity casks assumed for the EIS. Furthermore, such a fuel represents a very small fraction of the waste inventory. Thus, a reasonably foreseeable accident that could involve shipment of this fuel would be much less severe than the maximum reasonably foreseeable accident in the EIS because of the lower quantity of the material available for release from an affected cask.

Similarly, for the maximum reasonably foreseeable repository accidents, exclusive involvement of younger fuel would not be realistic because of the nature of the activities in the Waste Handling Building. Routine blending operations in the Waste Handling Building would include both younger and older spent nuclear fuel at any given time. Therefore, the Waste Handling Building would contain a mixture of younger, high-burnup and older, low-burnup fuel assemblies that would be equally affected in the event of an accident. The Final EIS defines the parameters of the "representative" commercial fuel and the rationale for developing this new type for use in accident analysis for the Final EIS.

This comment is correct in that whatever has happened to nuclear fuel at operating reactors would have an impact on the future behavior of the repository. For instance, the time the fuel spends in the reactor (the burnup) has a direct impact on the inventory of waste elements (radionuclides) and the heat output. These aspects are considered in design and modeling activities. DOE is evaluating certain aspects of dry cask storage related to the performance of commercial spent nuclear fuel cladding. This is necessary because dry cask storage results in much higher cladding temperatures than at-reactor pool storage. Such information was used to develop a refined clad performance model that is included in the Total System Performance Assessment analyses that support both the Site Recommendation process and the Final EIS. Models of commercial spent nuclear fuel dissolution are based on experimental tests where actual reactor fuel was used. In addition, models of waste package material performance are based on continuing long-term corrosion tests. Details regarding the models used for the Draft EIS are in Chapter 5 of the Draft EIS and of the Viability Assessment (DIRS 101779-DOE 1998). Descriptions of refined models can be found in documentation that supports both the Site Recommendation process and the Final EIS.

7.3 (3549)
Comment - 010114 / 0008
The lower temperature scenario assumes use of an area that hasn't been studied yet and what the fault lines are in that area that we're not aware of. These are things that need to be taken a look at.

Response
The waste inventory for the lower-temperature operating mode would be wholly contained in an area that has been studied during site characterization. Extended inventories (such as Modules 1 and 2) use some unstudied space in the "lower block." These inventories are not part of the Proposed Action, but are considered in the cumulative impacts as a reasonably foreseeable future action. If these additional waste inventories were authorized for disposal in the proposed repository, DOE would be required to characterize additional areas at Yucca Mountain.

7.3 (3599)
Comment - EIS000715 / 0009
In conclusion, I wish to make clear that the only things that the human race has learned about nuclear waste disposal is:

a. No human designed waste container has not leaked.

b. Nuclear waste always works its way lower into the earth carried by underground water.

So, 98% of the waste deposited in Yucca Mountain will end up, percolated and bubbling, beneath Death Valley National Park. It is true that only 2 percent will permanently poison the Las Vegas, acquifer.

Response
DOE acknowledges that it cannot build a containment system that would provide perfect containment forever. The Draft EIS provides the Department's best estimate of the impacts that would occur when the containment system degraded. DOE does confirm in the Draft EIS that the Proposed Action would be expected to result in a release of radioactive contamination to the environment beginning as early as a few thousand years after repository closure. However, the Draft EIS shows that these releases would not exceed environmental protection standards (40 CFR Part 197) within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations. In addition, whereas the repository design evaluated in the Draft EIS projected small releases within the 10,000-year compliance period, the enhanced design evaluated in the Final EIS projects that the Proposed Action probably would result in even smaller releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197).

With regard to potential flow of contaminants to Death Valley and as described in Section 3.1.4 of the EIS, DOE has conducted an extensive program to characterize the direction and nature of groundwater flow and transport from the Yucca Mountain site. The general path of water that percolates through Yucca Mountain is southward toward the Town of Amargosa Valley, then beneath the area around Death Valley Junction in the southern Amargosa Desert. The groundwater beneath Yucca Mountain merges and mixes with groundwater beneath Fortymile Wash. This groundwater then flows toward, and mixes with, the large groundwater reservoir in the Amargosa Desert. The natural discharge point of this groundwater occurs farther south in Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume might flow south toward Tecopa into the southern Death Valley area. A fraction of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks at the southeastern end of the Funeral Mountains toward springs in the Furnace Creek area of Death Valley. Potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. This divide would limit discharge from the shallow flow system, but would not necessarily affect the flow from the deeper carbonate aquifer that might contribute discharge to springs in the Furnace Creek area (DIRS 100465-Luckey et al. 1996).

Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and from deeper flow in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson 1975). Groundwater in the northwestern Amargosa Desert originates in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend southward from Yucca Mountain. Even if part of the flow from Yucca Mountain mixes with the carbonate pathway that supplies the springs in Furnace Creek, it would be too little to noticeably affect the water quality of these springs. Considering the small amount of water that would infiltrate though the repository footprint compared to the total amount of water flowing through the basin (about 0.2 percent), and the large distances involved [more than 60 kilometers (37 miles) from the source], any component of flow from Yucca Mountain that traveled along this long and complicated flow path would be diluted to such an extent that it would be indistinguishable.

As described in Chapter 5 of the EIS, modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at Yucca Mountain would keep the release of radionuclides well below the regulatory limits in 40 CFR Part 197. If, after more than 10,000 years, some contaminated groundwater flowed past Franklin Lake Playa and discharged at the springs in the Furnace Creek area of Death Valley, the mean peak dose would be less than the dose calculated at Franklin Lake Playa. See Section 5.4 of the EIS for additional information.

With regard to potential contamination of the Las Vegas aquifer, Sections 3.1.3 and 3.1.4 of the EIS describe the geologic and hydrologic settings of Yucca Mountain and the surrounding region in great detail. Estimated releases to the accessible environment after 10,000 years would be limited geographically to the groundwater flow system described in Section 3.1.4.2 of the EIS. Therefore, contaminants from the repository could not reach the Las Vegas Valley.

7.3 (3616)
Comment - EIS001031 / 0022
Isn't it risky, storing all this waste in one place?

Response
Chapter 5 of the EIS describes the environmental consequences of disposing of radioactive materials in one place. There are risks, but the purpose of this EIS is to present these risks to decisionmakers so they can make informed choices.

The risk of disposing of these materials in multiple locations has not been evaluated. However, the costs and risks of leaving the materials where they presently are have been evaluated in this EIS, and both long-term costs and risks would be lower if the Proposed Action was selected rather than either the 10,000-year maintenance and replacement of existing storage locations, or the abandonment of existing locations after 100 years. Neither alternative is likely to be the course the Nation would follow if the Proposed Action was not taken, but the analyses show the range of potential impacts if No Action was selected.

7.3 (3633)
Comment - EIS001179 / 0002
The recent findings at LANL (Haschke, et al.) regarding oxides of Pu [plutonium] do not seem (to me) to be of show-stopping concern. I believe that mobility and outgassing has been adequately addressed.

Response
Thank you for the comment.

7.3 (3777)
Comment - 010388 / 0003
Continue in-depth evaluations of priority issues as raised by NWTRB [Nuclear Waste Technical Review Board] to lay the scientific foundation for a positive Yucca Mountain site recommendation.

Incorporate a surface aging area for commercial spent nuclear fuel into the surface facilities plan for Yucca Mountain.

Conduct an in-depth investigation of a low temperature repository design, as an operating mode with optimum flexibility.

Response
The effects of thermal loading on the long-term performance of the proposed repository have been a subject of intense study and empirical data gathering for several years. Since the publication of the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance and improve operational safety and efficiency. The design evolution process has resulted in the development of the flexible design (see Chapter 2 of the Final EIS). In developing the flexible design, DOE considered the concerns expressed by the Nuclear Waste Technical Review Board about difficulties in reducing large uncertainties regarding waste package and repository performance related to high (above the boiling point of water) repository rock temperatures associated with the preliminary design in the Viability Assessment (DIRS 152574-Cohon 2000). The Board suggested that it might be possible to reduce such uncertainties by developing an adequate technical basis for a lower-temperature repository design.

The flexible design includes the ability to operate the repository in a range of operating modes that address higher and lower temperatures and associated humidity conditions. Higher-temperature means that at least a portion of the emplacement drift rock wall would have a maximum temperature above the boiling point of water at the elevation of the repository [96ºC (205ºF)]. The lower-temperature operating mode ranges include conditions under which the drift rock wall temperatures would be below the boiling point of water, and conditions under which the waste package surface temperatures would not exceed 85ºC (185ºF). To ensure the impact analysis covered the full range of potential impacts, DOE considered conditions under which the rock wall temperatures would be above the boiling point of water, and conditions under which waste package surface temperatures would not exceed 85ºC.

As discussed in Section 2.2.2.2.2 of the Supplement to the Draft EIS, the thermal output of the waste packages could be reduced by (1) placing low-heat-output (older) fuel with high-heat-output (younger) fuel in the same waste package (fuel blending), (2) limiting the number of spent nuclear fuel assemblies to less than the waste package design capacity (derating), (3) using smaller waste packages, or (4) placing younger fuel in a surface aging area to allow its heat output to dissipate so it could meet thermal goals for later emplacement. Chapter 4 of the Final EIS includes an evaluation of surface aging as much as 40,000 metric tons of heavy metal of commercial spent nuclear fuel during a 50-year period.

7.3 (4042)

Comment - EIS001524 / 0002

The Draft Environment Impact Statement is incomplete with regard to the definition of the "maximally exposed individual." The definition did not take into account differences in age, gender, and physical characteristics and also assumed that current lifestyles in the exposed area would remain consistent over the next 10,000 years. First of all, if the intent of the study is to determine protection for future generations, the maximally exposed individual should not be a person of mean or average lifestyle because it automatically results in some people (namely the old, young, sick, etc.) being less protected. In addition, while it is certainly not possible to know future lifestyle patterns, one cannot assume that characteristic conditions today will remain intact for thousands of years in the future. Therefore, the DEIS is wrong to rely on current averages to determine future levels of safety from the repository (DEIS, p. 5-26).

Response

DOE, the National Academy of Sciences, the Nuclear Regulatory Commission, and the Environmental Protection Agency all concur that "it is not possible to know future lifestyle patterns." In its report, *Technical Bases for Yucca Mountain Standards* (DIRS 100018-National Research Council 1995), a National Academy of Sciences committee concluded that there is no scientific basis for predicting future human behavior. The Committee recommended the use of default (or reference) scenarios to incorporate future human actions in compliance assessments.

DOE has followed this recommendation and used the concept of a reasonably maximally exposed individual (RMEI), as discussed by the Environmental Protection Agency in the preamble to 40 CFR Part 197, to project potential doses for long periods. The agency stated:

" … that the RMEI approach is sufficiently conservative and that it is fully protective of the general population (including women and children, the very young, the elderly, and the infirm). The risk factor upon which the dose level was established is very small, 5 chances in 10,000,000 per mrem [millirem] for fatal cancer. The lifetime risk then is this factor multiplied by the total dose received in each year of the individual's lifetime. We believe that the risk prior to birth is very similar to this risk level; however, relative to the rest of that individual's lifetime, the difference is small."

In addition, the Environmental Protection Agency defines the reasonably maximally exposed individual as an individual that has the food and water intake rates, diet, and physiology similar to those individuals currently living in communities in the downgradient direction of flow of the groundwater passing under Yucca Mountain. Thus, in estimating the risks to humans, DOE chooses factors typical of individuals living in the Yucca Mountain region of influence (for example, lifestyle, diet, water usage, farming and agricultural practices, and environmental parameters) that would lead to the highest exposures.

7.3 (4064)

Comment - EIS001181 / 0002

The N.Y. Times ran an extensive article about water flow, calcite crystals and their potential to corrode canisters. Also, the area's vulnerability to earthquakes and proximity to an ever-growing Las Vegas are cause for concern.

Response

DOE agrees that canister corrosion, earthquakes, and the proximity of population centers are important issues in the assessment of the performance of the proposed repository.

The longevity of the waste package is a principal factor in the Repository safety case. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of a thick inner shell of stainless steel and a thick corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). However, the updated analysis in the Final EIS projects between zero and five waste packages failing due to manufacturing defects.

DOE has evaluated the long-term geologic stability of Yucca Mountain. Earthquakes have occurred in the Yucca Mountain area in the past and are likely to occur in the future. They could affect the postclosure performance of the proposed repository in two ways: (1) through ground motions that could disturb the engineered structures and (2) by direct offset along a block-bounding fault that could act as a pathway for water flow and radionuclide migration to the underlying aquifer. To minimize the potential impacts of earthquakes, DOE would design the engineered structures to withstand the most severe ground motions (see Section I.2.1.7 of the EIS), and would place the waste emplacement drifts away from faults that could serve as fast paths for water.

DOE has conducted an extensive site characterization program, including the regional groundwater flow system around Yucca Mountain. The Department believes that there are no surface-water or groundwater pathways that could affect the population of Las Vegas. All flowpaths terminate in playas where water evaporates and perhaps makes a minor contribution to some local springs. However, all the water flows to the west and cannot reach the Las Vegas area. EIS Sections 3.1.4.2 and 3.1.4.2.2 describe the status of the understanding of the regional groundwater flow, and work continues to enhance our understanding of the regional flow system.

7.3 (4156)

Comment - EIS001512 / 0004

The DEIS includes the statement that the "most important process controlling waste package lifetime is whether water would drip from the seeps onto a waste package." (DEIS, 1999, 5-11.) On the previous page of the DEIS, the statement is made that, "After the water returned to the repository walls, it would drip into the repository but only in relatively few places. The number of seeps that could occur and the amount of water that would be available to drip would be restricted by the low rate at which water flows through Yucca Mountain." (DEIS, 1999, 5-10.) As was previously mentioned, a climate shift could cause a dramatic increase in the water that flows through Yucca Mountain to the repository. In addition, the flow of water through this area is affected by the surrounding geologic conditions, which are uncertain, by the DOE's own admission. On page 5-10 (DEIS, 1999), the DOE admits that the effect of heat (which could arise 15-25 years after closure of the repository as a result of the decay of nuclear materials, or as a result of volcanic activity in the surrounding area) on the water flow and geologic conditions is unknown. The DOE is planning future studies to determine the effect of heat on repository conditions (DEIS, 1999, 5-18), but until that data is known, the DOE's claim that little water would seep into the repository and cause damage to the waste packages is weakened by inconsistency.

Response

DOE based the corrosion models for the waste package design discussed in Section 5.2.2 of the Draft EIS on expert elicitation. The experts felt that Alloy-22 would corrode faster under dripping conditions. Subsequent experimental data, as documented in the "Waste Package Degradation Process Model Report" (DIRS 151624-CRWMS M&O 2000), show the corrosion of the new waste package would be insensitive to the amount of water contacting it (as long as there was any water). The corrosion rate would be the same whether there was only humid air or fast-dripping water. Thus, the effect of seepage on waste package corrosion would not be significant. But to reduce uncertainty in environmental conditions and reduce the potential for rockfall to damage the waste package, the flexible design evaluated in the Final EIS includes a drip shield over the waste package. The drip shield gives defense-in-depth and added assurance that the repository would perform adequately to protect the public health and safety.

DOE has completed several rock-heating tests, and one large underground test continues. These tests suggest that flow into the heated drifts is highly unlikely. However, the updated analysis performed for the Final EIS conservatively allows for some degree of seepage into a heated repository. The results of the updated analysis, however, indicated that this small amount of seepage would have little effect on the engineered system.

7.3 (4158)
Comment - EIS001512 / 0006
The scientist[s] involved insist that by the time a large portion of the radioactive material in the waste packages could reach groundwater supplies, their concentration would be non-toxic. The non-toxicity of these levels of groundwater contamination is not an assurance that they would not still be detrimental to humans. Furthermore, if the water table were to rise or if the water flow in the area surrounding the repository were to change as a result of heat, the concentrations of radioactive materials contaminating groundwater supplied could also increase. It is likely, if this were to occur, that the concentration of radioactive materials in groundwater would reach toxic levels.

Response
DOE acknowledges that the performance assessment models discussed in Appendix I of the EIS indicate that, eventually, the waste packages would fail and that radioactive materials would be released into the underlying aquifers where they would enter possible exposure pathways to humans. However, the potential exposure routes and acceptable, long-term concentrations of these materials are subject to the environmental protection standards promulgated, at the request of Congress, by the Environmental Protection Agency (40 CFR Part 197). The Department will continue to use the best scientific and engineering techniques available to provide a reasonable expectation that the repository would meet the requirements of 40 CFR Part 197, thus ensuring the long-term protection of the general public and the environment.

Section 3.1.4.2.2 of the EIS discusses several opposing views concerning fluctuations in the elevation of the water table. A small number of investigators believe that the water table at Yucca Mountain has risen in the past to elevations higher than that of the proposed emplacement horizon beneath Yucca Mountain. Based on the results of analyses reported in Section 3.1.4.2.2, DOE does not believe that any credible combination of future climate change, earthquakes, and volcanic eruptions could raise the water table sufficiently high to inundate the emplacement horizon.

7.3 (4159)
Comment - EIS001512 / 0007
Beyond the uncertainty of the above four DEIS claims, there is fundamental error in the modeling done by the DOE to assess the environmental consequences of volcanism, seismicity, and human intrusion. In modeling the possible consequences of these events, the DOE has assumed that only one of these will occur at a time. In other words, the simulations used to assess the environmental impact of these occurrences do not consider the possibility of an earthquake and a volcanic eruption at the same time. The DOE admits the likelihood of a thermal pulse 15-25 years after closure of the repository (DEIS, 1999, 5-10), along with high probability of seismic activity in the area (see 5-16, DEIS, 1999). Modeling the consequences of only one of these possibilities at a time, therefore, incompletely assesses possible environmental impacts.

Response
Since the publication of the Draft EIS, DOE has updated the Total System Performance Assessment to reflect the latest available information. The nominal scenario (undisturbed performance) now includes seismic events because of the likelihood of seismic activity occurring in the 10,000-year compliance period. Igneous activity (or volcanism) is included in the disruptive event modeling. Because DOE modeled the disruptive event as a perturbation of the nominal scenario, seismic and volcanic events can occur (in the probabilistic treatment) at effectively the same time.

The impact of the human intrusion event would be so small that its occurrence in conjunction with other events would be essentially the same.

7.3 (4161)
<u>Comment</u> - EIS001313 / 0002
Yucca Mountain is a poor site for long-term storage, partly because of the rapid movement of water through the ground, which would corrode the underground metal containers and wash the waste into the groundwater, creating a sacrifice zone for a very long time.

<u>Response</u>
As documented in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000), the corrosion of a waste package would be insensitive to the amount of water contacting it (as long as there was any moisture at all). The corrosion rate would be the same whether there was humid air or dripping water. The waste packages would corrode over time and would release waste into the groundwater. However, the updated analysis in the Final EIS projects between zero and five waste packages failing due to manufacturing defects. Chapter 5 of the EIS provides the estimates of potential dose rates, and discusses the uncertainties in those rates.

7.3 (4234)
<u>Comment</u> - EIS001160 / 0049
Examples of possible “worst case” scenarios which should be considered within the FEIS as a means to bound impact assessment and to identify reasonable mitigation measures include:

Disruptive event (i.e. volcanism, nuclear criticality) of unanticipated nature through repository horizon and of sufficient force to produce an emission plume and related deposition across White Pine County. Direct impacts include increased risk to residents and visitors of the County to exposure to radionuclides. Indirect impacts include enhanced public perception of risk and related area stigmatization.

<u>Response</u>
The EIS does not present a worst-case scenario for dose-to-receptor analysis and calculations because no matter what worst-case choice was presented, it would be always possible for someone to develop a worse scenario. This was recognized as a potential issue by the regulators, and in their regulations they settled the issue by prescribing a modeling approach and identifying the potential dose recipients to be evaluated in the analyses. As part of the analytical approach, DOE uses a statistical method to sample distributions of variable parameters relating to the calculation of dose. Realistic distributions of parameters are randomly sampled 300 times and these values are used for 300 simulations of repository performance, in terms of potential doses to receptors. The simulation results are used to show the mean and 95th-percentile doses (risks) to receptors.

The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probability and effect of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicate the potential risk, as reported in the EIS.

One change in the Final EIS is the addition of an aerial pathway for release from the analyzed eruptive scenario. This scenario was added to the three already analyzed in the Draft EIS (Chapter 5, Section 5.7.2, p. 5-43). The dose rates reported in Chapter 5 are well below the Environmental Protection Agency standards (40 CFR Part 197).

The Department recognizes that there is often a difference between calculated and perceived risk. However, the Department has focused its analyses upon impacts that can be estimated. It is then up to the decisionmakers and regulators that represent the public to make informed decisions regarding the future of the project. See Section 2.5.4 and Appendix N of the EIS for treatment of this topic.

7.3 (4316)
<u>Comment</u> - EIS001219 / 0005
The concentration of 70,000 metric tons of high level radioactive waste poses a high threat of overheating, risking atmospheric releases and all of the canisters will eventually leak, poisoning the ground water.

<u>Response</u>
The effects of thermal loading on the long-term performance of the proposed repository have been a subject of intense study and empirical data gathering for several years. Since the publication of the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance and improve operational safety and efficiency. The design evolution process has resulted in the development of the flexible design (see Chapter 2 of the Final EIS). In developing the flexible design, DOE considered the concerns expressed by the Nuclear Waste Technical Review Board about difficulties in reducing large uncertainties regarding waste package and repository performance related to high (above the boiling point of water) repository rock temperatures associated with the preliminary design in the Viability Assessment (DIRS 152574-Cohon 2000). The Board suggested that it might be possible to reduce such uncertainties by developing an adequate technical basis for a lower-temperature repository design.

The flexible design includes the ability to operate the repository in a range of operating modes that address higher and lower temperatures and associated humidity conditions. Higher-temperature means that at least a portion of the emplacement drift rock wall would have a maximum temperature above the boiling point of water at the elevation of the repository [96ºC (205ºF)]. The lower-temperature operating mode ranges include conditions under which the drift rock wall temperatures would be below the boiling point of water, and conditions under which the waste package surface temperatures would not exceed 85ºC (185ºF). To ensure the impact analysis covered the full range of potential impacts, DOE considered conditions under which the rock wall temperatures would be above the boiling point of water, and conditions under which waste package surface temperatures would not exceed 85ºC.

The risks of package failures leading to atmospheric releases would be extremely small based on test results and calculations that consider all plausible features, events, and processes. Eventually, however, the waste packages would fail to contain the waste. At that time there would be small releases of gases to the atmosphere as well as releases to the underlying aquifer. With the understanding that absolute assurance of “zero” release of waste materials is not possible over long periods, the Environmental Protection Agency has promulgated environmental protection standards for the Yucca Mountain Repository based on the concept of “reasonable expectation” (40 CFR Part 197). Prior to the Secretary recommending development of the proposed repository, DOE must provide a reasonable expectation of compliance with these long-term environmental protection standards as well as a reasonable expectation that the Yucca Mountain site would meet Nuclear Regulatory Commission site suitability standards (10 CFR Part 63). These regulations have been promulgated to ensure protection of the public and the environment. Chapter 5 of the Final EIS indicates that the flexible design would meet the environmental protection standards.

7.3 (4323)
<u>Comment</u> - EIS001222 / 0002
I recommend that this proposal be dropped immediately and permanently for the following reasons:

Any containers holding the waste are vulnerable to decay during the extremely long time that waste continues to be hazardous (thousands to millions of years). Because many containers could begin to leak at about the same time, it may be impossible to send people in to repair damaged containers without their receiving a fatal dose of radiation. This could allow contamination to spread into the surrounding area. Furthermore, leaks could occur long after our civilization has died out, leaving no one to take proper action to prevent large-scale releases.

If containers do leak and cannot be repaired, it is possible that a sufficient concentration of radioactive material could exist at some point to begin a chain reaction which could lead to a very serious nuclear explosion and spreading of radioactive particles over a large portion of the US and the world.

<u>Response</u>
DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. This EIS provides the Department’s best estimate of the impacts that could occur when the containment system inevitably degraded. The EIS confirms that the Proposed Action would be expected to result in release of radioactive contamination to the environment. However, the EIS also shows that these releases under the Proposed Action would not exceed environmental protection standards (40 CFR Part 197) within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations.

Federal regulations (10 CFR Part 63) require that the repository be designed to preserve the option of waste retrieval on a reasonable schedule for as long as 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the Yucca Mountain Repository provides for a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving the waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly more than 300 years in the event of a decision to retrieve the waste either to protect the public health and safety or the environment or to recover resources from spent nuclear fuel.

As explained in Section 5.8 of the EIS, DOE believes that an explosive nuclear criticality event would not be credible. Supporting information, including the scientific bases, regarding nuclear criticality can be found in the Science and Engineering Report (DIRS 153849-DOE 2001) and its referenced supporting documents.

7.3 (4328)
Comment - EIS001222 / 0007
The wastes will be hazardous long after our civilization has died out. No method to communicate the dangers and effective handling procedures to future civilizations has been devised. It is highly irresponsible to subject our descendents to hazards of which they know nothing, especially since it can be so easily avoided.

Response
DOE and other scientific advisory groups continue to study effective means of communicating hazards to future civilizations. However, the current belief is that the repository area would be identified by monuments designed, fabricated, and placed to be as permanent as practicable. These monuments would be intended to notify persons in the area that the repository exists. The notification allows the intruders the option to make informed decisions regarding the use of the surface and subsurface areas for habitation or other activities. Although the design and ultimate placement of these monuments is still under study, National Research Council (DIRS 100018-1995) contains additional information on the subject of human intrusion and long-term passive institutional controls.

7.3 (4572)
Comment - EIS001521 / 0086
Page 9-12, 9.2.8 LONG-TERM REPOSITORY PERFORMANCE, third paragraph, first bullet-- (Long-Term Performance Measures Under the Proposed Action) Given that the thickness of the unsaturated zone between the proposed repository horizon and the water table would range from 175 to 365 meters (see page 3-41, fifth paragraph), saying that the thickness is about 300 meters is incorrect. Hopefully the thickness range, and the lesser number in particular, was used in designing the engineered-barrier system.

Response
DOE agrees that it would have been more accurate to specify the range of overburden thickness between the surface and the repository depth. Therefore, the Final EIS was revised to indicate the actual range rather than an approximation value.

The Total System Performance Assessment of the long-term consequences reported in Chapters 5 and Section 8.3.1 did, in fact, use the actual depth range from the surface to the repository and the actual depth range from the repository to the regional water table, in a multidimensional modeling approach.

7.3 (4578)
Comment - EIS001521 / 0092
Pages I-88 through I-96, Figures I-27 through I-35, respectively--Very few faults are shown on the base maps of these figures and as such, they misrepresent the complex faulted-geologic structure that is representative of the Yucca Mountain area. By looking at these figures one would conclude that not one major, or minor, fault is coincident with the location of a proposed repository block and this simply is not true! An accurate depiction should be shown on all figures.

Response
The level of detail for Figures I-27 through I-35 of the Draft EIS was appropriate to the purpose of each of these figures. Major block-bounding faults shown in these figures were for the purpose of assisting the reader to visualize

the location of the repository blocks relative to major geologic structures. Section 3.1.3.2 presents the details of mapped fault structures at the Yucca Mountain site. No figures like these appear in the Final EIS.

7.3 (4607)
Comment - EIS001430 / 0004
I note that Long term (100 to 10,000 years) impacts also seem to be pretty well bounded but with more uncertainty (e.g. Table 5-3, page 5-22). However, impacts beyond 10,000 years seem to need more study, indeed, DOE is planning additional studies as discussed on page 5-13. I would hope that results would be available for the final EIS. If not, the mitigation measure to delay closure up to 300 years (p. 9-16) is recommended.

Response
The additional studies referred to in the Draft EIS are continuing. Some results from those studies have provided refinements for the analysis in the Final EIS, especially in the areas of engineered barrier degradation and radionuclide mobilization. The refinements include the use of more experimental data, accounting for more process coupling in the near field, refined and expanded colloid transport models, and other modeling and basis data changes. DOE agrees that the robustness of the engineered barrier system would dominate early behavior (up to 10,000 years) and that modeling and data related to mobilization and transport become much more important in analyzing impacts for the longer period (1 million years). The ongoing studies have helped provide a more refined forecast of very long-term behavior.

Decisions on mitigation measures such as a delay of closure to 300 years would depend on many considerations, which could include postclosure performance. While the projected 1-million-year performance could play a role in such decisions, other equally important factors might not favor such a move.

7.3 (4641)
Comment - EIS001164 / 0002
Another part of the assumptions built into the analysis are the hydrologic assumptions. I have spent my life in a profession that is just now awakening to the fact that climate has changed pretty dramatically and is going to change very dramatically in the future. That may not be a problem for the present generation, but of course, it’s a tremendous problem for future generations, and it’s for the future generations that really motivates me to come here because we are proposing to dispose of nuclear waste that will be toxic for longer than all civilizations have existed on earth. That is frankly an immoral act.

Response
DOE is committed to protecting public health and safety and the environment, both current and future, by designing a suitable repository for the Nation’s radioactive waste. Climate is one of the important considerations in analyzing the future behavior of the proposed repository. As discussed in Section 5.2.4.1 of the EIS, no one can predict future climate exactly. However, based on past climatic conditions and long-term climate cycles, possible future climates can be postulated. The long-term performance analysis in this EIS considered the effects of these future climates by including a pattern of wetter and cooler climates as indicated by the geologic record.

7.3 (4780)
Comment - EIS001519 / 0006
It is impossible to guarantee the safety and functionality of the storage canisters over the long term in regards to the construction of the canisters. Primarily, the actual canisters have not been built yet. Only blueprints exist from which the DOE has made predictions. In addition, seismic events or corrosion and destruction of the surrounding rock by the intense heat from the decaying fuel could subject the canisters to extreme pressures or weights that could cause them to rupture. Faulty canister construction would also present the possibility of waste fuel contaminating the area.

Response
The experiments and analyses documented in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000) provide the basis for the waste package modeling and life expectancies. This report identifies and discusses each potential waste package degradation mode. The degradation model includes those modes that analyses did not screen out as highly improbable.

The longevity of the waste package is a principal factor in the repository safety case. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of a thick inner shell of stainless steel and a thick corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). However, the updated analysis in the Final EIS projects between zero and three packages failing due to manufacturing defects.

Obviously, there is uncertainty associated with the extrapolation of experimental results for such long periods and for the other human factors mentioned in the comment. DOE selected the design analyzed in the Final EIS to mitigate the uncertainties by adding features (such as the drip shield) to provide defense-in-depth. This provides greater assurance that the repository would meet its performance standards in the face of uncertainty.

7.3 (4814)
Comment - EIS000938 / 0009
Volume II, Page I-9 through I-12. What is the conclusion or impact of these [nuclides] on public health both in the repository and during transportation to the site? Page I-14, Table I-9, why was the performance assessment calculations only modeled to the year 2055 when some of the materials have a half life of over a million years?

Response
Chapter 4 of the EIS describes the short-term (about 100 years) impacts resulting from construction, operation and monitoring, and eventual closure of the repository. Similarly, Chapter 5 describes the potential long-term impacts related to the expected performance of the repository for up to 1 million years after closure. In addition, Chapter 6 describes the impacts of transporting spent nuclear fuel and high-level radioactive waste from 77 sites in the United States to Yucca Mountain. Consistent with the National Environmental Policy Act process, DOE has presented environmental information in the EIS without conclusions as to whether the level of environmental impacts may be acceptably small or unacceptably large. These are in essence policy decisions that will ultimately be made by the President and Congress, if necessary, based, in part, on recommendation of the Secretary of Energy.

Table I-9 of the Draft EIS summarizes radioactivity data for the nine radionuclides modeled in the long-term performance assessment calculations using inventories projected through to 2055. DOE conservatively assumed 2055 because that year would include all of the spent nuclear fuel and high-level radioactive waste projected to be generated at commercial and DOE sites as well as all Greater-Than-Class-C low-level waste resulting from the decontamination and decommissioning of commercial nuclear reactors. The periods for analyzing public health impacts and estimating peak dose rates are 10,000 years and 1 million years, respectively. Note that further ingrowth of radionuclides and reduction of some others by decay after 2055 is accounted for in the long-term performance analysis.

7.3 (4840)
Comment - EIS001340 / 0001
In EIS Report Chapter 2.4.1. Proposed Action and No-Action Alternative: Under scenario 2, EIS assumes in 100 years there would be no effective institutional controls at present storage facilities, allowing for possible leakage due to deterioration of stored canisters, but in Yucca [Mountain], storage after 110 or 120 years, if it's possible for casks to leak on sites now after 100 years. What happens to casks or canisters underground in the proposed Yucca [Mountain] site when they do the reclamation they propose and cover all tunnels, fill in shafts and remove all signs of entrances and the canisters then overheat or start to leak?

The metal canisters being experimented with by infallible man did not hold up to the expectations. There would be no way to retrieve them after closure of the site. When the cooling shafts are filled in and tunnels closed off unexpected temperatures could create the previous mentioned volcanic eruptions of radioactive materials into the atmosphere under such pressure it could go much further than any previously thought accident occurrences. Its hard for me to conceive a cooldown of this waste in only 100 to 120 years when it's actively dangerous for up to 250,000 years!

Response
Section 2.1.2.4 of the EIS discusses the steps DOE would take to close the Yucca Mountain Repository. Since the publication of the Draft EIS, the Department has modified the repository design to include drip shields over the

waste packages and forced ventilation during the operation and monitoring phase. The drip shields would be placed over the waste packages immediately before closure. The forced ventilation would end when DOE closed the repository. The current design does not involve the placement of backfill over waste packages.

DOE selected the waste package materials and designed the packages to function in the postclosure environment. This includes heating of the packages over several hundred to 1,000 years as a result of radioactive decay of the wastes. Over a span of about a few thousand years, DOE estimates that the temperature in the repository environment would return to preemplacement conditions. Under the higher-temperature operating mode of the updated design discussed in the Final EIS, DOE anticipates that only a small portion of the rock would be above 100ºC (212ºF) for a relatively short period. The waste packages would experience slightly higher temperatures. These temperatures would not result in volcanic activity at Yucca Mountain.

The updated analysis in the Final EIS indicates that only one or two waste packages would be likely to fail in the first 10,000 years. However, the analysis also indicates that over long periods, water would eventually contact the waste packages, that the packages would ultimately corrode, and that waste materials would be released from the repository.

Prior to recommendation of the Yucca Mountain site for development of a geologic repository, DOE would have to provide a reasonable expectation that the repository could meet the environmental protections standards (40 CFR Part 197) developed by the EPA to protect human health and the environment.

7.3 (4881)
Comment - EIS000337 / 0021
Pg. 5-23, 4th par, last sentence: "...DOE believes the performance results of this EIS are conservative estimates...." The question to be asked, "Who knows how conservative the DOE estimates are?"

Response
The probabilistic approach (Monte Carlo method) to the impact simulations that DOE uses in the long-term performance analysis in this EIS is intended to account for uncertainty in data and models. All the principal data used in the simulations for the long-term impacts are distributions or ranges. These parameter distributions use conservative assumptions when there is insufficient information available to provide reasonable expectation that the estimated consequences are not underestimated. In the EIS, the results of the of the multiple simulations are presented in terms of mean and 95th percentile values, which represent the likely consequence and the consequence level where 95 percent of the simulations are less than the reported value, respectively. The spread of these values provides insight into the level of uncertainty and conservatism.

7.3 (4883)
Comment - EIS000337 / 0023
Pg. 5-37, last par, 3rd line: "...zirconium alloy would provide some impediment...if the waste package was breached." Another example of adjectives that have no meaning in an engineering report.

Response
This comment cites a statement in Section 5.4.4 of the Draft EIS that summarizes results of a quantitative analysis. Table 5-16 lists the impact results.

7.3 (5418)
Comment - EIS001887 / 0119
Page 2-57; Section 2.1.4.2 - Design Features and Alternatives to Control the Thermal/Moisture Environment in the Repository

Any continuous postclosure ventilation considerations should eliminate all options that result in postclosure openings from the interior of Yucca Mountain to the surface. (See Appendix E at E.2.2.3). Any openings would constitute a large and unacceptable uncertainty in postclosure performance that could not be mitigated. Site characterization studies have shown that, due to the fractured nature of the rock, Yucca Mountain is a naturally ventilated setting above the water table. This fact must be taken into account in long-term performance assessment.

Response
Table 2-4 of the Draft EIS contained an error that suggested that DOE considered continuous postclosure ventilation to be part of every Enhanced Design Alternative. Section E.2.2.3, correctly indicated that all Enhanced Design Alternatives except one included preclosure – but not postclosure – continuous ventilation.

The Draft EIS evaluated the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for repository surface facilities, and disposal containers (waste packages). It also evaluated the plans for the construction, operation and monitoring, and closure of the repository. To ensure flexibility to future decisionmakers, the Draft EIS reported that DOE was designing a repository with the capability for closure as early as 50 years or as late as 300 years after the start of emplacement.

DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of a final repository design and as a result of any licensing review of the repository by the Nuclear Regulatory Commission. The design evolution resulted in the flexible design evaluated in the Supplement to the Draft EIS and subsequently integrated into the Final EIS. The Supplement to the Draft EIS incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements.

For the reasons stated above, DOE developed analytical scenarios to estimate the range of environmental impacts that could result from the Proposed Action for the analyses performed for the Supplement to the Draft EIS. These analytical scenarios include the low, intermediate, and high thermal load scenarios presented in the Draft EIS, as well as the higher- and lower-temperature repository operating modes being considered for the flexible design. Section 2.2.1 of the Supplement summarizes the operational parameters for the three thermal load scenarios analyzed in the Draft EIS and the two repository operating modes analyzed in the Supplement. Section 2.2.2.2 describes the operational parameters for the higher- and lower-temperature operating modes. The lower-temperature operating mode considered for the flexible design included evaluation of a postemplacement ventilation period as long as 300 years. However, at the present time, continuous postclosure ventilation is not an option under consideration for the flexible design and, therefore, has not been included in the evaluation of long-term performance presented in Chapter 5 of the Final EIS. Chapter 2 of the Final EIS states that only postemplacement ventilation is under consideration for the flexible design. If postclosure continuous ventilation became incorporated in a future design, DOE would conduct the evaluations suggested in the comment.

7.3 (5444)
Comment - EIS001887 / 0136
Page 2-75; Table 2-7 - Impacts Associated with the Proposed Action and No-Action Alternative
Long-term air quality: It is possible that there would be carbon-14 releases to the air from the postclosure repository. It is incorrect to say there would be no air releases.

Response
It is true that there could be postclosure releases of carbon-14 to the air from the repository. In fact, all of the very small carbon-14 releases estimated in Section 5.5 of the Draft EIS were predicted to occur after repository closure. In addition, Chapters 5 and 8 of the Final EIS now include analyses of atmospheric releases of radon-222 in the postclosure environment. Therefore, Table 2-7 has been revised in the Final EIS to reflect the appropriate impacts.

7.3 (5632)
Comment - 010062 / 0003
I noted the stated radionuclides that may be water soluble. What percentage of the waste packages will these be within spent fuel rods for how long before deterioration/decay? I assume a substantial portion of the cask's content is water-soluble radionuclides initially, since all isotopes of uranium are reportedly water soluble.

Response
In the simulations of long-term performance all of the radionuclides are considered to be water-soluble. The solubilities and rates of dissolution are characterized in the models for release of material after a package is breached. The solubilities are input as ranges of possible numbers in a statistical distribution and are very important to the results that are reported in the EIS.

7.3 (5650)
Comment - EIS001887 / 0268
Page 5-6; Section 5.1 - Inventory for Performance Assessment Calculations

Plutonium should be included in both the radionuclide inventory assessment and the chemical toxicity assessment. Recent evidence indicates that plutonium moves more quickly than originally thought.

Response
As described in Section I.3.2.1 of the Draft EIS (Section I.3.2 of the Final EIS), the radiological toxicity of plutonium far exceeds its chemical toxicity. In addition, while there are established radiological limits for exposure to plutonium, there are no such limits for chemical toxicity. Therefore, because DOE thoroughly evaluated the radiological consequences of plutonium, it did not analyze it for chemical toxicity.

Recent evidence indicates that plutonium moves more quickly in groundwater than originally thought. This is believed to be due to its association with colloids. The models discussed in Appendix I of the Final EIS include colloid-facilitated transport of plutonium. This modeling is informed by both experimental and analytical work, and benefited from observations made on the Nevada Test Site where plutonium was found to be associated with colloids in groundwater.

7.3 (5656)
Comment - EIS001887 / 0276
Page 5-17; Section 5.2.4.1 - Uncertainty Associated With Societal Changes, Climate, and Other Long-Term Phenomena

The statement regarding benefits from future human activities such as technology for radiation removal from water and the environment and cures for cancer is not relevant in this Draft EIS. These concepts cannot be offered or committed to as mitigation measures and surely cannot be justified as an excuse for releasing radionuclides to the environment. This statement should be removed.

The time and magnitude of the projected peak dose is sensitive to the idealized climate cycle pulses. The uncertainty associated with the superpluvial pulses should be illustrated.

This section fails to include the potential for global climate change to affect repository performance and environmental consequences. The oversight also exists in Section 5.9, page 5-46, Consequences to Biological Resources and Soils. The section does address the thermal loading effect (Table 5-18, page 5-47) to biological resources and soil. However, the potential temperature increases are overly conservative and their estimated ranges from low to high are ignored. Clearly, there is a potential for vegetation to disappear above the repository and for the soil cover to be eroded away. The consequences of this to the site's geohydrology and repository performance should be addressed in Section 5.4.1, 5.4.2, and 5.4.3. These weaknesses exist because DOE failed to adopt an ecosystem approach for the Draft EIS, as recommended in Attachments [to this comment document] F, G, K, and L and by Bartlett and Malone (1993), Clark and Canter (1977), and Salk and others (1998).

Response
DOE agrees that the potential benefits from future developments, such as radiation removal technology and cancer cures, are not relevant to this Proposed Action and that such benefits do not justify releasing radionuclides to the environment. Section 5.2.4.1 of the EIS specifically notes that DOE did not take such benefits into account.

Global climate cycles and superpluvial pulses would affect repository performance, and the time and magnitude of the projected peak dose. As stated in Section 5.2.4.1, estimates of future climatic conditions are based on what is known about the past, with consideration given to climate impacts caused by human activities. DOE based updates to the model representing global climate change on the latest research of the U.S. Geological Survey and the Desert Research Institute. The long-term performance analysis in this EIS captures the uncertainty associated with the superpluvial pulses, and this EIS presents sensitivity analyses to indicate the effect of such pulses on overall system performance.

Since the publication of the *Viability Assessment for a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) and the Draft EIS, DOE has evaluated different thermal management strategies for lower- and higher-temperature operating modes. As a result, the design basis for the proposed repository has evolved. The thermal load is determined by such factors as inventory, burnup, number and mix of assemblies per waste package, age from discharge, staging receipt and emplacement of assemblies, spacing of waste packages and drifts, ventilation rates and periods, and the overall repository footprint. The thermal load would affect the temperature distributions in the engineered system, the near-field environment, the geologic environment, and the surface temperature of soils in the accessible environment. DOE has evaluated these temperature distributions and the coupled thermal-hydrological-chemical-mechanical effects on repository performance.

Section 5.9 of the EIS describes impacts to surface soils, vegetation, erosion, runoff, and plant and animal habitats. Table 5-15 lists predicted increases in soil temperature as a function of depth for the high thermal load scenario. Although not modeled, the magnitude of the increase in soil temperature would be smaller for the low and intermediate thermal loads. Thus, DOE agrees that the predicted temperature increases listed in Table 5-15 would be a conservative upper limit. Section 5.9 specifically acknowledges that there is a potential for diminished vegetation and soil erosion. These, in turn, could lead to an increase in sediment load in the surface runoff from Yucca Mountain.

Sections 5.4.1, 5.4.2, and 5.4.3 of the Draft EIS consider the radiological consequences of the potential future release and migration of radionuclides from the repository for the high, intermediate, and low thermal load scenarios, respectively. The consequences would occur because of the hydrogeologic conditions of the Yucca Mountain area, which are documented in the Viability Assessment (DIRS 101779-DOE 1998) and its companion 11-volume Technical Basis Document (DIRS 108000-CRWMS M&O 1998). Soil erosion localized over the repository footprint of several hundred acres would have little impact on the regional groundwater flow system comprising an area of hundreds of square miles. Thus, the EIS evaluates the influence of hydrogeologic conditions on repository performance, not the converse.

Section 3.1.5 of the EIS acknowledges the opposing views of the State of Nevada, Malone and others to an integrated ecosystem approach. DOE relied on extensive interdisciplinary collaboration to evaluate system impacts. When applicable, the Department adopted the concepts of ecosystem management of the Council on Environmental Quality (DIRS 155275-CEQ 1993), as required by DOE Policy 430.1, *Land and Facility Use Planning*. DOE has conducted extensive studies of the ecosystem surrounding Yucca Mountain for many years, and used the results of those studies to make decisions necessary to maintain or improve ecosystem integrity and diversity and to predict future impacts of the Proposed Action. Appendix C summarizes DOE interactions with state and Federal agencies to ensure protection of the ecosystem. For example, it has interacted with the National Park Service to protect pupfish and with the U.S. Fish and Wildlife Service to protect desert tortoises, the only species in the repository land withdrawal area that is listed as threatened under the Endangered Species Act. Therefore, DOE believes that the assessment methods it used to develop the EIS were extensive, consistent with the regulatory framework provided by 40 CFR 1502.25 and 10 CFR 1021.341(b), and sufficient for evaluating potential impacts of the Proposed Action.

7.3 (5657)
Comment - EIS001887 / 0275
Page 5-16; Section 5.2.3.6 - Nuclear Criticality

The Draft EIS should provide more information as to what "minor effects" a nuclear criticality incident would have on repository performance and what analysis was performed to support this conclusion.

Response
Section 5.8 of the EIS summarizes the impacts of a nuclear criticality on repository performance. Updated analyses regarding criticality have been completed since the publication of the Draft EIS. This EIS summarizes the results of these analyses. This summarization is based on analyses documented in the Science and Engineering Report (DIRS 153849-DOE 2001) and its referenced supporting documents.

The results of these analyses indicate that for a steady-state in-package criticality, the additional heat output is only about 2 kilowatts per package, which is inconsequential compared with the overall repository heat load. Additionally, a small increase in the radionuclide inventory (25 percent increase in total radioactivity in one waste package) would occur. Because of the small increases in radioactivity and heat output, there is no chance that the waste package and the engineered barrier system could be mechanically disrupted by a criticality.

In the unlikely event that an external criticality occurred, the resultant increase in the radionuclide inventory would be very small.

7.3 (5659)
Comment - EIS001887 / 0278
Page 5-20; Section 5.2.4.3.2 - Weighting of Alternative Conceptual Models

The reference designs of the repository and waste package in the Draft EIS are not the designs currently under consideration. This alone undermines DOE's ability to use the TSPA [Total System Performance Assessment] results in this Draft EIS for selection of the preferred alternative.

There has been considerable debate over the actual flow paths that would be followed by the radionuclides released from the repository. Modeling results performed by the State of Nevada (Lehman and Brown, 1994, Lehman and Brown, 1995) indicate major differences may exist in flow path direction, velocity, and sorptive capability compared to that used in the latest assessments by DOE, including the Draft EIS, if all data sets are utilized.

By failing to evaluate credible alternative models or opposing views of the saturated zone, DOE is not in compliance with NEPA [National Environmental Policy Act]. Being out of compliance with NEPA means automatic noncompliance with the NWPA. DOE is specifically out of compliance with NEPA 1502 for not summarizing, discussing, or using important data sets. DOE has failed to evaluate credible opposing viewpoints and does not propose testing to reduce uncertainty in the choice between alternative conceptual flowpaths. (See Attachment [to this comment document] U for a more detailed discussion of this issue.)

Response
The EIS now contains analysis of the updated design and incorporates a refined Total System Performance Assessment model (DIRS 153246-CRWMS M&O 2000) that includes many new modeling approaches. The new modeling approaches account for many alternative conceptual models, including the ones mentioned in the comment.

The *Saturated Zone Flow and Transport Process Model Report* (DIRS 151948-CRWMS M&O 2000) describes alternative conceptual models of the saturated zone flow system. Specifically, it discusses the model presented by Lehman and Brown (DIRS 149173-1996; DIRS 101254-1998). The main difference between the models is the length of the flowpath through the alluvium. In the performance assessment calculations for the Final EIS, the length of the flowpath through the alluvium was varied to account for uncertainty. Furthermore, DOE used data obtained by Nye County to support the saturated zone model and help define the uncertainty range for the alluvium flowpath length.

7.3 (5664)
Comment - EIS001887 / 0283
Page 5-27; Section 5.4.1 - Consequences from the Groundwater Exposure Pathway for the High Thermal Load Scenario

The assumption that radionuclides would mix in the unsaturated zone has no basis. DOE's own statement, on page 5-10, implies that DOE cannot adequately model the unsaturated zone.

Diluting the concentration of the yearly infiltration from Yucca Mountain into the 17.3 million cubic meters of water use in Amargosa Valley is not conservative. Data from Nye County drilling indicates that the flow is compartmentalized, and there would not be a large amount of dilution of the radionuclides. This statement applies also to the similar dilution used in the Intermediate and Low Thermal Load scenarios.

Response
The approach to modeling reflected in the Supplement to the Draft EIS and the Final EIS (see Sections 5.4.2 and I.2) is very different from that described in the Draft EIS. The saturated zone model in the new model approach is a

three-dimensional model that provides a more realistic representation of the very small amount of mixing in the saturated zone between the proposed repository and the reasonably maximally exposed individual (RMEI) location at approximately 18 kilometers (11 miles). The radionuclide flux arriving at the RMEI location is diluted in a water usage by a hypothetical farming community at that location, as prescribed in the Environmental Protection Agency standard at 40 CFR Part 197. This usage is sampled in a range of approximately 890 to 3,370 acre-feet per year with an average of about 1,940 acre-feet per year. Increasing mixing is allowed in the flow path from 18 kilometers to 60 kilometers (37 miles) because the aquifer changes from mostly fractured rock to mostly alluvial deposits (sand and gravel) in this region (see Section 5.4.1).

The dose to the RMEI and to the individual with RMEI characteristics but located at other distances is derived from this new approach. The approach in the Draft EIS was used because the modeling was one-dimensional, so that a scaling approach was necessary. The results of the new model indicate that the Draft EIS approach was probably quite reasonable and perhaps somewhat conservative.

7.3 (5668)
Comment - EIS001887 / 0286
Page 5-30; Table 5-7 - Peak Radionuclide Concentrations

The Draft EIS should provide Maximum Contaminant Levels (MCLs) as set by EPA [Environmental Protection Agency] for drinking water systems to compare with the peak radionuclide concentrations given in this table.

Response
Section 3.1.4.2.2 of the EIS discusses saturated groundwater quality. The parameters include average combined radium-226 and –228, average gross alpha, average total uranium, average gross beta, and average radon-222. The results of sampling analyses at Yucca Mountain and in the region are listed in Table 3-19. Applicable Maximum Contaminant Level Goals are also listed in the table. DOE elected to list these values here rather than in Table 5-7 because it considers them to be part of the baseline or affected environment. The accompanying text states that analyses also included tritium, carbon-14, chlorine-36, nickel-59, strontium-89 and –90, technetium-99, iodine-129, and cesium-137. Parameters were listed only if concentrations were above a minimum detectable activity level. In the Final EIS, DOE has added Table 3-12 to show Maximum Contaminant Level Goals for nonradiological chemicals.

7.3 (5669)
Comment - EIS001887 / 0290
Page 5-38; Section 5.5 - Atmospheric Radiological Consequences

What analysis supports the expectation that Iodine-129 will dissolve in the groundwater rather than migrating as a gas?

Response
The amount of iodine-129 going to the atmosphere versus that going to water is governed (in the case of a reasonably slow process) by the vapor-liquid equilibrium between dissolved iodine and iodine-bearing vapor in the gas phase. A dominant species with the highest tendency toward the vapor phase would be hydrogen iodide. At 25ºC (77ºF), the partial pressure of hydrogen iodide over a 56-percent aqueous solution (very high concentration) is 0.10 millimeters of mercury. If it is assumed that the repository is at about standard pressure (760 millimeters of mercury), then the mole fraction of the hydrogen iodide in the air over that aqueous solution is 0.00013 or 0.06 weight percent (DIRS 104946-Perry and Chilton 1973). Thus, the partitioning of iodine in a very concentrated solution greatly favors the liquid phase. In a very dilute concentration of 4-percent iodine the vapor phase would be at 0.00064 millimeter of mercury and, therefore, 8.4×10^{-7} mole fraction or 0.00004 weight percent (DIRS 104946-Perry and Chilton 1973). Thus, at low concentrations there is a 10,000-to-1 bias toward the liquid; at very high concentration this becomes a 1,000-to-1 bias. It is a reasonable assumption that essentially all of the iodine would go to the water. If the temperature was much higher, there would probably be a tendency for the iodine to be more predominant in the vapor phase but, because only a few (zero to three, and possibly as many as five) waste packages would fail before the repository had cooled back to ambient conditions, this would not be a factor.

7.3 (5671)
<u>Comment</u> - EIS001887 / 0291
Page 5-38; Section 5.5.1 - Carbon-14 Source Term

This analysis is highly sensitive to the large uncertainties in waste package and cladding degradation models. The uncertainty in the source term associated with these two factors should be discussed in this section.

<u>Response</u>
The commenter is correct that atmospheric radioactive material impacts are sensitive to the uncertainties in the waste package and cladding degradation models. As discussed in Section I.7.1 of the Draft EIS, the impacts from the atmospheric release of carbon-14 were estimated using expected value models for waste package and cladding performance. DOE believes the simplifying assumption used in these models is appropriate given the inconsequential impact estimates.

7.3 (5672)
<u>Comment</u> - EIS001887 / 0293
Page 5-39; Section 5.6.1 - Human Health Impacts From Chromium, and Table 5-17

At the 5 and 20 km locations, the expected chromium concentrations are relatively close to the Maximum Contaminant Level Goal (MCL) and highly subject to uncertainty in waste package failure expectations (and at 20 km, the saturated zone flow model). A slight (but not unreasonable) change in the assumption regarding juvenile waste package failures would result in the Maximum Contaminant Level Goal being exceeded. The conclusion that, for the high and intermediate thermal load alternatives, "DOE anticipates no detrimental impacts to water quality due to chromium contamination" (Page 5-40) is not justified when reasonable uncertainties are taken into account. The analysis is also somewhat sensitive to the waste package design, which, in the Draft EIS, is not the same as that being currently considered. The current design is likely to permit more rapid mobilization of chromium.

<u>Response</u>
As noted by the commenter, the waste package design in the Final EIS is different from the design in the Draft EIS. There is quite a bit more Alloy-22 used in the updated design, much of which would be exposed on the outside of the waste package and supports. However, because of the presence of titanium drip shields, water is not expected to reach much of the chromium-bearing material for 10,000 years after closure. Thus during this period, the most important mechanisms for mobilization of the chromium is the very slow humid-air corrosion of the exposed surfaces under the drip shields and diffusive transport of dissolved materials to the unsaturated zone water. To evaluate the potential outcome of these processes, a conservative calculation was made assuming that all the exposed chromium material would corrode in the humid air and immediately dissolve in the unsaturated zone water. All of this material is then diluted in the standard average uptake in a well at 18 kilometers (11 miles). The results showed concentrations well below the Maximum Contaminant Level Goal for chromium (see Section I.6 of Appendix I of the EIS). Because of the conservative nature of these calculations, DOE believes it is very unlikely that actual concentrations would be much larger.

7.3 (5674)
<u>Comment</u> - EIS001887 / 0294
Page 5-40; Section 5.6.2 - Human Health Impacts From Molybdenum

The above comments regarding chromium also apply to molybdenum in terms of the amount of metal that could be mobilized if uncertainty due to a single assumption regarding juvenile waste package failure and the current waste package design are taken into account. The lack of a drinking water standard is not a justification for releases of molybdenum into groundwater in amounts similar to chromium, especially when adverse effects of molybdenum in water used by livestock have been documented for years.

<u>Response</u>
Concerning molybdenum, Alloy-22 contains 13.5 percent molybdenum. Maximally corroded waste packages and other components containing Alloy-22 would release molybdenum in a manner similar to that of chromium but with a lower activity. Section 5.6 of the EIS states that the estimated 10,000-year peak concentration of chromium in groundwater, based on releases from the preferred repository design, would fall well below present Environmental

Protection Agency guidelines for chromium in groundwater. Although there are no specific standards for molybdenum concentration in drinking water, low concentrations of dissolved molybdenum occur in most public water supplies. There is no established general heath hazard associated with public water supplies with this range of dissolved molybdenum. The concentrations in approved public water supplies are in the range of dissolved molybdenum that would be likely to be released from the proposed Yucca Mountain Repository. Therefore, DOE does not expect potential molybdenum health hazards associated with the use of Alloy-22.

7.3 (5675)
Comment - EIS001887 / 0295
Page 5-42; Section 5.7 - Consequences From Disruptive Events

Because of the wide range of uncertainty associated with the base case dose calculations and the questionable representativeness of the mean of the model realizations, the base case performance should be represented by the 95th percentile of the calculations rather than the mean.

Response
This EIS contains revised calculations of the consequences from the base case (now called *nominal scenario*) and from disruptive events. The results of these calculations discuss both mean and 95th-percentile estimates. DOE included the mean value because the regulators require it.

7.3 (5683)
Comment - EIS001887 / 0299
Page 5-48; Section 5.9 - Consequences to Biological Resources and Soils

The discussion of estimated doses from irrigation water and discharge at Franklin Lake Playa should indicate that the time period considered is 10,000 years. As seen in the referenced Draft EIS sections, peak doses, even at 20 km, could be as high as 1.4 rem/year. None of the peak doses calculated can be considered small and would certainly exceed any standard established for a repository.

Response
DOE agrees that readability could have been improved by stating that the doses referenced on page 5-48 of the Draft EIS were the 10,000-year peak doses. However, the updated analysis for the flexible design in the Final EIS predicts that releases during the first 10,000 years after repository closure would be very small and, therefore, impacts to biological resources and soils would be expected to be very small. The 10,000-year period following closure of the repository is clearly defined in the Final EIS as the compliance period consistent with the Environmental Protection Agency Yucca Mountain environmental protection standards (40 CFR Part 197).

In addition to estimating doses during the 10,000-year compliance period, DOE performed analyses to determine peak doses during the 1-million-year period following repository closure. However, the Department agrees with the Environmental Protection Agency that there would be considerable uncertainty associated with projections for tens of thousands to hundreds of thousands of years. As the Agency notes in 40 CFR Part 197, "Simply because such models can provide projections for those time periods does not mean that those projections are either meaningful for decisionmakers or accurate." The peak dose rates are included in the EIS as a best estimate of a range of possible impacts given the long periods and uncertainties involved. However, because of the large uncertainties associated with these post-10,000-year peak doses, DOE believes that the estimation of impacts that could arise from these doses would be too speculative to be useful to the decisionmaking process and has therefore limited the results for postcompliance periods to consequences (that is, dose).

7.3 (5757)
Comment - EIS001887 / 0360
Page 10-2; Section 10.1.1.3 - Hydrology

This section of the Draft EIS should point out that the resultant peak doses expected from releases of radionuclides to the groundwater are much larger than considered acceptable under any reasonable standard. To illustrate the extent of expected contamination, reference should be made to Table 8-41 on page 8-63, which provides peak dose calculations at various distances from the waste emplacement area. It must also be recognized that the Proposed

Action results in an irreversible commitment of groundwater in Amargosa Valley, Franklin Lake Playa, and springs in Death Valley to contamination by radionuclides at a level that makes the water unfit for human use and a significant danger to the environment.

Response
Chapters 5 and 8 of the EIS describe peak dose rates for the Proposed Action and the cumulative effects of possible past, present, and reasonably foreseeable actions, respectively. Chapter 10 of the EIS, which includes a discussion of irreversible impacts, was prepared pursuant to the Council on Environmental Quality regulations (40 CFR 1502.16) that require the consideration of any irreversible or irretrievable commitments of resources that would be involved in the proposal should it be implemented. In that context, DOE is most concerned with the repository and associated actions and believes reference to cumulative impacts would mask the incremental contribution the repository could have on resource commitments.

As described in Section 3.1.4 of the EIS, DOE has conducted an extensive program to characterize the direction and nature of groundwater flow from the Yucca Mountain site. The general path of water that percolates through Yucca Mountain is southward toward the Town of Amargosa Valley, then beneath the area around Death Valley Junction in the southern Amargosa Desert. The groundwater beneath Yucca Mountain merges and mixes with groundwater beneath Fortymile Wash. This groundwater then flows toward, and mixes with, the large groundwater reservoir in the Amargosa Desert. The natural discharge point of this groundwater occurs farther south in Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume may flow south toward Tecopa into the southern Death Valley area. A fraction of the groundwater may flow through fractures in the relatively impermeable Precambrian rocks at the southeastern end of the Funeral Mountains toward springs in the Furnace Creek area of Death Valley. Potentiometric data indicate that a divide could exist in the Funeral Mountains between Amargosa Desert and Death Valley. This divide would limit discharge from the shallow flow system, but would not necessarily affect the flow from the deeper carbonate aquifer that may contribute discharge to springs in the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Potential Furnace Creek area impacts would be less than the low impacts described in Chapter 5 for Franklin Lake Playa because impacts would decline with distance from the repository.

The Nuclear Regulatory Commission and the Environmental Protection Agency have developed standards for the long-term performance of the proposed repository. These standards would apply to the first 10,000 years, and the EIS analyses indicate that the repository would meet them.

As appropriate, DOE will continue to evaluate physical locations that the annual peak dose could affect and perform analysis consistent with the risk identified. DOE will also continue to focus its attention at the point of regulatory compliance, which represents a location where impacts would be most likely given the greater possibility for groundwater withdrawal at this location.

7.3 (5759)
Comment - EIS001887 / 0365
Page 10-9; Section 10.2.1.2 - Hydrology

The last statement in this section is specious, at best. Yucca Mountain will result in contamination of a large aquifer and surface water expressions, and the shipping campaign could cause the contamination of many major and minor water bodies throughout the U.S. The perception given by this statement is that it is acceptable to contaminate water in Nevada, but not anywhere else.

Response
DOE acknowledges that some contamination of the aquifers in the Yucca Mountain region could occur. However, the EIS shows that the timing would be very long and the amount of contamination would be very low and within established regulatory standards, which were developed to ensure acceptable human health and environmental impacts. Only minimal surface contamination would occur at Franklin Lake Playa. This is an area of ephemeral surface water, and the impacts would be very low in relation to the standards. The analysis of transportation alternatives indicates no radiological contamination of water bodies of the United States.

The minimal potential impacts to Nevada water bodies would be less than the potentially larger impacts to water bodies near the large population centers in proximity to the generator sites. Chapter 7 of the EIS contains a discussion of the potential of leaving the waste material at commercial nuclear power plants and DOE sites.

7.3 (5775)
<u>Comment</u> - EIS001887 / 0377
Multi-Barrier Concept

Contrary to how a permanent geologic repository is intended to perform under the Nuclear Waste Policy Act, the geological formation is not proposed as the primary containment barrier at Yucca Mountain. Instead, the packaging, consisting of the fuel matrix itself, the fuel rod cladding, and the double wall package must function as the primary containment barrier. Once radionuclides move from the fuel matrix and the waste package, the Yucca Mountain geologic setting provides little resistance. Under the Proposed Action, the function of the geologic setting at Yucca Mountain to merely to decrease the likelihood of human intrusion.

The waste package design in the Draft EIS (not the design currently used by DOE) consists of an outer wall, 10-cm thick layer of carbon steel (corrosion-allowance material) and an inner 2-cm layer of chromium-molybdenum Alloy-22 (corrosion-resistant material). (p. I-34) The computer software WAPDEG quantifies the range of expected degradation. The major factors are temperature and moisture. WAPDEG evaluates generalized and localized corrosion. Corrosion of carbon steel generally begins when the temperature of water is below the boiling point. (p. I-35)

According to these theoretical models, by 5,000 years, nearly every package has a single corrosion-allowance material breach. (page I-40) By 20,000 to 30,000 years, corrosion-resistant material is also breached. High thermal loads generate the earliest breaches. Spent fuel dissolution depends critically on temperature, carbonate concentration, and pH.

DOE calculates the dose for a reference person in the Amargosa Valley – an adult, who lives year-round on a farm, grows a garden, and raises livestock. (page I-48)

In addition to food, radiation pathways considered by DOE include incidental ingestion of contaminated soil and groundshine. (page I-49) It is not clear that the radiation pathway, dust resuspension, was considered. DOE conducted a survey to determine food consumption habits in Amargosa Valley. To calculate health effects from radioactive input, DOE used ICRP-30 dose conversion factors. It is important to note that the more recent dose conversion factors from ICRP-60 would have allowed DOE to also calculate the dose to children rather than a reference adult, which would likely have resulted in higher dose calculations. Four locations to estimate doses were considered – 5, 20, 30, and 80 kilometers distant. As calculated, the maximum peak dose would occur well after 10,000 years. For 10,000 years, the highest dose would be at 5 km. (page I-51) The first failure for the intermediate thermal load scenario is 9,000 years after repository closure. (page I-52) For the low thermal load case, the first failure occurs at 27,000 years after repository closure.

DOE has high expectations for the containment potential of the cladding. Not taking credit for the cladding increases the mean dose at 20 km from 0.22 mr/y [millirem per year] to 5.4 mr/y at 10,000 years. (page I-54) At 1,000,000 years, the doses can be quite high, 260 mr/y at 20 km with cladding credit, and 3,000 mr/y without cladding credit. These latter doses are extremely high, far above regulatory limits and entirely unacceptable.

Note: Because the performance assessment for long-term repository performance used in this DEIS is not the one that will be used in the FEIS to support site recommendation, no further review of Appendix I was undertaken. For this reason alone, the DEIS is insufficient.

<u>Response</u>
The design and performance of the repository as described in the Draft EIS and in the Final EIS are not contrary to the Nuclear Waste Policy Act of 1982, which calls for the use of a deep geologic repository for the disposal but does not prohibit the use of engineered systems as part of the facility. The Act also calls for the location of repository in a deep geologic medium but does not set down any specific requirement that the primary containment be the geologic system. Section 2(18) of the Act defines the repository as follows:

"The term repository means any system licensed by the Commission that is intended to be used for, or may be used for, the permanent deep geologic disposal of high-level radioactive waste and spent nuclear fuel, whether or not such system is designed to permit the recovery, for a limited period during initial operation, of any materials placed in such system. Such term includes both surface and subsurface areas at which high-level radioactive waste and spent nuclear fuel handling activities are conducted."

The use of a multiple barrier system for accomplishing the isolation and providing a defense-in-depth approach is also identified, as is the need for possible retrieval of the material if deemed necessary during the operations and monitoring period:

"Such criteria shall provide for the use of a system of multiple barriers in the design of the repository and shall include such restrictions on the retrievability of the solidified high-level radioactive waste and spent fuel emplaced in the repository as the Commission deems appropriate." (Section 121(b)(1)B of the NWPA)

Several items indicate that the Yucca Mountain disposal concept, as described in this EIS, is indeed a geologic disposal concept. First, there is the reliance on the geology after eventual waste package failure to (1) contain those radionuclides that have a very low natural solubility in this geologic setting; and (2) control the movement of the more soluble fraction of radionuclides by having relatively little water available to aid movement. Of that more soluble fraction, the cationic (positively charged) radionuclide species are expected to be strongly sorbed to the minerals of the underlying tuff rock layers. Finally, the depth to water in the geology under and adjacent to Yucca Mountain essentially prevents inadvertent use of water for small-scale domestic or agricultural purposes until almost 20 kilometers south of the proposed repository.

Part of the compliance strategy is a defense-in-depth approach where various components of the engineered and natural system supply independent attenuation of dose impacts. To support the defense-in-depth case, a number of analyses have been performed where the contribution of individual components has been minimized by assuming a 95-percent failure of the component. The results, reported in the Science and Engineering Report (DIRS 153849-DOE 2001) indicate that the system is quite robust even with failures of individual components.

Refined models of the cladding have been developed as a result of additional available data and considerable effort since the Draft EIS. The new models are very conservative yet they indicate only minor cladding failures beyond the initial assumed failures for very long times. A sensitivity study of the contribution of cladding to the overall system performance presented in the Science and Engineering Report indicates that peak dose increases about 40 percent when the cladding is assumed to have failed completely (DIRS 153849-DOE 2001). This would increase the peak annual committed effective dose equivalent for the current design from about 150 millirem (about 40 percent of background) to about 210 millirem (about 60 percent of background).

In the Final EIS, the typical receptor is assumed to be an adult living at the distance chosen for the analysis. Only the impacts to this representative adult are presented in the EIS. DOE has determined that this amount of information is sufficient to identify the potential risks relative to making a decision under the applicable Federal regulations.

With regard to estimating dose to special groups within the general population (for example, children, pregnant women, and the fetus), DOE recognizes that metabolic models weighting factors [such as those described in ICRP (DIRS 101836-1991)] are constantly under study and refinement. This research will no doubt continue into the future. For this reason, DOE has decided to use the methodology specified by the regulatory standards for the Yucca Mountain Repository promulgated by the Environmental Protection Agency (40 CFR Part 197) and the Nuclear Regulatory Commission (10 CFR Part 63). This method of dosimetry is fully described in (DIRS 101075-ICRP 1979; DIRS 110351-ICRP 1980; and DIRS 110352-ICRP 1981). The dose conversion factors derived from this methodology and used in the EIS are provided in Federal Guidance Reports 11 and 12 (DIRS 101069-Eckerman, Wolbarst, and Richardson 1988 and DIRS 107684-Eckerman and Ryman 1993, respectively). In addition, the EIS has incorporated the reasonably maximally exposed individual (RMEI) concept, described in the preamble to 40 CFR Part 197, to project potential doses for long periods. In specifying its use, the Environmental Protection Agency stated that it believes:

". . . that the RMEI approach is sufficiently conservative and that it is fully protective of the general population (including women and children, the very young, the elderly, and the infirm). The risk factor upon which the dose level was established is very small, 5 chances in 10,000,000 per rem for fatal cancer. The lifetime risk then is this factor multiplied by the total dose received in each year of the individual's lifetime. We believe that the risk prior to birth is very similar to this risk level; however, relative to the rest of that individual's lifetime, the difference is small."

In addition, the Environmental Protection Agency defines the reasonably maximally exposed individual as an individual that has the food and water intake rates, diet, and physiology similar to those individuals in communities currently living in the downgradient direction of flow of the groundwater passing under Yucca Mountain. Thus, in estimating the risks to humans, DOE chose factors typical of individuals living in the Yucca Mountain region of influence, such as lifestyle, diet, water usage, farming and agricultural practices, and environmental parameters, that would lead to the highest exposures.

DOE recognizes that the Environmental Protection Agency has recently published an age-specific risk factor of 5.75 chances in 10 million per millirem for fatal cancer (DIRS 153733-EPA 2000). However, for the EIS, DOE used the values of 5.0 and 4.0 chances in 10 million per millirem for fatal cancer as recommended by the International Commission on Radiological Protection (DIRS 101836-ICRP 1991). Both the Environmental Protection Agency and DOE recognize that there are large uncertainties associated with these risk factors as expressed by the National Council on Radiation Protection and Measurements comment on the result of their uncertainty analysis in the risk coefficients that " … show a range (90 percent confidence intervals) of uncertainty values for the lifetime risk for both a population of all ages and an adult worker population from about a factor of 2.5 to 3 below and above the 50th percentile value" (DIRS 101884-NCRP 1997). DOE believes that the 15-percent difference in these risk factors is well within other uncertainties and would provide little additional information to the decisionmaking process that this document informs. For these reasons, DOE will continue to use risk factors recommended by the International Commission on Radiological Protection in its National Environmental Policy Act documents.

Chapter 5 of the EIS states the consequences of two repository operating modes in terms of radiological dose and converted to incremental lifetime risk (70 years) of contracting a fatal cancer. The estimates in the EIS assume a risk of 0.0005 latent cancer per millirem for members of the public, based on risk estimates provided by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993). Thus, there is no appreciable difference between the lifetime risk factors of the Environmental Protection Agency and National Council on Radiation Protection and Measurements, both of which capture the increased sensitivity of the fetus and children.

The Final EIS contains long-term performance results based on the newer design and improved models for Total System Performance Assessment.

7.3 (5942)

Comment - EIS001622 / 0045

Page 5-10, last paragraph. DOE states that water "would drip into the repository but only in a *relative few* (emphasis added) places." What percentage of the repository does DOE estimate will be affected by dripping water?

Response

The percentage of the repository waste packages predicted to be subject to dripping varies with the climate, the thermal-hydrologic state, and the region of the repository. For example, the Draft EIS reported that under the high thermal load scenario for the present-day (dry) climate and expected (nonstochastic) values, the fraction of waste packages affected by dripping water for modeled repository regions 1 through 6 would range from 0.0082 to 0.093.

Similarly, for the long-term average climate the fraction would range from 0.23 to 0.33 for these six regions. For the superpluvial climate used in the Draft EIS, the range was from 0.42 to 0.49 for regions 1 through 6. These values are illustrative in that they are deterministic (expected mean) values for a single thermal load scenario, and will differ for the other thermal load scenarios and vary stochastically in the full simulations used to prepare the long-term consequences.

Chapter 5 of the Final EIS presents results from analyses updated from those in the Draft EIS, in terms of design and climate and natural system modeling. The general pattern discussed above has not changed dramatically except that drip shields now afford further protection, and the superpluvial climate is now incorporated as a short-duration characteristic of any pluvial state. The latter change is reflected in the input parameter distribution for the pluvial condition of future climate.

The waste packages are subject to local and regional changes induced by these changing climatic conditions, sequentially, during the simulation. Using the above ranges from the Draft EIS, less than 1 percent of the waste packages would be dripped on under the present-day climate, but roughly 20 to 33 percent would be dripped on under potential future climates. If there were an equivalent episode corresponding to the Draft EIS superpluvial climate, about 45 percent of waste packages would see drips over a short duration. Waste package failure would occur over very long times, so that many waste packages would only be subject to dripping conditions during the wetter climates, and would be dry between. The releases that lead to the long-term consequences reported in Chapter 5 of the Draft EIS incorporated all of this information, and these models have been updated for the analyses reported in the Final EIS.

Experimental data, as documented in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000), show the corrosion of the waste package would be insensitive to the amount of water contacting it (as long as there was any water). The corrosion rate would be the same whether there was humid air or dripping water. The effect of seepage on waste package corrosion would not be significant.

7.3 (5975)
Comment - EIS001879 / 0007
The impacts of Yucca Mountain on the County's precious water resources are also of paramount concern. The Draft EIS confirms that proposed action will result in the release of radioactive contamination into the only source of water available to the community of Amargosa Valley; only the timing and magnitude of the releases are uncertain. Additionally, the proposed action has the potential to render the water supplies of the Town of Pahrump and all of southeastern Nye County vulnerable to contamination. The DOE's hypothetical maximally exposed individuals will, in reality, be Nye County citizens, real people with real families. The United States must guarantee that the future generations of Nye County residents will have a reliable supply of safe water.

Response
As stated in the comment, the EIS confirms that the Proposed Action would be likely to result in the release of radioactive contamination into the saturated zone that provides water to the community of Amargosa Valley. However, the EIS shows that these releases would well below regulatory standards within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations.

The general direction of groundwater flow from the Yucca Mountain site is south, with Franklin Lake Playa the most likely surface discharge point. Because Pahrump is southeast of Yucca Mountain and considerably out of the groundwater flow path, that community would not likely experience any groundwater impact.

7.3 (5982)
Comment - 010140 / 0004
Table 3-14, this table absolutely says there's no engineered barrier failure before 10,000 years. This is very optimistic and is based on a new magic bullet alloy. DOE wants the reader to believe that within one year the corrosion rates have decreased in either temperature scenario so as to have no failures. This is very suspect.

The last line of the table indicates that the actinides have a half-life of less than a million years. This is not true. All the waste packages have failed and I'd like to know what the controlling parameter was that made it only 800,000 years.

Response
DOE based the development of models that predict the performance of corrosion-resistant, nickel-based Alloy-22 in the repository on data from research literature and testing (including long- and short-term tests). The Department performs long-term tests under expected repository conditions, and short-term tests under expected repository conditions and very aggressive conditions. The American Society for Testing and Materials codified this approach

in a standard procedure (DIRS 105725-ASTM 1998). Analyses of the tests used a suite of tools, including standard microstructural evaluation and atomic force microscopy, which permits the examination of surface films in such great detail that even very slow degradation rates can be evaluated. DOE would continue to test samples of Alloy-22 and other alloys that would be exposed in the repository and in the laboratory for decades to confirm the results collected to date. In addition, DOE would explore analogs of Alloy-22 to provide confidence in its long-term performance.

DOE based its selection of materials on input from independent experts and laboratory tests, and from the actual performance of materials in full-size industrial applications. The corrosion tests involve Alloy-22 and other candidate waste package materials subjected to environments that are at least as aggressive as any expected inside Yucca Mountain. DOE would continue these tests during waste emplacement operations to confirm the expected waste package performance.

In the Final EIS, analyses have been refined and include early failures caused by defects in the waste package. The results show a very small dose from these failures. See Section 5.4 for more details.

7.3 (5988)
Comment - EIS001879 / 0012
The evaluation of chemically toxic constituents does not account for background concentrations that are already in the groundwater, decay products, nor the contribution from underground testing areas and other contaminant sources on the Nevada Test Site (NTS). The first constituent in Table I-13, barium, is used for illustrative purposes, but these comments apply to other toxic constituents as well. Table I-10 gives the inventory of barium placed in the repository as 19,000 kilograms and Table I-13 summarizes the release concentration for barium from the release of high-level radioactive waste due to the corrosion of a waste container using a “series of simple calculations.” Based on this methodology, barium was eliminated from further detailed analysis. However, the “series of simple calculations” fails to account for a number or factors.

If a leak from Yucca Mountain occurs, the concentration of barium in the groundwater will depend upon a number of factors including the form of the barium (as a salt such as barium sulfate or as a metal hydroxide resulting from the decay of dissolved cesium), the chemistry of the water (particularly the sulfate concentration), the chemistry of the formations through which the water flows (particularly with respect to whether or not reducing or oxidizing environments are present), and the ion activity of the Group IIA alkaline earth metals and the anionic species (typically Cl, SO_4, F,CO_3, HCO_3, etc.).

The ultimate concentration of barium (or any other constituent for that matter) must be based upon an understanding of the natural baseline concentration and the three potential additional sources: 1) the quantity released from the wastes and/or waste package; 2) the quantity resulting from the decay of radioactive isotopes released from the wastes or CRUD; and 3) the quantity that could be contributed from the underground testing areas located on the NTS. In assessing the total inventory of barium that will be released, the Draft EIS does not take into account the decay of cesium to barium. Cesium will be released from the dissolution of the waste materials and any cesium released will be fully decayed to barium in about 1,000 years. Any release of cesium from the repository, or its decay products, could lead to a significant increase in the barium concentration in the groundwater above the levels shown in Table I-13. After only one half-life for cesium (30 years), more than 23,000 kilograms of barium will have been created through the decay of cesium, an increase in the total barium inventory of more than 100 percent. The EIS should be revised to account for the decay of cesium, other toxic constituents, and the decay products of radionuclides in the evaluation of release concentrations and subsequent wellhead concentrations.

The release of barium from the wastes and/or waste package will depend largely on the specific barium salt (or salts) that form in the repository and the sulfate concentrations in the near field. Other anions available from the wastes and/or waste package may locally increase the solubility of barium to levels that effectively overwhelm the available sulfate through precipitation with a corresponding reduction in the sulfate concentration and a corresponding increase in solubility. A “front” of barium-enriched water may thus migrate away from the leaks in the repository in the form of a plume of contaminated groundwater.

The basis for the barium concentration limit listed in Table I-13 is not given in the Draft EIS. Table I-11 lists source concentrations for some toxic materials based upon solubility in repository water but does not include barium.

Given that natural concentrations of barium in public water supply systems in the United States average 0.043 mg/L [milligram per liter] and that the groundwater down gradient of Yucca Mountain has barium concentrations as high as 0.04 mg/L, the concentration limit of 0.00412 mg/L listed in Table I-13 is obviously too low. Similarly, the concentration limit listed in Table I-13 for manganese is 4.4 x 10-11 mg/L but the concentrations as high as 0.1 mg/L are known to occur in the groundwater down gradient of Yucca Mountain, almost ten orders of magnitude greater than the concentration limit listed in Table I-13. The rationale for selecting the constituents listed in Table I-13 should be presented in the EIS along with a clear explanation of how the concentration limits were derived and an explanation of why some of the contaminants occur at background concentrations one to ten orders of magnitude above the "concentration limit" listed in Table I-13.

The EIS must be revised to accurately present the concentrations of chemically toxic and radioactive constituents in the groundwater. The use of a "series of simple calculations" must not be used in lieu of more accurate tools, specifically chemical models that can account for the complexities of multiple contaminant sources, different receiving waters, variations in the formations through which the flow occurs, and the contribution of nonradiologic contaminants from the decay of radionuclides.

The dilution factors given for the chemically toxic materials are questionable (page I-19, Table I-13, and accompanying text). The Draft EIS gives no rationale for an order of magnitude dilution for the saturated zone. Presumably this factor is from the Total System Performance Assessment (TSPA). However, the TSPA clearly indicates that dilution factors may be as low as 1.0 or as high as 72. Thus the saturated zone dilution factor (based upon 100 realizations of the conditional, axiomatic performance assessment models) would range from one full order of magnitude less to 70 times greater than the value used in the Draft EIS calculations. A conservative approach based on simple calculations should use conservative values based upon the range of outcomes from the models, rather than a single expected value. The EIS should be revised accordingly.

With respect to the unsaturated zone, the Draft EIS used the ratio of the total cross-sectional of all waste packages to the total surface area of the repository. This simple approach takes the maximum credit for dilution. When coupled with the equally simplistic annual fractional release rates given on page I-18, the resulting approach is not conservative.

The well concentrations listed in Table I-13 and the accompanying text does not give any indication of the time since the release or the distance to the "well." The EIS should be revised to include this information. If the "well" is located at the point of the leak, then it should be so stated in the EIS.

With respect to the contribution of contamination from the NTS, the Draft EIS states (page 8-76) that the estimate of the maximum potential dose from the underground testing area has a high degree of uncertainty but that "the use of bounding assumptions ensures that any reduction in uncertainty would only lower the already low estimated impact." The statement is inconsistent with the assumptions used in the analysis regarding the removal of technetium through precipitation caused by reducing conditions along the carbonate aquifer flow paths, dilution in uncontaminated water from recharge over the NTS, and aquifer mixing with transport. These assumptions all tend to dilute the dose and are thus not conservative.

For example, technetium would not be removed unless flow is through carbonate aquifers, which has not been established over most areas and is known to be a hydraulic impossibility in some areas where the head in the carbonate aquifer is above the volcanic confining units. Recharge is not equally distributed over the testing areas so any uniform dilution with bulk recharge over the NTS would not result in a conservative dose estimate; rather, the approach takes the maximum credit for dilution from recharge. Assuming that all of the underground testing inventory would migrate through the same locations as releases from the repository is, as correctly stated in the Draft EIS, a conservative approach. However, without much more detail concerning the other assumptions and what specific dilution factors were used in the analysis, it is misleading for the Draft EIS to characterize the overall results as being conservative. The results are presented to the nearest 0.01 millirem, which implies a much greater degree of certainty than actually exists. The EIS should be revised to clearly state the assumptions, the values of the dilution factors that were used, and the uncertainty in the results.

Given all of these considerations, the wellhead concentrations listed in Table I-13 may not represent reasonably expected conditions, and must be recalculated and revised to include the baseline natural concentrations, the toxic materials generated by the decay of radioactive constituents, a range of dilution factors, and realistic concentration limits.

The Draft EIS does not clearly present how the concentrations used in the screening process and presented in Table I-13 relate to the concentrations presented in Table 5-17. The value presented in Table I-13 for the well concentration of chromium is 1.1 mg/L while the highest value in Table 5-17 is only 0.037 mg/L. These values suggest that chromium released from the repository at a maximum concentration of 300 mg/L is diluted by a factor of 8, 100 in only five km of transport. Such a large dilution factor is not considered likely and there is insufficient information given in the Draft EIS Chapter 5, Appendix I, and the TSPA to determine the validity of the numbers presented. The specific methods used in calculating the concentrations for chromium listed in Table 5-17 should be given. The EIS and its supporting documents should be revised so that the methods used in modeling the concentrations are clear and can be tracked by readers and decision makers.

With regard to Table 5-5, the text of the Draft EIS states, "(T)he values in Table 5-5 include a scaling factor for water use." The EIS should be revised to state the scaling factor value, and the rationale for the use of the scaling factor.

Later in the same paragraph the Draft EIS states, "The performance assessment transport model calculated the dose rates for the maximally exposed individual assuming dissolved radionuclides would mix only in water that flowed through the unsaturated zone of Yucca Mountain with no further mixing in the saturated zone aquifer. Infiltration through the Yucca Mountain repository accounts for only about 27,000 cubic meters of water per year. This compares to an annual water use in the Amargosa Valley of about 17.3 million cubic meters. **The analysis diluted the concentration of the nuclides in the 27,000 cubic meters of water throughout the 17.3 million cubic meters of water prior to calculating the population dose**," (emphasis added).

The rationale for the three order-of-magnitude dilution factor and resulting doses and latent cancer fatality (LCF) probabilities should be clearly stated in the EIS as being an artifact of the use of a 1990 population distribution and the use of an assumed dilution factor that is based on the entire water production of the hydrographic basin without regard for where that production occurs. The population of Amargosa Valley has gown since the 1990 census and Nye County projections suggest that growth in this community will continue into the foreseeable future. The use of the 1990 census data results in an overall analysis that is not conservative.

The dilution factor is not correct as it includes water that is not along the flow path between Yucca Mountain and a receptor population. For example, in 1998, more than 2,000 acre-feet of groundwater was used by the Barrick Bullfrog mine and the American Borate operations. The groundwater was produced from areas that are not between Yucca Mountain and the receptor population. The inclusion of the agricultural water production in the dilution factor is also questionable. In 1998, more than 12,000 acre-feet of groundwater were pumped for irrigation in Amargosa Desert. Only a portion of this production was derived from areas between Yucca Mountain and the receptor population, that is, from the area where the simulated plume would occur.

Finally there is some question as to whether or not any dilution factor of this type should be included at all. The approach used assumes that dilution will occur in direct proportion to the water extracted, and this might not be true. If the contamination were the result of a one-time release, then the contaminants would probably be diluted to some extent depending upon the location of the drinking water supply wells with respect to the contaminant plume. The contamination will be continuous, however, at the annual release rates provided in Section I.3.2.3.2 (page I-18) of the Draft EIS and will thus be far less likely to be diluted.

Receptors who rely on water pumped from a well having a capture zone that intercepts a portion of a plume will drink water that has contaminant concentrations represented by the relative proportions of the capture zone intercepting and not intercepting the plume. As the capture zone of a well is directly proportional to the volume pumped and the duration of pumping (and is also affected by the aquifer mechanics and the hydraulic gradient), a domestic well will typically exhibit a very small capture zone while an agricultural production well will have a much larger capture zone. Thus, the well of concern, that is the one used to supply drinking water, is likely to have far less dilution than an agricultural production well. The use of a simplistic approach toward dilution based on total water withdrawals is certainly not conservative and the evaluations should be revised using a range of realistic dilution factors.

Response
The basis for eliminating most chemical elements has changed in the Final EIS. Because of the new design, there would be a limited number of waste package failures in the first 10,000 years (one to three and possibly as many as five) and only a small fraction would fail even at 50,000 years. Therefore, an insignificant quantity of chemical constituents inside the package containment would be released in the first 10,000 years, the maximum period for evaluation of hazardous constituents. Constituents outside the waste package such as chromium from Alloy-22 have been further evaluated in the updated Appendix I and reported in Chapter 5. The inventory of barium has been corrected in the Final EIS to account for ingrowth from cesium decay. It should be noted however, that the "simple calculations" in the Draft EIS were conservative in nature because maximum source terms were calculated. All complex processes thereafter serve only to attenuate the value of these "simple calculations."

7.3 (5995)
Comment - EIS001879 / 0022
Comment: p. 5-39, Section 5.6 Consequences of Chemically Toxic Materials

An evaluation of the human health impacts from lead should be included in this section.

Response
DOE used a preanalysis (called a "screening analysis") in the EIS to determine if any potentially toxic materials would have a likelihood of producing a significant impact if they leaked from the repository. Section I.3.2.3.2 of the Draft EIS describes the first stage of the screening analysis. Using a very conservative estimate, the largest concentration of lead projected to reach a well 20 kilometers (12 miles) away would be a small percentage of the Maximum Concentration Level for lead (0.015 milligram per liter as established in 40 CFR 141.2; see Table I-13 of the Draft EIS.) This was the basis for eliminating lead from further evaluation, and the work to incorporate the new design strengthens this conclusion.

7.3 (5997)
Comment - EIS001879 / 0025
With regard to the groundwater measures under the proposed action, it must be clearly stated in the Draft EIS that in spite of all of the wonderful characteristics of the site, the Performance Assessment results indicate that the repository will leak and that the groundwater will be contaminated.

The statement that, "The sparsely populated hydrogeologic basin into which groundwater from Yucca Mountain flows is closed, providing a barrier to a general spread of radionuclides in the event waste packages were breached and radionuclides reached groundwater" is incorrect, misleading, and should be deleted from the EIS. The Jackass Flats hydrographic basin is not closed nor is the Amargosa Desert hydrographic basin. There is no barrier between the general spread of radionuclides from the repository to receptor populations in Nye County.

Response
DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. This EIS provides the Department's best estimate of the impacts that could occur when the containment system inevitably degraded. The updated analysis in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197), which would be between zero and five packages projected to fail due to manufacturing defects.

DOE has conducted an extensive program to determine the suitability of the Yucca Mountain site for a geologic repository. DOE recognizes that additional data would further define the flow system and reduce uncertainties about the interactions among the alluvial, volcanic, and carbonate aquifers in the saturated zone. Studies are planned to gather this information. Section 2.1.2.3 of the EIS describes the types of tests, experiments, and analyses that DOE would conduct as performance confirmation activities. This program would continue for perhaps for more than 300 years after the end of waste emplacement (through closure of the repository as described in Section 2.1.2.4). The purpose of the performance confirmation program is to determine if the repository is performing as predicted and discussed in Chapter 5 of the EIS.

DOE has initiated a program to evaluate the hydrologic processes in the saturated zone, particularly the hydrogeologic relationships between the volcanic, alluvial, and carbonate aquifers. This is currently being addressed through a cooperative agreement between Nye County and DOE, referred to as the Early Warning Drilling Program. Recent results from this program have been incorporated into the Final EIS; this program is described briefly in the next paragraphs.

The purpose of the Early Warning Drilling Program is to characterize and monitor the saturated zone along possible transport pathways from Yucca Mountain. DOE would continue to characterize the saturated zone south of Yucca Mountain through simultaneously collecting data from this program, in addition to using data obtained by Nye County scientists. These data would be used to refine the understanding of flow and transport mechanics in the saturated alluvium and valley-fill material south of the repository, and to update conceptual and numerical models.

In addition to the Early Warning Drilling Program, a series of test wells is planned along the groundwater flow path between the Yucca Mountain site and the town of Amargosa Valley as part of an Alluvial Testing Complex. The objective of this program is to better characterize the alluvial deposits beneath Fortymile Wash to strengthen the basis of the site-scale saturated flow and transport model. Single-well and multiwell tracer tests will be conducted using both reactive and conservative tracers. DOE supports continuing research in all aspects of the geology or hydrology that enhances the understanding of the site. If any critical information should be found, DOE would re-evaluate its impact on the suitability of the site.

7.3 (6027)
Comment - EIS001898 / 0001
In preparing the FEIS, NRC [Nuclear Regulatory Commission] also requests that DOE consider relevant technical comments previously submitted by the NRC. The NRC has provided such technical comments in reports on specific technical issues and in comments on DOE’s Viability Assessment in June 1999.

The comments on the Viability Assessment also address the issue of quality assurance (QA). DOE’s application of a rigorous and effective QA program is crucial to its ability to demonstrate the validity of its findings and analyses in any license application. The NRC staff will continue to evaluate DOE’s efforts to implement an effective QA program.

Response
DOE has an ongoing program to address Nuclear Regulatory Commission comments on the Viability Assessment and other technical issues, largely as they have been translated into its comprehensive listing of scientific modeling issues in the Commission’s Issue Resolution Status Reports (see, for example, DIRS 135160-Bell 1996; DIRS 154605-NRC 2000). Not all technical issues raised by the Commission are closed, but DOE has made and will continue to make a good faith effort to address each issue to the extent practicable. As reported in the Final EIS, the Department has made a number of modifications to the design of the repository and to the Total System Performance Assessment model that address Commission concerns. As of September 2001, the Key Technical Issues have all been declared “Closed-Pending” by the Commission.

DOE has made a similar best effort to address the status of model validation and data quality assurance. The Department recognizes that it needs to apply a rigorous and effective quality assurance program, and that doing so will be crucial to demonstrating the validity of findings and analyses in any License Application. In response to previous Nuclear Regulatory Commission comments in this area, DOE has established a schedule for achieving quality assurance goals by the time of the License Application, if Yucca Mountain is found suitable and approved for development of a repository. DOE has met interim quality assurance goals for the Site Recommendation phase.

In the September 6, 2001, Quarterly Meeting with the Nuclear Regulatory Commission, DOE outlined the transition plans for the respective quality assurance programs which would support becoming a licensee. The Commission indicated further evaluation of implementation of these plans would take place in approximately 6 months.

7.3 (6106)
Comment - EIS001654 / 0052
Another example of such potential confusion to the layperson is Table 5-7 displaying “peak radionuclide concentrations” in picocuries per liter for ten different radionuclides at four distances from the repository with both

mean and 95th percentile consequences. Such data may be helpful to the scientists involved in the repository design or later in license application review, but it lacks meaning to the non-expert.

What is the meaning of population dose? It is presented in terms of "person-rem." There is a definition in the box on page 5-25, but we are unaware that there is a proposed standard for such a parameter. It is calculated for the three thermal load cases but the explanation of the value of the data is not clearly presented.

Put another way, which data is the most appropriate figure of merit for radiological consequences:

- Peak dose rate (millirem/year)
- Population dose (person-rem), or
- Peak radionuclide concentrations (picocuries/liter)?

This section (5.4) should be revised and tied in more explicitly to the EPA [Environmental Protection Agency] proposed standards.

Finally, it would be helpful to make notation on all charts, such as Figure 5-4, when non-linear scales are use used.

Response
DOE carefully designed the formats of the tables in Chapter 5, such as Table 5-7 of the Draft EIS, to present the complex results of a stochastic analysis as simply as possible. The EIS must meet often-conflicting demands to be technically accurate and to acknowledge uncertainty, and at the same time to communicate impacts to the public. DOE used mean and 95th-percentile consequences to provide a sense of the expected behavior of the system and an acknowledgement of the prospect of poorer performance that would be possible given the uncertainties. DOE believes that this strikes a balance between the detailed presentation of full stochastic results (which might indeed interest only scientists involved in repository design) and the presentation of a single value that would fail to acknowledge the system uncertainty.

The population dose is the sum of individual doses in a defined population. It is a commonly used measurement for expressing impacts to a population rather than a defined individual. The commenter is correct in that there is no standard for this measurement. However, because there is interest in impacts to populations as well as to a reasonably maximally exposed individual, DOE has included it in the analysis.

Each measurement mentioned (peak annual individual dose, population dose, groundwater protection consequences) is appropriate for different purposes. For proposed regulatory standards expressed in terms of peak individual dose limits (or public interest in the highest dose to an individual), the peak annual individual dose (millirem) is appropriate. For interest in impacts for the local population as a whole, the population dose (person-rem) is appropriate. For groundwater protection standards (in addition to health-based dose standards), the peak radionuclide concentration (picocuries per liter) or drinking water dose (millirem per year) is appropriate.

The Environmental Protection Agency had not released its proposed Environmental Radiation Protection Standards for Yucca Mountain, Nevada (64 *FR* 46976, August 27, 1999) when DOE published the Draft EIS. The results described in the Final EIS address the final standards and include other information that may be of interest to the public and decisionmakers.

The suggestion to use additional notation to point out the use of nonlinear scales in figures is a helpful one, and DOE has inserted the additional notation in the relevant figures.

7.3 (6275)
Comment - EIS001639 / 0003
The EIS is flawed in that discussions concerning waterborne radiological consequences are vague. The tables and conclusions can not be independently verified because the various tables are presented with inconsistent units and without enough information to verify the conversion calculations. It is also impossible to trace information from one table to another. As a result the conclusions of the waterborne radiological consequences as presented are unverifiable.

Response
Without specific knowledge of which tables or calculations concern the commenter, DOE cannot make corrections or revisions to the EIS. In general, however, DOE acknowledges the complexity of the issues considered in the EIS and has extensively revised the document to improve readability. With regard to the presentation of quantitative information in the EIS (the presentation of numerical estimates, standard use of units, conversion factors, etc.), interested readers will need to read the cited reference material for a complete understanding of the derivation of, and interrelationships between, specific entries. Because of the volume and complexity of supporting documents, it is not feasible to publish the reference material as part of the EIS. Information on these documents is available from DOE on the Internet (*www.ymp.gov*) and at DOE Reading Rooms (listed in Appendix D).

7.3 (6278)
Comment - EIS001639 / 0005
When exploring the effects of a 27,000 cubic meter spill of contaminated ground water into the water supply of Amargosa Valley the EIS assumes dilution of the contaminates into the valley's entire yearly water usage of 17.3 million cubic meters. Clearly, the contamination would occur over a very short period and should have been diluted over the period of the spill. This calculation probably would have far exceeded the safe level of allowable radionuclides.

Response
The purpose of the repository is to protect the public health and safety as required by the regulations, such as the Nuclear Regulatory Commission regulations specifying licensing criteria at 10 CFR Part 63. The regulation specifies the critical group to protect, its location, and how to calculate the dose rate to the critical group based on the annual radionuclide release rate 20 kilometers (12 miles) from the repository and the annual water usage of the critical group.

The 27,000 cubic meters (7.1 million gallons) of water flowing through Yucca Mountain every year is an ongoing, continuous process, not a spill. Because the release would be continuous after a waste package began to fail, an estimate of dilution in the water used by the critical group is based on the ratio of water infiltrating through the repository footprint (that is, 27,000 cubic meters) and the annual water use of Amargosa Valley (that is, 17.3 million cubic meters). DOE believes that application of this dilution factor is conservative (that is, tending to overestimate impacts) because credit has not been taken for additional dilution that is likely to occur in the saturated zone.

7.3 (6349)
Comment - EIS001793 / 0004
It is known that the steel containment canisters last used to vitrify in an attempt to stabilize nuclear waste fuel rods would not remain intact for more than a few centuries in any known storage method.

Response
DOE agrees that the long-term protectiveness of the stainless-steel canister that surrounds the vitrified high-level radioactive waste form is limited. It is for that reason that the performance assessments discussed in the Draft and Final EIS took no credit for this material as a barrier.

The long-term performance analysis in the Final EIS conservatively neglected the potential benefit of stainless steel, which would be the inner barrier of the waste package, and thus neglects the potential delay to water entering a waste package provided by this barrier. Its function would be to provide structural strength for handling and emplacement of the waste packages. In addition, the high-level radioactive waste (in a glass matrix) would be in a stainless-steel canister. This canister would be inserted into the waste package and would be in contact with its inner barrier of stainless steel. Having the same metals inside each other would minimize the likelihood of crevice corrosion as water enters the cracks between the two metals. But in any event, for conservatism, the stainless-steel canister is not modeled as a barrier.

7.3 (6403)
Comment - EIS001632 / 0002
EPA [Environmental Protection Agency] could not always find data or explanations to support the conclusions drawn. A prime example of this is that EPA found insufficient data to support the prediction of the movement of radionuclides in the saturated zone beneath the repository. These data are needed to determine if the facility's

performance will satisfy applicable radiation standards designed to protect ground water resources and public water supplies. As you know, EPA has proposed standards applicable to Yucca Mountain.

Response
DOE assumes that the fundamental data referred to in the comment mean such things as aquifer properties, retardation coefficients, hydraulic heads, etc. Such data are detailed in the documents referenced in Appendix I of the EIS.

Appendix I contains detailed information in support of Chapter 5 of the EIS. As stated in the introduction to Appendix I, the long-term performance analysis was conducted using a TSPA model and supporting data derived from the TSPA models and data that support other Yucca Mountain Project documents. As also stated, the purpose of Appendix I is not to republish the large body of available information but to reference the sources of the information and describe any special additional modeling and data used for the EIS. Some common background material was duplicated as an overview to enhance understanding of the incremental material. Thus, much of the detailed data on saturated zone modeling in this EIS is from the *Total System Performance Assessment for the Site Recommendation* (DIRS 153246-CRWMS M&O 2000) and the *FY 01 Supplemental Science and Performance Analyses* (DIRS 155950-BSC 2001), as referenced in the Final EIS.

The Final EIS discusses the new Environmental Protection Agency standard (40 CFR Part 197).

7.3 (6443)
Comment - EIS001632 / 0016
Page 2-74, Section 2.4-3, first paragraph: The last sentence indicates that long-term (100 to 10,000 years) impacts were assessed only where DOE "could establish estimates of impacts." Were there any important impacts which were not assessed for this reason? If so, how does DOE plan to address them? (See 40 CFR § 1502.22)

Response
The full quote of the last sentence is:

"Because these projections are based essentially on best available scientific techniques, DOE focused the assessment of long-term impacts on human health, biological resources, surface-water and groundwater resources, and other resource areas for which the analysis determined the information was particularly important and could establish estimates of impacts." (Draft EIS, p. 2-74)

The intent of this statement is that DOE assessed all important impacts in the long-term period. No analyses were omitted because of inability to establish an estimate. Some resource areas (such as noise, utilities, and services) were deemed to have no foreseeable impact and no detailed analysis was necessary. DOE realizes that even the full quote is confusing and has, therefore, revised the language in the Final EIS.

7.3 (6501)
Comment - EIS001632 / 0036
Container breaches. The final EIS should discuss the expected scenarios for container breaches and the associated impacts on groundwater, taking into account groundwater contamination levels at various distances and under various repository loadings. These analyses should cross-reference discussions on impacts to groundwater.

Response
In the analysis of long-term performance, breaches of the containers were not treated as separate scenarios but rather the result of modeling a number of features, processes, and events that then lead to various types of container breaches. As such then, there are no expected scenarios for container breaches. The impacts to groundwater result directly from the overall scenarios considered: nominal or "undisturbed" scenario, volcanic events, and human intrusion. These are clearly differentiated in the Draft EIS and the Final EIS with regard to groundwater impacts. Container breach is merely a process that is component to these broader scenarios. The Final EIS points out that general corrosion is a primary process for failure driving the dose results for the whole post-10,000-year period. Section I.5.1 of the Final EIS discusses waste package failures versus time and discusses the modes of failure and the relationship to the annual dose history.

7.3 (6544)
Comment - EIS001632 / 0041
Long-Term Repository Performance: General Comment

EPA [Environmental Protection Agency] disagrees with certain aspects of the performance assessment described in Section 5 an in Appendix I. The Total System Performance Assessment, presented in the Viability Assessment for Yucca Mountain and captured in the draft EIS analysis, relies in some instances on extreme performance cases which either omit or overestimate certain effects.

EPA recommends using an approach--reasonable expectation--which focuses on a more realistic depiction of repository performance and which recognizes the inherent uncertainties in projecting repository performance over the long term. This more realistic approach projects the expected behavior of the waste containment and isolation system, but avoids extreme assumptions and use of unrealistic performance scenarios.

We believe the final EIS would be strengthened by identifying the more conservative assumptions used in the assessment. Identifying these would give the reader a better sense of the variability inherent in the estimates of repository performance and provide the public with a more balanced performance projection.

Response
In general, the uncertainty approach used in the EIS uses realistic ranges of values for inputs and, where possible, acknowledges the uncertainty. In some instances, conservative assumptions are necessary to avoid the possibility of understating the potential impacts of the proposed Yucca Mountain Repository.

An interesting outcome of a full uncertainty analysis of a system such as the proposed repository is that the use of "expected values" (for example, averages) for all parameters does not actually predict the expected outcome very well. Because of the skewed aspect of many input parameters to the models (a reflection of the real nature of the underlying data), the results predicted using only mean values actually produce a low-probability occurrence, usually in the 90th percentile or above of the outcomes predicted in a full stochastic assessment. Thus, it is more reasonable to perform a full stochastic assessment and report the expected outcome in terms of the statistics computed from the results. DOE did this in the EIS by reporting the mean outcome and the tail probability (95th percentile). However, the EIS has been revised to more clearly and more fully discuss both the modeling uncertainties and the degree of conservatism in the modeling.

7.3 (6546)
Comment - EIS001632 / 0042
Table S-1 on page 5-5 and the related discussion in sections 5.1 and 8.3.1.2.3 (Atmospheric Radioactive Material Impacts) fail to consider post-closure releases of radon from the spent nuclear fuel in the time period beyond 10,000 years. EPA's [Environmental Protection Agency's] proposed standards for Yucca Mountain at 40 CFR Part 197 require an analysis of the dose to a reasonably maximally exposed individual for the period beyond 10,000 years through the time of peak dose (64 *FR* 46976, August 27, 1999). The National Academy of Sciences' Yucca Mountain panel in 1995 estimated that the Yucca Mountain site would be stable on the order of one million years. The final EIS must therefore discuss releases of radon-222 (222 Rn), which will result from the decay of the considerable inventory of uranium in the spent nuclear fuel.

Response
Chapter 5 and Section 8.3.1 of the EIS now include analyses of atmospheric releases of radon-222 to the time of peak dose.

7.3 (6547)
Comment - EIS001632 / 0043
Section 5.5 (Atmospheric Radiologic Consequences) concludes that carbon-14 (14C) is the only radionuclide that has the potential for transport through the atmosphere. Likewise, section 8.3.1.2 addresses only 14C releases with respect to cumulative impacts. The draft EIS does examine the exposures to workers and offsite individuals from radon as a result of various operations. However, as noted by Sullivan and Pescatore ("Release of Radon

Contaminants from Yucca Mountain: The Role of Buoyancy Driven Flow," T.M. Sullivan and C. Pescatore, Brookhaven National Laboratory, PNL-52468, February 1994):

"Barometric and wind pumping at Yucca Mountain may cause long-term 222Rn removal from the oxidized spent fuel waste. The problem of enhanced 222Rn release to the accessible environment would pose itself later in time (after 20,000 years and peaking in roughly 200,000 years) and would last for as long as unsaturated conditions would prevail at Yucca Mountain."

Response
Chapter 5 and Section 8.3.1 of the EIS now include analyses of atmospheric releases of radon-222 to the time of peak dose.

7.3 (6548)
Comment - EIS001632 / 0044
EPA's [Environmental Protection Agency's] analysis of spent fuel radionuclide inventories in support of the promulgation of 40 CFR Part 191 (see EPA 520/4-79-007A, 1977) indicates a 222Rn [radon-222] content of about 1 curie per metric ton of heavy metal, at 100,000 years following discharge from a light water reactor. This would imply a repository inventory for 222Rn of about 63,000 curies at about 100,000 years for the currently authorized Yucca Mountain repository. Because of its energetic radiations and numerous daughter radionuclides, 222Rn presents a significantly larger risk per unit of radioactivity than 14C.

Response
Chapter 5 and Section 8.3.1 of the EIS now include analyses of atmospheric releases of radon-222 to the time of peak dose.

7.3 (6550)
Comment - EIS001632 / 0045
Section 5.5 also indicates (introductory paragraph) that impacts for the global population were estimated. What value was used for the projected collective dose received by the global population?

Response
The referenced statement in Section 5.5 of the Draft EIS is an error. There was no global population calculation performed for the Draft EIS. The statement has been removed.

7.3 (6552)
Comment - EIS001632 / 0046
Page 5-5: The final EIS should explain the statement on page 5-5 that chemically toxic materials were eliminated from consideration because "their total quantity would be very low and dilution in the repository environment would reduce their concentration to below toxic levels before they entered the saturated ground water system."

Response
The overview of the screening process in the Draft EIS referred to a process detailed in Appendix I. DOE believes that Appendix I provided sufficient detail for a full understanding of what was done. In the updated analysis presented in the Final EIS, a different screening process was used due to design changes. This new screening process is detailed in Appendix I and cross-referenced in Chapter 5 of the Final EIS. The discussion in Final EIS Appendix I was designed to provide as clear and comprehensive explanation as possible.

7.3 (6563)
Comment - EIS001632 / 0050
Page 5-43, Section 5.7.2, second paragraph: It would be helpful to have a graphic representation of the results of the volcanic activity analyses.

Response
Section 5.7.2 of the Final EIS presents dose history curves for the volcanic scenarios showing the mean and 95th-percentile curves along with lines for the nominal case for comparison to results for various volcanic disturbance scenarios and the undisturbed waterborne release results.

7.3 (6591)
Comment - EIS001380 / 0014
APPENDIX I (Environmental consequences of long-term repository performance), page I-25, section 1.3.3.

I am aware of the data in NRC [Nuclear Regulatory Commission] NUREG-2907 regarding routine radionuclide airborne and liquid releases from commercial nuclear power plants that generate 90% of the wastes targeted for Yucca Mountain. That compilation documents dozens of reportable radionuclides and noble gases that nuclear reactors and their fuel generate. It is known by everyone in the industry that tritium passes through nuclear fuel cladding. Why wasn't tritium included in the analysis in this section? Thus, I find the statement that "the only radionuclide that would have a relatively large inventory and a potential for gas transport would be C-14" to be ridiculous and very inaccurate. What does a statement like "relatively large inventory" signify, relative to what? To most of the public, the inventory is monstrous compared to any other nuclear repository in the world. This too brief paragraph needs to be rewritten to reflect the true facts.

Response
The majority of radionuclides routinely released from operating commercial nuclear reactors consist of noble gases and tritium. Although tritium is produced in the fuel rods as a fission product, the majority of tritium released by these plants is produced as a fission or activation product in the coolant water circulating outside the fuel rods. In addition, at high temperatures tritium will migrate through most metals, including those typically used as fuel cladding. However, once the fuel rods are removed from the reactor environment and allowed to cool, this process slows appreciably. On the other hand, most of the noble gases are produced as fission products inside the fuel rods. However, most of these gases have half-lives on the order of minutes or hours and are therefore of little consequence within days after the reactor is shut down.

Tritium, with a half-life of 12.3 years, will remain within the fuel rods for some time after shutdown, but migration through the fuel rods is not appreciable at temperatures experienced during storage or disposal. In addition, the analysis in the Draft and Final EISs indicates that all but about three waste packages are unlikely to fail within several thousand years. Therefore, the tritium contained within the waste packages would decay to inconsequential quantities before any releases to the environment would be likely. For this reason, tritium was screened out as a potentially important isotope for consideration of long-term repository performance.

The statement "relatively large inventory" implies what was said above. The use of the word "relative" in this context means in relation to other gaseous radionuclides in the repository inventory.

The radioactive inventory emplaced in the Yucca Mountain Repository would be large. However, prior to recommendation of the Yucca Mountain site for development of a geologic repository, DOE would have to provide a reasonable expectation that the repository could meet the environmental protections standards developed by the Environmental Protection Agency to protect human health and the environment (40 CFR Part 197).

7.3 (6637)
Comment - EIS001632 / 0072
Section I.3.2 states that waterborne chemically toxic materials that could threaten human health are present in materials disposed of in the repository, the most abundant being uranium, as well as nickel, chromium and molybdenum (used in the waste package). EPA [Environmental Protection Agency] agrees with the analysis on page 5-6 of the conditions under which waste materials disposed at Yucca Mountain could threaten human health: (1) the waste packages and their contents are exposed to water, (2) radionuclides and/or chemically toxic materials in the package materials or wastes become dissolved or mobilized in the water, and (3) radionuclides or chemically toxic materials are transported in water to an aquifer; further, such water must be withdrawn via a well or surface discharge point and used by humans as drinking water or in the human food chain.

Response
Thank you for your comment.

7.3 (6650)
Comment - EIS001522 / 0002
The DEIS is scientifically and empirically questionable because it repeatedly alleges that "in general the EIS analyses showed that the environmental impacts associated with the Proposed Action would be small" (DEIS, 1999, 2-74). This claim is questionable, in part, because it relies on a logical fallacy of composition. This fallacy consists of assuming that because something is true of the whole therefore it is true of the part, or assuming that a necessary condition for something to be true of a part is that it be true of the whole. Committing this fallacy, the DOE asserts that "no substantial impacts were identified; therefore, cumulative impacts…would not cause…concerns" (DEIS, 1999, 8-59). However, there could be no large impacts from radiological exposures over a given year, but the cumulative impact of these exposures could be great. For example, an annual chest x-ray might not be an important source of exposure, but having one every year for 30 years might have a substantial cumulative impact.

Another reason that the DOE errs in claiming that there will be no substantial impacts of the Yucca Mountain repository, over its life, is that the DOE's own peer reviewers unanimously concluded that it was impossible to show, scientifically and statistically, that the impacts would be small, because they could not be calculated; as the DOE peer reviewers noted, in a unanimous "Consensus Statement:

Many aspects of site suitability…predictions involving future geologic activity, future value of mineral deposits and mineral occurrence models…rates of tectonic activity and volcanism, as well as mineral resource occurrence and value, will be fraught with substantial uncertainties that cannot be qualified using standard statistical methods (Younker, Albrecht, et al, B-2).

Moreover, the National Academy of Sciences committee on Yucca Mountain admitted that it was impossible to calculate the effects of repository intrusion, something that must be known in order to conclude that the environmental impacts will be small (NRC 1995). The same Academy Committee also noted that it was impossible to predict human/social factors, such as institutional control of radioactive waste, beyond one hundred years (NRC 1995). If the National Academy believes that one cannot predict human intrusion and meaningful human behavior after 100 years, then the DOE DEIS (1999, 7-6) needs to explain how it can claim to predict what will happen 10,000 years into the future, and especially, that there will be no adverse environmental impacts as a result of the proposed Yucca Mountain facility. That is, it is scientifically impossible to conclude that the impacts of a repository, for thousands of years into the future, will be small, because it is impossible to know the future to the degree of precision necessary to draw this conclusion. There is no prior experience with permanent radioactive waste disposal on which to draw, and no nation has yet successfully employed permanent disposal.

Response
As part of its analysis of cumulative impacts, DOE attempted to quantify, where possible, the total radiation dose that may have been received by local residents from past activities in the Yucca Mountain area. The Department calculated the total risk to the population based on the assumption that radiation risks from actions evaluated in the EIS would be additive. However, the Department cannot, in this analysis, account for each individual resident's past or future radiation exposure. To do so would require accounting for lifestyle habits such as the frequency of airline flights, past residences in locations that receive substantially higher or lower cosmic radiation, the type and frequency of medical diagnostic tests and treatments, and a myriad of other factors. Therefore, the EIS provides a baseline estimate of the exposure of affected individuals in Chapter 3 and Appendix F and provides estimates of the incremental impacts from the Proposed Action in Chapters 4 and 6. In addition, in Chapter 8, the EIS identifies those actions that are imminent or reasonably foreseeable to add to these impacts to determine the overall cumulative impact estimates.

In the case of the quote in the comment from page 8-59 of the Draft EIS, the statement is referring to the evaluation of short-term environmental justice impacts. As discussed in Sections 8.2.13 and 8.4.2.1.2 of the EIS, environmental justice impacts would exist (1) if an activity would have significant environmental impacts and (2) if such impacts would have disproportionately high and adverse human health or environmental effects on minority or low-income populations. Under these criteria, DOE believes that there would be no significant impacts with regard to environmental justice.

The Total System Performance Assessment Peer Review panel stated "…the panel finds that, at the present time, an assessment of the future probable behavior of the proposed repository may be beyond the analytical capabilities of any scientific and engineering team. This is due to the complexity of the system and the nature of the data that now exist or that could be obtained within a reasonable time and cost." However, the panel also noted that the goal of the performance assessment is "whether it can be shown with reasonable expectation that the repository will comply with the applicable regulatory limits" (DIRS 102726-Budnitz et al. 1999). Reasonable assurance is the standard applied in the licensing of commercial nuclear facilities and has served the Nation well in terms of assuring safety in and around nuclear facilities. DOE maintains that it can perform projections of long-term behavior consistent with the regulatory goals of providing a reasonable expectation or reasonable assurance of compliance with dose-based standards.

The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can statistically incorporate them into the risk analysis. Chapter 5 of the Final EIS contains an assessment of the probability and effect of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

As discussed in Section 3.1.3.4 of the EIS, site characterization activities have found no economic deposits of base or precious metals, industrial rocks or minerals, or energy resources based on present use, extraction technology, and economic value. The operating gold and silver mines visible from the mountain are in a different type of rock than Yucca Mountain. Those rocks formed deep in the earth and uplift has exposed them. Yucca Mountain was formed by volcanic ash flow and ash fall.

Questions concerning human intrusion have been considered by DOE and are acknowledged to be an important issue because the future behaviors of humans cannot be predicted. The Nuclear Regulatory Commission and Environmental Protection Agency have specified in their respective regulations for Yucca Mountain the way to analyze human intrusion. The regulations describe a stylized calculation that attempts to address why humans would intrude into the repository. DOE incorporated the advice provided by National Research Council (DIRS 100018-National Research Council 1995).

DOE recognizes that there is uncertainty in both the scientific predictive capability and in the likelihood and nature of human error. Therefore, a defense-in-depth approach is being used that, for example, places a drip shield over waste packages to reduce uncertainties in repository performance that result from the inability to predict, with certainty, the locations and rates of water seeps into the repository. Multiple levels of validation are practiced to discover and fix errors. Multiple levels of sophisticated checking are being planned to ensure that the manufacturing of the engineered components would be as error-free as modern technology will allow. DOE is highly aware of the problems errors can cause and is doing its utmost to protect the public from both the short-term and long-term potential effects that could result from such errors.

DOE has adopted this defense-in-depth philosophy and a performance assessment methodology that accounts for the variability inherent in natural processes, limits to our knowledge and information, differing views of experts, unpredictability of some phenomena, and uncertainty in system behavior. The methodology is widely accepted both nationally and internationally. It is based on recommendations of the National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission. It conforms to international practices in other countries, including Member States of the Nuclear Energy Agency and the United Nations' International Atomic Energy Agency. Peer review groups with expertise in the analysis of environmental risks have endorsed the general approach.

DOE agrees that it is not possible to predict with certainty what will happen hundreds or thousands of years in the future. However, the same physical, chemical, and geologic processes active today would likely be active in the future. Thus models built to explain such processes as waste package degradation and radionuclide and water movement in the present are expected to be representative of those same processes in the future. Scientists from outside the Yucca Mountain Project evaluated the degree to which one may have confidence in the predictive ability of the scientific models. Though they supplied some critical observations, they also suggested work that could bolster the scientific basis of the modeling. This EIS shows the results of more than two years of work addressing those external review committee suggestions, and that work continues.

DOE believes that the EIS adequately analyzes and represents the possible range of environmental impacts at the repository and that the EIS is one of the documents that provides information to the decisionmaking process. Any decision to approve the site also requires the Site Recommendation document, which specifically addresses the case for compliance with the requirements of the Site Suitability Guidelines (10 CFR Part 963), which in turn incorporates requirements from regulations by the Environmental Protection Agency and the Nuclear Regulatory Commission. If this societal decision was made, the licensing process, with its focus on science and supporting detail, would help increase the basis for confidence in the long-term projections of potential risk. This EIS supports an important step in the decisionmaking process, but it is not the last step, and work will continue to increase the basis for confidence.

7.3 (6750)

Comment - EIS001522 / 0005

The DEIS allegation that environmental impacts of Yucca Mountain "in general…would be small" (DEIS, 1999, 2-74) is not only inconsistent with existing empirical data and with the DOE's own claims about groundwater, perched water, and upwelling, but this DOE claim is also logically invalid because it begs the question. It begs the question because the DOE has not yet determined many scientific facts whose validity is essential to drawing this conclusion. For one thing, to allege that future impacts would be small, despite the million-year lifetime of the repository, seems incredible, because it is impossible to predict the specifics of what will happen over so long a time frame. Also such DOE predictions are disguised as scientific when, in reality, they are no more than guesses.

Response

Council on Environmental Quality regulations require consideration of both "context" and "intensity" when assessing the significance of a Proposed Action (40 CFR 1508.27). The regulations also require that National Environmental Policy Act documents are written in plain language so the widest audience can readily understand them. As a consequence, DOE has used descriptive terms, such as "small," to help convey the relative impacts of various actions on the environment.

In keeping with these requirements and consistent with standards established by the Nuclear Regulatory Commission (DIRS 101899-NRC 1996), DOE has determined, in general, that "small" means potential environmental effects (with or without mitigation) that would not be detectable or that would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource. For example, human health impacts that do not exceed permissible levels as defined in Federal or state regulations are generally considered to be small because adverse health effects would be unlikely for exposure to these levels.

Although uncertainties will always exist in long-term predictions of complex system performance, DOE maintains that it can perform projections of long-term behavior that are consistent with the regulatory goals of providing a reasonable expectation of compliance with dose-based standards. The Department believes that the EIS adequately analyzes and represents the possible range of environmental impacts at the repository and that the EIS is one of the documents that can provide information to the decisionmaking process.

7.3 (6876)

Comment - EIS001522 / 0014

Throughout the Yucca Mountain DEIS, the DOE ignores factual events that are difficult, if not impossible to know, and then, despite these omissions, invalidly concludes that the impact from the proposed waste facility will be low. Consider some of these omissions: "The impact of such human intrusion was not included directly in the final presentation of results...the probability of human intrusion occurring was not modeled" (DEIS, 1999, 5-16). After ignoring crucial variables, such as human intrusion, that could cause massive environmental impacts, the DOE notes that it will use "insight based on the best information and scientific judgments available" in its analyses (DEIS, 1999, 5-17). Likewise the DOE says that, regarding radiological impacts on populations over long periods of time, "the DOE does not have the means to predict such changes quantitatively with great accuracy; therefore, the analysis does not attempt to quantify the resultant effects on overall impacts" (DEIS, 1999, 5-17).

DOE's ignoring key considerations, about which it is ignorant, is especially problematic because the very things about which it is most ignorant are those things to which conclusions about repository safety are most sensitive, and even the DOE admits this. For example, the DOE considers approximately 20 parameters and then assesses its confidence in its models' accuracy, as well as the sensitivity of the repository safety/performance, relative to each of these parameters. Interestingly, the DOE admitted that its confidence in its models for water seepage into drifts, in its models for transport of radionuclides through the unsaturated zone, and in its models for transport of radionuclides through the saturated zone, all were “low,” even through the significance of these parameters, for repository safety/performance, respectively, was “high,” “high,” and “medium” (DEIS, 1999, 5-22). If the crucial factors that affect repository safety are those about which DOE confidence is low then how is it that the DOE can allege that the proposed repository will have no significant environmental impacts? Obviously, if the DOE claims about low confidence are to believed, then they are not consistent with its claims about low impacts from the proposed repository.

Moreover, the DOE admitted that the peer review panel gave 145 pages of suggestions for improvement of its analyses, and then noted that “all of the suggestions are being addressed” (DEIS, 1999, 5-23). If even the peer review panel was critical of DOE efforts, then one wonders why the public should be railroaded into approval of the Yucca Mountain facility before all the concerns of the peer review committee have been dealt with. Indeed, these corrections should all have been completed before the DEIS was even submitted. To submit it prior to such correction is to show that DOE’s decision -- about moving forward on Yucca Mountain -- is completely independent of what expert scientists say. Since when are projects submitted for approval on the basis of a promissory note, a promise to remedy poor science that should not even have occurred in the first place? The peer review committee noted that “the report of the DOE failed to provide a statement of the ‘probable behavior of the repository’ as requested by Congress” (DEIS, 1999, 5-23). If the peer review committee is correct that DOE has not accomplished the Congressional mandate, then there is no reason, other than bias, that the DEIS should be presented for approval.

Response

The probability of human intrusion occurring was not modeled, but the possible consequences were qualitatively evaluated for a few intrusion scenarios. What this means is that DOE assessed the consequences of an intrusion event and stated them as if the probability was 1. Figure 5-7 of the Draft EIS shows dose history curves resulting from intrusion scenarios. In the case of the large intrusion scenario (the higher of the two scenarios analyzed) and the assumed high dissolution rate, the figure shows an estimated incremental dose increase of about 1 millirem per year over the undisturbed case. Thus, DOE did not ignore the human intrusion possibility but carefully analyzed it in a manner suggested by National Research Council (DIRS 100018-National Research Council 1995) and required by the Environmental Protection Agency’s recent *Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (40 CFR Part 197). The result reported in the Draft EIS was one-fifteenth of the standard set by the Environmental Protection Agency. The Final EIS includes an updated version of this analysis.

The quote “…the DOE does not have the means to predict such changes quantitatively with great accuracy...” from Section 5.2.4.1 of the Draft EIS refers to the movement of populations and changes in the magnitude of populations, societal habits, etc. This position agrees with recommendations of National Research Council (DIRS 10018-National Research Council 1995). In addition, the Environmental Protection Agency standard for the performance of the repository embraces this concept. Furthermore, the size of the population would have no effect on the fundamental long-term impact (dose to the reasonably maximally exposed individual) because that impact would concern a single hypothetical individual. Population dose would be estimated as a simple linear multiple of the number of people in the potentially affected area. Thus, DOE considered future population changes based on recommendations of the National Research Council and the Environmental Protection Agency, both of which Congress directed to participate in setting appropriate standards for the performance of the proposed repository [via Section 801(b) of the Energy Policy Act of 1992.

DOE acknowledges that the *Final Report/Total System Performance Assessment Peer Review Panel* (DIRS 102726-Budnitz et al. 1999) was negative in its comments on several important aspects. The Peer Review Panel did report that DOE had failed to provide a statement of the probable behavior of the repository. However, DOE feels that the panel interpreted the Congressional language narrowly. DOE believes that the intent of Congress was for the Viability Assessment (DIRS 101779-DOE 1998) to make a preliminary determination “…of whether it can be shown with reasonable assurance or reasonable expectation that the repository will comply with the applicable regulatory limits” [Energy Policy Act, Section 801(b)]. However, in the absence of final standards for Yucca Mountain at that time, DOE could not make comparisons to them.

The Peer Review report went on to say that:

"As noted above, the assigned objective of the TSPA-VA [Total System Performance Assessment-Viability Assessment] was to assess the probable behavior of the repository. In contrast, the objective for TSPA-LA [Total System Performance Assessment-License Application] will be to determine whether it can be shown with reasonable expectation that the repository will comply with the applicable regulatory limits. These are significantly different objectives, and recognition of this distinction should be an important element of the path forward to the TSPA-LA" (DIRS 102726-Budnitz et al. 1999).

The Panel did not intend for its recommendations to enable the calculation of "probable behavior," as it saw the meaning of that term. Rather, it thought that satisfying these recommendations would enable a determination "… of whether it can be shown with reasonable assurance that the repository would comply with applicable regulatory limits."

DOE has addressed many of the Panel's recommendations in the revised TSPA models used to support long-term performance analysis reported in the Supplement to the Draft EIS and in the Final EIS. This EIS and supporting reports describe the manner in which DOE has addressed these recommendations.

7.3 (6906)
Comment - EIS001784 / 0002
I worry about some of the basic scientific assumptions implicit in the Yucca Mountain EIS, specifically many assumptions are based on the DOE and NRC [Nuclear Regulatory Commission] being able to predict and plan for what will occur 10,000 years down the road. No, I didn't make a mistake -- I wish I had. The figure used repeatedly is 10,000 years, not days or months. To me, this is absurd rationalization. Suppose, for example, Yucca Mountain incurred a direct nuclear bomb attack and the stockpile was damaged or became unstable. How would that affect the carefully constructed 10,000 year timetable? We are assured the Yucca Mountain waste containers are invulnerable. However, there is abundant evidence of leakage from the current repository casks at nuclear power and weapons plants. Why hasn't this same degree of proposed engineering safety been built into existing facilities? After all, haven't the NRC and DOE been safeguarding us all along?

Response
Examination of the elements of the Total System Performance Assessment model can lead to the conclusion that many things have been left out of consideration. It is important to recognize that the model is a product of a much broader analysis of all possible features of the system, events, and processes that could be important to the behavior of the system. The development of the model proceeded as follows:

- Development of a list of possible features, events, and processes based on lists previously compiled on an international scale and on input from many experts

- Estimates of the effect on performance of each item on the list

- Estimates of the probability of occurrence of each item on the list

- Development of screening arguments for items to be deleted from further consideration in the model. These arguments are based on three major considerations:

  - Consequences
  - Probability
  - Regulatory considerations (some items are specifically eliminated in the regulations)

- Incorporation of appropriate items into the model

This screening process is documented in a Features, Events, and Processes Database that lists the items and screening arguments (DIRS 154365-Freeze, Brodsky, and Swift 2001).

The features, events, and processes considered in the process described above include such things as nuclear bomb attack events and others, in addition to expected processes such as the eventual degradation of waste packages over a long period of time. Therefore, the analysis provided by use of the Total System Performance Assessment model actually reflects a greater analysis that considered all conceivable things that could affect performance and is not, as characterized by the comment, a "carefully constructed 10,000-year timetable." Rather, it is a carefully constructed set of scenarios developed from a complete list of all that could be wrong or go wrong, and are known to definitely affect performance.

The experiments and analyses documented in the "Waste Package Degradation Process Model Report" (DIRS 151624-CRWMS M&O 2000) provide the basis for the waste package modeling and life expectancies. This report identifies and discusses each potential waste package degradation mode. The degradation model includes those modes that analyses did not screen out as highly improbable.

The longevity of the waste package is a principal factor in the Repository safety case. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of a thick inner shell of stainless steel and a thick corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). However, the updated analysis in the Final EIS projects between zero and five waste packages failing due to manufacturing defects.

There is obvious uncertainty associated with the extrapolation of experimental results for such long periods and the other human factors mentioned in the comment. DOE selected the design analyzed in the Final EIS to mitigate the uncertainties by adding features (such as the drip shield) to provide defense-in-depth. This provides greater assurance that the repository would meet its performance standards in the face of uncertainty.

DOE acknowledges that it cannot build a containment system that can provide perfect containment forever. The EIS provides DOE's best estimate of the impacts that could occur when the containment system inevitably degraded. The EIS confirms that the Proposed Action would likely result in release of radioactive contamination to the environment. However, the EIS shows that these releases under the Proposed Action would be well within environmental protection standards (40 CFR Part 197) within 10,000 years of repository closure, standards specifically enacted to ensure the safety of future generations. See Section 5.3 of the EIS for additional information.

7.3 (6947)
Comment - EIS000812 / 0004
I have read that groundwater studies have shown that tritium is present in the water in the unsaturated zone. This was not mentioned in the Summary. If in fact this is the case, tritium was unleashed by nuclear weapons testing in the area in the 40's, 50's and 60's. In other words, it has taken about 50 years for the tritium to percolate through the volcanic rock. The summary has stated that minor releases of gases and carbon 14 would happen from time to time. How long will it take for that material to filter through to the ground water. What will happen when the containers are breached (as there seems to be a good deal of agreement by all that this may happen in the future) and radioactivity is released into the ground water, maybe not in the next century, but in 2 or 300 years? What would be a plan of action to counteract this problem?

Response
It is true that the waste packages would fail in the distant future, and the gaseous release estimates given in Section 5.5 are based on the expected failure rates of the waste packages. Section 5.5.2 details the impacts to the local population. Because the resulting doses would be exceedingly small, no action would be taken to counteract them.

Note that the tritium (as well as chlorine-36) present deep in the unsaturated zone at Yucca Mountain arises mostly from ocean testing in the Pacific during the 1940s, 1950s, and 1960s, not from surface testing at the Nevada Test Site during the same period. This tritium and chlorine "signature" occurs throughout the world, and is still widely found in low-infiltration areas (deserts). Data gathered on the presence and distribution of these isotopes led to improved models of vadose zone hydrology for Yucca Mountain that recognize the possibility of more rapid movement of some of the infiltrating water. These improved vadose zone hydrology models were used in the Draft EIS. The Final EIS includes results based on improvements to these models since DOE issued the Draft EIS.

7.3 (7109)

Comment - 010229 / 0002

The supplement to the draft EIS shows, in Table 3-14, that the peak annual dose and the time of the peak are exactly the same for the higher- and lower-temperature operating modes. Because corrosion rates, coupled processes, and the size of the repository footprint are likely to be temperature-dependent, the Board is concerned that this result may reflect model limitations. In its September 2000 letter to the DOE, the Board identified a number of limitations in the DOE's performance assessment models that could hinder an accurate prediction of the effects of temperature on repository performance. The Board recommends that the DOE revise its performance assessment models to capture the effects of temperature more accurately, allowing an improved assessment of the merits of higher-temperature versus lower-temperature repository designs.

Response

In considering the points in this comment, it is important to focus on a fundamental idea: The period of significant heat release is very short compared to the lifetime of waste packages. Thus, even if the heat were to be detrimental to waste packages and performance in general, the heat is gone before any significant amount of waste package failures occur and thus has no important influence on long-term performance. This was seen in the Draft EIS case and also in the Final EIS case (see Section 5.4).

Sensitivity studies, which included a temperature sensitive model of corrosion, showed improved performance (less than half the mean peak dose that is reported in the Final EIS) (DIRS 155950-BSC 2001). The fact that there is improved performance is not surprising because the non-temperature-dependent model is conservative and actually uses what is essentially corrosion under all adverse conditions including high temperature. When the temperature-dependent model is employed, the conservatism of assuming a constant, higher rate is removed so that corrosion after the short heat pulse is much slower than that of the conservative model. Improved performance then results. Even in these sensitivity studies the higher-temperature operating mode results differ by about 30 percent from the lower-temperature operating mode (DIRS 154659-BSC 2001) because of the fundamental fact that the period of heat generation is short compared to package and drip shield lifetimes.

After consideration of the Draft EIS and a large body of subsequent study and analysis, DOE concluded that general lowering of repository temperature would not improve the overall long-term performance of the repository.

7.3 (7131)

Comment - EIS001879 / 0013

The Draft EIS presents an assessment of human health and safety that purports to meaningfully portray the risks associated with the repository. Unfortunately, this assessment is based on an approach that is fraught with uncertainty and plagued by a lack of data. Further, the results have been severely criticized by expert panels assembled specifically to evaluate the validity and results of the specific models used to predict risk associated with the proposed repository.

The Draft EIS analysis in Chapter 5 follows the approach recommended by the National Research Council, 1995 Technical Bases for Yucca Mountain Standards; hereafter referenced as NRC, 1995). In Section 5.2.4.1, the Draft EIS goes on to state "The analysis in this chapter follows the recommended approach, using as defaults societal conditions as they exist today; as such, **it is based on the assumptions that populations would remain at their present locations and population densities would remain at their current levels**," (emphasis added). The approach introduces uncertainty into the analysis and the basis for the assumption is not valid. The reference to NRC (1995) is taken out of context; the discussion to which it is germane is the NRC's consideration of a population-risk standard, not impact analysis in a NEPA [National Environmental Policy Act] document. The Draft EIS attempts to use the NRC discussion as a rationale for ignoring the present (1999-2000) population of Amargosa Valley and short-term (50 year) future growth in the area, which is very predictable.

With respect to the future number of cancer fatalities in the vicinity of Yucca Mountain, NRC (1995, page 61) states, "...the total number of fatal cancers cannot be known without knowledge of the number of future persons residing in the Yucca Mountain vicinity. This number is obviously unknowable." Further, the NRC (1995, page 63) states, "For identifying the distribution and the varied lifestyles of a larger population, more assumptions of greater uncertainty would be required. The resulting data for a risk assessment would become so arbitrary that no adequate decision basis would result. **We therefore conclude that there is no technical basis for establishing a**

population-risk standard that would limit the risk to the nearby population for a Yucca Mountain repository," (emphasis added). Later in the same report (NRC, 1995; p. 96) additional findings are made with respect to future populations and future scenarios, "**(A)s far as we are able to determine, there is no sound basis for quantifying the likelihood of future scenarios in which exposures do or do not occur; about all that can be said is that both are possible .... Any particular scenario about the future of human society near Yucca Mountain that might be adopted for the purposes of calculation is likely to be arbitrary, and should not be interpreted as reflecting conditions that eventually will occur,**" (emphasis added).

DOE clearly disregarded these portions of the cited document in the preparation of the Draft EIS insofar as Tables 5-5, 5-9, 5-13, 5-13, 8-40, 8-44, and 8-48 all contain population-based impacts that are based upon the arbitrary assumption that the population levels in 10,000 years will be the same, and will be distributed in the same manner as in 1990. As a consequence, the information in these tables is misleading, is based upon a number of other arbitrary assumptions, and does not provide an adequate decision basis. The decision maker, when reading these tables, might misinterpret the values to be based upon proven science, an adequate database, and logical assumptions, when in fact the values are based upon an unrealistic scenario, inadequate data, arbitrary assumptions, and questionable judgment. These tables must be deleted from the EIS.

Section 5.2.4.2 has the heading "Uncertainty Associated with Currently Available Data," yet contains nothing about this uncertainty. Rather, the entire discussion is a synopsis of the DOE's plan to collect additional data to reduce the amount of uncertainty. The entire discussion in this section should be deleted and replaced with a discussion of the adequacy of the existing database (not the results of models, but rather actual data) for each key parameter in performance assessment. The section should clearly state that the data used to support the TSPA [Total System Performance Assessment] did not include any permeability, porosity, transmissivity, storativity, groundwater age, or water chemistry data for the area between Yucca Mountain and the closest receptor population, in the Lathrop Wells area of Amargosa Valley. This section should also make it clear that the corrosion rates, fractional release rates, and other key parameters used in the TSPA are based upon inadequate testing and measurements.

Section 5.2.4.3.5 ("Confidence in the Long-Term Performance Estimates") does not accurately summarize the uncertainty associated with long-term performance estimates. For example, Table 5-3 lists the confidence in models to reasonably represent specific impacts and processes, and the significance of uncertainty to the estimate of performance, and cites the Viability Assessment as the source document for the information presented in the table. A review of the corresponding portion of the Viability Assessment (Volume 4, Section 2.2.4.1) reveals that the significance of uncertainty estimates were made "by considering quantitatively the effects of uncertainties associated with each principal factor on the peak dose rate calculated by TSPA. Judgments were then made taking into account limitations of the quantitative approach." The EIS should be revised to state that the significance of uncertainty measures listed in Table 5-3 is based upon judgment.

Additional uncertainty is contributed from the time periods used for analysis. The Draft EIS breaks the analysis into two periods: 1) construction, operation, and monitoring and closure through the year 2025; and 2) long-term repository performance during the first 10,000 years after closure. However, the Draft EIS does not have comparable evaluations for both periods of time nor does the Draft EIS present the consequences of radionuclide and hazardous chemical contamination for the period between closure and 10,000 years after closure and simply states that "all peaks [for radionuclides] occur at or near 10,000 years." This statement appears to be based on the results of the TSPA-VA [Total System Performance Assessment – Viability Assessment}, which used bulk permeability values that were based either on expert elicitation or the results of the USGS [U.S. Geological Survey] site-scale model. The use of bulk permeability values does not yield a conservative result, but rather an average result. In actuality, the permeability values vary considerably and result in a similar variability in groundwater travel times and hence breakthrough curves for contaminants at a given distance from Yucca Mountain. Of importance with respect to groundwater flow and contaminant transport is that flow will predominate through preferential pathways that exhibit the fastest, not the bulk permeabilities.

Further, the statement is inconsistent with the findings of the TSPA-VA, which indicate that several specific contaminants have breakthrough curves that peak well before 10,000 years, such as technetium, plutonium on colloids, carbon-14, and others.

Response
DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency, and Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex systems over long periods. In 10 CFR Part 63, the Nuclear Regulatory Commission acknowledges that "proof that the geologic repository will conform with the objective for postclosure performance are not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation." In 40 CFR Part 197, the Environmental Protection Agency establishes "reasonable expectation" as a test of compliance, with diminished "weight of evidence" with time. The Agency also recognizes the need for expert judgment in assigning scenario probabilities, selecting simulation models, and assigning parameter distributions. Consistent with National Academy of Sciences observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events.

DOE confidence in the disposal techniques is based on defense-in-depth that, for example, would place drip shields over waste packages to account for uncertainties. DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components. DOE believes this process results in a representative estimation of impacts that is sufficient for comparing the relative merits of the various repository scenarios, including the preferred alternative. DOE continues to evaluate the sufficiency of its approach to dealing with uncertainty at the process level (scientific) and the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before License Application, should the repository be recommended as a suitable site.

With regard to criticism from expert panels, DOE welcomes the reviews and suggestions provided by the Total System Performance Assessment Peer Review Panel and other groups and individuals. DOE has responded to these organizations by improving models and incorporating design enhancements to reduce uncertainties in long-term performance predictions. DOE has incorporated responses to the comments of the expert panels in the analyses conducted for Supplement to the Draft EIS and the Final EIS.

For the Final EIS, DOE projected Nye County population through 2035 (see Section 3.1.7). Figure 3-25 shows estimated residences within an 80-kilometer (50- mile) radius of the repository. The Department also projected population through 2035 for each sector within the grid. The Nye County population projections and allocation of population to grids within the 80-kilometer area includes Amargosa Valley. DOE has revised the discussion of conservatisms, limitations, and uncertainties associated with potential radiation health effects in Section F.1.1.5.

Although DOE recognizes that the National Research Council rejected a population risk standard in favor of an individual risk standard, it has traditionally included potential impacts to affected populations in its National Environmental Policy Act documents as a measure for use in the decisionmaking process. When providing these estimates, the Department is careful to state all important assumptions and limitations applied in the calculation and interpretation of the values. For example, the text discussing the summary population impacts (see Table 5-17) states that adverse health impacts would be unlikely to result from groundwater contamination. The updated population dose analysis in the Final EIS uses the updated 2035 population values.

In general, it is DOE policy to not republish details in an EIS that are available in other public documents because of the enormous volume of this supporting material. A detailed discussion of the database in the EIS would be voluminous. The intent of the discussion in Section 5.2.4.2 of the Draft EIS was to provide the reader an understanding of how DOE handled uncertainties in the projections. DOE has improved cross-referencing to help the reader find such details in the Final EIS. In addition, DOE the Department incorporated data from many of the studies discussed in the EIS characterizing the area near the Lathrop Wells area -- much of this from well testing by Nye County. A significant amount of additional data from seepage and heater testing has been used in both model formulation and in data used in the Total System Performance Assessment. Comprehensive data from new Alloy-22 corrosion tests have been incorporated, as has a new suite of colloid transport models. Details of most of the data and associated uncertainties are in various Analysis/Model Reports and Process Model Reports referenced in Section 5.2.4 of the Final EIS.

Section 5.2.4.3.5 of the Draft EIS was partially based on judgment but also on a number of sensitivity studies in the Viability Assessment (DIRS 101779-DOE 1998). DOE agrees that the judgment aspect should have been stated more clearly. This section required a complete rewrite because of large revisions to the design and the performance assessment models. DOE has deleted the section, including Table 5-3, and instead has provided a discussion of unquantified uncertainties from an ongoing study. In addition, many referenced sections of other supporting documents provide further insight into the modeling confidence.

DOE is not sure what thus comment means by "comparable evaluations" for preclosure and postclosure-to-10,000-year periods. Each of these evaluations has many unique aspects including how the public could be exposed and many processes unique to the time scale involved. As such, they would be two different types of analyses. Because it is much harder to account for processes and properties over many thousands of years, the uncertainties are much more extensive in the second period. The only comparable feature then would be the result, forecast of dose to the public, and this is included in the analysis. Chapter 5 of the Draft EIS reports a third period (10,000 to 1 million years), and the consequences (as dose or concentration) of radionuclides and hazardous chemicals for the period from closure to 10,000 years. The statement that peaks would occur at 10,000 years is for the closure-to-10,000-year period. This is because the dose curve would still be rising at that time. Because the discussion of peaks was for the total dose from all radionuclides, the statement is true even though some individual contributors (especially short-lived radionuclides) could have peaked before 10,000 years. Furthermore, Chapter 5 reports the all-time peaks as the 1-million-year results. These peaks would be higher that those for the 10,000-year period and would occur much later. With regard to bulk permeabilities, the model in the Draft EIS was much simpler than that used in the Final EIS, but all key parameters were sampled over a wide range, including very pessimistic values that could contribute to doses from preferential pathways. Thus, the long-term dose forecast contains much higher values for the 95th-percentile case than for the mean. Pessimistic situations such as preferential pathways, lower sorption values, and less dispersion are accounted for in the very wide distributions sampled in the probabilistic formulation. These are manifested in the 95th-percentile values given in the EIS.

7.3 (7137)
<u>Comment</u> - EIS001898 / 0017
The methodology for estimating the environmental impacts from the release and transport of toxic materials should be well documented in the FEIS. The estimates should incorporate the current waste package materials and design.

Basis:

The release and transport of toxic materials (chromium (Cr) and molybdenum (Mo)) from waste package corrosion to a receptor group was modeled using the EQ6 geochemical speciation code (Figure 1-1). It is unclear how this code was used to estimate the corrosion products or the corrosion rate for toxic materials.

The assumed dissolution rates and mineral formation kinetics are critical to substantiating the claim that release and eventual exposure of a receptor group to the potentially toxic waste package corrosion products (e.g., chromate, molybdate) is minimal as stated in Section 5.6 (Environmental Consequences from Long-Term Repository Performance-Consequences from Chemically Toxic Materials).

We understand that DOE is expected to select Enhanced Design Alternative II (EDA-II) for the potential license application in the near term (TRW, 1999). EDA-II includes an outer overpack of 5cm thick Alloy-22. The DEIS design includes a 2cm thick inner overpack of Alloy-22, so the quantities of Alloy-22 will more than double, even assuming constant numbers of waste packages, if the EDA-II design is used. Because Alloy-22 is approximately 56 percent Ni by weight, the volume of Ni present in the repository is considerably more than the amount of Cr and Mo present. In addition, nickel (Ni) will also likely dissolve at roughly the same rate as Cr and Mo during corrosion. The FEIS should document that Ni does not pose a health risk.

Recommendation:

The discussion of toxic materials should be consistent with the current waste package design at the time of the FEIS. DOE should provide the technical basis for waste package corrosion rates, and should provide technical support for claims that exposure to potentially toxic materials released by waste package corrosion is minimal.

Reference:

TRW Environmental Safety Systems, Inc., *License Application Design Selection Report*. B00000000-01717-4600-00123. Revision 01. Las Vegas, NV: TRW Environmental Safety Systems Inc. May 28, 1999.

Response
The Draft EIS methodology for estimating source concentrations was detailed in Appendix I on pages I-15 to I-18 (Section I.3.2.3.1). This section describes in detail how the values in Tables I-11 and I-12 were developed using the EQ3/6 software. The values in Tables I-11 and I-12 were then used to develop the screening information in Table I-13 as explained in section I.3.2.3.2 (pages I-18 to I-19). This screening process determined which elements required more rigorous analysis (taking into account many other mitigating processes). Chemicals eliminated in the screening process demonstrated such low potential concentrations, in these calculations, that more rigorous analysis (which would account for additional mitigating processes) was unnecessary to establish there would be no significant impacts. In the screening analysis, EQ6 simulations of the reaction of the solution resulting from corrosion with the host rock demonstrated that nearly all the dissolved nickel would precipitate (resulting in a concentration of only about 0.0001 milligram per liter) upon contact with the crushed tuff invert (see Draft EIS Table I-12 and accompanying discussion). For this reason, nickel was not considered further in the impact analyses. Detailed analysis for those chemicals not screened out are described in Section I.6 of the Draft EIS. This material was referred to in Chapter 5 of the Draft EIS on page 5-39.

The Final EIS analyzes the new waste package design (Alloy-22 outer shell with stainless-steel sleeve). The new analysis conservatively assumes the nickel reaction with tuff would not take place. As detailed in Section I.6 of the Final EIS, bounding calculations (not taking into account many mitigating processes) still indicate a nickel concentration producing only a small fraction of the oral reference dose for nickel.

7.3 (7232)
Comment - EIS001337 / 0108
Page 5-6 Section 5.2. The postulated sequence of events does not include the potential for atmospheric releases due to volcanism, gaseous releases, and human intrusion. Other possible sequences of events relating to atmospheric pathways should be described and analyzed in the DEIS.

Page 5-16 3rd paragraph. Why did the DEIS not consider the potential for portions of the content of a waste package to be brought to the surface as a result of drilling induced human intrusion? Such an occurrence seems more plausible than release to the water table and would likely occur prior to drilling reaching the water table. In practice, a drill penetrating a cask would likely result in fatal exposure to the drill crew at the surface and drilling would likely not proceed to the water table.

Page 5-49 Section 5.10. Table 5-19 should also show LCF’s [latent cancer fatalities] during the year of projected peak dose, which is expected to be some time after 10,000 years.

Response
The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probabilities and effects of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

One change in the EIS is that now there is an aerial pathway release from the analyzed eruptive scenario. The dose rates in Chapter 5 are well below the 40 CFR Part 197 environmental protection standards. In addition, Section 5.5 discusses the potential impacts associated with atmospheric releases.

The drilling intrusion scenario is a prescribed scenario defined in the regulations (40 CFR Part 197 and 10 CFR Part 63). As prescribed the scenario does not provide for effects on the drilling crew or any other transport to the surface.

In the preamble to 40 CFR Part 197, the Environmental Protection Agency recognized that, while there is no scientific basis for limiting the time period of the individual risk standard to 10,000 years or any other period, there is considerable uncertainty that current modeling can provide meaningful projections for tens of thousands to hundreds of thousands of years. The preamble states that "Simply because such models can provide projections for those time periods does not mean that those projections are either meaningful for decisionmakers or accurate." It further states that " … as the compliance period is extended to such lengths, uncertainty increases and the resulting projected doses are increasingly meaningless from a policy perspective."

The Environmental Protection Agency requires a calculation of peak dose (40 CFR 197.30) within the period of geologic stability, which is 1 million years for the repository. The Agency requires DOE to include these results and their bases in the EIS for Yucca Mountain as an indicator of long-term performance. This analysis also serves as another source of information for the decisionmakers in making both design and licensing decisions. However, the Agency has recognized the inherent uncertainties associated with these long-term projections and has, therefore, not applied a regulatory standard to the results. Therefore, DOE considers estimates of resultant health impacts to be too speculative and has not included them in the EIS.

7.3 (7404)
Comment - EIS001957 / 0023
Section 5.4 Waterborne Radiological Consequences -- This section of the draft EIS does not address potential waterborne radiological consequences to Death Valley NP [National Park], its resources, staff, or visitors from water from the regional groundwater flow systems overlain by the proposed repository. Analysis of those potential impacts must be completed in the final EIS.

Also, there is little explanation of the basis for the estimation of a 1,150 person-exposure to possible groundwater contamination events within 50 miles of the proposed site. We are concerned this underestimates the current combined population and daily visitation in the area, and is even more inconsistent with projected trends into the foreseeable future.

Response
As described in Section 3.1.4 of the EIS, DOE has conducted an extensive program to characterize the direction and nature of groundwater flow from the Yucca Mountain site. The general path of water that percolates through Yucca Mountain is southward toward the Town of Amargosa Valley, then beneath the area around Death Valley Junction in the southern Amargosa Desert. The groundwater beneath Yucca Mountain merges and mixes with groundwater beneath Fortymile Wash. This groundwater then flows toward, and mixes with, the large groundwater reservoir in the Amargosa Desert. The natural discharge point of this groundwater occurs farther south in Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume may flow south toward Tecopa into the southern Death Valley area. A fraction of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks at the southeastern end of the Funeral Mountains toward springs in the Furnace Creek area of Death Valley. Potentiometric data indicate that a divide could exist in the Funeral Mountains between Amargosa Desert and Death Valley. This divide would limit discharge from the shallow flow system, but would not necessarily affect the flow from the deeper carbonate aquifer that may contribute discharge to springs in the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Potential Furnace Creek area impacts would be less than the low impacts described in Chapter 5 for Franklin Lake Playa because impacts would decline with distance from the repository.

The 1,150-person figure referred to in the comment can be found in Section 5.4.1 of the Draft EIS and represents the estimated population of residents that would continue to live in the present location. The Final EIS uses a figure of 74,000 people based on the projected population for 2035 (see Figure 3-20a of the Final EIS). This figure is much higher than the Draft EIS because a much wider population was included (the whole southern half of the population plot) for conservatism and the total population also increased somewhat from the year 2000 figures used in the draft. Because it is impossible to make accurate predictions of future lifestyles and residence locations, the approach used to estimate the potentially affected population is consistent with the recommendation made by the National Academy of Sciences (DIRS 100018-National Research Council 1995). The population estimates in the Final EIS have been revised to reflect the most recent population data. Section 3.1.7 of the EIS describes the derivation of population estimates and Section 3.1.8 discusses an 80-kilometer (50-mile) population grid.

7.3 (7580)

Comment - EIS001912 / 0070

Pg. 5-1 para. 2 states, "Therefore, analysis of impacts to land use, noise, socioeconomics, cultural resources, surface water resources, aesthetics, utilities, or services after closure is not required." Given that the actual consequences of long-term repository performance is unknown, dismissing impacts to these resources is inappropriate at this time. These resource impacts may be relevant under a worst case scenario.

Response

The cited statement needs to be placed in context. No analysis of the listed subject areas would be required for the long-term postclosure period because no activities would take place that could affect these resource areas. All impacts to these areas would take place before final closure.

The EIS presents the long-term performance results in probabilistic terms – a mean and 95th-percentile result. This statistical spread reflects the range of possible behavior DOE believes is credible for the repository system based on wide ranges of parameters. As such, the "worst case" is contained within the range of results. The worst case could be realized as the results approached at the 100th percentile.

7.3 (7603)

Comment - EIS001912 / 0074

Again a worst case scenario needs to be included in the analysis of long-term repository performance. Potential impacts to resources such as land use, consumptive water use, impediments to growth and loss of property values need to be considered if the worst case scenario show a potential for radioactive waste contamination to exceed regulatory levels.

Response

The EIS presents the long-term performance results in probabilistic terms—a mean and 95th-percentile result. This statistical spread reflects the range of possible behavior DOE believes is credible for the repository system based on wide ranges of parameters. As such, the worst case is contained within the range of results. The worst case could be realized as the results approached at the 100th percentile.

The potential long-term (10,000-year) consequences of the proposed repository are presented in Section 5.4 of the Draft EIS and include estimated groundwater concentrations of radionuclides (Table 5-7) for each of the three thermal load scenarios evaluated. In addition, potential consequences (radiation dose) and human health impacts (latent cancer fatalities) resulting from consumption and irrigation of food and feed crops are presented (Tables 5-4 and 5-5), for both reasonably maximally exposed individuals and populations for the three thermal load scenarios evaluated. These estimated consequences are a small fraction of the environmental protection standards (40 CFR Part 197) promulgated by the Environmental Protection Agency for the proposed Yucca Mountain Repository to ensure protection of the environment and human health. Therefore, DOE expects no adverse radiation-related health impacts of any kind to the population around Yucca Mountain within 10,000 years of repository closure. In addition, whereas the repository design evaluated in the Draft EIS projected small releases within the 10,000-year compliance period, the enhanced design evaluated in the Final EIS projects that the Proposed Action probably would result in even smaller releases of radioactive contamination to the environment in the first 10,000 years after repository closure.

With regard to potential impacts to regional use resulting from groundwater contamination, the new analysis presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than .0001 millirem, including milk pathways, which is more than 100,000 times less than the individual protection standard set by 40 CFR Part 197.

The long-term impacts on land use and property values are too speculative to be meaningful. After closure, DOE would not modify or develop additional land. Therefore, all direct land-use impacts would have occurred before closure. Secondary impacts to such resource areas as socioeconomics or land use would come from groundwater contamination outside acceptable limits, but the EIS analysis shows there would be no case resulting in contamination levels exceeding acceptable limits.

7.3 (7616)
<u>Comment</u> - EIS002027 / 0003
What will we do when or if it gets in our water?

<u>Response</u>
The EIS analyzes the process of waste package failure and radionuclide migration; Chapter 5 presents the results of the analysis as estimated dose to groundwater users after repository closure, at various distances from the Yucca Mountain site. Because these estimated doses would meet regulatory and licensing requirements, the potential impact to the population would be in the range where no additional water treatment would be needed for domestic or agricultural use of groundwater at the populated locations. If the analyses determined that the repository would not meet the requirements, DOE could not recommend the site, because it cannot plan to mitigate impacts thousands of years in the future.

7.3 (7618)
<u>Comment</u> - EIS001912 / 0109
None of the discussion in the long-term performance section has much to do with mitigation. It has more to do with site selection, design, and defense in depth. Without these measures it is doubtful that DOE would even have a proposed action which could meet regulatory standards.

<u>Response</u>
Section 9.2.10 of the EIS discusses mitigation measures related to the long-term performance of the repository. DOE regulations (10 CFR 1021.331) require preparation of a Mitigation Action Plan when mitigation measures are identified in a Record of Decision. Because DOE does not anticipate issuing a Record of Decision, a Mitigation Action Plan might not be prepared. However, the Yucca Mountain site, if approved consistent with provisions of the NWPA would be subject to licensing by the Nuclear Regulatory Commission. DOE, in submitting its application to construct and operate the repository, would identify relevant commitments and contingencies, including those identified in the Final EIS, for consideration. DOE would reasonably expect a comprehensive set of mitigation measures or conditions of approval to be part of the licensing process.

The estimated long-term consequences associated with the repository (see Chapter 5 of the EIS) would be a small fraction of the environmental protection standards (40 CFR Part 197) promulgated by the Environmental Protection Agency to ensure protection of the environment and human health. In addition, whereas the repository design evaluated in the Draft EIS projected small releases within the 10,000-year compliance period, the enhanced design evaluated in the Final EIS projects that the Proposed Action would likely result in even smaller releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197). As a consequence, DOE does not believe mitigation actions would be required to meet applicable standards, though some mitigation actions could be required to meet License Application conditions or temper potential impacts not subject to regulatory standards.

7.3 (7729)
<u>Comment</u> - EIS002018 / 0004
How long will the nuclear waste be with us?

<u>Response</u>
Some of the radioactive half-lives of the waste materials proposed for disposal at Yucca Mountain are in the millions of years. These time frames are far longer than any natural or manmade isolation system envisioned today could be expected to totally contain the waste.

Eventually, the waste packages would fail to contain the waste. As discussed in Chapter 5 of the EIS, there would at that time be small releases of gases to the atmosphere as well as releases to the underlying aquifer. With the understanding that absolute assurance of “zero” release of waste materials is not possible over long periods, the Environmental Protection Agency has promulgated environmental protection standards for the Yucca Mountain Repository based on the concept of “reasonable expectation” (40 CFR Part 197). Prior to the Secretary recommending development of the proposed repository, DOE comply with those standards as well as the Nuclear Regulatory Commission’s Yucca Mountain site suitability standards (10 CFR Part 63). These regulations have been promulgated to ensure adequate protection of the public and the environment. The results in Chapter 5 of the Final EIS indicate that the flexible design would meet the environmental protection standards.

7.3 (7785)
Comment - EIS001999 / 0001
In class we have been learning about what radiation can do and how long it can last and what effects it can have on plants and animals. I don't think we should put it in that mountain because if it does leak it's going to seep into the water supply. That is my main concern because eventually the desert uses that water and if it contaminates the soil it will kill many plants and animals.

Response
Section 5.4 of the EIS indicates that predicted long-term levels of radionuclide concentration in groundwater and the resultant dose levels at the predicted discharge area in Amargosa Valley, Nevada, would be low. DOE does not expect that the dose rates to plants and animals at that location would cause measurable detrimental effects in populations of any species because the rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992). DOE acknowledged in Section 3.1.4.2.1 of the EIS that a small amount of groundwater might move beyond the primary groundwater discharge point in Amargosa Valley to discharge in the Furnace Creek area of Death Valley. However, even if this occurred, potential impacts in the Furnace Creek area would be even less than those at the discharge location, because concentrations would decline with distance from the proposed repository.

7.3 (7794)
Comment - EIS001213 / 0002
Once it has been stored there, the DOE can only offer unreal and unproven long-term projections as [to] what the consequences of such disposal would be. The TRANSPORT and STORE plan is pabulum when it comes to addressing the long-term problem. It is a problem that is larger than many of the present election campaign issues. Congress should not be resting on Laws that were passed in 1982. What might have been an acceptable two decades ago is UNACCEPTABLE.

Response
DOE agrees that it can make only projections given the long timeframes involved. However, the objective is to provide "reasonable expectation" of compliance with regulations and standards set forth by the Environmental Protection Agency (40 CFR Part 197) and the Nuclear Regulatory Commission (10 CFR Part 63). Congress commissioned these regulations through the statutory process.

The purpose of the proposed Yucca Mountain Repository is for "permanent" disposal rather than storage. The concept of permanently disposing of nuclear waste in a deep geologic repository stems from studies initiated in the 1950s by the National Academy of Sciences. Continued studies here and abroad have concluded that deep geologic disposal can keep nuclear waste isolated from the environment in geologic formations known to have been stable for millions of years, thus providing a safe location for the waste to decay into a stable form. Sixteen nuclear nations have sanctioned the repository approach to the disposal of spent nuclear fuel and high-level radioactive waste after more than 30 years of consideration.

In 1980 the Department published the *Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste* (DIRS 104832-DOE 1980). That EIS examined both geologic disposal and alternatives to geologic disposal, including deep seabed disposal, ice sheet disposal, disposal in deep boreholes, transmutation, and space disposal. It concluded, in agreement with the National Academy of Sciences, that deep geologic disposal was the preferred alternative, and that the alternatives to geologic disposal other than continued storage were not technologically viable at the time. Continued storage is viable and safe, but simply postpones the decision to the future in the hope that technology to solve the problem will become available.

DOE's Yucca Mountain-related activities are steered by the requirements of the NWPA, which directs the Department to only consider the Yucca Mountain site for development of a geologic repository. As required by the Act, DOE is proceeding with site characterization activities at Yucca Mountain to determine its suitability as a potential repository for disposal of the Nation's high-level radioactive waste and spent nuclear fuel. At the same time, DOE is continuing with development of a repository design for Yucca Mountain, which includes extensive review by independent technical peers including the National Academy of Sciences and the Nuclear Waste Technical Review Board. Ultimately, the repository would be licensed by the Nuclear Regulatory Commission, using standards established by the Environmental Protection Agency. These scientific peer reviews and regulatory requirements ensure that the repository design would be based on sound science.

7.3 (7826)

Comment - EIS001653 / 0023

Pg. 2-56 Sec 2.1.4 states, "This analysis used conceptual designs, which is typical of an EIS". Conceptual designs are not typical of an EIS when they have not been proven to work. It is appropriate to conceptualize designs, which are known to work such as roads, bridges, buildings, etc. However, DOE cannot currently demonstrate with any level of assurance which design may or may not meet regulatory standards. As of the date of publication of this DEIS can DOE demonstrate with a reasonable degree of assurance which design alternative will perform to regulatory standards? Subsequent to the release of the DEIS, has DOE dropped consideration of a hot repository? If yes, it does not appear that the hot repository design alternative was viable-its certainly brings into question the other as well. The FEIS should discuss changes to designs that have been made and how such changes improve performance.

Response

The Draft EIS evaluates the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998). It also evaluates the plans for the construction, operation and monitoring, and closure of the repository. DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review of the repository by the Nuclear Regulatory Commission. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement to the Draft EIS incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

For the reasons stated above, the analyses performed for the Supplement to the Draft EIS, DOE developed analytical scenarios to estimate the range of environmental impacts that could result from the Proposed Action. These analytical scenarios included the low, intermediate, and high thermal load scenarios presented in the Draft EIS, as well as the higher-temperature and lower-temperature repository operating modes being considered for the reference design. The low, intermediate, and high thermal load scenarios presented in the Draft EIS were not carried forward to the Final EIS. Section 2.2.1 of the Supplement summarizes the operational parameters for the three thermal load scenarios analyzed in the Draft EIS and the two repository operating modes analyzed in the Supplement. Section 2.2.2.2 describes the operational parameters for the higher-temperature and lower-temperature repository operating modes. DOE developed these scenarios and operating modes to accommodate and maintain flexibility for the potential future evolution of the design and plans for the repository. To not underestimate the impacts that could result from future design evolution, these scenarios and operating modes incorporate conservative assumptions. Sections 2.2.1 and 2.2.2 of the Supplement discuss the design and operational evolution, respectively.

The Supplement evaluates the environmental impacts of the flexible design higher-temperature repository operating mode, which is the design focus of the Science and Engineering Report (DIRS 153849-DOE 2001). In addition, the Supplement evaluates the impacts for the flexible design lower-temperature repository operating mode [which embraces a range of operational parameters, as described primarily in Section 2 of the Science and Engineering Report (DIRS 153849-DOE 2001)]. The differences between these modes deal with the highest postclosure temperatures of the waste package surface, the temperature of the emplacement drift rock walls, and the overall temperature of the repository rock. Section 2.3 of the Supplement describes the design modifications including the addition of drip shields and refined waste packages. DOE is not currently considering any backfill in the emplacement drifts as part of the design.

The Final EIS carries forward the information presented in the Supplement and addresses all aspects of the Proposed Action, including the flexible design. DOE acknowledges in the EIS that the flexible design could be further modified or refined during the license application process, if the site is approved for development. DOE believes that the information on the environmental impacts that could result from the Proposed Action or the No-Action Alternative complies with the Nuclear Waste Policy Act requirements for a Final EIS to accompany any recommendation by the Secretary of Energy to the President to approve Yucca Mountain for development as a repository. This belief is based on the level of information and analysis, the analytical methods and approaches used to represent conservatively the reasonably foreseeable impacts that could occur, and the use of bounding assumptions where information is incomplete or unavailable or where uncertainties exist.

Chapters 4, 5, and 6 of the EIS describe the environmental impacts of the Proposed Action. The results in these chapters indicate that there would be small risks associated with the proposed repository. However, prior to the Secretary recommending development of the proposed repository, DOE must provide a reasonable expectation of compliance with Environmental Protection Agency long-term environmental protection standards (40 CFR Part 197) as well as a reasonable expectation that the Yucca Mountain site would meet the Nuclear Regulatory Commission licensing requirements (10 CFR Part 63). These regulations have been promulgated to ensure protection of the public and the environment.

7.3 (7962)
Comment - EIS002041 / 0005
My class and I are also worried about our water supply. If there is a leak from a cask and it goes into our water supply almost or all the people would get contaminated.

Response
DOE is very concerned about the environmental impacts of the proposed Yucca Mountain Repository and the design and evaluation of the repository reflects those concerns. The Environmental Protection Agency provides standards for protecting public health and safety, including specific provisions for protecting the quality of water supplies (40 CFR Part 197). DOE recognizes that groundwater and surface water provide potential exposure pathways and is proposing a system of multiple natural and engineered barriers designed to protect human health and the environment for thousands of years.

DOE includes groundwater pathways in its analyses of the health risks of the proposed repository. The largest potential risk to groundwater users lies with the people of Amargosa Valley because groundwater in the saturated zone beneath the proposed Yucca Mountain Repository flows in a generally southerly direction toward this community.

The EIS examines the potential consequences to individuals in the Amargosa Valley from both radioactive and nonradioactive contaminants transported through air, water, soil and food pathways. Chapter 5 of the EIS presents an evaluation of the long-term environmental impacts of the proposed repository on the people of Amargosa Valley. These evaluations demonstrate compliance with the Environmental Protection Agency environmental protection standards. Therefore, DOE believes adverse health impacts to people in Amargosa Valley and Amargosa Desert would be highly unlikely.

7.3 (8005)
Comment - EIS000817 / 0060
Has this fill placement system for closure really been thought out in detail? What about weight and pressure of the fill on the containers? What happens when you cut the ventilation off? What goes first? -- The seals? The welds? The supports for the casks? How will things fall apart inside and outside the cask over time? -- How will the casks affect each other?

Response
Since the publication of the Draft EIS and the *FY 01 Supplemental Science and Performance Analyses* (DIRS 155950-BSC 2001), DOE has modified the repository design (flexible design) to include drip shields over the waste packages and forced-air ventilation during the operation and monitoring phase. In addition to the elimination of backfill material, the flexible design incorporates modified ground support and corrosion-resistant packages and package supports. Detailed descriptions of the important features and degradation mechanisms of the flexible design (including natural barriers, drip shields, and package failure modes) are described in the *Total System Performance Assessment – Site Recommendation* (DIRS 153246-CRWMS M&O 2000). As discussed in that document, the primary failure mode of the waste packages is expected to be at the welds where the outer and middle

closure lids are joined. However, the analysis has determined that these failures are not likely to occur within 10,000 years of repository closure. However, failure of up to 5 waste packages because of manufacturing defects is included in the model. Section 5.4 describes the potential long-term impacts of the flexible design.

The primary way in which casks affect each other is through the generation of heat or thermal load. In the Draft EIS DOE evaluated three thermal load scenarios including: high thermal load [85 MTHM (metric tons of heavy metal) per acre], intermediate thermal load (60 MTHM per acre), and low thermal load (25 MTHM per acre). In contrast to the focus of the Draft EIS on areal mass loading, the flexible design focuses on controlling the temperature of the rock between the drifts, as well as the surfaces of the waste packages and the drift walls, to meet thermal management goals established for possible repository operating modes. As a consequence, the designs differ with respect to some operating parameters. For example, the flexible design differs from the design evaluated in the Draft EIS in the range of areal mass loading considered (25 to 56 MTHM per acre versus 25 to 85 MTHM per acre, respectively). However, the flexible design would achieve its thermal management goals by varying other parameters, such as the linear thermal load (heat output per unit length of emplacement drift, expressed in terms of kilowatts per meter). The flexible design also would emplace waste packages relatively closer together than the Draft EIS design, which did not consider linear thermal load. Under the flexible design, DOE could vary other operating parameters such as ventilation rates and the blending of hotter and cooler spent nuclear fuel.

7.3 (8111)
Comment - EIS001653 / 0070
Throughout the DEIS, DOE has relied upon boundary analysis to determine a range of possible impacts. If the performance assessment process is currently unable to accurately predict possible long-term repository performance, and the high thermal load alternative is no longer viable, does the analysis is Chapter 5 still depict a reasonable range of impacts? Please explain.

Response
DOE used stochastic analyses to characterize impacts with respect to uncertainty in inputs, models, and conceptualizations where possible, and has used a range of calculations as necessary to ensure that the predicted impacts would be conservative (that is, would not underestimate impacts).

A high-accuracy prediction of impacts for the long periods involved for the disposal of spent nuclear fuel and high-level radioactive waste is not possible and, therefore, the Nuclear Regulatory Commission and Environmental Protection Agency regulations and the National Environmental Policy Act do not require such a level of accuracy. Rather, they require the best estimate of the impacts, calculated using the best available information. Chapter 5 of the Draft EIS did provide this estimate.

DOE has updated the repository design since publication of the Draft EIS to reduce uncertainties and to improve long-term performance. The Final EIS evaluates this newer design, including the range of impacts that could occur under different operating modes. The Department believes that the impacts presented in Chapter 5 represent a reasonable range of impacts that could occur.

7.3 (8147)
Comment - EIS000817 / 0081
P. 3-14 -- As I look at the climate, it looks like there can be heavy downpours -- “an inch in a matter of hours” -- what do you do if you find out later that water is coming into the tunnels before expected? Can you pump it out or dry it out in any way? Is there any brainstorming on such a problem? What do they do in mines when this happens?

Response
Heavy downpours of precipitation can occur anywhere in the continental United States. In desert environments such as the Great Basin where the proposed repository would be, torrential rains are often accompanied by rapid surface runoff, flooding, gullying, and other erosive processes because of the lack of vegetation and the thin soil cover. These surface conditions mean that during large precipitation events the land is not able to absorb as much precipitation as during comparable events in nondesert environments. DOE’s design for the surface facilities includes water diversion structures to accommodate these possible events. These design features channel, divert, or otherwise control this runoff to prevent incursion of this fluid into the subsurface facilities.

7.3 (8175)
Comment - EIS000817 / 0089
I am very concerned about the evaluation of the peer review panel and their view on uncertainties in [the] corrosion rate of the waste package. That is my biggest concern too. The NRC report says that the water seepage calculations vary by several orders of magnitude -- why?

Response
As a result of the evaluation of the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) and concerns such as those of the Total System Performance Assessment Peer Review Panel, DOE changed the waste package design and added a drip shield over the waste package. The waste package would have Alloy-22 as the outside layer with stainless steel on the inside. The titanium drip shield would add further defense-in-depth to the design.

The peer review panel pointing out that DOE based the waste package corrosion model for Alloy-22 in the Viability Assessment (DIRS 101779-DOE 1998) (and the Draft EIS) on very little data. In fact, it was based on expert elicitation. For the Final EIS, DOE based the waste package corrosion model on corrosion experiments on Alloy-22 at Lawrence Livermore National Laboratory. Those experiments showed that Alloy-22 is very corrosion resistant and, even accounting for uncertainty, would be unlikely to fail for many thousands of years.

Seepage remains uncertain because of heterogeneity of the rock. The seepage models acknowledge and account for the uncertainty. In addition, DOE has added a drip shield to the design to help mitigate some of the uncertainty and sensitivity to seepage. The recent corrosion data also indicates a reduced sensitivity of corrosion rates to seepage (DIRS 155950-BSC 2001 and DIRS 153246-BSC 2001).

7.3 (8184)
Comment - EIS000817 / 0090
Scientists are conducting tests of the first full scale mock radioactive waste casks heated in the rock to see effect on water -- did water actually “pour out of the borehole in July”? If so, then you have a lot of work to do in this area. If chlorine 36 percolated halfway through the mountain in just 50 years, you have a big problem here. The fact that concern over water collecting above the repository and heating up made you scrap the hot design just last year shows you have a long way to go. 81 meters of spacing might not keep boiling water in drainage routes you expect. You continue to be “surprised by the water.” It will go wherever it can. And you don’t know for sure how fast radionuclides will travel through the rock either. It can hitch a ride on a lot of particles you may not expect at all. What are tests here?

Response
The Drift Scale Test, which is a full-scale mockup of radioactive waste emplacement, is providing much useful information about the movement of water in response to heat. DOE anticipated the fact that water collected in (the comment says “poured out of”) a borehole. During the test, the heating evaporates water out of the matrix, and the water condenses in cooler regions and flows in the fractures. This test heats the rock to a similar degree as the current repository design would and helps validate models of water drainage between the drifts. The design analyzed for the Draft EIS would have boiled the water between the emplacement drifts and prohibited free drainage during the boiling period. The uncertainties in analyzing the rewetting of the entire repository horizon were part of the reason for the new design, which would have a portion of the rock between drifts below boiling, allowing drainage.

The chlorine-36 analysis indicated that water moved quickly through known through-going faults and well-developed fracture systems close to those faults. Overall, most of the water that infiltrates Yucca Mountain moves slowly through the matrix of the rock during some of its journey to the level of the proposed repository. Similarly, water (and radioactive contamination) would move through the mountain much more slowly than the limited chlorine-36 data would indicate.

Other tests, such as radionuclide transport tests, helped develop conceptual models for radionuclide transport through Yucca Mountain. The results of these tests constrain the useful data for the transport models. These tests also looked at the mobility of particles of very small size. In addition, work done in cooperation with Nevada Test Site geochemical investigations into the potential for colloids, very fine mineral particles, has shown there is some potential for colloid-enhanced radionuclide movement. These facts have been incorporated into the modeling of radionuclide transport that is part of the total system evaluation in the Final EIS.

7.3 (8195)
Comment - EIS001873 / 0014
Yucca Mountain is essentially a radionuclide delivery system. Eventually the repository will leak, canisters will deteriorate, the environment will be contaminated and people will be exposed. Geologic and climatic events, which cannot be predicted, will likely speed up the process, as will completely unforeseeable events involving human intrusion.

Response
DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency, and Nuclear Regulatory Commission also recognize the difficulty of understanding the behavior of complex systems over long periods. In 10 CFR Part 63, the Nuclear Regulatory Commission acknowledges that "proof that the geologic repository will conform with the objective for postclosure performance are not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation." In 40 CFR Part 197, the Environmental Protection Agency establishes "reasonable expectation" as a test of compliance, with diminished "weight of evidence" with time. The Agency also recognizes the need for expert judgment in assigning scenario probabilities, selecting simulation models, and assigning parameter distributions. Consistent with National Academy of Sciences observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events. These models, using the best available information and methods, also account for the uncertainties related to the inability to accurately predict geologic and climatic disruptive events as well as our inability to predict future human behavior.

DOE acknowledges that it cannot build a system that can provide perfect containment forever. This EIS provides the Department's best estimate of the impacts that could occur when the containment system inevitably degraded. The updated analysis in the Final EIS projects between zero and five waste packages would fail due to manufacturing defects within 10,000 years. This small number of package failures probably would result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197).

7.3 (8197)
Comment - EIS000817 / 0091
To predict that the containers will last 10,000 years is absolute folly in my opinion. To expect one container to fail in 1000 years is more folly. The fabrication of storage casks so far has been a disaster, and with so many new designs coming up, and new fabricators and inexperienced subcontractors -- expect a lot less than perfection in QA, fabrication, materials, inspections. As more and more casks are needed by commercial reactors, and the need is to get them "fabricated yesterday" as pools are filling rapidly -- expect more of the likes of March Metalfab -- where some weld repairs were not even documented! (People have been forbidden from this work as punishment for NRC [Nuclear Regulatory Commission] violations.) And even the NRC, in licensing the certificates for more and more casks, is making a huge mistake in "generic" rulemaking and handing out exemptions, as far as I can see it.

Response
The experiments and analyses documented in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000) provide the basis for the waste package modeling and life expectancies. This report identifies and discusses each potential waste package degradation mode. The degradation model includes those modes that analyses did not screen out as highly improbable.

The longevity of the waste package is a principal factor in the isolation of waste in the repository. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of a thick inner shell of stainless steel and a thick corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). However, the updated analysis in the Final EIS projects the probability that a number of waste packages would fail due to manufacturing defects. The probability of failure of waste packages is provided in Table I-3.

Obviously, there is uncertainty associated with the extrapolation of experimental results for such long periods and the other "human factors" mentioned in the comment. DOE selected the design analyzed in the Final EIS to mitigate the uncertainties by adding features (such as the drip shield) to provide defense-in-depth. This provides greater assurance that the repository would meet its performance standards in the face of uncertainty.

7.3 (8200)
<u>Comment</u> - EIS000817 / 0093
You know for Mr. Van Luik to say "In some sense, it's science fiction to project out 300,000 years," is right -- it is science fiction. For him to say then, "Absolutely nobody is going to get hurt by this repository for hundreds of thousands of years," implies that then somebody will -- this is all fiction too -- it may happen long before then.

<u>Response</u>
The quotations cited in the comment were part of a discussion of how uncertainties spread and grow with time because there is no sure way to forecast the future. However, the second quotation is a judgement made by a DOE employee in the face of that uncertainty. In other words, as time projections move farther away it is less likely that they are reliable, but we have greater confidence in the first few hundred thousand years, and greater confidence yet in the first 10,000 years.

Uncertainty is a reality when projecting the actions of natural processes in the future. Uncertainties are introduced by the long timeframes involved and by the evolution of natural and human systems over time. In addition, uncertainties remain about the heterogeneous nature of the site and the innate complexity of an engineered system placed within a natural system. However, this does not mean there is an inability to capture the long-term behavior of the system within a distribution of probable outcomes generated through accepted probabilistic analysis techniques that cover a range of potential futures.

In recognition of the complexity of such techniques and what the results mean, and in recognition of the genuine uncertainty in the results, DOE is using several other approaches to build confidence in the overall safety of the system. First and foremost is demonstrating that the mean values of properly conducted probabilistic calculations are realistic or conservative (not optimistic) indicators of likely performance. Next is the demonstration of a margin between these results and the applicable safety standards. Finally, there is a defense-in-depth approach that can include the use of an additional barrier to provide assurance.

DOE is charged with providing a safe facility for disposing of the Nation's spent nuclear fuel and high-level radioactive waste. In the 1980s regulators made special provisions for the irreducible uncertainties that come with evaluating systems over unprecedented periods. Nevertheless, where those uncertainties could bring system safety into question, action must be taken to ensure confidence. DOE must be confident in its ability to ensure safety at Yucca Mountain. Without confidence within DOE, the Secretary will not recommend the Yucca Mountain site to the President. But confidence does not mean the lack of all uncertainty; rather, it means that uncertainties are recognized, evaluated, and in some cases dealt with through taking action to remove or lessen the importance of an uncertain process to potential performance.

7.3 (8206)
<u>Comment</u> - EIS000817 / 0096
P. 3-51 -- Single borehole tests prove nothing -- I wonder how the groundwater path may change over time or the saturation zone level -- you can't take for granted that water flowing out of the repository in the future will do what you expect. What if the tunnels are "washed out" long before you expect?

<u>Response</u>
Single-borehole tests constitute one of many sources of data and information that DOE used to prepare the analyses summarized in this EIS. The reference to single-borehole testing in Section 3.1.4.2.2 includes qualifications of the limitations of such tests, and DOE has used the derived information accordingly.

The future states of the saturated zone system are included in the saturated zone process modeling which supports the total system performance assessment model. Modeling incorporates uncertainty in many aspects of the flow system (including climate change) and makes a number of conservative assumptions (dilution rates, for example) to avoid any chance of underestimating future impacts.

The tunnels in which DOE would emplace the waste are in the unsaturated zone. The long-term geologic record provides nothing to suggest that the tunnels would wash out during the life of the repository.

7.3 (8209)
Comment - EIS001021 / 0003
We are assured the Yucca Mountain waste containers are invulnerable. However, there is abundant evidence of leakage from the current repository casks at nuclear power and weapons plants. Why hasn't this same degree of proposed engineering safety been built into existing facilities?

Response
DOE acknowledges the difficulties in design and implementation of effective quality assurance programs. However, much has been learned over the past decades about the fabrication, installation, and maintenance of components important to nuclear safety.

The longevity of the waste package is a principal factor in the isolation of waste in the repository. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of a thick inner shell of stainless steel and a thick corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). The updated analysis in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197), which would be due to the probability that a small number of waste packages (between zero and three, and possibly as many as five) would fail due to manufacturing defects. The probability of failure of waste packages due to manufacturing defects is provided in Table I-3.

7.3 (8236)
Comment - 010229 / 0003
Section 3.2.3 discusses the predicted long-term performance of a Yucca Mountain repository. According to this section, predicted radiation doses during the first 10,000 years are zero "...because waste packages would remain intact for more than 10,000 years." Unclear from this section is whether the analysis considered the potential for defective waste packages to be produced that could fail in less than 10,000 years, potentially causing radiation doses 1earlier than predicted in the supplemental draft EIS. The final EIS should discuss the potential for early (first 10,000 years) waste package failures.

For the S&ER design, the waste packages may contain more potentially toxic metals, such as chromium and nickel, because stainless steel has replaced carbon steel as a component of the packages. The final EIS should provide new estimates of the concentrations of these elements that humans could be exposed to through groundwater near Yucca Mountain and should evaluate the potential cumulative public health and environmental hazards that could occur if groundwater also contains radionuclides released from a Yucca Mountain repository.

Response
The Final EIS includes analysis of possible early failures brought on by defects in the waste package. The results show a very small but not-zero dose from these failures (see Section 5.4).

The Final EIS contains an analysis of non-nuclear toxic materials based on the new design of the repository and waste packages. The analyses show that even under very conservative and bounding assumptions, toxic materials have no significant impacts during the compliance period. Further details can be found in Sections 5.6 and I.6.

7.3 (8320)
Comment - EIS001160 / 0101
Page 5-38: The entire paragraph for Section 5.5.1 is vague. It doesn't reference what estimates were used to arrive at the calculation. Admittedly, carbon-14 release would in most probability be small, especially after traversing from storage facility to outside air. However, because the data points were not included, even in the appendices, the reviewer cannot ascertain how the conclusions were reached. Any time "average values for stochastic (random) values" are used, it leads the reader to the suspicion that the values were "made up." The 14C existing in the atmosphere is being formed continually as a result of nuclear reactions between atmospheric nitrogen and neutrons from cosmic rays (DOE Radiological Handbook). At the very least, the baseline data used for this computation and the assumptions made should be listed in the appendices for confirmatory purposes.

Response
Section I.7 details the assumptions used to estimate impacts of atmospheric releases provided in Section 5.5.1. The most important factor for estimating impacts is the expected waste package failure rate. To simplify the analysis, DOE used the average values of stochastic distributions to represent the failure rate. Because the impacts would be exceedingly small, DOE believes that using average values was appropriate. In addition, whereas the repository design evaluated in the Draft EIS projected small releases within the 10,000-year compliance period, the enhanced design evaluated in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197), which would be due to a small number of waste package failures (between zero and five packages) due to manufacturing defects. DOE has updated Section 5.5.1 of the EIS to reflect impacts of atmospheric releases resulting from these package failures.

7.3 (8334)
Comment - EIS000817 / 0115
P. 5-3. Why [are]"idealized" packages with "identical contents" evaluated? This is certainly not dealing with reality. And the steady level of radon will produce problems if it escapes into any monitoring enclosure or if some mechanical robotic things don't function right and people have to go in there and fix things to retrieve the waste later on.

Response
The commenter is correct in that different waste packages would have different radionuclide inventories. The assumption of idealized waste packages with identical inventories was necessary because it is not practical to model 12,000 individual waste packages. However, the use of conservative assumptions related to waste package failure and affected inventories provides reasonable expectation that the potential impacts are not underestimated.

If it became necessary to reenter the repository area, radon and heat protection would be provided by forced ventilation. In addition, protection from direct radiation exposure would be provided, where necessary, by shielding and remote operations similar to emplacement operations. As with emplacement activities, equipment breakdown would be an expected occurrence and has been planned for in such a manner as to ensure the safety of repository workers.

7.3 (8335)
Comment - EIS000817 / 0116
P. 5-4. 250 types of DOE fuel? 16 categories? Wow! What a mess of different materials all together when they degrade. I don't see how you can evaluate possible interactions of materials for all this in the big "radioactive soup" of Yucca Mountain at the point all the casks degrade and get wet. Seems impossible. Too big a risk to take.

Response
To allow for a practical long-term performance assessment of a complex system such as the proposed repository, certain simplifying assumptions must be made. DOE recognizes that these simplifying assumptions introduce uncertainties into the final result. These uncertainties are minimized to the extent possible by use of conservative assumptions, where appropriate, to provide reasonable expectation that potential impacts are not underestimated.

DOE confidence in the disposal techniques is based on defense-in-depth that, for example, places drip shields over waste packages to account for uncertainties. DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components.

DOE believes this process results in a representative estimation of impacts that is sufficient for comparing the relative merits of the various repository scenarios. DOE continues to evaluate the sufficiency of its approach to dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended as a suitable site.

7.3 (8336)
Comment - EIS000817 / 0118
P. 5-5. You say the material "screening process" considered total inventory, solubility of the material in water, and chemical toxicity -- but all these materials -- under heat, pressure, and radiation -- could form new materials, couldn't they? And don't count on water to dilute things. Could water make some reactions worse? How do concrete binders and conditioners react with material in degraded BPRAs [burnable poison rod assemblies], for example? You say DOE "selected" chromium, molybdenum, and uranium for detailed assessments. Why wasn't every material possibly created in there given a detailed assessment? The biggest mistake NRC [Nuclear Regulatory Commission] made in certifying the VSC-24 [Ventilated Storage Cask, Model 24] cask was that neither NRC, the vendor, or the utility looked at possible material interactions during all handling procedures -- and the casks' effect on pool water as well as the pool water's effect on the cask! Presto -- an explosion at Pt. Black in Wisconsin that nobody -- nobody expected. So don't expect me to be satisfied with your "selecting" certain materials to look at for detailed interactions. Looks like alloy-22 may not be the answer for a waste container material if it's going to cause many problems when casks finally fall apart and get into the water.

Response
DOE cataloged all materials in the repository (see Draft EIS Table I-10). DOE did not arbitrarily "select" a few materials but rather used the screening process that consisted of a very conservative process to determine which materials could present higher than insignificant impacts (Draft EIS, Section I.3.2.3). These materials were then subjected to a full transport analysis using the same mitigating processes as for the radionuclide analysis (Draft EIS, Section I.6). The starting list was developed in terms of chemical elements (1) because all materials of concern are inorganic and (2) because they are then free to form any species (again a conservative approach). The elements would retain their identity (there would be no significant transmutation effects other than decay in these waste materials). The only new materials formed would be various inorganic oxides, chlorides, carbonates, etc. The main concern would be the dissolved ionic forms (such as Cr+6).

This comment asserts that DOE cannot rely on water for dilution. The Department maintains that, in this system where concentrations are generally small and water is abundant in the saturated zone, such reliance is reasonable. The anecdote concerning a cask does not seem to bear any analogy to the chemical transport concern that this comment addresses.

In the Final EIS the original screening analysis has been replaced by a somewhat different one, but the specific materials emerging are the same. An analysis of the remaining materials continues to indicate that no impacts of concern would be likely. This is due largely to the drip shields and other new design features that greatly curtail corrosion of chromium-, molybdenum-, and vanadium-bearing materials.

7.3 (8337)
Comment - EIS000817 / 0119
P. 5-6. Are you sure about trapped gases? Zircaloy can create hydrogen, can't it? Under what conditions? Remember the bubble at Three Mile Island? What caused it? Do we even know really? Or do we know the makeup of the mess left at Chernobyl? Really, do we know the content and interactions there?

Response
Zircaloy can evolve hydrogen gas through chemical reactions with water at very high temperatures. These are the types of temperatures that can occur under severe accident conditions at nuclear reactors (for example, Three Mile Island and Chernobyl). At repository temperatures, however, Zircaloy could not evolve hydrogen gas.

7.3 (8339)

Comment - EIS000817 / 0120

P. 5-7. Water and the waste package = what? You worry most about drips from above. -- But -- be creative. -- What else could water do in there? Could it actually condense on the surface of the cask under certain conditions? Especially as the thermal load becomes less over time? Could it collect on the stands holding the casks and form rust there? Think of your water heater in your basement on bricks -- the plumbers always put it on something to let air circulate beneath the bottom surface in moist basements and where does the hot water heater rust and leak? On the bottom where its surface is on the bricks most likely, right? Or could water collect on the floor of the tunnels -- run in there from fracture paths? Could the drift liner actually be a hindrance by causing moisture to collect on its outer surface or on its inner surface? Could the drift liner crack and let water come in there? Could the drip shield crack if rocks fall on it, and actually exacerbate corrosion by causing water to drip on one area of the cask a great deal by being sort of funneled to the lowest point of the drip shield? -- What could end up focusing a water drip, or a water collection, on one specific area of the cask, causing a hole to form or exacerbate degradation? All sorts of things could happen -- a chip or dent or uneven surface causes water to collect. -- Look at your concrete driveway. -- The pits are the low points and that's where cracks start too. With nobody to check the concrete or the metal as they do at ISFSIs [independent spent fuel storage installations] at reactors, things will just get worse over time if a cask or drift wall has a fabrication defect or is damaged in handling.

Response

In the analyses for the Final EIS, DOE formally documented a screening process for features, events, and processes (DIRS 154365-Freeze, Brodsky, and Swift 2001) that itemizes all known factors that could affect the performance of the repository, from which a determination is made whether to include it or exclude it from the Total System Performance Assessment model used for long-term performance analysis in this EIS. The database discusses each feature, event, and process, along with references to the analysis documenting the screening argument for excluded items or the disposition in the Total System Performance Assessment model for included items. The analysis screens out a factor if it has low probability or low consequence. The issues listed in the comment (condensation, rusting at contact points, rockfall, focused dripping, etc.) are examples of features, events, and processes that DOE has considered in the screening process and, as appropriate, included in the Total System Performance Assessment model.

7.3 (8356)

Comment - EIS000817 / 0123

P. 5-10. Why would the water and gas flow back to the repository? What else could happen here? Temperature and pressure effects on water movement [are] of the utmost importance here. As is rock mineral alteration. We need to know the answers here.

Response

As described in Section 3.2 of the *Total System Performance Assessment-Viability Assessment Plan* (DIRS 100319-CRWMS M&O 1996) and referred to in the EIS, moisture in the rocks around the repository could be vaporized by the postemplacement thermal pulse and driven away from the repository. As this vapor moved away from the heating of the repository, it would eventually condense into liquid. Once condensed, some of this water could intercept the repository and some could flow past the repository. During this period, there would be no additional temperature and pressure effects on the water movement, although the temperature of the flowing water would respond to the ambient conditions of the material through which it would flow. In addition, free water moving through the rock and soil above the repository could affect the local geochemistry, to include even localized alteration of minerals. However, mineral alteration in this context would be confined primarily to the minerals exposed on fracture surfaces, with minimal matrix alteration. DOE expects that the products of this mineral alteration would have no significant effect on the performance of the repository.

The EIS incorporates the possible effects of this water on waste package corrosion and other elements of the engineered barrier system. Chapter 5 of the *Total System Performance Assessment - Viability Assessment Plan* (DIRS 100359-CRWMS M&O 1998) describes the possible corrosion reactions due to water entering the repository. No other effects are likely from the movement or presence of this condensed water.

7.3 (8358)

Comment - EIS000817 / 0124

P. 5-13. Vapor processes need a lot of study as does solubility of materials from casks. Why are we dealing with only “pits and patches”? What about cracks? Especially cracks in welds? Could high thermal loads and radiation exacerbate any small crack that was initially acceptable in UT tests [ultrasonic tests]? Could the crack lengthen or deepen or widen? Current UT testing does not do well with (1) cracks in a line but not connected, (2) parallel cracks, (3) radial cracks, (4) the width of cracks, or (5) transverse cracks. Just how will DOE criteria for closure welds on casks deal with this issue? It took something like 9 months for Palisades to find cracks in welds “to be acceptable” after UT tests on the pad on loaded casks. Then NRC [Nuclear Regulatory Commission] allowed licenses to restrict movement temperature to 35º in order to allow larger cracks in the welds to be acceptable. The cask was certified to be able to be moved at 0º. How will DOE deal with such a situation? How will welds be tested? What cracks will DOE find acceptable? How will these cracks act over time under repository conditions?

Response

The *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000) and its supporting Analysis Model Reports document all of the waste package degradation issues. The *General Corrosion and Localized Corrosion of Waste Package Outer Barrier* (DIRS 152097-CRWMS M&O 2000) discusses the patch and pit corrosion of Alloy-22 and determines that Alloy-22 is not susceptible to localized or pitting corrosion. The *Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier and the Stainless Steel Structural Material* (DIRS 148375-CRWMS M&O 2000) discusses stress corrosion cracking in the Alloy-22 welds and develops a model for calculating waste package failure by stress corrosion cracking. *Analysis of Mechanisms for Early Waste Package Failure* (DIRS 147359-CRWMS M&O 2000) discusses testing for defects and analyzes the mechanisms and probabilities for early waste package failures.

The issues mentioned in the comment, including cracks, are only some of the degradation mechanisms analyzed in these reports. All credible mechanisms are considered. These analyses document the basis for the waste package degradation model that supports the EIS.

This comment is correct in that weld failure could be an important mechanism. DOE recognizes that residual stress in the weld at the time of manufacture, a well-characterized quantity can lead to the first very thin cracks that constitute a waste package failure in the analyses. The remainder of the waste package is still there, of course, for a long time after the first crack penetration in a weld. Two outer lids in the design means two consecutive weld cracks would have to develop before water could contact the inner stainless-steel barrier. In addition, the analysis conservatively assumes no containment credit for the stainless-steel inner liner.

7.3 (8402)

Comment - EIS001606 / 0002

When people speak about the science, you have got two conflicting methods of science currently. One would be called deterministic where people go into the lab and take some water from Yucca Mountain and soil and rocks and do experiments. And the others are the computer model people, and they don’t get along too well. And so we have an ongoing problem.

Response

In DOE’s view, deterministic and probabilistic methods are complementary, rather than conflicting. Both methods play a role in characterizing the Yucca Mountain site, developing the design, and evaluating the safety of the proposed repository. The OECD Nuclear Energy Agency describes the roles, differences and commonalties of these methods in “Lessons Learnt From Ten Performance Assessment Studies” (DIRS 103445-OECD 1997).

Laboratory and field experiments are obviously limited to specific sample sizes, volumes, and locations. DOE has adopted a probabilistic performance assessment method that accounts not only for the spatial and temporal variability and uncertainty in the properties of system components, but also limits to our knowledge and information, unpredictability of some phenomena, and low-probability events. The method is widely accepted nationally and internationally. It is based on recommendations of the National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission. It provides an overall estimate of repository performance for comparison to performance measures specified in 40 CFR Part 197 and 10 CFR Part 63. It conforms to international practices in other countries, including Member States of the OECD Nuclear Energy

Agency and the United Nations International Atomic Energy Agency. Peer review groups with expertise in the analysis of environmental risks have endorsed it.

7.3 (8407)

Comment - EIS000817 / 0125

P. 5-13. I find the reference to colloids interesting, for I was reading about colloid transport in a book recently concerning PCB [polychlorinated biphenyl] transport. It also referred to radionuclides moving faster than expected when they attached to colloids.

Response

DOE recognizes that some radionuclides (for example, plutonium and americium) are subject to colloidal transport. Sections I.2.6, I.2.7, and I.2.8 of the Final EIS and their referenced sources describe the colloidal transport in the Total System Performance Assessment model used to generate the estimates of long-term environmental impacts. Through cooperation with other DOE scientific programs, substantial knowledge and experience have been gained recently in modeling colloidal radionuclide transport in the repository environment. The Final EIS includes updated results based the improvements in colloidal transport modeling techniques gained through these efforts.

7.3 (8413)

Comment - EIS000817 / 0127

P. 5-14. You say the dilution factor was “recommended in an expert elicitation exercise” -- What? This is curious. Please explain. Is this all based on a recommendation by one person on his so-called “expert opinion”? Why?

Response

The expert elicitation process assesses uncertainties in processes where data are not readily available or are obtainable only through an unreasonably large commitment of resources. Such an assessment enables analysts to determine the range of possible values for parameters that pertain to the processes, and to sample this range of values for modeling purposes. For example, measuring corrosion of waste package materials under real-time repository conditions would take tens of thousands of years or longer. Therefore, DOE began testing of materials under artificially accelerated conditions. For the purposes of the Viability Assessment and the Draft EIS, DOE also convened a panel of corrosion experts to estimate the range of expected values for parameters used to calculate the resulting range of corrosion rates. Similarly, expert elicitation resulted in a range of dilution factors for the saturated zone modeling. The *Viability Assessment of a Repository at Yucca Mountain* contains details of this expert elicitation (DIRS 101779-DOE 1998).

The process does not rely on a single expert. In the instance mentioned in this comment related to dilution factors, five panelists participated in a 3-day meeting, as documented in CRWMS M&O (DIRS 100353-1998). DOE prefers, however, to obtain data through experiment and field-testing wherever possible. Therefore, the modeling reported in the Final EIS has been updated. The corrosion model is now based on the results of the second year of accelerated corrosion testing. The saturated zone dilution factor, although it has changed little from the expert elicitation value, is now based on data obtained through the Nye County saturated zone drilling program coupled with updated regional and local modeling of the saturated zone.

7.3 (8462)

Comment - EIS000817 / 0138

P. 5-39 -- Alloy-22 needs questioning if it provides 70% of chromium. What else could be used? You don’t even know the hexavalent chromium oral route exposure carcinogenicity now.

Response

DOE agrees that oral-route carcinogenicity for chromium is not well known. Because the carcinogenicity of chromium in water has not been established, the Environmental Protection Agency drinking water recommendations are based on the measured occurrence of elements such as chromium in public water supplies. It is these standards for public water supplies to which EIS chromium concentrations are compared.

In the updated design in the Final EIS there is quite a bit more Alloy-22 and much of it is exposed on the outside of the waste package and supports. However, because of the presence of the drip shields (made from titanium) water would not conduct much of the chromium-bearing material during the first 10,000 years after closure. Thus, during this period, the most important mechanisms for mobilization of the chromium would be the very slow humid-air corrosion of the exposed surfaces (under the drip shields) and diffusive transport of dissolved materials to the unsaturated zone. To evaluate the potential outcome of these processes, a conservative calculation was made assuming that all the exposed chromium material would corrode at the humid-air rate and immediately dissolve in the unsaturated zone water. All of this material would then be diluted in the standard average uptake in the well at approximately 18 kilometers (11 miles). The result shows concentrations would be well below the Maximum Contaminant Level Goal for chromium (40 CFR 141.51). Because of the conservative nature of these calculations, DOE believes that actual concentrations could be much smaller.

7.3 (8463)
Comment - EIS000817 / 0139
P. 5-45. You cannot predict rock size in falls -- nor where they will hit the cask -- or if that part of the cask is already corroded by drips, etc.

Response
The Drift Degradation Analysis (DIRS 119414-CRWMS M&O 2000) and the Engineered Barrier System Degradation, Flow, and Transport Process Model Report (DIRS 151804-CRWMS M&O 2000) documents the rockfall analysis. Based on the rock stresses in the mountain, the drift orientation, the rock fractures, and rock heating and cooling, a model was developed to predict in a statistical sense the probability of a rock of a particular size falling on a waste package. The maximum credible rock would be 13 metric tons (14 tons). For 10,000 years or more, the waste package would withstand that size rockfall without damage. A drip shield over the waste package would also withstand the rockfall. The drip shield and waste package combination would make a very robust design that could withstand the rockfall. Even though the waste package is designed to withstand rockfall for times exceeding 10,000 years, the model for cladding failure allows cladding to fail due to ground motion before the waste container fails. Thus, the effects of seismic events are incorporated in the impacts reported in Chapter 5.

No one can predict exactly what rock could fall or how big it would be. However, the analysis does show that the rocks would be small enough so that the waste package would not be breached from a rock fall. By the time the waste package would have thinned to the point where it could be breached, it would have already corroded through and been considered failed in the analysis. For this reason, the effects of rockfall on the waste package are not a part of the long-term performance analysis in the Final EIS. The previously mentioned analysis showed the effects on system performance would not be significant.

7.3 (8557)
Comment - EIS000817 / 0169
P. 9-13 Barriers: I'm very interested in the ceramic coating idea, but [it] seems to me any rock fall could crack it and exacerbate corrosion in the crack then. Drip shields could get dented by rock fall, form a "funnel type" area where water collects, and also exacerbate corrosion by ending up directing more water on one area of the cask. Could backfill provide a pathway for moisture to the casks, and prevent ventilation from evaporating moisture collecting on the casks and stands?

Response
Ceramic coatings on the waste package or drip shield are not a part of the current design. If it became part of the design, DOE would carefully consider the effect of rockfall and other requirements.

Analyses documented in the Waste Package Degradation Process Model Report (DIRS 138396-CRWMS M&O 2000) show that rockfall has an insignificant effect on either the drip shield or the waste package. For 10,000 years or more, both the drip shield and the waste package would be strong enough to withstand the forces of 13 metric tons (14 tons) of rock falling on them, which is the largest credible rockfall. Therefore, the effects of rockfall on the waste package or drip shield would be insignificant and are excluded from the Total System Performance Assessment model. Even though the waste package is designed to withstand rockfall for times exceeding 10,000 years, the model for cladding failure allows cladding to fail due to ground motion before the waste container fails. Thus, the effects of seismic events are incorporated in the impacts reported in Chapter 5.

Backfill is not a part of the current repository design. It was removed from the design because its water-diverting function was not important to the longevity of the newer waste package design, and also because its thermal insulation properties, as if it were a blanket, would lead to higher than desirable waste package internal temperatures.

7.3 (8558)
Comment - EIS000817 / 0170
"Richards Barrier"? I'm thinking of how we tried to preserve our garden carrots in sand in a container this year -- didn't work. The sand may delay moisture reaching the package, but it could also be saturated and actually collect moisture and hold it close to the cask surface, not allowing it to dry out at all. "Diffusion barrier," if saturated before expected, would also possibly bring water closer to the bottom of the cask and hold it there rather than letting the cask dry out and remain above the emplacement drift and above seepage flow on the bottom floor. You seem to be torn between ventilation keeping the cask dry and "smothering" the cask with some material to keep water away from it. You can't have both. Either air dry it or encase it, but make sure you have good reasons why.

Response
A Richard's Barrier is a system of two layers of material, a finer one over a coarser one. Testing under many conditions has shown that this barrier can be effective in diverting water because water, unless it is saturating all pores, tends to stay in the finer grade material. It is an important design component in earthfill dams.

As the comment suggests, there are other considerations in the selection of a design and its features. In DOE's evaluations of design options, a Richard's Barrier was included and tested among a number of designs and features. The current design does not include either a backfill or a Richard's Barrier, however. Section 2.1.2.4 summarizes the reasons for the selection of the design and its features.

The invert material would be crushed tuff, the volcanic rock of the repository site. Although there could be substantial water content in the invert as the repository cools, the waste package would begin to corrode as soon as the relative humidity exceeded the threshold relative humidity (50 to 80 percent, depending on the temperature). This would occur before the invert became nearly saturated as the comment suggests it might. Testing and analyses suggest that Alloy-22, the material for the outer barrier of the waste package, would not be susceptible to localized corrosion at contacts with the invert even if it has a high water content.

Ventilation would keep the waste packages dry and the relative humidity low to prevent corrosion before closure. The corrosion models account for the effect of moisture, vapor and liquid, after closure.

7.3 (8560)
Comment - EIS000817 / 0171
The idea of putting spent fuel in canisters first before [putting it] in the casks is an idea, but sounds costly and certainly not "space saving." Adds another containment to corrode through and sounds like a good idea to me. The more full containment barriers, the better, as far as I'm concerned -- for if the welds "go" on one, at least there is another beneath it. All these fillers and barriers have spaces between the particles for water to collect, so I distrust any of them really. They may backfire in your expectations.

Response
The comment contains important insights that have been considered in the formulation of the design reported in the Final EIS. For example, there would be two sequential outer lids and seals rather than one. The potential for crevice corrosion in the gap between the inner and outer layers, as mentioned in this comment, is one reason for using corrosion-resistant Alloy-22 as the outer layer of the waste package and stainless steel for the inner layer. This combination of metals would not be susceptible to enhanced corrosion even if water entered the inevitable thin cracks between the two metals.

The long-term performance analysis for this EIS conservatively neglected the potential benefit of stainless steel, which is the inner barrier of the waste package, and thus neglects the potential delay to water entering a waste package provided by this barrier. Its function is to provide structural strength for handling and emplacement of the waste packages.

Approximately 99 percent of the commercial spent nuclear fuel would have Zircaloy cladding to help protect it. The remainder of the commercial spent nuclear fuel either has stainless-steel cladding or developed perforations while in the reactor. The high-level radioactive waste (in a glass matrix) would be in a stainless-steel canister. This canister would then be inserted into the waste package and would be in contact with its inner barrier of stainless steel. Having the same metals inside each other minimizes the likelihood of crevice corrosion as water enters the cracks between the two metals. But in any event, the canister is not modeled as a barrier either, for the sake of conservatism. In addition, a drip shield over the waste packages would give further assurance that water would not contact the waste for a long time.

7.3 (8563)

Comment - EIS000817 / 0172

"Getters" could hold water too, couldn't they? I don't know about iron oxides or aluminum in the waste packages. If you ever had to retrieve the fuel -- this could create a real mess in getting assemblies out of a package. And if a canister breached long before expected -- (say a cave-in in the ceiling for some reason) -- could the filler exacerbate corrosion if air and water get in the cask?

Response

Certain design conceptualizations for waste disposal call for the use of various materials with a propensity to sorb radionuclides in waste packages, in backfill materials mixed with the invert material in drifts to support the waste packages, or as part of the properties of the tuffaceous rock around and beneath the repository. However, the repository design used in the EIS does not use or take credit for "getters," as sorbing materials are sometimes called, in the waste package. Although some arguments support the concept that some waste and waste package degradation products might have sorptive properties, there is no credit for these phenomena in the performance assessment model. Although some sorbing materials could retain water and complicate the analysis of corrosion in the waste packages, the overall effect of the use of sorbing materials in the performance assessment would be to make the performance assessment model less conservative. Thus, the present model and design are conservative with respect to sorption processes in and around the waste packages, although some credit can be and is taken for sorbing properties of the invert material in certain design conceptualizations of the engineered barrier system.

7.3 (8874)

Comment - EIS002086 / 0003

Although the EIS document reflects the examination of the analytical structure, accumulative impact evaluations, and substantiates various scientific testing, various impact scenarios, etc., etc., for up to ten thousand years, the secondary impacts have not been considered and the effects it will have on the environment, especially water. And David Chavez spoke of some of the effects and some of the concerns that he has for his tribe. The Colorado River Indian Tribes' livelihood is based upon its economic base, agriculture, and water is very sacred.

Response

DOE has conducted an extensive site characterization program, including a study of groundwater flow in the region around Yucca Mountain (See Section 3.1.4 of the EIS). The proposed repository would be in a closed hydrologic basin from which surface water and groundwater leaves only by evaporation from the soil and transpiration from plants. Based on the evaluations described in Sections 4.1.3 and 5.4, DOE does not believe that the watershed of the Colorado River is at risk from contamination from the repository. As a consequence, there would be no impacts on agricultural or economic resources in the Colorado River basin.

7.3 (8904)

Comment - EIS000869 / 0032

Groundwater contamination at the site could have devastating ramifications for the livestock and agricultural communities surrounding the area, specifically the Amargosa Valley.

Response

This comment raises a concern for the well being of the people and livestock of agricultural communities, specifically Amargosa Valley, the closest population center to the proposed Yucca Mountain repository. Amargosa Valley is most at risk because the water in the saturated zone beneath Yucca Mountain flows in a generally southerly direction.

The EIS examines the potential consequences to individuals in the Amargosa Valley from both radioactive and nonradioactive contaminants transported through air, water, soil, and food chains. Figure 3-75 of Volume 3 of the

Viability Assessment of a Repository at Yucca Mountain (DIRS 101779-DOE 1998) illustrates the pathways incorporated into the biosphere analyses; farming and agriculture practices are included.

The Viability Assessment (DIRS 101779-DOE 1998) describes a 1997 survey that permits an accurate representation of agricultural practices within the 80-kilometer (50-mile) radiological monitoring grid surrounding Yucca Mountain:

"Amargosa Valley is primarily rural agrarian. Agriculture is mainly directed toward growing livestock feed, for example, alfalfa; however, gardening and animal husbandry are common. Water for household uses, agriculture, horticulture, and animal husbandry is primarily acquired from local wells. Although sparsely populated, the Amargosa Valley region does support a population of 1,270 in approximately 450 households. Commercial agriculture in the Amargosa Valley farming triangle area includes a relatively large dairy that operates with approximately 4,500 milk cows and employs approximately 50 people, a garlic farm that produces about 2,000 pounds of garlic per year, and a catfish farm that sustains approximately 15,000 catfish. The area contains approximately 1,800 acres planted in alfalfa, 30 acres in oats, 80 acres in pistachios, and 10 acres in grapes." (DIRS 101779-DOE 1998).

Table 3-25 of that document specifies the consumption rates of drinking water and agricultural products, estimated from the results of the survey and used in the biosphere model. Hence, there is a defensible and traceable basis for addressing potential impacts to Amargosa Valley. Section 5.10 of the EIS describes the long-term environmental consequences of the proposed repository on the people of Amargosa Valley.

7.3 (9028)
Comment - EIS001204 / 0005
The casks would corrode and even before that, would emit great heat and radiation, rendering the place toxic. It would remain so until the year 207,000.

Response
The longevity of the waste package is a principal factor in the isolation of waste in the repository. The evaluation of alternative waste package designs presents a sound technical basis for likely projected lifetimes beyond 10,000 years for the reference dual-shell design under a range of thermal, geochemical, hydrological, and radiological conditions. This container would consist of a thick inner shell of stainless steel and a thick corrosion-resistant outer shell of a high-nickel alloy (Alloy-22). However, the updated analysis in the Final EIS projects between zero and five packages failing due to manufacturing defects.

Before recommendation of the Yucca Mountain site for development as a geologic repository, DOE will have to provide a reasonable expectation that the repository would meet Environmental Protection Agency standards (40 CFR Part 197) to protect human health and the environment. Compliance with these standards will ensure that concentrations of toxic materials would be such that the occurrence of adverse health effect would be highly unlikely for all potentially exposed populations in the region of influence.

7.3 (9038)
Comment - EIS000817 / 0117
P. 5-5. I think your theory that all these gases formed will decay, before canisters fail, is totally wrong.

Response
The wastes that would be disposed in the proposed Yucca Mountain Repository contain some radionuclides in gaseous form. However, the half-lives of most of these radionuclides are short (on the order of a few hundred years) compared to the waste package lifetimes (thousands of years). Thus, most gaseous radionuclides, except carbon-14, would have decayed away prior to breach of the waste packages. Section 5.5 of the EIS describes the impacts of carbon-14 releases.

The final EIS also considers (see section I.7.3) the gas radon-222 that is formed as part of the radionuclide decay chain resulting from emplacing uranium-234 in the repository. This gas is expected to decay before reaching the ground surface because it has a half-life of about 3.8 days.

7.3 (9150)
Comment - 010447 / 0001
I am most doubtful that the Yucca Mountain Project is based on sound science and undisputed facts establishing long-term safety and stability of nuclear waste deposited there.

First, the region is suspected to be seismically active.
In addition, water flows beneath the mountain, so it could infiltrate the waste containers, corrode them and carry radioactive waste into the groundwater.

Response
As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring seismic activity and studying the geologic structure at and near Yucca Mountain since 1978. Using the results of these and other studies conducted in the region, along with input from panels of recognized experts on seismic risks and hazards, surface facilities at the repository would be designed to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of once in 10,000 years. This is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

The 1992 earthquake at Little Skull Mountain 20 kilometers (12 miles) southeast of Yucca Mountain was the largest recorded earthquake within 50 kilometers (31 miles) of the proposed site of the repository. This earthquake, with a Richter magnitude of 5.6, did not damage facilities or structures at Yucca Mountain. It did, however, cause about $100,000 damage to buildings at the Field Operations Center in Jackass Flats about 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility). These buildings were not constructed to the seismic design specifications that would be used for surface facilities at Yucca Mountain.

The State of Nevada ranks third, behind Alaska and California, in seismic activity. Nevada's reputation as a seismically active state comes from major historic earthquakes in western and central Nevada with magnitudes of 7 or more on the Richter scale. This seismic belt may be an extension into Nevada of the Death Valley-Furnace Creek fault system in southeastern California. The average frequency of earthquakes of magnitude 6.0 to 6.9 in western Nevada has been about one every 10 years; earthquakes of magnitude 7 and greater average about one every 27 years. Yucca Mountain does not lie within this highly active seismic belt. Nevertheless, DOE estimated the impacts from extremely large and unlikely seismic events ("beyond design-basis") that could cause the waste-handling building to collapse and damage the pressurized-water reactor fuel assemblies. DOE concluded that the impacts from such an extreme event would be small because of the physical form of the fuel assemblies, protection by the building rubble, and the long distance to the nearest population.

As described in Chapter 5 of the EIS, during the first 10,000 years after closure of the repository, earthquake-induced shaking could dislodge rocks from the roof of the emplacement drifts. The likelihood of falling rocks splitting open a waste package is essentially zero because waste packages would be protected by titanium drip shields. Even if a drip shield were ruptured by falling rocks, the force and impact would be absorbed by the drip shield and not transferred completely to the waste package. Furthermore, the metal walls of the waste package itself would be designed to withstand the impact from falling rocks.

Based on the results of analyses reported in Chapter 5 of the EIS, DOE believes that a repository at Yucca Mountain would have negligible short and long-term environmental impacts. DOE recognizes that some radionuclides and potentially toxic chemicals would eventually enter the environment outside the repository. Modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers would keep the release of radioactive materials during the first 10,000 years after closure to very small amounts that would be well within the regulatory limits established by 40 CFR Part 197.

DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. Section 5.2.4 of the EIS describes how DOE dealt with these uncertainties. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Nuclear Regulatory Commission indicates that absolute proof is not to be had in the ordinary sense of the word (see

10 CFR Part 63), and the Environmental Protection Agency finds that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance (see 40 CFR Part 197).

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to assessing the long-term performance of the repository addresses and compensates for important uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.3 (9200)
Comment - EIS002111 / 0001
I'd like to show noncompliance and what should be further research with Yucca Mountain. Number one. Yucca Mountain did not comply with all appropriate regulation Section 40 CFR of -- because of generation of hazardous waste. Due to the corrosion, we're going to have three processes. One, it's generation of heavy metal plume; second, followed by radionuclide; and third is production of mixed waste of heavy metals and radionuclides presume.

Part of the page 528 is there is uncertainty in the EIS which claim the corrosion rate can be very high and very much expectable if this is the correct curve. There are two tables, 5-1 and 5-2, which listed the concentration of heavy metals and activity of radionuclide, and the way I can see it is the least -- no, the worst scenario showing in the risk assessment. The USEPA [Environmental Protection Agency] has a guidelines for complex mixtures, just the complex mixtures, and I listed one, two, three, four, and the latest one is there's a guidelines which addresses the future issue. DOE does not have an official procedure conducted risk assessment or complex mixtures.

There is only very limited information in the literature regarding what is complex mixture, and I'll just elaborate it. One is a Russian work, which was exposure threat to strontium and cesium and they show there was an interaction synergism. The second I presented a paper in 1994 that on heavy metals would show a synergistic effect, the problem which we have associated with risk assessment. Number one, there is no data provided for each if they are alone. Then we don't discuss what happened. Heavy metal would be probably more toxic, radionuclide will generate free radical byproduct to the immune system. There is noncompliance with EPA assessment guidelines for complex mixtures. One is important because if you're taking -- let's assume a 10 to minus EPA for chromium or whatever -- I'm not using this exact -- complex mixture can pose 10 to the minus 3 to 10 to the minus 2 cancer risk.

Response
DOE agrees that there is a likelihood that trace amounts of radionuclides as well as other metals dissolved from waste packages and their inner structural materials could appear in groundwater at some time in the future. The Department also agrees that there is merit in obtaining additional information on whether or not dilute mixtures represent an enhanced – or in some cases perhaps a reduced – risk because of potential negative or positive synergistic effects on toxicity from the presence of multiple metals and radioactive species. The Department feels, however, that this is a basic research issue for those charged with the responsibility for setting environmental protection standards. It is not specific to Yucca Mountain, but could apply as well to any other government, industrial, or natural setting where there are metallic or radioactive elements potentially going into solution that could reach the local water table. Therefore, it is not DOE's responsibility to sponsor research under the Yucca Mountain Project.

7.3 (9382)
Comment - EIS001888 / 0087
In discussing the effect of chemically toxic materials, DOE made the statement that organic materials (additions to the concrete) "could break down completely in response to exposure to high radiation fields for 100 years or more before closure." Does this mean that all of the repository will be open for a minimum of 100 years. In addition if there are high radiation fields, why is radiolysis ignored in the performance assessment calculations?

Response
The updated repository design discussed in the Final EIS does not employ the use of concrete liners. The modeling of the corrosion of waste package materials and other barriers qualitatively included the radiolysis processes. Radiolysis can be estimated through the use of reasonable assumptions about acid formation in nearby water, the primary mechanism for radiolytic influence on corrosion. The natural environment has a minor contribution. Alloy-22 was selected as a container material because it is corrosion-resistant in the ranges of alkaline as well as acidic environments likely inside Yucca Mountain.

Federal regulations (10 CFR Part 63) require that the repository be designed to preserve the option of waste retrieval on a reasonable schedule for as long as 50 years after the start of waste emplacement. Consistent with these requirements, the operational plan for the Yucca Mountain Repository provides for a design and management approach that isolates wastes from the public in the future while allowing flexibility to preserve options for modifying emplacement and retrieving waste. This design would maintain the ability to retrieve emplaced materials for at least 100 years and possibly more than 300 years in the event of a decision to retrieve the waste, either to protect the public health and safety or the environment, or to recover resources from spent nuclear fuel.

7.3 (9392)
Comment - EIS001888 / 0097
The VA [Viability Assessment] waste-package design is not an effective defense-in-depth design. Design options such as use of drip shields that were considered in the VA but not used in the TSPA-VA [Total System Performance Assessment-Viability Assessment] design have potential to significantly improve repository system performance.

Response
After further analysis, DOE came to similar conclusions. The revised design analyzed in the Final EIS includes a drip shield to provide defense-in-depth. The drip shield would be titanium alloy, a different material from those DOE would use in the waste package. Titanium would degrade by different mechanisms and would respond differently to the chemical environment, so it would degrade and fail by different processes from the waste package. Furthermore, the drip shield would provide additional protection of the waste package from rockfall damage.

7.3 (9709)
Comment - EIS002154 / 0006
Now if it contaminates the water, because they're going to have to use water to cool it. When that water drips down into the water system, then the lower part of your body is going to be involved in it. I mean, what kind of thinking is this? Do they have to have it all in one place? That's ridiculous.

Response
The proposed nuclear waste repository at Yucca Mountain is designed to permanently store commercial spent nuclear fuel and high-level radioactive waste. The repository would be constructed in the unsaturated zone several hundred feet above the zone containing groundwater aquifers. The repository is designed such that the configuration of waste packages and underground storage tunnels would naturally distribute the heat load and produce only a minimum heat stress to the surrounding rocks and adjacent waste packages. No water would be used to cool the repository.

Chapter 5 of the EIS points out that if and when waste packages fail, the release of radionuclides to the unsaturated zone and subsequently to groundwater would occur well after the repository had cooled, and would proceed at a very slow rate. Chapter 5 and Appendix I present calculations that show the possible dose to receptors in the Amargosa Valley at several distances from the repository. The calculations show that the dose to the population would present very small risks to human health.

7.3 (9809)
Comment - EIS002070 / 0004
DOE claims to be using "sound science and engineering," e.g. considerable commercial nuclear fuel is having burnups of, e.g., 47,000 MW[megawatt]-days per Metric Ton Uranium, but the key assumption is for much less on average (see p. A-14, Table A-5. ("averages" at 39,560 (PWR [pressurized-water reactor]) and 32,240 (BWR [boiling-water reactor]) Where does the "average" come from????

Oops, your site won't let me retrace my steps through the files so I can't give page number references, but under the spent fuel, TRW report dated (1998), See Appendix A, page A-14 Table 5, reference "a") lists key assumptions including number 039, that concern for criticality control extends beyond 10,000 years" which is appropriate in light of chain reactions in natural uranium ores, the clear infiltration of water into the proposed (politically selected) site as shown by the presence of Chlorine-36, e.g., deep in the proposed site, and the greater enrichment of, and presence of plutonium (fewer delayed neutrons from fission) in "spent" nuclear reactor fuel.

Yet only 10,000 years is selected. Why, when that very page notes a requirement to consider impacts beyond 10,000 years. Certainly the uranium [U], half life over 500 million years for U-235, 4.6 billion years for U-239, and even for Pu-239 [plutonium-239], about 24,000 years, shows that criticality will be of concern for far more than 10,000 years. NCCRG (North Carolina Citizens Research Group] also notes the huge number of assumptions in the "engineering update to EIS file" 3/99 (DOE website on Yucca [Mountain] DEIS), e.g. Section 2.1.1; yet many of these assumptions maybe very difficult to achieve in practice and thus are far from suitable bases for analysis in an EIS or elsewhere. For example, it is assumed that spent fuel is vertically loaded into a container free of liquids, but in practice loading commercial reactor "spent" fuel into a cask almost always leaves some liquid because the loading is done under water. Where is your analysis of how this can be avoided? This is a key issue because water is not only able to facilitate corrosion in many ways, but it also transfers heat well, can provide oxygen to react with zirconium fuel cladding, hydrogen by dissociation (or by Zr-H2O [zirconium-water] reaction) AND provides a means of transport for fission products, uranium and/or TRU [transuranic] elements, and corrosion products of all kinds. Also water turned to steam builds up pressure which can exploit leaks, force liquids and/or gases through cracks, create gaps through thermal expansion, etc.

Response
DOE obtained the average burnup values listed in Table A-5 of the Draft EIS from the cited reference. DOE analyses included spent nuclear fuel with a wide range of burnups, as discussed in Section I.3.1. DOE updated the inventory projections for the Final EIS.

The criticality analyses in support of the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) summarized in Section 5.2.3.6 of the Draft EIS and Section I.2.12 in the Final EIS considered criticality events occurring beyond 10,000 years. Because the waste packages should remain intact for much longer than 10,000 years, the analyses had to assume that consequences for determining the potential for criticalities after waste package degradation necessarily would occur in the longer periods. The analyses showed negligible possibilities for out-of-package criticalities in those long periods (see Section 5.8 of the Final EIS).

With regard to the assumption that waste packages would be free of liquid, Volume 2, Section 6.2.1, of the Viability Assessment (DIRS 101779-DOE 1998) states that wet fuel would be dried before being placed in the waste packages. In addition, dry handling of spent nuclear fuel is an option in the design of the surface facility. Therefore, the spent nuclear fuel would be free of liquid when placed in the waste packages.

7.3 (9811)
Comment - EIS001888 / 0397
[Clark County summary of comments it has received from the public.]

NPTE leakage in Santa Monica, CA. pertaining to the gas leakage in the water, has affected three states - California, Nevada, and Glendale (OH?) and Washington. This leakage has been since 1989 and they have no way of cleaning it up. It has caused cancer in these states and has affected the water and the air. This is my concern with the Yucca Mountain Project a similar situation could arise here.

Response
The commenter's concern relates to historical industrial leakage situations involving liquids and organic volatiles in comparatively short design-life systems. These events have led to organic compounds leaking into groundwater from underground storage tanks and pipelines. The materials that would be stored at Yucca Mountain would be low-solubility solids, many of which would have limited groundwater mobility and are thus not directly comparable to the situations cited by the commenter. Chapter 5 of the EIS provides information on the potential for long-term impacts of the repository via all applicable pathways, including air and water.

7.3 (9883)
Comment - EIS001888 / 0430
[Clark County summary of comments it has received from the public.]

Design measures to mitigate the effects of events and processes (e.g., loss of water resources from contamination) were also requested. Events and processes identified by commenters included: (1) criticality (different kinds of events, multiple and repeated events, events resulting in explosions, events due to different fuel enrichments and plutonium disposal), (2) extreme seismic activity (resulting in pathways for contaminant release), (3) volcanism (volcanic explosions, consideration of "recent" events at Lathrop Wells cone), (4) tectonic events (crustal faulting), (5) meteorological events, (6) hydrological events, and (7) biological events.

Response
DOE evaluated a wide range of factors as part of the long-term performance analysis to determine if the factors would influence repository performance and should be included in the analysis. All the features, events, and processes listed in the comment were considered. Some were screened out either because of low probability of occurrence or because of low consequence (that is, repository performance would not be affected). The EIS and its supporting documents discuss the screening process.

Section 9.2.10 of the EIS discusses mitigation measures related to the long-term performance of the repository. DOE regulations (10 CFR 1021.331) require preparation of a Mitigation Action Plan when mitigation measures are identified in a Record of Decision. Because DOE does not anticipate issuing a Record of Decision, a Mitigation Action Plan might not be prepared. However, the Yucca Mountain site, if approved consistent with provisions of the Nuclear Waste Policy Act, as amended, would be subject to licensing by the Nuclear Regulatory Commission. DOE, in submitting its application to construct and operate the repository to the Commission, would identify relevant commitments and contingencies, including those identified in the Final EIS, to the Commission for its consideration. DOE reasonably expects a comprehensive set of mitigation measures or conditions of approval to be part of the licensing process.

Design measures discussed in the Final EIS would mitigate some of the effects of various events and processes. DOE has included drip shields and updated the waste package to be more robust and longer-lived. Both of these updates would reduce the overall consequences, based on the involved uncertainties, associated with long-term performance.

7.3 (9886)
Comment - EIS001888 / 0434
[Clark County summary of comments it has received from the public.]

Others requested that the analyses consider gaseous pathways for radionuclide release, mineral deposits formed by thermal fluids, thermal overloading, thermal-induced ecosystem affects, thermal expansion and later subsidence, gaseous flux, groundwater heating, thermally induced fracturing affecting fluid flux, increased erosion due to ground surface denudation, local meteorological effects, the quality of the rock below the repository horizon, and radionuclide transport by mineral colloids.

Response
Section 5.5 of the EIS evaluates gaseous releases.

Mineral deposits formed by thermal fluids are included in the Total System Performance Assessment model used to calculate impacts reported in Chapter 5 of the EIS. Mineral deposits would develop as refluxed water drips through fractures and possibly onto waste packages throughout the boiling period. The effects of the salts formed in this process are included in the waste package degradation process modeling supporting the Total System Performance Assessment model.

What this comment means by the term "thermal overloading" is not sufficiently clear for a response, but DOE has considered the long-term performance assessment for a range of thermal load scenarios in the EIS.

Section 5.9 of the EIS considers thermally induced ecosystem affects.

Thermal expansion and later subsidence was considered in development of the Total System Performance Assessment model. The results can be found in CRWMS M&O (DIRS 153246-2000), as referenced in Appendix I of the EIS.

Gaseous flux was not considered in calculating gaseous releases because the DOE conservatively assumed instant transfer of gas-phase radionuclides to the atmosphere so that the flux to the atmosphere would be equal to the release rate from waste packages as a function of time (see Sections 5.5 and I.7 of the EIS).

Groundwater heating was included in the thermal-hydrologic process modeling supporting the Total System Performance Assessment used to produce results for Chapter 5 of the EIS. An overview of the modeling of these processes is contained in Section I.2.3 with details in referenced documents.

Thermally induced fracturing affecting fluid flux was considered in development of the Total System Performance Assessment model. Changes in fracture permeability around an emplacement drift because of thermal-mechanical effects have been calculated. The effects would be primarily within about two drift diameters of the drifts. Since the drift spacing is much larger (about 15 drift diameters), effects on large-scale flow and transport probably would not be significant. In addition, thermal mechanical effects on drift-scale flow (in particular, on seepage into drifts and radionuclide transport out of drifts) were neglected in the Total System Performance Assessment simulations because they are thought to be of little importance (DIRS 153246-CRWMS M&O 2000).

Colloidal transport of plutonium was modeled for the Draft EIS, and the Final EIS contains an expanded model for colloidal transport that extends to other radionuclides and contains a refined approach to the modeled processes (see Sections I.2.6 through I.2.8).

7.3 (9965)
Comment - EIS002311 / 0001
Section 5.7.3 of the 1999 Draft Environmental Impact Statement (DEIS) for the geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain, Nye County, Nevada, was arguably incorrect about the statement "Because the waste package would occupy about 40 percent of the space in a drift, a falling rock would have a 40-percent chance of hitting a waste package," because the statement assumes: 1) that the "space" referred to is an area (as opposed to volume), and 2) the size of the rock.

Response
DOE recognizes that the word "space" could be interpreted as an area or a volume. For the analysis in the Draft EIS, the probability of a falling rock hitting a package was estimated based on the surface area of the packages (footprint) and the cross-sectional area of the falling rock.

For the updated analysis in the Final EIS, DOE used the best available information to develop a model based on the rock stresses in the mountain, the drift orientation, the rock fractures, and rock heating and cooling to predict statistically the probability of a rock of a particular size falling on a waste package (DIRS 119414-CRWMS M&O 2000; DIRS 151804-CRWMS M&O 2000). This analysis determined that it would be highly unlikely for a rock larger than 13 metric tons to fall on a waste package. Thus, the waste package has been designed to withstand that size of rockfall without any damage. In addition, the newer design places a drip shield over the waste package that would withstand the rockfall. The combination makes a very robust design that could withstand the rockfall.

Resistance to rockfall would hold true as long as most waste packages and drip shields retain their initial strength. Results for undisturbed degradation show that nearly all packages would be at design integrity for well over the compliance period of 10,000 years; in fact this holds true for well over 50,000 years. Therefore, the effects of rockfall are not part of the long-term performance analysis calculations for the Final EIS since the Total System Performance Assessment model was originally developed for the compliance period of 10,000 years prescribed in 40 CFR Part 197. In the case of long-term peak doses that would occur at 500,000 years, there could be some seismic effects not accounted for because most packages would have been breached by that time. No analysis is available at this time to determine how much this could affect the peak doses.

7.3 (10432)
Comment - EIS002194 / 0006
What this Department of Energy is doing to us is insane.

I am suffering because of what the Department of Energy is doing. Other people are suffering. Thousands and thousands of people are suffering, and I want you to stop.

Again, I'd like an answer what's going to disqualify it, what's going to disqualify Yucca Mountain, and I want to understand.

I would like for you to justify to me -- I'd really like to hear something about what you think you're doing.

Let me flip through this one more second. Okay. Here we go. On page 67072 [64 *FR* 67072], it says here "with respect to qualifying and disqualifying conditions, DOE believes that it is not reasonable or necessary to maintain these conditions in a proposed new rule."

As I read that, that says that if the DOE says it's not reasonable or necessary to find any conditions which will disqualify Yucca Mountain.

I want to know when we're going to get the mountain back. Okay. I want to know when we're getting that mountain back.

When are you going to fill that tunnel back up, get that huge, ugly, disgusting, gross white boring machine out of there -- and it's boring.

Response
The EIS is only one in a series of documents prepared for the Site Recommendation determination for Yucca Mountain. The President and Congress, if necessary, would make the decision to proceed with the project. The goal of these documents is to provide the best available information as input to that decision.

This comment has extracted a quote from the preamble of DOE's proposed Yucca Mountain Site Suitability Guidelines (64 *FR* 67054, November 30, 1999) implying that DOE is dismissing the use of qualifying conditions in the decision process. A more inclusive quote from the guidelines states:

"With respect to qualifying and disqualifying conditions, DOE believes that it is not reasonable or necessary to maintain these conditions in a proposed new rule. DOE proposes eliminating individual disqualifiers, since maintaining them would mask how the system as an integrated whole would function, and would be inconsistent with the NRC [Nuclear Regulatory Commission] proposal. The only appropriate disqualifier is the applicable public health and safety standard."

The prevailing scientific view is that the most appropriate method for evaluating if a site is suitable for a repository is through a Total System Performance Assessment. Under 10 CFR Part 963, DOE would use this method to evaluate if a repository at the Yucca Mountain site would be likely to meet applicable Nuclear Regulatory Commission regulations and, thus, be suitable for development of a repository.

At the time the rule was proposed, DOE pointed out that it was replacing the use of individual disqualifiers with a site suitability evaluation based on total system performance. This is in keeping with a generally accepted approach that has international endorsement. The long-term performance analysis described in Chapter 5 of the EIS uses the same approach as the Total System Performance Assessment referred to in the quote. The analysis compares the Chapter 5 results to appropriate Environmental Protection Agency and Nuclear Regulatory Commission standards developed in companion rules 40 CFR Part 197 and 10 CFR Part 63, respectively. This type of information will be part of the input to the Secretary of Energy, who is responsible for the Site Recommendation, to the President for his consideration in deciding whether to recommend the site to Congress, and to the Nuclear Regulatory Commission, which would have to decide whether to license a repository at Yucca Mountain if the site was recommended by the President and a recommendation is upheld by Congress.

7.3 (10440)
Comment - EIS002194 / 0014
If you're going to do -- if you're going to only go by TSPA [Total System Performance Assessment], then you guys have to, you know, seriously think about the transportation.

Response
Chapter 6 of the EIS evaluates transportation risks as a separate consideration from the impacts evaluated by the Total System Performance Assessment.

7.3 (10441)
Comment - EIS002194 / 0015
I'd really like to see a response as to what will disqualify Yucca Mountain.

Response
Disqualification of the Yucca Mountain site could result from the inability of DOE to provide a reasonable expectation that the long-term repository performance would meet environmental protection standards promulgated by the Environmental Protection Agency at 40 CFR Part 197 and with Nuclear Regulatory Commission licensing requirements specified in 10 CFR Part 63.

7.3 (10494)
Comment - EIS002211 / 0002
It's axiomatic that the underground hydrogeologic domain is naturally ordered as in the state of variable dynamic flux. You knew that from the beginning.

Over the entire term of the geologic time scale continuum from inception through cessation inclusively, it's moving as we speak. This earth is not a bowling ball. It's not a monolithic solid steel sphere or anything of this sort. There's all kind of stuff under there.

There is more tonnage of bio-organisms within the earth than there is on top of it, on the onion's wafer skin surface. Ask any astronaut. It's public, then.

So our domain is rather irrelevant compared to the much broader underground domain.

You're talking about a safety -- deep hydrologic -- what is deep about something that's a depth of 900 feet along a radius of approximately 4,000 miles?

Can you equate that right away? How about 1/32 of a vis -- it's virtually surface, subsurface underground storage.

It shouldn't be there because if you're putting into directly injecting it into the environment, the ambient environment, you know it's going to end up as human accessible somewhere. Maybe Mesquite, maybe Pahrump, maybe Ash Meadows, maybe Death Valley Junction, maybe Lake Mead. Maybe all of them combined.

It will be in the children's milk and in their ice cream. It's a little worse than arsenic.

Consequently, it's impossible to guarantee the safe, secure and human intrusion impervious underground storage of high-level nuclear waste by any combination of natural and engineered barriers and statistical probabilistic modeling and institutional controls over any substantially enduring term, either at Yucca Mountain, Nevada, elsewhere nationally or anywhere on this particular planet.

Billions to find that out and you are not sure of it yet; is that correct? So put the billions back and go do something else, because you apparently don't know how to do this.

Response

DOE acknowledges that the State of Nevada ranks third, behind Alaska and California, in seismic activity. Nevada's reputation as a seismically active state comes from major historic earthquakes in western and central Nevada with magnitudes of 7 or more on the Richter scale. This seismic belt might be an extension into Nevada of the Death Valley-Furnace Creek fault system in southeastern California. The average frequency of earthquakes of magnitude 7 and greater average is about once every 27 years. Yucca Mountain is not in this highly active seismic belt.

This comment refers to bioorganisms in the Earth. The existence of microorganisms is an issue because of the possibility of microbially induced corrosion of metals.

DOE has updated the analysis of microbially induced corrosion for the Final EIS. Such corrosion is one of the waste package degradation processes discussed in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000). Experimental data described in that report show that Alloy-22 is not susceptible to microbially induced corrosion. However, to account for uncertainty, the analysis multiplied the general corrosion rate of Alloy-22 by an enhancement factor that simulates microbially induced corrosion. The *Near Field Environment Process Model Report* (DIRS 153363-CRWMS M&O 2000) describes the analysis of microbes at Yucca Mountain in more detail.

DOE acknowledges that it cannot build a system that can provide perfect containment forever. This EIS provides the Department's best estimate of the impacts that could occur when the containment system inevitably degraded.

The updated analysis in the Final EIS projects that the Proposed Action probably would result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197), which would be due to the very unlikely event of between one and five packages failing due to manufacturing defects.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed, consistent with 40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that would be much lower than background levels (see Chapter 5 of the EIS for details).

DOE is aware of the importance of potential releases from a Yucca Mountain Repository entering the food chain, particularly the milk supply, through groundwater pathways. This underscores the necessity of the system of multiple engineered and natural barriers, working together, to keep water away from the waste and to protect human health and the environment for thousands of years. The biosphere pathway model used for the long-term performance assessment in the EIS explicitly includes dairy farms and milk products in the food chain and potential exposure pathways. In addition, the Yucca Mountain Project and the DOE Nevada Operations Office have conducted environmental surveys to establish baseline concentrations of radionuclides in milk produced in the region.

7.3 (10502)
Comment - EIS002138 / 0009
Page 1-14, table 1-9, why was a performance assessment calculations only modeled to the year 2055 when some of the materials have a half-life of over a million years?

Response
The comment is actually about Table I-9 of Draft EIS Appendix I. That year is only a time chosen to compute the inventory, and is not the time to which the analysis computed long-term impacts. As indicated in Appendix I, the analysis computed impacts for 10,000 and 1 million years after closure.

The wastes listed in Table I-9 are radioactive but do not have a constant activity level over time. A date was therefore assumed for the purpose of establishing a start time and beginning inventory for the performance assessment. DOE chose 2055 to provide the activity level of materials listed in Table I-9.

7.3 (10513)
Comment - 010116 / 0012
Our computer programs have a difficult time predicting the weather one month into the future. Again DOE wants us to believe that they have all the data to predict performance out past 10,000 years. And to be safe, the predictions should go out to one half life of the actinides, that's over a million years.

Response
The EIS discusses estimates of potential behavior, not predictions. These estimates were carried out to 1 million years in the Draft EIS, the Supplement to the Draft EIS, and the Final EIS. The nature of these estimates is to provide input to the decision whether to move ahead with the repository. The decision to close would not occur until as much as 300 years from now, when a great deal of additional data and more advanced analysis techniques would be available. Therefore, the degree of accuracy and level of knowledge in the estimates in this EIS are more than adequate to assist in the initial decision. The standards for weather prediction are far more stringent than those for the long-term predictions in the EIS because weather predictions have an immediate impact.

7.3 (10632)
Comment - 010140 / 0003
Now, on page 3-21, table 3-13, I'm not going to go through all the different ones. That will be in my written report. But one of them, the experimental corrosion data replaces expert judgment. That was the rationale on why the estimated effect would be the decrease in dose up to 10,000 years. And the reason for that was that they claim that there will be no failure of any cask for 10,000 years based on this new alloy that they've had about a year's worth of study on. This is a very interesting piece of data.

DOE has improved the waste package on paper and now admits the waste package will fail before the half-life of plutonium is reached. The nonexistent natural barriers will be all that will be left after 10,000 years. Plutonium and the actinides with one half-life of at least a million years might as well be buried in a hole in the ground.

This entire analysis depends on the very limited corrosion data of Alloy 22. There's conflicting data on the accuracy of this data. And a small variation will result in a significant decrease in the life of the engineered barrier.

Response
DOE based the development of models that predict the performance of corrosion-resistant, nickel-based Alloy-22 in the repository on data from research literature and testing (including long- and short-term tests). The Department conducted long-term tests under expected repository conditions, and short-term tests under both expected repository conditions and very aggressive conditions. The American Society for Testing and Materials codified this approach in a standard procedure (DIRS 105725-ASTM 1998). Analyses of the tests use a suite of tools, including standard microstructural evaluation and atomic force microscopy, which permits the examination of surface films in such

great detail that even very slow degradation rates can be evaluated. Over the next several decades DOE would continue to test samples of Alloy-22 and other alloys that would be exposed in the repository to confirm the results collected to date. In addition, DOE would explore analogs of Alloy-22 to provide confidence in the long-term performance of Alloy-22.

DOE based its selection of materials on input from independent experts and laboratory tests, and from the actual performance of materials in full-size industrial applications. The corrosion tests involve Alloy-22 and other candidate waste package materials subjected to environments that are at least as aggressive as any expected inside Yucca Mountain. DOE would continue these tests during waste emplacement operations to confirm the expected waste package performance.

In the Final EIS, analyses have been refined and include early failures caused by defects in the waste package. The results show a very small dose from these failures. See Section 5.4 of the EIS for more details.

7.3 (10670)
Comment - EIS001966 / 0010
On-site storage at generation plant locations or Part 72 ISFSI's [independent spent fuel storage installations] for any period of time is not an alternative to a well-sited repository. Attached please find a copy of "Report of the Site Advisory Task Force, Goodhue County Dry Cask Storage Alternate Site Project, to the Minnesota Environmental Quality Board." I draw your attention to §8, Task Force Conclusions, including §8.7, Alternate Sites:

"None of the 16 properties proposed as alternate sites by concerned citizens are feasible and prudent for further consideration by the EQB. The permanency issue, public safety concerns involving transportation risks, the uncertainty of long-term exposure to low-level radioactivity, and the apparent lack of derived benefits to the estimated costs of construction and maintenance of an off-site facility are the primary reasons for this outcome. Simply put, there are no risk- and cost-acceptable alternatives to on-site storage. Even on-site storage for an undeterminable period of time is unacceptable."

Because of the obvious difficulties in siting at Yucca, the Task Force regarded potential storage in Florence Township and that established at Prairie Island as de facto permanent storage. The environmental, transportation, and emergency response problems cited in this report were applicable to Florence Township, Prairie Island, and they are applicable to Yucca Mountain. The risks of long-term nuclear waste storage are unknowable, and the risks of catastrophic error are too great to go forward.

Response
Many commenters expressed opposition to the Proposed Action. DOE recognizes both opposition to and support for the proposed Yucca Mountain Repository and the associated analyses in the EIS. Chapter 1 of the EIS describes the need for the repository and the extensive history associated with the selection of the Yucca Mountain location.
In particular, this comment is concerned that the long-term risks associated with the Proposed Action are unknowable. DOE believes that, through the extensive scientific investigations and analyses it has and will continue to conduct, it has determined the possible ranges of the impacts. DOE also believes that the results presented in Chapter 5 of the EIS and the supporting information in Appendix I and the reference documents show that there is reasonable expectation that the repository would meet the appropriate standards for human health and safety over the long term.

7.3 (10742)
Comment - EIS002101 / 0003
Just the other day I was working with some ranchers out of Amargosa Valley that came out to help us out with our well. They farm a thousand acres of hay. Part of their hay is organic hay that they feed the cows there. There's organic dairy there. They -- this one guy's talking about he started there when I was 15 years old. Now he's in his 60s. They turned that land into a place, you know, it was there, people used those springs for thousands and thousands of years before, maybe millions of years before, and now they're growing food for people there. They just want a chance to live, you know, but you just discounted them, you throw them away, and there's some government officials that we hear from, too, that say they want to be compensated. Well, you can't compensate when you destroy a piece of this earth.

Your twelve-mile boundary lines go right through Amargosa. Those are human people, and I work down here at the Federal courthouse doing groundwater remediation work, and I see that, you know, we're just people trying to get by, trying to make a living, want to go out here and see Yucca Mountain go through because it's going to mean a good paycheck for the next five or ten years, but they don't – we're not looking at after that point.

Response
The EIS examines the potential consequences to individuals in the Amargosa Valley from both radioactive and nonradioactive contaminants transported through air, water, soil and food pathways. Chapter 5 presents an evaluation of the long-term environmental impacts of the proposed repository on the people of Amargosa Valley. These evaluations demonstrate compliance with the Environmental Protection Agency environmental protection standards. Therefore, DOE believes adverse health impacts to people in Amargosa Valley would be highly unlikely to occur.

Figure 3-75 of Volume 3, *Total System Performance Assessment of the Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) illustrates the ingestion and direct exposure pathways, including dairy and hay operations, incorporated into the biosphere analyses. Section 3.8.1.3 of the Viability Assessment describes a 1997 survey designed to enable a representation of dietary patterns and lifestyle characteristics of residents within the 80-kilometer (50-mile) radiological monitoring grid surrounding Yucca Mountain. It states in part that Amargosa Valley is primarily rural agrarian, and that agriculture is mainly directed toward growing livestock feed (for example, approximately 1,800 acres planted in alfalfa, 30 acres in oats). Table 3-25 of the Viability Assessment specifies the consumption rates of drinking water and agricultural products estimated from the results of the survey and used in the biosphere model. DOE has created a database of this information for addressing potential impacts to the people of the Amargosa Valley.

7.3 (10885)
Comment - EIS001257 / 0004
There are too many unknown variables as to what effect this potential pollution problem will have on the future. [A] good example of this is the way that plutonium at the test site has traveled one mile from its test crater. It is inconceivable how large an area will be affected over a period of ten thousand years. This is unacceptable.

Response
The situation associated with past underground testing is very different from that of the proposed repository. The plutonium in the repository would be immobilized in ceramic fuel or an immobilized plutonium ceramic, whereas the plutonium at the Nevada Test Site is not. The immobilized plutonium at the repository would then be encased in a very robust engineered container emplaced in a repository system carefully engineered to minimize mobilization and transport. The plutonium from test detonations was forcibly ejected with a tremendous energy at extreme temperatures, which injected the material far into the rock and caused a large region of disturbed (fractured) and altered material.

The models used to project the movement of radionuclides through the rock of Yucca Mountain in the EIS were, however, revised based on another finding at the Test Site. For the Final EIS, the groundwater models have been updated to include consideration of colloidal transport similar to that found at the Test Site.

Even though the modeling now indicates a potential for more rapid movement of plutonium and several other radionuclide species, results of the updated analysis in Chapter 5 of the EIS indicate that these effects would not be important until more than 10,000 years after repository closure when the first significant number of waste package failures would occur. Even so, the results show that the radionuclide species that dominate the potential doses in the earlier tens of thousands of years are high-solubility nuclides that would not benefit from the carrying power of association with colloidal mineral fragments (DIRS 153246-CRWMS M&O 2000).

7.3 (11075)
Comment - EIS000475 / 0017
DOE has [an] obligation to fully address the suitability of the Yucca Mountain High Level Waste Repository site. DOE must consider long term consequences based upon best available technology and scientific knowledge. If DOE has anticipation, based upon agency experience and expertise, that Yucca Mountain will not permanently

isolate high-level radioactive waste from the natural and human environment for time periods of 100 and 10,000 years, DOE has obligation to say so in Final EIS.

Response
DOE agrees that it must consider all aspects of the suitability of the Yucca Mountain site before it submits a License Application to the Nuclear Regulatory Commission to construct and operate the proposed repository. The Department believes that it has used the best available scientific and engineering knowledge and technology to arrive at the environmental impacts described in the EIS. The EIS analyses show that there is a reasonable expectation that the repository would meet suitability and other regulatory criteria for safety during the operational period (more than 100 years) and for as long as 10,000 years after closure.

7.3 (11273)
Comment - EIS001814 / 0008
5.1 to 5.10 Environmental Consequences of Long-Term Repository Performance

The DEIS sections that analyze long-term performance are inadequate because they fail to account for the real possibility of a catastrophic accident due to human intrusion, volcanic activity, or seismic activity. The human intrusion scenario is based on only one future event occurring to intrude into the site. Similarly, the possibility of volcanic activity or significant seismic events are unaccountably minimized despite the fact that Yucca Mountain has a history of earthquakes and the surrounding area is volcanically active. An example of the failure of the DEIS to seriously analyze these real threats to the environment and human safety is found in the discussion of long-term consequences. The DEIS acknowledges that “[p]otential impacts to human health in the far future from a repository at Yucca Mountain would be dominated by impacts from radiological materials in the waterborne pathway under all three thermal load scenarios of the Proposed Action.” 5.10. But then goes on to minimize this impact.

Response
The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probabilities and effects of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

One change in the EIS is that now an aerial pathway release from an eruptive scenario is analyzed. The dose rates reported in Chapter 5 are well below the 40 CFR Part 197 environmental protection standards.

DOE has evaluated the long-term geologic stability of Yucca Mountain, including the potential for volcanoes. Volcanic activity has been waning in the recent geologic past and the probability of a volcano that could disturb the repository is very low (see EIS Section 3.1.3.1). Nevertheless, DOE presents an analysis of the effects of both a volcanic eruption, which could release volcanic ash and entrained wastes into the atmosphere, and the intrusion of magma into emplacement drifts, which could damage waste packages and contaminate the underlying aquifer. DOE estimated potential impacts on the nearest population to the south, conservatively assuming wind in that direction. Impacts in White Pine County would be a small fraction of nearby impacts such as those calculated. Sensitivity studies in the Total System Performance Assessment (DIRS 153246-CRWMS M&O 2000) suggest that the probability-adjusted dose from a volcanic, eruptive event at 20 kilometers (12 miles) in the direction of wind transport of an ash plume peaks at a few hundredths of a millirem per year. Because of radioactive decay in the repository there is a very low dose risk at 10,000 years. Therefore, given that White Pine County is considerably farther from the source, there is a negligible risk for dose from volcanism at Yucca Mountain.

DOE continues to include water pathways in its analyses of health risks of the proposed repository. The people of Amargosa Valley are most at risk because groundwater in the saturated zone beneath Yucca Mountain flows in a generally southerly direction into Amargosa Valley. They use water acquired primarily from local wells for household purposes, agriculture, dairy and catfish farms, horticulture, and animal husbandry.

Human intrusion into the repository is an issue because the future behavior of humans cannot be predicted. The Nuclear Regulatory Commission and Environmental Protection Agency have specified the way to analyze human intrusion in their regulations for Yucca Mountain. The regulations describe a stylized calculation that attempts to minimize the speculation as to why humans would intrude into the repository.

With regard to evaluating a single intrusion event, the National Research Council (DIRS 100018-1995) concluded that one borehole was a good test of system resiliency, and going further was so speculative that it served no purpose useful in judging the robustness of a system. The National Research Council also recommended the assumption of the use of current drilling technology to avoid speculation over future advances in drilling technology. The emphasis was recommended to be on the analysis of the creation of enhanced pathways for radionuclide transport from the repository to the saturated zone.

For the Draft EIS, DOE assumed the intrusion event to occur 10,000 years after closure of the repository. The Department chose this time because it is the earliest that waste packages (under the Draft EIS design) probably would have degraded to the extent necessary to allow penetration without the use of specialized drill bits. However, for the Final EIS, DOE assumed the intrusion event would occur at 30,000 years to simulate an intrusion at a time when the intruder might not detect the waste package because of its weakened state. Over time, as more waste packages failed (and potential doses rose toward a peak dose from the overall system), intrusion would become less, not more, meaningful because the more waste packages that fail, the less the additional waste package failure from drilling would contribute to the overall risk.

Section 5.7.1 of the Final EIS discusses the human intrusion scenario analysis and results.

7.3 (11560)
Comment - EIS002258 / 0004
An adequate discussion is not provided in the Draft EIS relative to whether the proposed repository containments are safe from the occurrence of seismic disturbances; for example, earthquakes are common to this area. The park service is concerned that this possibility alone may lead to a potential release of radionuclides into the environment, specifically the regional underground water system that underlies the proposed repository and downgrading springs, specifically those which discharge within the park.

Response
The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probabilities and effects of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

As discussed in Section 5.2.3.5 of the Draft EIS, the major effect of an earthquake at Yucca Mountain would be ground motion (shaking) rather than direct offset along a fault. The *Disruptive Events Process Model Report* (DIRS 151968-CRWMS M&O 2000) discusses the effect of offset along a fault. Past movement has been along existing faults, and the probability of new faults forming is low. DOE would not emplace waste packages near existing faults, so the probability of shearing a waste package would be very low.

The rockfall analysis discussed in the *Waste Package Degradation Process Model Report* (DIRS 138396-CRWMS M&O 2000) that supports the Total System Performance Assessment (DIRS 151968-CRWMS M&O 2000) and the Final EIS is much more detailed than that in the Draft EIS. DOE based the analysis of the probability of rocks of various sizes falling and damaging waste packages on the rock properties in the repository. Analyses of this new design (DIRS 114171-CRWMS M&O 1999), which includes a drip shield, show that the waste package could withstand the largest potential rockfall. Adding strong drip shields above the waste packages provides a very robust design that would be able to withstand any credible rockfall. This would hold true as long as most waste packages and drip shields retained their initial strength. Results for undisturbed degradation show that nearly all packages would be at design integrity for well over the compliance period of 10,000 years; in fact, this would be true for well over 50,000 years. Therefore, the effects of rockfall are not part of the long-term performance analysis calculations for the Final EIS—since this model was originally developed for the compliance period of 10,000 years prescribed in 40 CFR Part 197. In the case of long term peak doses which occur at 500,000 years there may be some seismic effects not accounted for since most packages have been breached by that time. No analysis is available at this time to determine how much the peak doses might be affected.

DOE's analyses also continue to include water pathways in its analyses of health risks of the proposed repository. The people of Amargosa Valley are most at risk because groundwater in the saturated zone beneath Yucca Mountain flows in a generally southerly direction that then turns to the west into Amargosa Valley. They use water acquired primarily from local wells for household purposes, agriculture, dairy and catfish farms, horticulture, and animal husbandry.

With respect to potential impacts on Death Valley, the DOE acknowledged in Chapter 3 of the EIS that a small amount of groundwater may move beyond the primary groundwater discharge point at Alkali Flat (Franklin Lake Playa) to discharge in the Furnace Creek area of Death Valley. However, even if this were the case, any impacts on the Furnace Creek area would be even less than the low impacts shown in Chapter 5 of the EIS for the discharge location (Franklin Lake Playa) because the impacts decline with distance from the repository.

7.3 (11561)
Comment - EIS002258 / 0005
The park service believes the Draft EIS inadequately assesses possible climatic changes over the next 10,000 years. Increase in precipitation could conceivably result in the transport of radionuclides from the repository to the water table.

Response
The Draft EIS included an evaluation of climate change and its effects on long-term performance. These effects included increased infiltration, increased flux at depth, increased radioactive material transport at depth after waste package failure, and a shortened path to the water table because of changes in water table elevation.

The Draft EIS performance assessment considered three climate scenarios: present day, long-term average (wetter than the present-day climate), and superpluvial (Section I.4.2.4). These scenarios were assumed to occur at short-duration, fixed intervals on a periodic basis during the 100,000-year period after waste emplacement. However, the modeling of climate states was changed for the Final EIS based on the latest research of the U.S. Geological Survey and the Desert Research Institute. As a consequence of this work, pluvial states were expanded to allow short-duration states within them resembling the previously modeled superpluvial states. Superpluvial states are no longer included as separate states based on the results of this continued research.

Models of future climates caused by global warming from increased atmospheric carbon dioxide are speculative, though they are supported by some global climate modeling and the general increase in global temperature noted in the past century. At Yucca Mountain the estimated effect of global warming would increase average precipitation to a level similar to the long-term average climate of the Draft EIS, which resembles the glacial-transition climate in the Final EIS. This estimate, which is based on atmospheric model input, resembles near-continuous El Niño conditions and the near doubling of the precipitation that accompanies these conditions. In other words, DOE considers global warming impacts on future climates to be within the bounds of predicted climate ranges used in the assessment of long-term performance. Chapter 5 of the Final EIS incorporates such climate impacts in the estimates of the environmental consequences of long-term repository performance. These impacts include the effects of global warming and future climate change in general.

Extreme precipitation events are mentioned in Section 3.1.2.2, but would not greatly influence the infiltration rates discussed and used for modeling purposes in Chapter 5 and Appendix I because the subsurface tends to "damp" extreme events (particularly in the Paintbrush nonwelded stratigraphic unit) to produce a nearly uniform infiltration rate with time at depth. If anything, extreme precipitation events are more closely associated with surface runoff events. Locality-based infiltration rates were used (not whole-mountain averages) to derive infiltration rates for repository zones modeled in the performance analysis. The approach to discretizing (dividing the repository into discrete zones) the repository for performance analysis calculations, and the areal infiltration rate applicable to each modeled zone, has been updated for the calculation results reported in the Final EIS (Section 5.4).

7.3 (11610)
Comment - EIS000113 / 0004
Now is DOT allowed to kill Death Valley monument?

Response

DOE assumes the commenter intended to say "DOE" rather than "DOT." Section 5.3 of the EIS discusses potential locations of long-term impacts from the repository. This section states that the general path of water that infiltrates through Yucca Mountain is south toward Amargosa Desert and into and through the area around Death Valley Junction. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, and spring discharge in Death Valley is a possibility. As listed in Table 5-8, the mean peak annual dose to a reasonably maximally exposed individual at the expected discharge location would be about 59 millirem, a very small dose compared to the background. Therefore, doses to reasonably maximally exposed individuals at unexpected discharge points in Death Valley would be even smaller. There is no evidence in the analyses available to DOE that would suggest significant impacts would occur to the Death Valley National Monument. DOE believes that the EIS provides sufficient information on possible impacts to Death Valley National Monument to support current decisionmaking.

7.3 (11829)

Comment - EIS001653 / 0113

5.6 DOE needs to provide a table in Chapter 5 which describes basic assumptions and key performance attributes of the repository system.

Response

DOE agrees with this comment and has included such a table (Table 5-4) as part of Section 5.2.3 in the EIS that is a cross-reference to detailed tables of key assumptions and associated performance-affecting attributes of the repository system. The tables of assumptions and attributes are extremely voluminous and are of an inappropriate level of detail for EIS. The tables can be reviewed in readily available public documents listed in Table 5-4.

7.3 (12037)

Comment - EIS000540 / 0009

Concerned that the DOE Yucca Mountain Safety Strategy allows for radioactive contamination of groundwater, relying on dilution of the waste to limit the radiation dose to nearby residents[10] who use the water for drinking, growing crops, and livestock, and for raising cows on the largest dairy in Nevada to supply the Los Angeles commercial milk market.

[10]US Department of Energy. Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect Public Health and Safety after Closure of a Yucca Mountain Repository. Office of Civilian Radioactive Waste Management, Las Vegas, Nevada, December 1998.

Response

The Environmental Protection Agency (EPA), in promulgating the Yucca Mountain environmental protection standards (see 40 CFR Part 197), recognized that, with the current state of technology, it is impossible to provide a reasonable expectation that there would be "zero" releases over 10,000 years or longer. Therefore, the EPA established standards that it believes provides comparable protections to those of other activities related to radioactive and nonradioactive wastes. These standards do not require complete isolation of the wastes over the compliance period (that is 10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment for Yucca Mountain is to evaluate whether the repository would be likely to meet these standards. The goal of this EIS is to describe the methods and results of that evaluation.

The performance assessments discussed in the Draft EIS and the Final EIS do not begin with the assumption that the repository would leak. Rather, the performance assessment assigns probability-of-occurrence values (referred to as probability distributions) to various parameter and process features that consider the uncertainty associated with a particular parameter or process. When multiple simulations of repository performance (realizations) are computed, the results indicate which of the various outcomes is more likely to occur (mean values). However, in addition to the most likely outcome, the distributions also show extreme cases (referred to as the 5th and 95th percentile values) that provide a measure of the uncertainty associated with a particular outcome. Although not likely, a number of realizations produced no leakage for extremely long times. The updated analysis in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197) and would be due to the very unlikely event of between zero and five packages failing due to manufacturing defects.

With regard to the use of dilution factors, DOE does not believe that dilution, in and of itself, is an acceptable method to meet environmental protection standards. However, the EPA has specified the location of the reasonably maximally exposed individual for compliance purposes (40 CFR 197.21), and DOE has used the best available information and generally accepted methods, which include credit for dilution, to estimate potential impacts to this hypothetically exposed individual.

With regard to potential milk contamination, the analysis in the Final EIS projects that the Proposed Action probably would result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These estimated releases would result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem, including milk pathways, which is more than 100,000 times less than the individual protection standard set by 40 CFR Part 197.

The EPA also requires a calculation of peak dose (40 CFR 197.30) within the period of geologic stability (1 million years). The EPA requires that DOE include these results and their bases in the EIS as an indicator of long-term performance. This analysis also serves as another source of information for the decisionmakers in making both design and licensing decisions. However, the EPA has recognized the inherent uncertainties associated with these long-term projections and has, therefore, not applied a regulatory standard to the results. Although the analysis in the Final EIS predicts small releases within the 1-million-year period, because of the large uncertainties associated with this prediction, DOE believes that population impacts (for example, those resulting from consumption of contaminated milk) resulting from these releases would be speculative and, therefore, has not included them in the EIS.

7.3 (12071)
Comment - EIS001912 / 0119
Pg. 4-1 Preconstruction Performance confirmation period. How can DOE suggest that performance confirmation will determine with reasonable assurance that the repository would meet performance objectives. Does DOE have a reasonable assurance now? If not why not? Will DOE have a contingency plan in the event that preconstruction performance confirmation activities have negative results? Because DOE cannot guarantee the repository will actually provide containment and that an extended period of performance confirmation will continue, the EIS needs to describe as part of the preferred alternative contingency actions.

Response
The EIS statement about “reasonable assurance” refers not just to the preconstruction period but to confirmation activities that would continue until repository closure. Their purpose would be to continue to build confidence in the system before closure. The information would provide additional assurance for the development of license amendments to proceed with closure sometime after 2110. The decision to close the repository would be very critical and would require the most advanced knowledge available.

The regulations applicable to the proposed Yucca Mountain Repository [see 10 CFR 63.101(a)(2) and 40 CFR 197.14, and 197.20] acknowledge there would be uncertainties, and they require no absolute proof of future performance, but instead require there to be “reasonable expectation” of compliance with safety standards. The challenge to DOE is to show compliance with the regulations while at the same time fully disclosing the uncertainties. The type of assurance needed now must support a decision to proceed to licensing and construction. DOE has to be confident enough in the projected system performance to justify the commitment of resources to this project. The projected range of performance based on current uncertainties must show that the system would likely meet the public health and safety standards set by the Environmental Protection Agency. This EIS is one of a number of documents that will provide input to the determination of whether to proceed with the proposed repository. Additional decision points would occur in the future.

The Proposed Action includes a lengthy program of monitoring, testing, and performance confirmation. This program would continue for perhaps as long as 300 years, through closure of the repository (see Section 2.1.2 of the EIS). It would give future decisionmakers the option to take corrective action if information developed during preclosure or as a result of monitoring, testing, and performance confirmation indicated the need for such actions.

This program would also provide information to support making societal choices on closing the repository or retrieving the wastes.

The details of the postclosure monitoring program would be further defined during the processing of the license amendment for permanent closure, but the types of monitoring that DOE would consider are discussed in Section 2.1.2 of the EIS. Deferring a description of this program until the closure period would enable the identification of appropriate technology, including technology that could become available in the future.

The EIS uses the best available data and analysis techniques to provide estimates of possible impacts. Therefore, testing and monitoring activities and action plans are part of ongoing studies and other documentation that could support licensing and other decisions at various stages of the project. A proposal to close the repository in the next century probably would be supported by a series of comprehensive documents and the experience gained during operations and developed with analytical techniques advanced beyond those in current use.

7.3 (12199)
Comment - EIS001888 / 0436
[Clark County summary of comments it has received from the public.]

Examples cited by other commenters were the potential for humans and the environment to be affected by transport of contaminated groundwater (Death Valley National Park, contamination of regional aquifer), and changes in the vadose zone from the high thermal load alternative. Some commenters questioned whether the EIS could provide information after failure of the waste packages such as mixing of various metals, minerals, isotopes, water, and heat. One commenter requested that a “maximum credible scenario” should be developed for releases from the repository.

Response
As described in Section 3.1.4.2 of the EIS, DOE has conducted an extensive program to characterize the direction and nature of groundwater flow from the Yucca Mountain site. The general path of water that percolates through Yucca Mountain is southward toward the Town of Amargosa Valley, then beneath the area around Death Valley Junction in the southern Amargosa Desert. The groundwater beneath Yucca Mountain merges and mixes with groundwater beneath Fortymile Wash. This groundwater then flows toward, and mixes with, the large groundwater reservoir in the Amargosa Desert. The natural discharge point of this groundwater occurs farther south in Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume may flow south toward Tecopa into the southern Death Valley area. A fraction of the groundwater may flow through fractures in the relatively impermeable Precambrian rocks at the southeastern end of the Funeral Mountains toward springs in the Furnace Creek area of Death Valley. Potentiometric data indicate that a divide could exist in the Funeral Mountains between Amargosa Desert and Death Valley. This divide would limit discharge from the shallow flow system, but would not necessarily affect the flow from the deeper carbonate aquifer that may contribute discharge to springs in the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Potential Furnace Creek area impacts would be less than the low impacts described in Chapter 5 for Franklin Lake Playa because impacts would decline with distance from the repository.

The long-term performance analysis calculations included changes to the unsaturated (or vadose) zone resulting from the thermal pulse under each of the three thermal loads. Waste package degradation following failure is the subject of detailed process-level modeling, the results of which DOE reported in Chapter 5 of the EIS.

With the regard to the suggestion of a “maximum credible scenario,” the EIS presents the long-term performance results in probabilistic terms – mean and 95th-percentile results. This statistical spread reflects the range of possible behavior DOE believes is credible for the repository system based on wide ranges of parameters. As such, the “worst case” is contained within the results. The worst case could be realized as the results approached at the 100th percentile.

7.3 (12310)
Comment - 010321 / 0001
Number one, the first comment is the heavy metals. I don’t believe that we have accurate --that nickel will not be released to the environment, particularly when I read both documents -- the Supplement and the engineering science

report *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation Consideration*.

I could not find any relation to zeolite absorption. And the question to come, what will happen which will make way first, the heavy metals or the radionuclides. Specifically what's happening is that hard water usually has an affect of absorption of nickel. I'l1 give an example.

Like in pure water nickel is absorbed about 58 percent, and hard water it's only 50 percent, so there is a question, which leads me to another conclusion that the rate of release which will come through the environment in the biosphere is not accurate.

Another point which I have not seen adequate response is the issue of complex mixtures. There was a question, how are we going to calculate the risk? The President, the Secretary of DOE, officials always say, we're going to use the best science. At this point in time nobody can tell me what is the real risk, because I can cite from the literature professional organization EPA [Environmental Protection Agency] guidelines which address the issue of complex mixtures and others very clear. There is over about 3,000 references which show interactions to various degrees between heavy metals, carcinogen and noncarcinogens and irradiation.

There is even a mathematical model which has been developed by Dr. Suzuki (phonetic) in Japan and never been implemented. I'm asking rhetorical questions why Yucca Mountain does not use the basic developed technology to describe and to predict the risk, because the current methods are incomplete. Specifically I'm talking about physiological and pharmacokinetic testing, which can take into account metabolism, distribution, extrusion, and being used and advocated by EPA to study complex mixtures.

It's advocated by the EPA, and I'm just puzzled why neither EPA or NRC [Nuclear Regulatory Commission] are looking, and specifically when an NRC official said we separated radionuclides from toxic chemicals. In the same document he forget to mention the recent recommendation for studies.

In my professional opinion unless all those studies would be completed, you should put a halt on Yucca Mountain because there are very serious uncertainties. You cannot predict the rate what so happened to the population. I can give an example.

For instance, if you take nickel, carcinogen is enhanced in the presence of chromium hexavalent. This is just an example, or I can give you references. When you irradiate nickel, the embryo tissue culture, nickel x-ray or UV, you get an increase in chromosome aberration, inhibition of repair of the DNA and subsequent genetic toxicity, which can increase the rate of carcinicity, and there is no doubt about it.

I am going to give all this information to Abe Van Luik, my friend, who will continue to argue. And I will challenge them, because when it comes to science you have to use to best science.

Response

The EIS presents the risks of exposure to ionizing radiation and hazardous chemicals separately, where the potential for these exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues were the same, because exposure pathways and cellular and molecular mechanisms of cancer induction could differ. The low levels of exposure to radiation and hazardous substances likely to occur from repository operations (Section 4.1) and long-term performance (Sections 5.4, 5.5, and 5.6) would be such that there would likely be no impacts, even though the linear, no-threshold application of risk factors generates fractional impact estimates, such as fractional latent cancer fatalities. Section F.1 contains more information.

7.3 (12317)
Comment - 010242 / 0028
Page 3-19: Section 3.2 - Long-Term Impacts

The Supplement has not, but should consider the impact of the long-term release to the environment of hazardous metals, other than radionuclides, from the repository's engineered components, as was done for the design scenarios in the DEIS.

Response
Section 3.1.12.2 of the Supplement to the Draft EIS mentions that the impacts from the release of hazardous materials would be small. This is further detailed in the Final EIS in Sections 5.6 and I.6. Bounding-case analysis indicates that the concentrations of these materials would be well below regulatory limits in water down-gradient from the repository.

7.3 (12382)
Comment - EIS001888 / 0438
[Clark County summary of comments it has received from the public.]

Commenters requested that the EIS consider the impacts of releases from the repository at the "population level." The EIS should report all dose response models and label each as to whether they are only fatal cancer models or include other health effects. Radon and other gaseous emissions via fracture pathways should also be evaluated. The long-term effects of heat on the ecosystem; and in turn how an altered ecosystem may effect waste isolation, should be analyzed in the EIS. Releases from the repository to the regional groundwater system (specifically Death Valley, Pahrump Valley aquifer, Ash Meadow area), based on a regional aquifer Characterization program, must be considered.

Response
Chapters 4, 5, and 6 of this EIS describe potential population doses to the public for the preclosure activities, postclosure performance, and transportation, respectively, including occupational doses to worker populations for preclosure activities and transportation. The human health impacts primer (Section F.1) describes how radiological doses from exposure to low or chronic levels of radiation convert to health effects. Section F.1.1.5 discusses potential health effects from low-level radiation exposure and their related importance.

In the system model of the proposed repository, gaseous radionuclides, such as radon-222 (which has a half-life of 3.8 days and is a progeny of radium-226) and carbon-14 (half-life of 5,730 years) are considered to be released as waste packages and cladding fails. The atmospheric transport of these gases to the local population is evaluated in Chapter 5.

Section 5.9 of the EIS describes potential local environmental consequences of the closed repository on the ecosystems in the vicinity of Yucca Mountain as a result of heating of the ground surface and of waste migration through groundwater to discharge points. The impacts of temperature increases, radiation exposures, and changes in surface soils and habitat on plants and animals are evaluated. Special attention is given to estimated increases in surface soil temperature that could affect the gender of hatchlings of the desert tortoise – the only species in the repository land withdrawal area that is listed as threatened under the Endangered Species Act.

EIS Section 3.1.4.2 describes the status of the understanding of the regional groundwater flow, based on an understanding of the saturated zone groundwater flow system updated by DOE and Nye County work.

7.3 (12435)
Comment - EIS000426 / 0004
Another problem with this project is the information provided or shall I say not provided. In your environmental impact statement you failed to provide some important information on the surrounding areas of Yucca Mountain. Last time I checked an environmental impact statement, it is supposed to include all potential effects of the designated area for the site. If this is true then why did you fail to mention the impact the Yucca Mountain Site will have on the nearby dairy farm? The milk products coming from this farm, if contaminated, will not only effect the people of that area but also all the people who receive their milk from that region.

Response
The *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) and the biosphere pathways model used for the long-term performance assessment in the EIS explicitly include dairy farms and milk products in the food chain and potential exposure pathways. In addition, the Yucca Mountain Site Characterization Project and the DOE Nevada Operations Office have conducted environmental surveys to establish baseline concentrations of radionuclides in milk produced in the region.

Figure 3-75 of Volume 3 of the Viability Assessment (DIRS 101779-DOE 1998) shows the ingestion, inhalation, and direct exposure pathways, including dairy operations, incorporated in the biosphere analyses. Section 3.8.1.3 of that document describes a 1997 survey designed to permit an accurate representation of dietary patterns and lifestyle characteristics of residents within the 80-kilometer (50-mile) radiological monitoring grid surrounding Yucca Mountain. It states: "Commercial agriculture in the Amargosa Valley farming triangle area includes a relatively large dairy that operates with approximately 4,500 milk cows and employs approximately 50 people." Table 3-25 of the Viability Assessment lists the consumption rates of drinking water and agricultural products, including milk, estimated from the results of the survey and used in the biosphere model. Thus, there is a defensible and traceable basis for addressing potential impacts of contaminated milk products.

The results and interpretation of the biosphere modeling in Section 3.8.3 of the Viability Assessment (DIRS 101779-DOE 1998) indicate that exposure pathways involving drinking water and leafy vegetables are more important than those involving milk.

7.3 (12438)
Comment - EIS001886 / 0003
IEER [Institute for Energy and Environmental Research] applauds and appreciates the fact the DOE evaluated peak doses for up to 1 million years and did not restrict itself to the arbitrary time limit of 10,000 years in the draft EPA [Environmental Protection Agency] Yucca Mountain standard. The 10,000 year limit has been rejected more than once by the National Research Council and by many others, including IEER. This feature of the EIS should be maintained.

Response
DOE appreciates the encouragement to continue to address peak dose in its calculations. The Department has done so in the Final EIS, and will continue to evaluate peak dose hereafter as a means to better understand long-term performance of and to improve the design of the proposed repository. However, DOE also agrees with the Environmental Protection Agency that, because of the large uncertainties, these estimates should not be used to assess compliance with environmental protection standards.

7.3 (12439)
Comment - EIS001888 / 0093
DOE's selection of values for performance parameters was often based on limited data or recommendations from expert elicitations that were conducted in lieu of data. In some cases, such as waste package wall material corrosion rates (discussed in Attachment [to this comment document] B), the base-case expected values used may not adequately represent the potential for radionuclide release and transport.

DOE often selected features for TSPA-VA [Total System Performance Assessment-Viability Assessment] models that would produce high values for radionuclide release and transport. For example, it was assumed that the entire surface of the waste package is wetted when dripped on, that all seepage that contacts a package enters the package when the wall is penetrated, and that all of the waste form is exposed in a fuel rod with breached cladding.

Some performance factors that could contribute to repository system performance, such as in-package dilution, were omitted from the TSPA-VA codes because the basis for characterizing performance parameter values was uncertain.

A key feature of the models and computer codes used for the TSPA-VA analyses was uncoupling of thermal, hydrologic, chemical and mechanical phenomena that are known to be coupled. Coupled effects may be important to performance of a repository with the temperature and heat-load characteristics assumed for the TSPA-VA analyses, but the characteristics of coupling and their effects, and the effect of model uncoupling on the reliability of the TSPA-VA results, are uncertain.

Response
Since the publication of the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) and the Draft EIS, DOE has minimized reliance on expert elicitation and has developed many new models. The waste package degradation model for the Final EIS is based primarily on experimental data, which indicate likely waste package lifetimes of more than 10,000 years.

As noted in the comment, the Viability Assessment and the Draft EIS did not analyze coupled thermal, hydrologic, chemical, and mechanical processes, but stopped with thermal and hydrologic coupling only. The analyses for the Final EIS, as documented in the *Near Field Environment Process Model Report* (DIRS 153363-CRWMS M&O 2000) evaluate thermal, hydrologic, and chemical coupling and thermal, hydrologic, and mechanical coupling. The effects would be small. DOE used the chemical effects directly in the Total System Performance Assessment model. It did not use the mechanical effects because they would have negligible effects on system performance.

The comment also notes that many of the models are conservative and that they neglect many beneficial processes. DOE intentionally incorporates such conservatisms into its analyses to ensure that impacts are not underestimated. This should provide confidence that the repository would protect public health and safety and would be able to comply with regulations, and that actual repository performance would be much better than the calculations of the long-term performance analysis in the EIS.

7.3 (12440)
Comment - EIS001923 / 0002
This document which, at first glance, looks like a document that is the work of unbiased authors. Upon reading this document one very quickly comes to the conclusion that the authors purposely have attempted to confuse the public. The DOE over the past year has attempted to convince the readers and anyone who would listen that the proper way to determine the suitability of this project was the “Total Systems Performance Assessment” [TSPA]. The EIS in Volume 1 presents data that shows that in the eyes of the DOE the project is viable. On page 1-19 volume 1 DOE states that the TSPA is based on the data available in 1998 DOE continues by stating “This EIS summarizes results from the Viability Assessment where applicable and data analysis that continued after the completion of the Viability Assessment.” That on the surface sounds like the results can be clearly stated for the Secretary of Energy to easily sign off on the safety of the proposed project. The EIS is supposed to be a document that can be understood by people outside of DOE. On page 1-19, Volume 1 the DOE refers the reader to Chapter 5. Table 5-1 on page 5-5 presents the average radionuclide inventory used for the performance assessment calculations. One can see in this table the 1/2 lives of the material. I focus on this because DOE states that the data used in the computer runs is not an exact match with the inventory data in Appendix A. The values vary by a factor of over 100. Now I do not pretend to know how bad it is but when a simulation is conducted and is the basis of providing the Secretary of Energy the technical input that insure [ensures] him that the project meets all the criteria for safety and health for the environment and humans, I expect that analysis to be the best it can be. When the data used is off by more than a factor of a hundred and this error occurs in a time period that will, (you notice I didn’t say can) contaminate the earth and humans after the containers are gone. The assessment must be done with the latest data and clearly spell out why a radiation level of greater than 11 curries [curies] per package will not impact the human race for over a million years after the containers are gone. Would DOE bury that much material in the ground today?

Response
The inventory in Section 5.1 of the Draft and Final EISs is based on an abstraction of the actual inventory (presented in Appendix A). Direct comparison of inventories in Section 5.1 to values in Appendix A cannot be done. The abstracted inventory has been carefully formulated to make it representative of the repository inventory for the purposes of the Total System Performance Assessment modeling. This is explained in detail in Section I.3. Details of the screening analysis for radionuclides are also in Section I.3, and other sources are referenced in Section I.3.

7.3 (12534)
Comment - EIS001078 / 0002
I spent 25 years of my career as a government meteorologist assigned to the Nevada Test Site nuclear underground testing program in the period from the 1960s through early 1980s. One thing that impressed me about the underground testing program was the difficulty in assuring against ventings of nuclear materials during tests. Despite every apparent effort at containment, there were unexpected prompt massive ventings at the time of certain nuclear experiments that more than once literally shut down the test program for months while better containment

procedures and models were developed to try and avoid the unexpected geological and hydrological situations and the shortcomings in test hole backfill procedures that were felt lead [led] to these accidental releases.

The lesson from this as applied to a 10,000 year isolation problem is that mother nature and human shortcomings in methodology will almost certainly deliver up surprises that will result in serious problems of noncontainment sometime in the 10,000 year life of the project. Meteorological predictions have their limitations, but geological predictions have far, far greater prediction uncertainties.

The sad thing about this 10,000 year project is that future generations, perhaps those well beyond the duration of unpredictable civilization changes that have occurred throughout all history since the birth of Christianity, will likely have to contend with these problems. It's anyone's guess as to how well these future generations, these future political systems, future cultures, future population sizes, future densities of population near the storage facility, will be able to cope.

Response
DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC) also recognize the difficulty of understanding the behavior of complex systems over long periods. In 10 CFR Part 63, the NRC acknowledges that "proof that the geologic repository will conform with the objective for postclosure performance are not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation (consistent with 40 CFR Part 197)." In 40 CFR Part 197, EPA establishes "reasonable expectation" as a test of compliance, with diminished "weight of evidence" with time. EPA also recognizes the need for expert judgment in assigning scenario probabilities, selecting simulation models, and assigning parameter distributions. Consistent with National Academy of Sciences observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events.

DOE confidence in the disposal techniques is based on defense-in-depth that, for example, places drip shields over waste packages to account for uncertainties. The Department has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components. DOE believes that this process results in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios, including the preferred alternative.

DOE continues to evaluate the sufficiency of its approach to dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended as a suitable site.

As described in Chapter 1 of the EIS, Congress determined through the passage of the Nuclear Waste Policy Act of 1982 that the Federal Government has the responsibility to permanently dispose of spent nuclear fuel and high-level radioactive waste to protect the public health and safety and the environment. The Act says that the Federal Government needs to take precautions to ensure that these materials do not adversely affect this and future generations. For this reason, EPA has been careful to promulgate environmental protection standards for Yucca Mountain (40 CFR Part 197) that include repository performance criteria that would represent potential risk to future generations no greater than those that present society would be willing to accept. Before recommending development of the proposed repository, the Secretary of Energy must provide a reasonable expectation that the repository would be able to meet these standards.

7.3 (12544)
Comment - EIS001287 / 0002
One of our concerns with the YMP [Yucca Mountain Project] is the effect buried wastes could have over the very long periods during which they will remain radioactive. The EIS uses two time frames of analysis. One is "short-term" -- the next hundred years. The second is "long-term," -- the next 10,000 years. In our fast paced society, where short-term often means the next three months, or the next year, 10,000 years seems an absurdly long-time. But consider the half-life of Plutonium 239, one the radioactive elements proposed to be buried in Yucca Mountain. It has a radioactive half-life of 24,360 years. This means that after that time period, half the radioactivity remains.

After a mere 10,000 years, the plutonium in the repository would be about 80% as dangerous as when it was first buried. After 100,000 years, tens times longer than the "long-term" effects period analyzed in the EIS, one-sixteenth of the radioactivity will remain. This is a quite a lot, considering that plutonium is the most deadly substance known, with one particle lodged in a lung almost certain to result in a cancer. We find it incredible that the EIS does not discuss the radioactive half-life of the elements to be buried at Yucca Mountain. If it had been discussed in the EIS it would beg a question about what "long-term" really means. And the answer would be "much longer than 10,000 years."

What will be left of America in ten thousand years? Will the U.S. Government survive? What about the State of Nevada? Who will be here to reap the deadly harvest of the seeds to be sown in Yucca Mountain? One hundred thousand years may seem an inconceivably long time. But at the end of that period, significant radioactivity would continue to emit inside Yucca Mountain. With some luck it would remain contained there. Consider that in one hundred thousand years, the North American continent is likely to drift 2.5 km or more than 1.5 miles from its present location. I ask, with some seriousness, where will Yucca Mountain be by then? And what will happen to the storage canisters and the still deadly nuclear waste within them? The EIS estimates the probability of volcanic disruption at or near the repository was one in 7000. No doubt the probability over one hundred thousand years is much greater. One hundred thousand years may seem inconceivable, but the EIS must still make some attempt to conceive it, to examine the truly long-term consequences of the burial of this waste.

Response

DOE recognizes that some components of spent nuclear fuel and high-level radioactive waste will pose a hazard after 10,000 years. However, as directed by Congress in the Energy Policy Act of 1992, the Environmental Protection Agency (not DOE) is responsible for establishing the radiation protection standards for the Yucca Mountain repository, and the Nuclear Regulatory Commission is responsible for developing criteria for licensing the repository that are consistent with those standards.

Thus, the projections of impacts to 10,000 years (and beyond) in the Draft EIS were based on a design comprising various engineered barriers and the natural barrier system. The projections were developed in consideration of the proposed Environmental Protection Agency (EPA) and Nuclear Regulatory Commission rules that specified 10,000 years as the period of performance to be evaluated for licensing purposes. The Environmental Protection Agency rule (40 CFR Part 197), which established environmental radiation protection standards for Yucca Mountain, required that DOE demonstrate that there is a reasonable expectation of compliance with the standards specified in the rule for 10,000 years following disposal. If the Department cannot make this demonstration, then the Nuclear Regulatory Commission cannot issue a license pursuant to its criteria (10 CFR Part 63).

EPA also requires a calculation of peak dose (40 CFR 197.30) within the period of geologic stability which, for the Repository, is 1 million years. EPA requires DOE to include these results and their bases in the EIS for Yucca Mountain as an indicator of long-term disposal system performance. This analysis, which includes consideration of disruptive events such as volcanism, also serves as another source of information for the decisionmakers in making both design and licensing decisions. However, the EPA has recognized the inherent uncertainties associated with these long-term projections and has, therefore, not applied a regulatory standard to the results.

As described in Chapter 1 of the EIS, Congress has determined through the passage of the NWPA, that the Federal Government has the responsibility to permanently dispose of spent nuclear fuel and high-level radioactive waste to protect the public health and safety and the environment. The Act goes on to require the Federal Government to take precautions to ensure that these materials do not adversely affect this and future generations.

DOE recognizes that no containment, natural or engineered, can be guaranteed indefinitely. Rather than a goal of "zero leakage," which is unattainable, the repository is being designed to meet those standards for the amount and timing of releases of radioactive materials to the environment. DOE estimates that no individual would receive more than a few millirem (a thousandth of a rem) per year during the preclosure period (see Section 4.1 of the EIS) or more than 0.001 millirem during the 10,000-year period after repository closure (see Section 5.4 of the EIS).

DOE also recognizes that "predicting societal change over the long-term is impossible." As a consequence, the Department has structured conservative assumptions and scenarios taking into account the regulatory guidance provided by EPA and NRC, the National Academy of Science, and other scientific authorities that have provided review of the Total System Performance Assessment. These assumptions and scenarios attempt to reasonably accommodate the inherent uncertainties with estimating long-term repository performance.

7.3 (12561)
Comment - 010116 / 0009
Nowhere in this report or in the EIS have I found any discussion of the corrosion caused by contact of two dissimilar metals. Is there any possibility of a current flowing through the waste packages? A very low current could cause big problems over periods of time. I was surprised that DOE chose 316 stainless. It's magnetic and corrodes very easily. Has any analysis been conducted on whether the magnetic material can develop a small current?

Response
No credit was taken for the stainless-steel sleeve, which would be only a structural reinforcement before a breach of the Alloy-22. Until the Alloy-22 was breached, the interface would be unwetted and not exposed to oxygen. Therefore, damage to the passive layer would be of no consequence. After the Alloy-22 became breached, corrosion would proceed from the inside, and such things as the presence of stainless steel would be accounted for.

7.3 (12603)
Comment - EIS001957 / 0024
Section 5.7.3 Consequences from Disruptive Events, Seismic Disturbances -- In this section, it is stated that:

"The probability of earthquake occurrence in the Yucca Mountain vicinity is sufficiently high that DOE evaluated potential effects of seismic activity on repository performance. The potential effects of seismic activity would be vibratory ground motion in the repository, causing falling rock to damage waste packages, and a nearby event causing changes in hydrologic properties."

Later in the section, it is stated that:

"Most waste package failures caused by seismic activity probably would occur when the waste package outer wall was completely corroded.… At times greater than 100,000 years after repository closure, damage from falling rocks would be more likely because the waste packages would be corroded. … There is less than a one- percent probability that a falling rock would breach a waste package during the first 10,000 years after repository closure… Over 1 million years, falling rocks could breach about 30 percent of the waste packages in the repository."

The DOE states that waste packages are subject to corrosion. The DOE admits that the probability of seismic events that might breach a waste package in the proposed repository is approximately 10^{-2} during the first 10,000 years, and that after 1 million years, about 30% of the waste packages could be breached. Given that potentially harmful radionuclides with half-lives of well over 1 million years (e.g., Neptunium 237) are to be included in these waste packages, the draft EIS does not address the potential effects of seismic hazards on repository performance, especially the structural integrity of the waste packages, and subsequent effects on down-gradient springs if the packages leak. It is also suggested that the supplemental draft EIS address whether--within an accelerated timeframe for possible radionuclide contamination due to seismic damage-necessary remediation and restoration sciences will be refined sufficiently to respond to impacts which ensue.

Response
The EIS does contain analyses of impacts that could arise from natural catastrophic events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can incorporate them statistically into the risk analysis. Chapter 5 of the EIS contains an assessment of the probabilities and effects of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicates the potential risk, as reported in the EIS.

As discussed in Section 5.2.3.5 of the Draft EIS, the major effect of an earthquake at Yucca Mountain would be ground motion (shaking) rather than direct offset along a fault. The *Disruptive Events Process Model Report* (DIRS 151968-CRWMS M&O 2000) discusses the effect of offset along a fault. Past movement has been along existing faults, and the probability of new faults forming is low. DOE would not emplace waste packages near existing faults, so the probability of shearing a waste package would be very low.

The rockfall analysis discussed in the *Waste Package Degradation Process Model Report* (DIRS 138396-CRWMS M&O 2000) that supports the Total System Performance Assessment (DIRS 151968-CRWMS M&O 2000) and the Final EIS is much more detailed than that in the Draft EIS. DOE based the analysis of the probability of rocks of various sizes falling and damaging waste packages on the rock properties in the repository. Analyses of this new design (DIRS 114171-CRWMS M&O 1999), which includes a drip shield, show that the waste package could withstand the largest potential rockfall. Adding strong drip shields above the waste packages provides a very robust design that would be able to withstand any credible rockfall. Therefore, the effects of rockfall are not part of the long-term performance analysis calculations for the Final EIS.

DOE's analyses also continue to include water pathways in its analyses of health risks of the proposed repository. The people of Amargosa Desert are most at risk because groundwater in the saturated zone beneath Yucca Mountain flows in a generally southerly direction that then turns to the west into Amargosa Desert. They use water acquired primarily from local wells for household purposes, agriculture, dairy and catfish farms, horticulture, and animal husbandry.

With respect to potential impacts on Death Valley, the DOE acknowledged in Chapter 3 of the EIS that a small amount of groundwater may move beyond the primary groundwater discharge point at Alkali Flat (Franklin Lake Playa) to discharge in the Furnace Creek area of Death Valley. However, even if this were the case, any impacts on the Furnace Creek area would be even less than the low impacts shown in Chapter 5 of the EIS for the discharge location (Franklin Lake Playa) because the impacts decline with distance from the repository.

7.3 (12655)
Comment - EIS000475 / 0002
The agency is proposing to construct a facility designed to isolate High Level Radioactive Waste [HLRW] from the human and natural environment based upon a proposed standard which would be in effect for 10,000 years. Human history has little track record with 10,000 year construction projects. In actual fact minus interested party spin doctoring, present day humans have little, if any, knowledge of human construction projects completed and/or attempted 10,000 years in the past in the Nevada desert or elsewhere.

To further compound the lack of scientific coherence, the numbers don't add! Peak doses from the disposed HLRW are anticipated to occur some 200,000 thousand years in the future. "Acceptable" levels of radioactive releases from the Yucca Mountain disposal facility should, according to sound science (and basic logic) be calculated to correspond with the same time frame which scientific calculations indicate peak doses are most likely to occur--some 200,000 thousand years into the future. 1999 or 2000 calendar year best available technology apparently is insufficient to adequately contain the radioactivity of HLRW for 10,000 years, for 200,000 years, and for the half-lives of Plutonium-239 (24,130 years), Technetium-99 (213,000 years), Thorium-232 (14 Billion years), Uranium-235 (7 million years), and Uranium-238 (45 million years). However, the agency has mandate to adhere the standards of protection currently in law rather than rewrite lower standards and "permanently" withdraw 230 square miles of federal land to isolate a site of less than 2 square miles in actual site size.

A maximally exposed individual (MEI) who has the highest exposure within the receptor group is assumed by the agency to be located at the point of maximum concentration of contaminants 24 hours a day, 7 days a week for the period of operations (which is multiple generations of human lifetimes). Regulatory dose limits for individual members of the public as applied to all other sites are currently defined by U.S. EPA [Environmental Protection Agency] and NRC [Nuclear Regulatory Commission] regulations and DOE orders. Safe Drinking Water Act limits (apparent exception for the Yucca Mountain Repository) 4 mrem/yr. [millirem per year] maximum dose from drinking water. Clean Air Act sets maximum dose limit from airborne emissions at 10/mrem/yr. (apparent exception to population and MEI surrounding Yucca Mountain). Dose limitations for all pathways combined is set by DOE Order 5400.5 and NRC regulations 10 CFR 20 at 100 mrem/yr. (apparent exception to Yucca Mountain MEI and surrounding population) (DOE 1999). What "sound science" serves as the basis for agency determination in draft EIS to lower standards currently in regulations and agency order currently adopted as necessary for the protection of the public health and safety? It appears that the agency feels mandated under Nuclear Waste Policy Act to give the Yucca Mountain repository site its stamp of approval by lowering the current public health protection standards, even if the agency required to side-step science and regulations to do so.

Response
The response to this comment is divided into four related parts.

First, DOE agrees there are uncertainties about the efficacy of 10,000-year engineered structures. This EIS discusses those uncertainties at some length (for example, Section 5.2.4 discusses uncertainties associated with consequences of long-term repository performance). The regulations applicable to the proposed Yucca Mountain Repository [10 CFR 63.101(a)(2) and 40 CFR 197.14 and 197.20] acknowledge there would be uncertainties and require no absolute proof of future performance, but instead require “a reasonable expectation” of compliance with safety standards. The challenge to DOE is to show compliance with the regulations while fully disclosing the uncertainties.

The Environmental Protection Agency (EPA) standards for a repository at Yucca Mountain acknowledge that the radioactive waste to be disposed in Yucca Mountain would remain dangerous and, hence, require isolation for longer than 10,000 years. For that reason the EPA standard requires a calculation of potential peak doses, within a million years, in this EIS (see 40 CFR 197.35). These very long-term calculations might be more uncertain than the 10,000-year calculations required for the very exacting licensing process. Thus, the EIS informs the public and decisionmakers that going forward with this project could entail a very far future impact of the magnitude shown.

The anticipated land withdrawal area is large compared to the repository size. This allows for protection of the repository itself, its surface transportation and other handling facilities, its waste packaging facilities, its offices, and its transporter decontamination facilities. Denying unauthorized access to such facilities is standard and a required practice in the nuclear industry as well as at DOE facilities. The current Nevada Test Site boundaries illustrate the historic approach to maintaining large buffer zones between hazardous activities and the public, if the land is available to do so. The approximately 18-kilometer (11-mile) distance prescribed by the regulators for calculating potential doses to hypothetical recipients (the reasonably maximally exposed individual) was not based on the proposed land withdrawal boundary, but was defined as the southern boundary of the Nevada Test Site. The potential dose receptor location was based on estimating the likely future location of a small community of persons and farms, given the physical setting of the potentially affected area, and the depth to water in that setting. After the period of institutional control ceased, persons could live much closer to the Yucca Mountain Repository. But after society loses interest in or knowledge of the repository, if that indeed ever happens, it is still unlikely that individuals would locate their homes, and especially their farms, in an area that is steep, rugged, and more importantly, has a very deep water table.

After closure, DOE would establish and maintain passive and active institutional controls over the repository, as required by the Nuclear Regulatory Commission (NRC) regulations (see 10 CFR Part 63, particularly 10 CFR 63.102). However, consistent with NRC regulations [10 CFR 63.102(k)], DOE believes that active and passive institutional controls would be expected to reduce, but not eliminate, the potential for inadvertent human activities to cause or accelerate the release of radioactive material from the repository. Thus, DOE assumed for purposes of analysis that institutional controls would remain effective only for 100 years after closure, after which time human activities could intrude on the repository. This approach results in an upper estimate of the impacts from an intrusion, because only minimal radioactive decay would have occurred by 100 years after closure. Section 5.7.1 discusses the results of a drilling intrusion analysis.

Finally, with respect to the observation that Yucca Mountain Repository regulations are inconsistent with or different from other regulations, it is not true that the repository system is exempted from Safe Drinking Water Act regulatory limits or other applicable standards and requirements. These limits have been incorporated into the performance standard developed by the EPA specifically for Yucca Mountain (40 CFR Part 197). That standard also explains that airborne releases from the proposed Yucca Mountain Repository would not likely be significant, therefore they are not addressed. During the operational period, however, prior to permanent closure, the system and its facilities have to meet all currently applicable standards, regulations, and DOE orders containing radiological release restrictions applicable to nuclear facilities. This comment refers to dose limitations of 100 millirem per year under DOE Order 5400.5 and NRC regulations (10 CFR Part 20) and suggests there is an “apparent exception to Yucca Mountain reasonably maximally exposed individual and surrounding population.” These requirements are for operating facilities such as the repository prior to closure. However, the repository after closure must meet a more stringent standard than 100 millirem per year for the first 10,000 years.

Chapter 11 of the EIS identifies the numerous other statutory and regulatory requirements that could apply to the Proposed Action and includes a list of the permits, licenses, and approvals that may be needed from other Federal and State agencies.

7.3 (12700)

Comment - EIS001632 / 0022

EPA [Environmental Protection Agency] has previously discussed with DOE and NRC [Nuclear Regulatory Commission] the calculations used to determine whether applicable radiation standards are met; determining whether the standard is met requires DOE to project the concentration of radionuclides in the water at the point of compliance. In order to do this, DOE must identify various scenarios for the type and quantity of waste released over time, transport path, and the concentrations predicted for the various options for representative volumes of ground water (e.g. 10 to 1,285 acre feet), at the various distances selected as possible points of compliance. We did not find this data identifiable in the draft EIS and suggest that the final EIS provide a discussion of this information and a summary table.

Response

The Draft EIS reported groundwater concentrations and then compared the results to current Safe Drinking Water Act standards for four points of compliance: 5, 20, 30 and 80 kilometers (3, 12, 19, and 50 miles) from the repository. It reported the concentrations for both the mean and 95th percentile of a set of 100 stochastic realizations of the undisturbed case release scenario, which determines the type and quantity of waste released over time. Chapter 5, Appendix I, and the Viability Assessment (DIRS 101779-DOE 1998) discuss this scenario. The Draft EIS reported results for three thermal load scenarios for the peak occurring within 10,000 years after repository closure.

DOE did not use the concept of representative volume in the Draft EIS because of the nature of the groundwater model, which was the same as that used for the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998). This model simulates the saturated zone transport as a series of six parallel tubes that follow the general flow of groundwater south through Amargosa Valley to the surface discharge point at Franklin Lake Playa. These one-dimensional tubes have a concentration identified at the repository footprint (that is, all repository footprint water flows through the tubes), a dilution factor characterizes how much dispersion would occur, and a delay factor accounts for sorption. Thus, at the point of compliance the model assumes that groundwater is repository footprint water with a conservative dilution factor and delay time.

Since publication of the Draft EIS, the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission finalized their environmental protection and licensing criteria regulations (40 CFR Part 197 and 10 CFR Part 63, respectively), which provide an individual protection standard for the proposed Yucca Mountain Repository.

For the Final EIS, DOE used the definition of the Reasonably Maximally Exposed Individual (RMEI) from 40 CFR 197.21, which defines the individual as a hypothetical person who could meet the following criteria:

(a) Has a diet and living style representative of the people who are now residing in the Town of Amargosa Valley, Nevada. DOE must use the most accurate projections, which might be based upon surveys of the people residing in the Town of Amargosa Valley, Nevada, to determine their current diets and living styles and use the mean values in the assessments conducted for Sections 197.20 and 197.25.

(b) Drinks 2 liters (0.5 gallon) of water per day from wells drilled into the groundwater at the location where the RMEI lives.

The location of the RMEI described in 40 CFR Part 197 would be where the predominant groundwater flow path crosses the southern boundary of the Nevada Test Site which coincides with the southern boundary of the controlled area as defined in the regulation. This point is approximately 18 kilometers (11 miles) from the proposed repository. DOE has concluded that it is not necessary to analyze in the Final EIS a hypothetical individual at locations closer than approximately 18 kilometers to the repository because it is unreasonable to assume that anyone would reside in this area, because:

- An individual would need to install and operate a water well in volcanic rock at more than 360 meters (1,200 feet) deep to reach the water table at costs significantly above (and likely prohibitive) those that would be incurred several kilometers farther south of the repository where the water tables lies less than 60 meters (200 feet) beneath the surface through sand and gravel. and

- Locations closer than 18 kilometers (11 miles) are within the controlled area defined in the EPA standard for a Yucca Mountain repository and therefore not in the postclosure accessible environment defined by EPA.

The updated analysis in the Final EIS estimates potential groundwater impacts reported for the compliance point prescribed in 40 CFR Part 197 [approximately 18 kilometers (11 miles) from the proposed repository]. As part of a comprehensive presentation of impacts, this EIS is charged with providing groundwater impacts for two other important down gradient locations. These are 30 kilometers (19 miles), where most of the current population in the groundwater path is located, and 60 kilometers (37 miles) where the aquifer discharges to the surface (this location is also known as Franklin Lake Playa). This analysis indicates that for the first 10,000 years there would be only very limited releases, attributable to a small number of early waste package failures (zero to three, and possibly as many as five) due to waste package manufacturing defects, with very small radiological consequences (see Table 5-6). For the first 10,000 years after repository closure, the mean and 95th-percentile peak annual individual dose would be thousands of times less than the Environmental Protection Agency standard, which allows up to 15-millirem-per-year dose rates during the first 10,000 years. The peaks would be even smaller at greater distances.

DOE has revised the definitions of the maximally exposed individual and RMEI in the Final EIS. Chapters 4, 6, and 7 now use the term “maximally exposed individual,” and Chapter 5 uses “individual.” The individual is the “reasonably maximally exposed individual” defined in 40 CFR Part 197.

In addition, the Final EIS updated the groundwater protection analyses consistent with criteria provided at 40 CFR 197.30. The results of these analyses are provided in Tables 5-6 and 5-10 of Chapter 5 of the Final EIS and show that both the mean and 95th percentile estimated radionuclide concentrations during the 10,000 regulatory period are thousands of times less than the regulatory limits.

7.3 (12774)
Comment - 010116 / 0004
DOE is attempting to address the Draft EIS design. Part of the Draft EIS design is to perform subsystems. This report eliminates the subsystem requirement and tests or simulations and instead depends totally on the total system performance assessment. The subsystem simulations addressed specific requirements that are to be done or to be met. DOE cannot disregard these requirements unless higher authority waives them.

Response
The performance of individual subsystems has been studied extensively and reports of individual subsystem performance are cited in Chapter 5 and Appendix I of the EIS, and in the Science and Engineering Report (DIRS 153849-DOE 2001). DOE is not aware of any statutory requirements for subsystem performance. The standard for performance is contained in 40 CFR Part 197.

7.3 (12775)
Comment - 010116 / 0005
Section 2.6 [Page 2-6], Section 2.2.2, sixth line, relative humidity could affect the corrosion rate. By this time in the program DOE should understand this elementary engineering problem, and not say could. I think this is the big red herring in the whole thing. What are you talking about in corrosion rates over greater than 10,000 years?

Response
DOE agrees that the choice of words in the statement cited was not the best. Humidity is an important factor when considering corrosion of the containment system materials. This has been accounted for in the models used to forecast the degradation of these materials. These models are based on detailed testing. While the length of the tests

is short and requires large extrapolations of time, the models are designed to incorporate the large uncertainties involved.

Operation of the repository would include contingency planning for continued performance monitoring and for possible retrieval of the waste if data indicated that the repository would not operate safely. During the period between the decision to construct and operate the repository, through preclosure, research would continue. This period could extend to more than 300 years. It is likely that by the time of closure there would be sufficient information on canister integrity and other components of the repository to confidently support a decision to either permanently close the repository or retrieve the emplaced materials. However, the results to date of research on the performance of these materials under simulated repository conditions provide confidence that they would perform as expected.

7.3 (12776)
Comment - 010116 / 0006
The proposal speaks of 75 years of forced air ventilation to keep the temperature within the design limit. This is page 2-9, last paragraph of Section 2.2.2.2.2. How soon after the ceasing of the forced air due to sensing of contaminants in the exhaust pool to the outside air will the temperature rise above the safe limits of the cask, assume the placement to be the closest spacing? This information should be provided in the EIS, not as a backup document. I take issue with this form of engineering variance that will cause a failure and then thus directly emit into the atmosphere.

Response
The purpose of ventilation is not to just maintain packages within design-limit temperatures but to mitigate various mechanisms that can potentially contribute to release of material. At no time is the design limit of the waste package exceeded. There are substantial safety margins employed so that temperatures are maintained at extremely low conservative levels. In developing the EIS an effort was made to keep the EIS of manageable size by not republishing already available information but rather providing comprehensive references to other supporting documents that are readily available. The body of such information is extremely large and is comprised of hundreds of documents, many of which are quite lengthy.

7.3 (12904)
Comment - 010314 / 0012
Is the DOE claiming that the only radioactive gaseous releases from the repository would be the naturally-occurring radon that would emanate from the exposed rock surfaces surrounding the repository? ("Supplement," pp. 3-3, 3-4) What estimates has the DOE developed for the amount of radioactive fission gases that will continue to be generated from the fuel rods and that may be released from the aging waste packages as they corrode and disintegrate -- such as tritium, xenon, krypton, argon and perhaps other fission gases?

Response
The purpose of the Supplement to the Draft EIS, as its name implies, was to provide information that was supplementary to the Draft EIS. That is, it added information that was new or changed from the Draft EIS. As such, the Draft EIS and the Supplement are companion documents, and not everything in the Draft EIS was repeated in the Supplement. Because the effects of long-term release of radioactive gases did not change significantly, no additional analysis was included in the Supplement. Section 5.5 of the Final EIS provides an updated analysis of the impacts of gaseous materials from the waste.

7.3 (12949)
Comment - 010249 / 0003
NEI [the Nuclear Energy Institute] understands, based on recent DOE presentations to the Nuclear Waste Technical Review Board that DOE will be revising its analysis to postulate 'early failures' of waste packages due to, for example, manufacturing defects. According to these presentations, this new analysis calculates annual doses for the first 10,000 years to no longer be absolute zero, but something less than 0.0001 mrem [millirem] (a level we consider to be 'essentially zero' since it is a million times less than natural background). NEI endorses this change as further evidence that DOE is taking an appropriate, multiple barrier, approach to repository safety. These new results demonstrate that Yucca Mountain's natural systems are capable of protecting public health and safety even if engineered systems do not perform as designed. DOE should clearly communicate in the FEIS that this new

analysis is being added to demonstrate defense-in-depth and that it does not reflect any real decrease in confidence regarding the performance of the repository.

Response
DOE thanks the commenter for the support and confidence for the analyses in the EIS. The inclusion of early failures in the analysis was the result of further studies and the desire to maintain as conservative an evaluation as possible, especially with respect to the first 10,000 years. Defense-in-depth from the inclusion of drip shields and the presence of natural barriers is an important factor for the first 10,000 years and for many more tens of thousands of years. However, the principal reason for the dose being very small during the first 10,000 years is primary containment integrity (protected by the additional defense of the drip shields). The dose would be small because there would be very few early failures. Studies of manufacturing led to the inclusion of a Poisson distribution ranging from zero to five early failures that is sampled for each realization. Fewer than 25 percent of the realizations showed any failures and the total failures rarely exceeded one package. Thus, the dose would be small because the source quantity would be small. The new analysis was added to reflect more conservatively and accurately the possibility of early defects, not to demonstrate defense-in-depth. But defense-in-depth is certainly what limits releases to early failures in the first 10,000 years. This is clearly explained in the Final EIS.

7.3 (13135)
Comment - 010237 / 0004
The site was originally selected due to the lack of groundwater. If the new design indicates the need for drip shields within the storage drifts it is obvious that the site is not as dry as originally thought. If new groundwater impacts and impacts to the site by groundwater have been identified, the site should not be used.

Response
An important factor in the selection of the Yucca Mountain site for study was that a repository could be located in unsaturated rock, far above the water table. This has never meant that there was no water infiltrating through the unsaturated zone.

Additional information about water flow through the unsaturated zone does not disqualify the site as long as a suitable design can be shown to meet the radiation protection standards in 40 CFR Part 197. In fact, DOE did not incorporate the drip shields in the flexible design described in the Supplement to the Draft EIS because of new information on water flow. Data on the water flow in the unsaturated zone has not changed substantially since DOE issued the Draft EIS. DOE added the drip shields primarily as a second line of defense. They would be made of different material than the waste packages, so different processes would drive their degradation. While intact, the drip shields would protect the waste packages from falling rocks as the drifts degraded, and would protect the waste packages from dripping water. The waste packages could be the primary engineered barriers to radionuclide transport. Corrosion of the waste packages would be more rapid if liquid water dripped directly on them. DOE added the drip shields primarily as an additional layer of conservatism for the licensing safety case and to compensate for uncertainties in the corrosion rates of the waste package materials.

7.3 (13170)
Comment - 010243 / 0017
One of the primary reasons for issuing the SDEIS would appear to be to evaluate the performance of a lower temperature repository option. It is not clear to Clark County how this evaluation can be made when some of the near field models used are not coupled and do not consider the critical temperature dependence of coupled chemical hydrological processes and their subsequent effect on corrosion.

Response
Low-temperature performance was not a primary reason for issuing the Supplement to the Draft EIS. In fact, the lower-temperature operating mode is not of great interest in assessing long-term performance. The period of significant heat release would be very short compared to the lifetime of waste packages. Thus, even if the heat was detrimental to waste packages and performance in general, it would be gone before a major amount of waste package failures occurred and would have no real influence on long-term performance. This was shown in the Draft and Final EISs (see Section 5.4). Sensitivity studies, which included a temperature-sensitive model of corrosion, showed improved performance (less than half the mean peak dose reported in the Final EIS) (DIRS 155950-BSC 2001). The fact that there would be improved performance is not surprising because the non-temperature-dependent

model is conservative and uses what is essentially corrosion under all adverse conditions, including high temperature. When the temperature-dependent model was used, the conservatism of always assuming a higher rate was removed, so corrosion after the short heat pulse would be much slower than that of the conservative model. Improved performance would result. Even in the sensitivity studies, the results for the high-temperature operating mode are nearly indistinguishable from those for the low-temperature mode because the period of heat generation would be so short in comparison to package and drip shield lifetimes. For these reasons the Supplement had little to say about this case.

7.3 (13171)
Comment - 010243 / 0018
On Page 3-20 Section 3.2.2 the DOE indicates that the software for the integration of the TSPA [Total System Performance Assessment] has been changed. Even though this is an important and major change from the DEIS no analyses were shown that would indicate the scope and effect of this change on the TSPA.

Response
Golder Associates, Inc., developed both GoldSim (the integrating software used for the Supplement to the Draft EIS and Final EIS) and RIP (the software used for the Draft EIS). GoldSim is a new generation of the RIP program, not an entirely different program. The differences have more to do with user interface convenience and the mechanics of data handling than with the actual modeling. Nevertheless, as part of the production, delivery, and documentation of GoldSim, Golder Associates validated that program against RIP by running similar cases in both. Thus, differences in the integrating software caused no differences between the Draft EIS, the Supplement to the Draft EIS, and the Final EIS.

7.3 (13229)
Comment - 010244 / 0028
DOE projects there would be zero individual radionuclide doses in the first 10,000 years and a 120-[millirem] release at 20 km [kilometers] after that period and peak dose at 550,000 years after closure. DOE provides no substantiated proof that the waste packages will not fail before 10,000 years as projected in the Supplement, which would again alter DOE's projections.

Response
The Final EIS includes an analysis of possible early failures brought on by defects in the waste package. The results show a very small dose from these failures (see Section 5.4).

7.3 (13230)
Comment - 010244 / 0029
The range of operating modes would result in post closure repository temperatures that could vary from the above boiling point of water to an average waste package surface temperature below 85ºC. The heat could affect the geochemistry, hydrology, and mechanical stability of the emplacement drifts, which in turn would influence the flow of ground water and the transport of radionuclides for the engineered and natural barrier systems. The Supplement does not mitigate the consequences of temperatures above the boiling point of water and the ability of the engineered and natural barrier systems to isolate the emplaced waste from the human environment.

Response
The results of long-term performance analyses reported in the Supplement to the Draft EIS and in the Final EIS accounted for all of the prevailing conditions expected in the repository, especially temperature. The newer models used for the Supplement and the Final EIS were able to account for the coupled effects of heat and water flow compared to the models used for the Draft EIS. The latest evaluations show that the design features of the repository would mitigate the effects of these conditions to the extent that the repository is expected to have performance far below the established standard set by the Environmental Protection Agency for the compliance period and have all-time mean peak doses that are less than normal background. Therefore, the design is demonstrated to adequately isolate the waste materials from the human environment.

7.3 (13248)

Comment - 010328 / 0002

I realize it's going to be real hot and the water will probably be boiled out of the mountain around the waste, yet it does indicate that on section -- page 2-25, section 2.3.4.1 it says that water dripping on the waste packages, and I quote, increases the likelihood of corrosion. So you got waste in there, and it's sitting in there for 300 years and then the drip shields go in, but there's rain, not all the time but it's not like we're in Oregon, but often enough that the waste packages could get wet.

And we're talking about waste packages with a 20-year old metal. I hope everybody here understands Alloy 22 is 20 years old. I mean, I understand it's under peer review right now, but this is a 20-year old metal that's supposed to protect us, protect us for at least 10,000 years. Come on. This isn't three-card monte. This is our lives we're talking about.

So the drip shields, concerns with the drip shields, I didn't see it adequately addressed in this document, how the plans -- I mean, I guess the temperature, the heat, but it didn't -- it just didn't do it for me.

So again I don't have a reference page for you on this one, but if no quantitative evaluation was done on the impacts of, I'm getting technical here, the impacts of the variable drift spacing, and these are probably your words, how does the DOE know that the effects would be less than the effect of waste package spacing?

So basically what I'm saying, the drifts, if the drifts are further apart, what's the difference in that between the actual packages being further apart? I didn't see that really addressed.

Response

All of the issues raised in this comment are addressed in detail either in the Final EIS or its referenced source documents. The long-term performance analysis includes a comprehensive evaluation of the processes mentioned including uncertainty evaluations. Two cases for waste package spacing are reported in the Final EIS.

7.3 (13279)

Comment - 010231 / 0012

Page 3-20, Section 3.2.2. Following Table 3-12 is a statement that the integrating software for the Total System Performance Assessment has changed from that used for the original DEIS to GoldSim(c), and that "GoldSim(c) incorporates much the same performance assessment calculational approach, but with substantial improvements in the user interface and data handling." The final EIS should provide support for this statement because changing the software which integrates the many programs which are used in the Total System Performance Assessment (TSPA) introduces uncertainty into the comparison of previous results.

Response

Golder Associates, Inc., developed both GoldSim (the integrating software used for the Supplement to the Draft EIS and Final EIS) and RIP (the software used for the Draft EIS). GoldSim is a new generation of the RIP program, not an entirely different program. The differences have more to do with user interface convenience and the mechanics of data handling than with the actual modeling. Nevertheless, as part of the production, delivery, and documentation of GoldSim, Golder Associates validated that program against RIP by running similar cases in both. Thus, differences in the integrating software caused no differences between the Draft EIS, the Supplement to the Draft EIS, and the Final EIS.

7.3 (13280)

Comment - 010231 / 0013

Page 3-21, Table 3-13. This table lists a change in the "Unsaturated zone flow" as "Coupling between thermal, hydrologic, and chemical effects." What is the status of the modeling and research on these coupled processes?

Response

The modeling for the Supplement and the Final EIS for long-term performance analysis includes improved coupling of these processes over the essentially uncoupled versions used for the Draft EIS. Section I.2.3 of the Final EIS and the documents referenced in that chapter discuss these models.

7.3 (13346)
Comment - 010296 / 0006
Nye County has not seen any reference to the environmental effects and impacts of the corrosion products. Although DOE claims that the material used are corrosion resistant, the amount of metal that is exposed in the facility is so large that a risk analyses will need to be performed to demonstrate that the drinking water standards will not be exceeded at any time. Also, it is not known whether the metal surfaces will be clean or treated with some protective substance. The solubility of the substances used on both the canisters and the drip shields should be evaluated and, if present, health risk analyses performed. Similarly, the potential impact of the steel sets should be presented. Unlike the heavy metals (uranium and other radioactive material) that are protected by the waste package cladding and other protective layers, the steel sets and other metals used are subject to degradation from the instant they are placed underground.

Response
The Final EIS analysis has been refined and includes analysis of possible early failures brought on by defects in the waste package. The results show a very small but not-zero dose from these failures (see Section 5.4).

The Final EIS contains a new analysis of non-nuclear toxic materials based on the new design of the repository and waste packages. The analyses show that even under very conservative and bounding assumptions, toxic materials have no significant impacts during the compliance period (see Sections 5.6. and I.6).

7.3 (13362)
Comment - 010182 / 0010
The SDEIS fails to analyze if the change in the emplacement of the waste would pose any problems. The proposed action indicates that as many as 6,000 additional canisters would be placed in Yucca Mountain.

Response
The NWPA only allows the Proposed Action to emplace 70,000 metric tons of heavy metal of waste (MTHM) in the proposed repository. Additional legislation would have to be passed to allow any additional MTHM in the repository. Therefore, the additional canisters are not a planned action but rather a possible future action evaluated as a cumulative effect. Cumulative impacts were presented in the Draft EIS but not discussed in detail in the Supplement to the Draft EIS because the amount of change from the Draft EIS would be similar to the reported changes in the Proposed Action. However, the Final EIS details these cumulative effects in Chapter 8.

7.3 (13363)
Comment - 010182 / 0011
The SDEIS should analyze potential juvenile failures of the canisters.

Response
Section 5.4 of the EIS analyzes the consequences of early failures caused by defects in waste packages. The results show there would be a very small dose from such failures.

7.3 (13364)
Comment - 010182 / 0012
It does not consider the potential for the Yucca Mountain geologic formation to accommodate spent fuel in amounts beyond that considered within the DEIS due to the closer spacing to be achieved through the flexible design. The SDEIS should provide a new estimate of the total potential spent fuel and other high-level radioactive waste that could be emplaced in Yucca Mountain. Although “DOE did not perform a quantitative evaluation of the environmental impacts of variable drift spacing due to a design trade-off” (Page 2-31, para 4), a quantitative analysis of variable drift spacing should be performed.

Response
The current law only allows the proposed action to emplace 70,000 metric tons of heavy metal of waste in the proposed repository. Additional legislation would have to be passed to allow any additional canisters in the repository. Therefore, the additional canisters are not a planned action but rather a possible future action evaluated as a cumulative effect. Cumulative impacts were presented in the Draft EIS but not discussed in the Supplement to the Draft EIS because the amount of change from the Draft EIS would be similar to the reported changes in the

Proposed Action. However, the Final EIS details these cumulative effects in Chapter 8. With regard to variable drift spacing, the text quoted in the comment gave the reason why variable spacing was not analyzed: It is no longer part of the design basis for the Proposed Action.

7.3 (13365)
Comment - 010182 / 0013
Furthermore, the SDEIS should consider what effect, if any, closer spacing of waste packages would have if a volcanic dike encountered one or more waste packages.

Response
The Final EIS contains detailed discussion of the analysis of such events and other related disruptive events in Section 5.7.2. Effects of igneous intrusion were evaluated for both the higher- and lower-temperature operating modes and the results are essentially identical. This is because while the wider spacing for the lower-temperature mode case would decrease the probability that an intrusion would intersect a waste package, the wider spacing also increases the repository footprint thus increasing the likelihood that an igneous intrusion would intersect the repository.

7.3 (13453)
Comment - 010296 / 0039
On page 4 38, the S&ER states that the USGS has conducted evaluations of three climatic conditions, the current climate, an interglacial monsoon climate, and a glacial-transition climate. While these studies did in fact evaluate average annual precipitation and the corresponding average infiltration rates, they did not evaluate the extremes of climate for the present, interglacial, and glacial-transition climates. The studies did not look at the increase in extreme precipitation events and the consequences of those events on l00-year floods, probable maximum floods, recharge or other events. Recharge occurs in response to precipitation events that exceed a given threshold and occurs as pulses follow a given event, typically the period of snowmelt or rarely, during the rare periods when rainfall occurs for several days or more. The threshold at which recharge begins to occur varies with season, antecedent moisture conditions, elevation, aspect, slope, vegetation, and a number of other factors. None of these factors were considered in the evaluations of future climate; only the average values were evaluated. The lack of extreme event evaluations is considered a deficiency in the S&ER. The S&ER and TSPA should be revised to include an analysis of the effects of extreme events on infiltration rates, recharge, flooding and repository performance using the Nogales, Hobbs, and Beowawe analogue stations as the basis for the extreme events. Consideration of these effects could result in a significant difference in the calculation of releases from the repository and the effects of such releases on potential receptors.

Response
As mentioned in the Science and Engineering Report (DIRS 153849-DOE 2001), such extremes were evaluated using the Nogales, Hobbs, and Beowawe analogue stations. More details on this are in the *Total System Performance Assessment – Site Recommendation* (DIRS 153246-CRWMS M&O 2000). Extreme lower and upper bounds were established for each climate state. In the case of the Monsoon Climate, the Nogales and Hobbs stations were used for upper-bound states. The Beowawe station was used for an extreme lower bound for the Glacial-Transition Climate. In the Total System Performance Assessment modeling, each climate state was represented by a probability distribution with a low, medium, and high value. In most cases, the distribution spanned a range of infiltrations in which the low and high values differed by factors of 10 to 100 (DIRS 153246-CRWMS M&O 2000). In this EIS, DOE expanded the climate model to six climate states with a similar treatment of extremes (DIRS 153246-CRWMS M&O 2000). These extremes are often manifested as significant changes in the annual dose from groundwater. This can be seen as large spikes in the dose history curves (see Section 5.4 of the EIS).

7.3 (13454)
Comment - 010296 / 0040
A worldwide search can no doubt identify analogue models of almost any type of condition. The use of such analogues in lieu of site- or region-specific data for Yucca Mountain is not considered adequate for the purposes of characterizing flow, transport, and seepage at Yucca Mountain. The DSEIS should be revised to fairly state that there are locations within the region that show the transport of water at depth. In the case of the Spirit Cave mummy and the pack rat middens, the analogue approach is particularly misleading. The Spirit Cave mummy and pack rat middens occur very near the surface in caves or small voids in surface slopes, not at depths of more than

1,000 meters in a tunnel, mine, or deep cave. Again, analogues are selected and discussed that are favorable while the many analogues that would lead to quite different conclusions were not selected and evaluated.

Findings in caves (page 2-31) analogous to deep geological repository support the idea that the environment of a naturally ventilated underground system, could under certain conditions preserve materials several thousand years old. The reference to DOE 2001a, Sec. 2.1.5.4 is in the SR Consideration, and refers to cave paintings in southeastern France and a mummy found in Spirit Cave near Reno. For example, there are preserved cave bear skulls, paws, teeth, etc. in the Ural Mountains, etc. A comparison of what has been destroyed under similar conditions would also provide useful information. How many caves have had smashed or destroyed artifacts, skeletons, paintings, etc.? How many bodies were not mummified. The analogues are weak, and more work should be done in this area.

Response

There was no intent to use analog information "in lieu of site- or region-specific data," but rather to supplement site data with analogs for subsystems, especially using examples that represent periods that cannot be investigated at the site. The discussion cited in the comment is an abbreviated discussion of analog information and, as such, might not adequately convey the intended information. The point of mentioning Spirit Cave was not that it is a good analog to a deep underground tunnel, but rather how well even biological remains can be preserved if they remain dry. Packrat middens were mentioned because they must remain dry to be preserved. Although not stated here, they exist in hundreds of caves in the desert Southwest. Thus, the ability of caves to protect delicate remains is a common feature.

This comment correctly notes that evidence of destroyed remains is difficult to evaluate. This question is addressed to a degree in Stuckless (DIRS 151957-2000). However, even with no intent to do so, ancient man left easily destroyed artifacts that have lasted tens of thousands of years.

The comment also correctly notes that ventilation might be an important variable. Nye County representatives and the U.S. Geological Survey have strongly suggested the consideration of long-term ventilation. This option is evaluated in Final EIS. While there are some advantages for various methods to reduce heat content, changes in the heat pulse for a higher-temperature to lower-temperature operating mode would have only about a 30 percent effect on total dose results for postclosure performance, even with a highly temperature-sensitive model for corrosion. However, there are many other possible advantages for the lower-temperature operating mode.

The comment suggests that more work needs to be done on analogues. This EIS is only one among many documents that will provide input to the phases of the project from site recommendation through licensing to closure. The EIS and its supporting documents contain sufficient information for an appropriate level of decision. If the site was recommended and the project continued, DOE would perform more work in this area to support subsequent phases.

7.3 (13457)

Comment - 010296 / 0043

DOE needs to consider potential for condensation of vapor in LTOM design. Peak dose of zero, seems to indicate that no corrosion is assumed to occur in the first 10,000 years. Surface temperature of all the waste packages should be considered when making such assumptions. To assume that the repository will perform uniformly or with predictability of 100% is to be overoptimistic. Variation in canister and drip shield surface temperature may occur due to uncontrolled or unpredicted conditions of the waste package or the host rock interactions. The probability of condensation occurring during some period of time in some location of the repository is high, regardless of the operational mode of the repository. The closer the packing of the canisters and the smaller the repository, the more uniform and predictable the temperature of the surface of the waste canister will be.

Response

The analysis assumed that Alloy-22 corrosion would proceed under the drip shields. It assumed that the bulk rate of corrosion would be the same before and after drip shield failure. Other corrosion mechanisms were added when there would be significant dripping on the packages after drip shield failure. The simulations in the Final EIS show early failures before 10,000 years (unlike those reported in the Supplement to the Draft EIS). Using different models and data sets, the analysis found that the long-term performance would be essentially insensitive to heat loadings and operation modes, primarily because the time of the heat pulse would be so short in comparison to package lifetimes and the period over which materials would be released.

7.3 (13459)
Comment - 010296 / 0045
Table 3-13 Changes to the TSPA model lists 17 changes and their estimated effects. Of these, there are far more increasing than decreasing. The FEIS should explain the causes of these differences.

Response
Many of the changes to the Total System Performance Assessment model were made for conservatism and, therefore, increased the impacts. However, some changes resulted in decreasing the dose, which was much more significant than the combined effect of several increasing effects. For example, the effect of refined solubility models, which consider the formation of secondary phases, accounts for a decrease approaching a factor of 4 while the effect of many other increasing changes (such as the increase in the number of radionuclides considered) would be only a few percent. Section I.2 of the EIS and the referenced supporting document discuss the model components. In addition, the introduction to Chapter 5 discusses changes since the publication of the Draft EIS.

7.3 (13474)
Comment - 010372 / 0004
Page 3-21 indicates that waste packages will remain intact for 10,000 years. Any design options DOE proposes would be acceptable because the waste canister is the most important containment mechanism. If DOE continues to rely upon this rationale, there does not appear to be any need to continue to strive for improved repository performance because as long as the containers stay intact it would appear that all designs would meet performance requirements. As we have asked repeatedly, DOE needs to consider under what conditions the repository would fail to meet performance standards.

Response
The Final EIS analysis has been refined and includes analysis of possible early failures brought on by defects in the waste package. The results show a very small but not-zero dose from these failures (see Section 5.4).

All credible features, processes, and events have been accounted for in the TSPA. Therefore, it has been shown that under no credible conditions would the repository fail to meet performance standards.

7.3 (13475)
Comment - 010372 / 0005
Page 3-22 Table 3-14 please explain what causes the peak mean dose of the S&ER design be lower but occur sooner than the DEIS thermal load scenarios. The supplement only reports the results of the performance assessment but provides no explanation as to the differences in performance among the various thermal designs.

Response
Details of the analysis are in the referenced supporting document, the Science and Engineering Report (DIRS 153849-DOE 2001). The various model changes listed in Table 3-13 of the Draft EIS contributed in a variety of ways to the outcome. The reduced result is due largely to the revised solubility models. The difference in time is partially due to refinements in the climate cycles over the 1 million years. Several changes were made in the climate cycle based on further research. The time change and amount of peak mean dose are influenced by changes in the waste package degradation model, among several other things. These trends continue to show in the updated results reported in the Final EIS.

7.3 (13536)
Comment - 010305 / 0008
The affected area contains the Beatty dump and U.S. Ecology in the huge Amargosa Valley. Have the 7,500 dairy cows or their feed been tested for radionuclides or chemical poisons?

Response
The Milk Surveillance Network consists of 11 sampling locations within 300 kilometers (190 miles) of the Nevada Test Site, which includes the Yucca Mountain Site (DIRS 104544-CRWMS M&O 1999). In 1997, samples were

collected from 10 locations only. The network includes family-owned cows and goats and commercial dairies. In 1997, the estimated radiation dose associated with drinking this milk was 0.011 millirem per year, primarily from naturally occurring radionuclides along with small quantities of manmade fallout-derived radionuclides (strontium-90 and cesium-137). These results are consistent with data from previous years and indicate little or no change.

Deer and cattle forage was collected from both near- and far-field locations. A total of 143 near-field deer forage samples were collected from 32 sampling locations between 1990 and 1995. In addition to deer, cattle graze on public grazing allotments near the Yucca Mountain Site. Seven cattle forage sampling locations were established in 1993, five in the Razorback grazing allotment and two in the Mt. Sterling allotment, from which 14 samples were collected and analyzed. Only very small amounts of fallout-derived radionuclides (strontium-90, cesium-137, and plutonium-239) were detected in the samples.

Although the available radiological data suggest that radioactivity reported at the Yucca Mountain Site is higher than average because of naturally occurring radionuclides in the soil, no evidence of above-normal manmade radioactivity has been found.

7.3.1 THERMAL LOAD SCENARIOS

7.3.1 (185)

Comment - 55 comments summarized

Since the Draft EIS was issued, DOE has continued work on the repository design. Several commenters cited studies including drip shields, a modified waste package design, and a reduced thermal load scenario. Some commenters noted that some intermediate considerations, such as the use of backfill, were not incorporated into the current design. Commenters felt that the EIS must evaluate long-term performance of these other design considerations. One commenter expressed the opinion that DOE should explain the role of the EIS in future design evolution. One commenter was concerned that the major changes currently contemplated for the License Application design would invalidate the performance assessment. Another commenter felt the EIS must evaluate a nearly final design and asked why DOE abandoned the high thermal load scenario described in the Draft EIS.

Several commenters made observations on the thermal load scenarios and expressed opinions on the relative merits of a hot or cold repository. Some commenters favored the low thermal load because they believed a cooler design would be easier to model. Some commenters felt that a hot repository would have fewer implications for groundwater flow and chemistry because of the potential to boil off groundwater infiltrating through the mountain. According to the commenters this would delay the transport of contaminated liquids into the saturated zones. Other commenters felt that a hot repository could accelerate contamination of the saturated zone because of accelerated waste package disintegration.

Response

DOE stated in the Draft EIS (in Section 2.1.1.5, for example) that the designs analyzed were preliminary and were likely to evolve in various ways. Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance, including the waste package design, and improve operational safety and efficiency. The result of the design evolution process was the development of the Science and Engineering Report flexible design (DIRS 153849-DOE 2001). This design focuses on controlling the temperature of the rock between waste emplacement drifts (as opposed to areal mass loading), but the basic elements of the Proposed Action to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain remain unchanged. DOE evaluated the flexible design in the Supplement to the Draft EIS, which was released for public review and comment in May 2001.

For the analyses performed for the Supplement to the Draft EIS, DOE developed analytical scenarios to estimate the range of environmental impacts that could result from the Proposed Action. These scenarios include the low, intermediate, and high thermal load scenarios presented in the Draft EIS, as well as the higher- and lower-temperature repository operating modes of the flexible design. The low, intermediate, and high thermal load scenarios presented in the Draft EIS were not carried forward to the Final EIS. Section 2.2.1 of the Supplement summarizes the operational parameters for the three thermal load scenarios analyzed in the Draft EIS and the two repository operating modes analyzed in the Supplement. Section 2.2.2.2 describes the operational parameters for the higher- and lower-temperature repository operating modes. DOE developed these scenarios and operating modes to accommodate and maintain flexibility for the future evolution of the design of the repository. So as not to underestimate the impacts that could result from future design evolution, these scenarios and operating modes incorporate conservative assumptions. Sections 2.2.1 and 2.2.2 of the Supplement discuss the design and operational evolution, respectively.

The Supplement to the Draft EIS evaluates the potential environmental impacts of the Reference Design higher-temperature repository operating mode, which is the design focus of the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001). In addition, the Supplement evaluates the impacts of the lower-temperature repository operating modes that embrace a range of operational parameters, as described primarily in Section 2.1.5 of the Science and Engineering Report. In the Supplement, the term "flexible design" refers to design features that are common to both the higher- and lower-temperature repository operating modes. The differences between these modes deal with the highest postclosure temperatures of the waste package surfaces, the temperature of the emplacement drift rock walls, and the overall temperature of the repository rock. Section 2.3 of the Supplement describes the design modifications including the addition of drip shields and refined waste packages. DOE is not currently considering backfill in the emplacement drifts.

The Final EIS addresses all aspects of the Proposed Action, including the flexible design. DOE acknowledges in the EIS that the flexible design could be further modified or refined during the License Application process, if the Yucca Mountain site was approved for development. DOE believes that the information on the impacts that could result from either the Proposed Action or the No-Action Alternative complies with the NWPA requirements for a Final EIS to accompany any recommendation by the Secretary of Energy to the President to approve Yucca Mountain for development as a repository. This belief is based on the level of information and analysis, the analytical methods and approaches used to represent conservatively the reasonably foreseeable impacts that could occur, and the use of bounding assumptions if information is incomplete or unavailable or where uncertainties existed.

Concerning the comments related to a hot versus cold repository, the flexible design discussed in the Final EIS shows that both higher- and lower-temperature operating modes would be in compliance with environmental protections standards at 40 CFR Part 197 (see Tables 5-6 and 5-10 in Chapter 5 of the Final EIS for results). Thus, from the standpoint of long-term repository performance, the operating temperature of the repository would not be the sole deciding factor. The flexible design described in the Supplement and the Final EIS allows for a range of operating temperatures by varying such operational parameters as waste package spacing, surface aging, and extended periods of ventilation.

7.3.1 (611)

Comment - EIS000150 / 0002

When I look at the thermal load modeling, and I see all of the modeling is based upon the fact that it's just heat in that environment, and in fact that heat is coming from somewhere. My own personal knowledge of nuclear physics states that it's probably coming from either beta decay or the emission of free neutrons which creates a radioactive environment which could lead to significant embrittling of the storage containers far before their projected lifetime. And I don't really see any radiological studies that are connected with the thermal loading studies. Obviously I believe at least that that environmental site at Yucca Mountain when it's loaded is going to be an operating low-level nuclear reactor with the radiation levels.

Response

No reaction of the type found in a nuclear reactor would occur under the Proposed Action, and analyses documented in the *Waste Package Degradation Process Model Report* (DIRS 151624-CRWMS M&O 2000) indicate that radiolysis would have no impact on waste package performance.

In a nuclear reactor, radiation affects the metals because there are a large number of high-energy free neutrons. The decay heat in the proposed repository would be due to a combination of alpha, beta, and gamma decay as well as neutron emission. The fission products would be mostly beta and gamma emitters and the actinides would be alpha emitters. The number of free neutrons would be small because the rate of spontaneous fission of the actinides would be extremely small. Materials such as the fuel itself, its cladding, and high-level radioactive waste glass and the pour canister would stop alpha and beta particles. Gamma rays could pass through the materials, but their interaction with the metal lattice would be small. The energy of the particles and gamma rays and the rate of emission would be low enough that they would not affect the waste package metal.

7.3.1 (1623)
Comment - EIS000498 / 0001
The EIS indicates that thermal loading may be a concern of the design of this repository. The previous viability assessment indicates that the surface facility is going to repackage the utilities' spent fuel assemblies underneath a cool water environment possibly to blend the hotter and cooler fuel assemblies so they can even out the temperatures.

It's been observed that industrial mishaps happen more frequently the more times you manipulate items. My comment is a very direct focused comment: To improve the EIS is to improve what discussions or agreement are in process between the DOE and the utilities to reduce the amount of spent fuel handling activity at the surface repository facility.

One possibility is staging or sequencing the delivery of hot and cold fuel so they don't have to assemble and mix and match them at the Yucca Mountain area.

Another way is to use the utility to mix and match the hot and cold fuel assemblies so that they don't have to disassemble these shipping casks or containers at the repository itself under water.

Response
As discussed in Section 2.2.2.2.2 of the Supplement to the Draft EIS and Section 2.1.1.2.2 of the Final EIS, commercial spent nuclear fuel would be the major contributor of heat in the repository. It would have a wide range of thermal outputs. The thermal output of the waste packages could, however, be reduced by varying waste package loading. Commercial spent nuclear fuel waste package loading could be varied by (1) placing low-heat-output (older) fuel with high-heat-output (younger) fuel in the same waste package (fuel blending), (2) limiting the number of spent nuclear fuel assemblies to less than the waste package design capacity (derating), (3) using smaller waste packages, or (4) placing younger fuel in a surface aging area to allow its heat output to dissipate so it could meet thermal goals for later emplacement. Section 2.3.2.1 of the Supplement to the Draft EIS and Section 2.1.1.2.2 of the Final EIS describe the fuel blending process further. Reducing the thermal output of the waste package through any of these means would achieve lower waste package and drift wall temperatures. DOE would consider surface aging as much as 40,000 metric tons of heavy metal of commercial spent nuclear fuel during a 50-year period.

Blending would involve some additional handling of the commercial spent nuclear fuel, the only waste form DOE would blend. Blending is merely the selective loading of disposal containers to control waste package temperature. Accidental assembly drops during handling and loading operations is evaluated in Appendix H of the EIS and impacts from such accidents are provided (see Section H.2.1.5). Releases from assembly drop accidents in the pool would be mitigated by retention in the pool water, and all accidents within the confines of the Waste Handling Building would be mitigated by the ventilation system, which controls the flow of any radioactive release and filters any airborne discharge to the atmosphere. Misloading of a waste package could occur, and such events could result in excessive temperatures. The possibility of such events has been considered, and it is expected that disposal container loading procedures would be developed based on thermal analyses of the various waste package configurations such that sufficient margin would be available to ensure that temperature criterion would not be violated for any credible misload (DIRS 150198-CRWMS M&O 2000).

The flexible design for the repository allows flexibility in the types of commercial spent nuclear fuel that DOE would receive. However, the estimated receipts are based on DOE projections of actions that would be taken by utilities to deliver spent nuclear fuel for disposal and are independent of the repository design. Instead, they are based on the terms of DOE's *Standard Contract for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste* contained in 10 CFR Part 961 and the generation and storage characteristics of each generator site (see discussion of CALVIN computer code in Section J.1.1.1 of the EIS). Therefore, DOE believes that the flexible design, including the blending facility, would accommodate fuel that would be shipped to a Yucca Mountain repository based on the terms of the Standard Contract.

DOE has no final plans for surface aging, although it is considering many options. Both blending and surface aging would be areas of active inquiry in the years just before the receipt of the first waste after 2010, if the President and Congress, if necessary, approved the site and the Nuclear Regulatory Commission issued a construction authorization in response to the License Application.

7.3.1 (4484)
Comment - EIS001430 / 0005
The repository layout for the low thermal load scenario (Figure 2-16 on page 2-26) has not been adequately addressed in Section 3. I suggest that Figures 3-7 and 3-8 (p. 3-22 and 3-23) be modified to include the low thermal load footprint and that additional discussion be added as necessary.

Response
The purpose of Chapter 3 is to describe the existing environmental conditions for the proposed repository and the region of influence. Chapter 2 describes the Proposed Action, including repository design and operating modes. Figure 3-7 provides general information on bedrock geology within the repository horizon. This is a complex figure, which DOE has modified to show fault lines. Because it is already complex, DOE has not included more features, such as the repository footprint, to the figure. Figure 3-8 is an updated elevation drawing that shows the approximate location of the repository within Yucca Mountain.

7.3.1 (4843)
Comment - EIS001340 / 0004
In Thermal Output Chapter A.2.3.5.4 - Current planning calls for blending by years 2013-2016 of certain types of waste materials which would make the batches of waste much hotter in canisters at maximum allowable watts. If such mixtures have not been experimented with for long periods, who's to say the temps allowed were not more than the canisters wall thickness could handle? And what if such canisters being prepared for shipment were miss marked or canisters began to leak during shipping? It could be missed for miles spewing death in its path across these many states.

Response
Commercial spent nuclear fuel would dominate the thermal, or heat, output of the nuclear waste that DOE would dispose of in the Yucca Mountain Repository. The heat output of this fuel would depend on the time the fuel spent in a reactor (the burnup) and the time the waste cooled before emplacement in the repository.

The repository design in the Final Environmental Impact Statement includes blending of commercial spent nuclear fuel assemblies. The purpose of such blending would be to constrain waste package temperatures by placing cooler (longer-cooled) spent nuclear fuel assemblies into the waste packages.

DOE would use a stringent quality control program during the packaging of wastes for shipment to the repository to ensure that there was no mismarking of waste packages. Transportation casks would be manufactured, loaded, and closed to ensure they were sealed. In addition, high-level radioactive waste would be in solid form and could not leak in the unlikely event of a transport cask penetration.

7.3.1 (5034)
Comment - EIS001520 / 0001
The final EIS should be based on an updated repository design and should include the updated performance assessment results that the DOE plans to produce to support a possible recommendation that the site be developed as a geologic repository.

The repository design that was assumed when preparing the draft EIS already has evolved and may change further before the final EIS is prepared. The Board recommends that the final EIS be based on the most advanced design concepts available at the time the final EIS is prepared.

Response
The Draft EIS evaluates the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for repository facilities and disposal containers (waste packages). It also evaluates the plans for the construction, operation and monitoring, and closure of the repository. DOE

recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any Nuclear Regulatory Commission licensing review. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement to the Draft EIS incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

For these reasons, for the analyses performed for the Supplement to the Draft EIS, DOE developed analytical scenarios to estimate the range of environmental impacts that could result from the Proposed Action. These analytical scenarios include the low, intermediate, and high thermal load scenarios in the Draft EIS, and the higher-temperature and lower-temperature repository operating modes described in the *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation* (DIRS 153849-DOE 2001). Section 2.2.1 of the Supplement summarizes the operational parameters for the three thermal load scenarios analyzed in the Draft EIS and the two repository operating modes analyzed in the Supplement. The three thermal load scenarios presented in the Draft EIS were not carried forward to the Final EIS. Section 2.2.2.2 of the Supplement describes the operational parameters for the higher-temperature and lower-temperature repository operating modes. DOE developed these scenarios and operating modes to accommodate and maintain flexibility for the future evolution of the design and plans for the repository. So as not to underestimate the impacts that could result from future design evolution, these scenarios and operating modes incorporate conservative assumptions. Sections 2.2.1 and 2.2.2 of the Supplement discuss the design and operational evolution, respectively.

The Supplement to the Draft EIS evaluates the environmental impacts of the higher-temperature repository operating mode, which is the design focus of the Science and Engineering Report (DIRS 153849-DOE 2001). The Supplement also evaluates the impacts for the lower-temperature repository operating mode (which embraces a range of operational parameters, including 300 years of extended ventilation. In the Supplement, the term *flexible design* refers to design features that are common to both the higher-temperature and lower-temperature repository operating modes. The differences between these modes deal with the highest postclosure temperatures of the waste package surface, the temperature of the emplacement drift rock walls, and the overall temperature of the repository rock. Section 2.3 of the Supplement describes the design modifications, including the addition of drip shields and waste package design changes.

7.3.1 (5038)
Comment - EIS001520 / 0007
The estimates of long-term repository performance for the proposed action of the draft EIS are essentially the same as those used by the DOE to prepare its 1998 Viability Assessment of a Yucca Mountain repository. After reviewing the Viability Assessment, the Board stated its belief that identifying important sources of uncertainty, estimating the magnitude of those uncertainties, reducing critical uncertainties, and evaluating the effects of residual uncertainties on expected repository performance are essential for supporting a technically defensible site suitability determination. The Board concluded that a significant amount of additional scientific and engineering work will be needed to increase confidence in a site-suitability determination. The Board recommended that the DOE evaluate alternative repository designs that have the potential to reduce uncertainties in projected repository performance, thereby reducing the scope of additional necessary scientific study. Because the draft EIS relies on essentially the same performance assessment capabilities as those used to prepare the Viability Assessment, the Board believes that these conclusions and recommendations are equally applicable to the draft EIS.

The performance assessment models and data used to project the long-term performance of a Yucca Mountain repository are very similar to those used by the U.S. Department of Energy (DOE) to prepare its 1998 Viability Assessment of a Yucca Mountain repository. The Board has previously commented on the Viability Assessment[(1)] and those comments would also apply to the draft Yucca Mountain EIS. The DOE intends to refine its models and collect additional data before the final Yucca Mountain EIS is prepared. The Board recommends that the final EIS include the updated performance assessment results that the DOE plans to produce to support a possible recommendation that the site be developed as a geologic repository.

[(1)]U.S. Nuclear Waste Technical Review Board, Moving Beyond the Yucca Mountain Viability Assessment, Washington, D.C., April, 1999.

Response
DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years into the future. Consistent with National Academy of Science observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events.

DOE confidence in the disposal techniques is based on defense-in-depth (for example, placing drip shields over waste packages to account for uncertainties). DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components. The bases of the approach are summarized as follows:

1. Site description is based on extensive underground exploratory studies and investigations of the surface environment.

2. Reference design is based on laboratory investigations and conceptual engineering studies.

3. Features, events, and processes that could affect the long-term safety of the repository are identified.

4. Evaluation of a wide range of exposure scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical, and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as use of water supply wells, irrigation of crops, exploratory drilling; and low-probability events such as volcanoes, earthquakes, and nuclear criticality.

5. Development of alternative conceptual and numerical models to represent the features, events, and processes of a particular scenario and to simulate system performance for that scenario.

6. Parameter distributions to represent the possible change of the system over the long term and use of conservative assessments that lead to over estimating of impacts when there is insufficient information for use of a probability distribution.

7. Performance of sensitivity analyses.

8. Extensive peer review and oversight.

DOE believes this process results in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios, including the preferred alternative.

DOE continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as the system level (modeling). DOE has organized a task force to review and outline further work to be completed on uncertainties before the time of license application, should Yucca Mountain be recommended as a suitable site for a repository.

The Draft EIS evaluates the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for repository facilities and disposal containers (waste packages). It also evaluates the plans for the construction, operation and monitoring, and closure of the repository. DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any Nuclear Regulatory Commission licensing review. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement to the Draft EIS incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

For these reasons, for the analyses performed for the Supplement to the Draft EIS, DOE developed analytical scenarios to estimate the range of environmental impacts that could result from the Proposed Action. These analytical scenarios include the low, intermediate, and high thermal load scenarios in the Draft EIS, and the higher-temperature and lower-temperature repository operating modes described in the *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation* (DIRS 153849-DOE 2001). Section 2.2.1 of the Supplement summarizes the operational parameters for the three thermal load scenarios analyzed in the Draft EIS and the two repository operating modes analyzed in the Supplement. Note that the three thermal load scenarios presented in the Draft EIS were not carried forward to the Final EIS. Section 2.2.2.2 of the Supplement describes the operational parameters for the higher-temperature and lower-temperature repository operating modes. DOE developed these scenarios and operating modes to accommodate and maintain flexibility for the future evolution of the design and plans for the repository. So as not to underestimate the impacts that could result from future design evolution, these scenarios and operating modes incorporate conservative assumptions. Sections 2.2.1 and 2.2.2 of the Supplement discuss the design and operational evolution, respectively.

The Supplement to the Draft EIS evaluates the environmental impacts of the higher-temperature repository operating mode, which is the design focus of the Science and Engineering Report (DIRS 153849-DOE 2001). The Supplement also evaluates the impacts for the lower-temperature repository operating mode (which embraces a range of operational parameters, including 300 years of extended ventilation. In the Supplement, the term *flexible design* refers to design features that are common to both the higher-temperature and lower-temperature repository operating modes. The differences between these modes deal with the highest postclosure temperatures of the waste package surface, the temperature of the emplacement drift rock walls, and the overall temperature of the repository rock. Section 2.3 of the Supplement describes the design modifications, including the addition of drip shields and waste package design changes.

7.3.1 (5363)
Comment - EIS001887 / 0081
Page 2-23; Section 2.1.2.2 - Repository Subsurface Facilities and Operations (Including Waste Packages)

The low thermal load repository would include Area 5 in order to provide sufficient underground emplacement area. Area 5 has not been the object of site characterization and, therefore, should not be included in the Draft EIS or repository planning until it has been characterized. According to the NWPA, the Secretary's site recommendation is to be made at the completion of site characterization. In the case of the low thermal load alternative design, site characterization has not been started, much less completed, in a portion of the area included in the Proposed Action. If the low thermal load alternative is to be considered a reasonable alternative, the Draft EIS should be deferred until characterization of Area 5 is satisfactorily completed.

This is especially important in light of currently developing information regarding saturated zone flow and transport. Essentially nothing is known about groundwater flow beneath Area 5 and how it might be influenced by the Solitario Canyon fault and other faults known and unknown. (See page 3-52 that states, "West of the Solitario Canyon fault groundwater probably flows southward either along the fault or beneath Crater Flat.") This introduces a new and major uncertainty in the performance assessment of the repository, to the extent that it precludes any certainty regarding flow paths along which radionuclides would travel from a significant portion of the repository. The Proposed Action is fatally flawed under these circumstances, as is the credibility of the impact analysis in the Draft EIS.

Response
DOE believes the EIS is consistent with National Environmental Policy Act requirements. The level of information and analyses, the analytical methods and approaches used to represent conservatively the reasonably foreseeable impacts that could occur, and the use of bounding assumptions if information was incomplete or unavailable or if there were uncertainties, provide a meaningful assessment of environmental impacts consistent with the regulations. DOE acknowledges that the results of analyses often have associated uncertainties and has described such uncertainties throughout the EIS.

For the low thermal load scenario described in the Draft EIS, DOE extrapolated information for Area 5 from neighboring regions. DOE believes that the natural uncertainty and variability in the models for the other regions encompass the properties of Area 5 (see Section I.4.2.3 of the Draft EIS and Section I.4.4.2 of the Final EIS).

7.3.1 (5723)
Comment - 010073 / 0012
Page 2-6 and 2-7 - The SDEIS should consider what, if any, effect closer spacing of waste package has upon the probability and consequence of a volcanic dike encountering one or more waste packages.

Response
The Final EIS contains detailed discussion of the analysis of such events and other related disruptive events in Section 5.7.2. Effects of igneous intrusion were evaluated for both the higher- and lower-temperature operating modes and the results were essentially identical. This is likely because while the wider spacing for the lower-temperature operating mode would decrease the probability that an intrusion would intersect a waste package, the wider spacing also increases the repository footprint thus increasing the likelihood that an igneous intrusion would intersect the repository.

7.3.1 (6147)
Comment - 010229 / 0001
The Board believes that the technical basis for projecting the long-term performance of the base-case (high-temperature) repository design has weaknesses. They include the apparently large uncertainties in projections of repository performance caused by the relatively high temperatures produced by the base-case design. The Board has urged the DOE to evaluate a low-temperature design so that its performance (and uncertainties in performance) can be compared with that of the high-temperature design. The DOE decided to address this area of Board concern by taking a single general repository design (referred to as the "Science and Engineering Report [S&ER] flexible design") and comparing its performance and associated uncertainties when it is operated at a high temperature and at a representative lower temperature. This choice was influenced, in part, by the fact that the same process models and performance assessments could be used to evaluate both the higher- and the lower-temperature design concepts. Information in the Supplemental Science and Performance Assessment report should provide some indication of the validity of this analytical approach. The final EIS should justify use of the S&ER design operated in a low-temperature mode as a surrogate for a true low-temperature design for purposes of projecting environmental effects, especially long-term releases of radionuclides to the environment.

Response
In considering the points in this comment, it is important to focus on a fundamental idea: The period of significant heat release would be very short compared to the lifetime of waste packages. Thus, even if the heat were to be detrimental to waste packages and performance in general, heat output would be dramatically reduced before any significant amount of waste package failures occurred and thus would have no important influence on long-term performance. This was seen in the Draft EIS case and also in the Final EIS case (see Section 5.4).

Sensitivity studies, which included a temperature sensitive model of corrosion, showed improved performance (less than half the mean peak dose that is reported in the Final EIS) (DIRS 155950-BSC 2001). The fact that there is improved performance is not surprising because the non-temperature-dependent model is conservative and actually uses what is essentially corrosion under all adverse conditions including high temperature. When the temperature-dependent model is employed, the conservatism of assuming a constant, higher rate is removed so that corrosion after the short heat pulse is much slower than that of the conservative model. Improved performance then results. Even in these sensitivity studies the higher-temperature repository operating mode results differ by about 30 percent from the lower-temperature repository operating mode (DIRS 154659-BSC 2001) because of the fundamental fact that the period of heat generation is short compared to package and drip shield lifetimes.

After consideration of the a large body of study and analysis, DOE does not believe that general lowering of repository temperature would not improve the overall long-term performance of the repository.

7.3.1 (6414)
Comment - EIS001632 / 0006
Page 2-6, final two paragraphs of 2.1.1: The repository performance and dose assessments in the draft EIS are based on models and assumptions in the DOE Viability Assessment Report (DOE/VA - DOE/RW-0508) that are now outdated. For example, the draft EIS analyzes the Module I & II inventory increases which were not part of the DOE/VA. Also, the DOE/VA examined the performance of a waste package design that is now obsolete. The

assessments in the final EIS should describe/assess the new EDA II design, particularly those aspects of the new design that modify the performance assessment.

Response
The Draft EIS evaluates the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for repository surface and subsurface facilities as well as disposal containers (waste packages). It also evaluates the plans for the construction, operation and monitoring, and closure of the repository. DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review of the repository by the U.S. Nuclear Regulatory Commission. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement to the Draft EIS incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

As described in the Supplement to the Draft EIS and incorporated into the Final EIS, the waste package has been redesigned to include a thick outer shell of corrosion-resistant high-nickel alloy (Alloy-22) and a thick inner shell of stainless steel for strength. This newer design resists corrosion far better than the design described in the Draft EIS, and has improved the predicted performance of the repository and reduced uncertainties associated with that performance. A description of the flexible design waste package can be found in Section 2.3.4.1 of the Supplement to the Draft EIS and Section 2.1.2.2.2 of the Final EIS.

The type and amount of neutron absorber necessary for a specific waste package design would be determined by DOE prior to receipt of a license from the Nuclear Regulatory Commission to receive and posses spent nuclear fuel and high-level radioactive waste. This would have to be done consistent with a criticality analysis methodology that has been accepted by the Commission. The specifics of that methodology are presented in Disposal Criticality Analysis Methodology Topical Report, which DOE submitted to the Commission in January 1999.

7.3.1 (6593)
Comment - EIS001632 / 0066
Pages 9-12 through 9-16, Section 9.2.8: The design alternatives discussed in this section are outdated with the Department's adoption of the EDA II design. The final EIS should discuss the new design of the engineered barrier components (e.g., elements designed to minimize water contact with the packages, increase containment lifetime, or retard radionuclide movement out of the repository); it should also discuss the operational choices (e.g., a prolonged retrievability period) that dictated the design changes and reduced uncertainties in assessing performance of the system.

The final EIS should also contrast significant changes in the engineered barrier performance assessment with the assessments for the older design. For example, the DOE/VA design assumed a juvenile package failure at 1,000 years, a major contributor to the dose calculations within 10,000 years. Estimating the rate and timing of juvenile failures is very difficult since the failure mechanisms are hard to predict. With the addition of drip shields, this uncertainty is effectively eliminated since releases would only occur if a drip shield is breached over a package with a juvenile failure -- a very low- probability event.

The performance assessment of the new design should describe the string of processes and events needed to release radionuclides, e.g., the probability that a drip shield would prematurely fail, the probability that a waste package would prematurely fail, the probability that these failures would be co-located, and the probability that a ground water seep would be located over the failed drip shield. A presentation in the final EIS that describes the new design in terms of its expected performance can help justify the design change, support the bounding argument for the older design, and increase confidence in the repository assessment.

Response
As the Environmental Protection Agency notes, the Draft EIS evaluated the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS-101779-DOE 1998) for repository surface facilities, and disposal containers (waste packages). It also evaluated the plans for the construction, operation and

monitoring, and closure of the repository. DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review of the repository by the U.S. Nuclear Regulatory Commission. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement to the Draft EIS incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies. Section 2.3.4 of the Supplement describes the design modifications (engineered barrier designs) including the addition of drip shields and refined waste packages.

With regard to the design process, DOE is moving forward with a final design but acknowledges, as noted above and as documented by the Supplement to the Draft EIS, the design could further evolve. The updated design information presented in the Supplement was carried forward to the Final EIS. However, DOE believes the design has progressed to a point that it provides a reasonable basis for estimating the range of potential short- and long-term impacts that would likely result from any final design.

7.3.1 (6699)
Comment - EIS001632 / 0090
Page 2-58, Section 2.1.4.3: This discussion does little to help the reader understand the design features and alternatives that affect operations and cost. We note that DOE intends to "evaluate the environmental impacts associated with the updated design in the final EIS." This section should be revised to clarify the discussion.

Response
As noted in the comment, DOE indicated in the Draft EIS its intention to evaluate updated designs in the Final EIS. Design updates were first presented and evaluated in the Supplement to the Draft EIS issued in May, 2001 and then integrated into the Final EIS. The Supplement to the Draft EIS presents new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

With regard to the design process, DOE is nearing a final design but acknowledges, as noted above and as documented by the Supplement to the Draft EIS, the design could further evolve. However, DOE believes the design has progressed to a point that it provides a reasonable basis for estimating the range of potential short- and long- term impacts that would likely result from any final design.

7.3.2 UNCERTAINTIES

7.3.2 (216)
Comment - 83 comments summarized
Commenters generally criticized the adequacy of the uncertainty discussions in the EIS. Commenters cited concerns with unavailable data, modeling, and the chaotic nature of the processes being evaluated. In addition, commenters noted expert disagreement and the length of time involved in the process as contributing to the level of uncertainty. As one commenter summarized, long-term impacts are based on arguably incomplete data fed into largely untested models. Several commenters expressed concerns that because of the scientific uncertainties and lack of data, DOE cannot determine with any certainty the long-term impacts of the repository, nor support the preferred alternative. The uncertainties call to question the claims of likely compliance with containment requirements.

Several commenters indicated that the uncertainty discussions were obscure, lack a systematic treatment, and should address a meaningful performance measure. Commenters suggested that real work, experimental work, would be better then testing compliance issues with computers. One commenter specifically criticized the use of the Monte Carlo sampling approach suggesting that any approach that produces a different answer with each calculation constitutes "criminal negligence."

Similar to the expressions of concern over uncertainty, several commenters expressed lack of confidence in long-term scientific projections, in general. Commenters suggested there was an insufficient basis for having any confidence in either the 10,000-year or 1-million-year potential dose calculations. One commenter asked for "a hundred percent confidence beyond a reasonable doubt."

Response

DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency, and Nuclear Regulatory Commission also recognize the difficulty of understanding the behavior of complex systems over long time periods. In 10 CFR Part 63, the Nuclear Regulatory Commission acknowledges that "proof that the geologic repository will conform with the objective for postclosure performance are not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation." In 40 CFR Part 197, the Environmental Protection Agency establishes "reasonable expectation" as a test of compliance, with diminished "weight of evidence" with time. The Agency also recognizes the need for expert judgment in assigning scenario probabilities, selecting simulation models, and assigning parameter distributions. Consistent with National Academy of Science observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events.

Since publication of the Draft EIS, the Science and Engineering Report (DIRS 153849-DOE 2001) has been published that supported the Supplement to the Draft EIS with the results of a comprehensive quantitative analysis of the possible future behavior of a Yucca Mountain repository. This analysis, known as the *Total System Performance Assessment – Site Recommendation* (DIRS 153246-CRWMS M&O 2000), combined the results of detailed conceptual and numerical models of each of the individual and coupled processes in a single probabilistic model that can be used to assess how a repository might perform over long periods of time. The *Total System Performance Assessment – Site Recommendation* was a next-generation analysis after the *Total System Performance Assessment – Viability Assessment*, used for analysis of long-term performance in the Draft EIS. This new analysis was the result of some significant design changes to the proposed repository and also some further advancement in knowledge from on-going research activities.

Despite the extensive scientific studies described in the Science and Engineering Report, DOE has always recognized that significant uncertainties will remain in any assessment of the performance of a repository over thousands of years, as discussed in the Science and Engineering Report (DIRS 153849-DOE 2001). These uncertainties are attributable to a variety of causes, ranging from uncertainty regarding the fundamental processes that could affect radionuclide migration to uncertainty related to the design and operation of the proposed repository. For this reason, one part of the DOE approach to dealing with uncertainty relies on multiple lines of evidence that may contribute to the understanding of the performance of the proposed repository. Another part of the DOE approach is a commitment to continued testing, monitoring, and analysis beyond the possible recommendation of the site.

One important aspect of the Total System Performance Assessment – Site Recommendation model was a variety of unquantified uncertainties. These are uncertainties for which a realistic distribution of parameters is not identified but rather a very conservative bounding value or bounding range is chosen. Additional studies have been conducted to investigate affects of unquantified uncertainties and sensitivities in the model. Part of the additional studies was to add several features to the Total System Performance Assessment to better quantify uncertainties and the affected processes. An additional report, known as the *FY 01 Supplemental Science and Performance Analyses* (DIRS 155950-BSC 2001), was prepared discussing this additional research and describing the modifications to the Total System Performance Assessment model. (See Section I.2 for more detailed discussion of the evolution of the Total System Performance Assessment model and application to this EIS.) This section summarizes areas in which the Supplemental Science and Performance Analysis model benefited from these additional uncertainty studies. Full details of the studies can be found in the *FY 01 Supplemental Science and Performance Analyses* (DIRS 155950-BSC 2001).

DOE confidence in the disposal techniques is based on defense-in-depth that, for example, places drip shields over waste packages to account for uncertainties. DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components, and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment
2. Consideration of features, events and processes that could affect repository performance over the long-term
3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality
4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario
5. Parameter distributions that represent the possible change of the system over the long term
6. Use of conservative assessments that lead to an overestimation of impacts
7. Performance of sensitivity analyses
8. Use of peer review and oversight

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

DOE continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended as a suitable site.

In response to the comment on the Monte Carlo technique, Monte Carlo is a widely accepted technique that randomly samples a range of input variables to produce different answers until enough results exist for a meaningful interpretation. These interpretations involve the application of accepted statistical tests and provide mean values as well as values for less likely outcomes.

7.3.2 (361)
Comment - EIS000043 / 0002
A number of design alternatives and options are described and their impacts evaluated. DOE's expectation is that whatever design is finally selected, its impacts will have been bounded by the analysis of the alternatives and options. The range of possible impacts, however, is wide, and they all lead to releases of radionuclides from the repository that contaminate a groundwater source currently used for drinking water and agricultural purposes in Nye County. What we don't know, and can't know from this Draft EIS, is how much is released, how fast it is released, and how soon it is released. In simple terms, this Draft EIS does not tell us what future risks of the proposed repository are to people and the environment.

Response
The long-term impacts resulting from the Proposed Action are summarized in Chapter 5 of the EIS. Additional detail related to assumptions and methodology used to estimate these impacts has been provided in Appendix I.

The Draft EIS evaluates the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998). It also evaluates the plans for the construction, operation and monitoring, and closure of the repository. DOE recognized before it published the Draft EIS that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review by the U.S. Nuclear Regulatory Commission. The design evolution is evaluated in the Supplement to the Draft EIS and integrated into the Final EIS. The Supplement incorporates new information, including an improved understanding of the interactions of potential repository features with the natural environment, the addition of design features for enhanced waste containment and isolation, and evolving regulatory requirements. The design will continue to evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

The updated analysis in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197) and are due to the very unlikely event of between zero and five packages failing due to manufacturing defects.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). DOE performed this evaluation, consistent with 40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that would be much lower than background levels (see Chapter 5 for details).

7.3.2 (1090)

Comment - EIS000217 / 0002

Because of grave uncertainties with regard to performance over the long term, it is important to build several layers of redundancy into any geologic storage program. For example, not only do analyses show the ineffectiveness of Yucca Mountain's geology in containing waste, serious questions exist as to whether the canister will perform as projected and even whether the performance of the canister can be characterized with any degree of certainty.
A DOE peer review panel criticized the canister containment in this 1998 report:

"Alloy C-22 is susceptible to localized corrosion only when wet in a critical temperature range. If C-22 remains passive in this range, its anticipated life, prior to penetration, is thousands of years. If it is not passive, then its life, prior to penetration, is as little as a few tens of years."

Chris Whipple et al Yucca Mountain Total System Performance Assessment Third Interim Peer Review Panel Report, 1998, pp. 20-22.

Response

The goal of geologic disposal is for engineered and natural barriers to work together to isolate the waste and allow only slow release to the environment to protect the public health and safety.

The waste package would be a principal barrier and its slow corrosion would be an important feature of the design. As noted by the commenter, factors such as critical temperature and chemistry would be crucial in determining the performance of the waste package. Experiments show that Alloy-22 (the waste package material) is not susceptible to localized corrosion in the conditions reasonably anticipated in the repository. The repository design as described in the Final EIS (which includes lower temperatures than described in the Draft EIS) would keep the waste packages cool enough so they would not be susceptible to localized corrosion. The updated analysis in the Final EIS projects the very unlikely event of between zero and five packages failing due to manufacturing defects. This small number of package failures would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (more than 100,000 times less than the individual protection standard set by 40 CFR Part 197).

Concerns about uncertainty expressed by the Peer Review Panel and others led to the design presented in the Final EIS. This design includes use of Alloy-22 for the outer rather than the inner layer of the waste package, the addition of titanium drip shields, and the consideration of a lower repository temperature resulting from fuel aging and other operational features.

7.3.2 (5660)
Comment - EIS001887 / 0279
Page 5-21; Section 5.2.4.3.3 - Uncertainty and the Proposed Action

The Draft EIS should compare the "lumped" performance analyses to the discrete analyses with each type of uncertainty isolated. This would provide information on the relative importance of each type of uncertainty so a value assessment can be made of various types of uncertainty reductions. For example, it would be important to know the relative importance of conceptual model uncertainty in the saturated zone flow model.

Response
The EIS contains estimates of the future environmental impacts of operating and closing a repository. The descriptions of these estimates include statements about the uncertainty in them. The EIS discusses uncertainties that existed at the time the analysis was performed, but does not address the estimates if these uncertainties were modified or reduced. Documents referenced in the EIS, such as the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) and the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001), investigate uncertainty and sensitivity in performance more fully. These documents and, in turn, their referenced technical documents (such as Process Model Reports and Analysis Model Reports) contain extensive detail on a large number of sensitivity and uncertainty analyses that studied the individual contribution of specific uncertainties.

In response to this and other comments on the Draft EIS, DOE has organized an internal task force to evaluate the sufficiency of the treatment of uncertainty at the process (scientific) and system (modeling) levels. The EIS discussion of uncertainty and its treatment in the supporting documents have benefited from this review.

7.3.2 (5661)
Comment - EIS001887 / 0280
Page 5-22; Section 5.2.4.3.5 - Confidence in the Long-Term Performance Estimates

This section of the Draft EIS concludes with the statement, "The EIS performance assessment represents a 'snapshot in time' and ongoing work will refine that snapshot." In fact, the performance assessment is not analogous to a "snapshot" at all. A snapshot implies a reasonable representation of reality. The Yucca Mountain performance assessment represents a compilation of incomplete data, buttressed by assumptions and guesswork, and analyzed using models of questionable validity in order lend an illusion of accuracy to its conclusions.

Response
DOE conducted iterative long-term repository performance assessments in 1991, 1993, 1995, and 1998 based on Yucca Mountain site and design information available at each of those times. The performance assessment described in the Draft EIS was based on the state of knowledge at the time as described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998). The long-term performance described in the Final EIS reflects advances in understanding of repository performance since that time. DOE will continue to collect data, refine designs, upgrade models, and conduct iterative assessments as it proceeds to License Application, construction, operation, and monitoring. Over time, with advances in knowledge and understanding, the iterative Total System Performance Assessment process helps to reduce but not eliminate uncertainty in the predicted repository performance.

DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. The National Academy of Sciences, Environmental Protection Agency, and Nuclear Regulatory Commission also recognize the difficulty of understanding the behavior of complex systems over long time periods. In 10 CFR Part 63, the Nuclear Regulatory Commission acknowledges that "proof that the geologic repository will conform with the objective for postclosure performance are not to be had in the ordinary sense of the word because of the uncertainties inherent in the geologic setting, biosphere and engineered barrier system. For such long-term performance, what is required is reasonable expectation." In 40 CFR Part 197, the Environmental Protection Agency establishes "reasonable expectation" as a test of compliance, with diminished "weight of evidence" with time. The Agency also recognizes the need for expert judgment in assigning scenario probabilities, selecting simulation models, and assigning parameter distributions. Consistent with National Academy of Science observations, DOE has designed performance assessments on a combination of mathematical modeling, natural analogs, and the possibility of remedial action in the event of unforeseen events. DOE believes this process results in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios, including the preferred alternative.

DOE continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended as a suitable site.

7.3.2 (7345)
Comment - EIS001106 / 0023
NEPA [National environmental Policy Act] is meant to assure achievement of high environmental quality far into the future. The full range of uncertain adverse impacts of the YMP [Yucca Mountain Project] that are meaningful in the context of future generations is missing from the YMP DEIS and must be corrected to meet NEPA's purpose for sufficient EIA [environmental impact assessment]. This applies in particular to the interactions between global climate change and future releases of radionuclides into the regional and global environment from the YMP.

Response
The regulations of the Council on Environmental Quality (40 CFR Parts 1500 to 1508) direct Federal agencies to use the process established by the National Environmental Policy Act to identify and assess reasonable alternatives to the proposed actions that could have effects on the quality of the human environment. DOE has prepared this EIS pursuant to those regulations and 10 CFR 1021. Additionally, DOE has adhered to the directions of the NWPA.

While DOE has taken steps to consider the pertinent long-term impacts of its action, uncertainties remain and are discussed (pursuant to 40 CFR 1502.22) in Section 5.2.4 of the EIS. With regard to the specific issue of climate, climate change was included in the long-term performance assessment calculations used to estimate environmental impacts from the repository. These impacts and the specifics of the projections are reported in Chapter 5, 8, and Appendix I of the EIS.

7.3.2 (7402)
Comment - EIS001957 / 0021
Section 5.1 Environmental Consequences of Long Term Repository Performance, Inventory for Performance Assessment Calculations -- Table 5-1 lists the average radionuclide inventory of waste packages to be emplaced at the proposed repository. The table lists nine radionuclides. Other than carbon 14, which has a half-life of 5,700 years, the radionuclides that comprise the proposed waste packages have half-lives that range from 24,000 years (Plutonium 239) to 16,000,000 years (Iodine 129). Neptunium 237, a key radionuclide that is thought to play an important role in human health risk, has a half-life of 2,100,000 years.

Section 5.2.4 Uncertainty Associated with Models and Model Parameters -- The draft EIS states:

"The total system performance model used to assess the impacts from groundwater migration includes a very large number of submodels and requires a large amount of input data to estimate the performance of the system."

In a contrasting article published in the Journal of Ground Water of the Association of Ground Water Scientists & Engineers, July-August 1999, by Konikow and Ewing, entitled: "Is Probabilistic Performance Assessment Enough?", it is stated that:

"The U.S. Department of Energy has just released the congressionally mandated 'total systems performance assessment' as part of the viability assessment of the proposed nuclear waste repository at Yucca Mountain. The linking of multiple complex, deterministic models in the PA approach makes it difficult to find and analyze weaknesses in the underlying conceptual models or even errors generated by faulty linkages and inconsistent assumptions among various submodels. We urge extreme caution before accepting the probabilistic outcomes generated by the PA approach. In summary, we offer a quote from Ansel Adams: "There is nothing more disturbing that a sharp image of a fuzzy concept.'"

There is excessive imprecision in the uncertainty analysis for the proposed repository at Yucca Mountain, due to the coupling of various models, each of which employ many assumptions. The degree of uncertainty in the analysis of long term environmental consequences is not and cannot be adequately assessed, due to the coupling of these various models, each of which has inherent uncertainty.

Response
The long half-lives of some of the radionuclides to be disposed of in the Yucca Mountain Repository (if it is approved) are why DOE continues to perform evaluations of the peak dose, up to a million years into the future. Regulatory concern exists over attempting to use calculations into the very far future in a licensing setting and therefore these evaluations to peak dose are outside the licensing setting. The uncertainties over the details of the unknowable future would quickly make it impossible to implement these evaluations in a rigorous licensing process.

The Total System Performance Assessment analyses in the EIS is not intended to be a definitive prediction of repository behavior With any impact estimate, there is a level of uncertainty associated with the forecast, especially when estimating over thousands of years. DOE recognizes that uncertainties exist from the onset of an analysis; however, forecasts are valuable in the decisionmaking process because they provide insight based on the best available information and scientific judgements available. Section 5.2.4 of the EIS addresses uncertainty related to total system performance analysis.

7.3.2 (7801)
Comment - EIS001653 / 0004
The FEIS needs to contain a strong worst-case scenario analysis. Currently, there are too many uncertainties in the performance assessment process. It is highly likely that even at the conclusion of the licensing process many uncertainties will still exist. DOE needs to include a worst-case scenario examining the conditions under which the repository waste containment would not achieve regulatory standards. This analysis should describe the probability of occurrence, the likely consequences, and the inherent weaknesses of the performance assessment process used in the DEIS. The FEIS should also clearly identify the progress and or improvements of the performance assessment since the issuance of the DEIS.

Response
The EIS presents the long-term performance results in probabilistic terms – a mean and 95th-percentile result. This statistical spread reflects the range of possible behavior DOE believes is credible for the repository system based on wide ranges of parameters. As such, the “worst case” is contained within the range of results. The worst case could be realized as the results approached at the 100th percentile.

The Draft EIS evaluated the preliminary design concept described in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for repository surface facilities, subsurface facilities, and disposal containers (waste packages). It also evaluated the plans for the construction, operation and monitoring, and closure of the repository. DOE recognized that plans for a repository would continue to evolve during the development of any final repository design and as a result of any licensing review by the Nuclear Regulatory Commission. In May 2001, DOE issued a Supplement to the Draft EIS providing information on the evolving design. Section 2.2.1 of the Supplement describes the new performance assessment results. Further updates to the results are described in Sections 2.4 and 5.4 of the Final EIS. Table 5-1 of the Final EIS describes the changes to the models since the Draft EIS.

7.3.2 (9885)
Comment - EIS001888 / 0433
[Clark County summary of comments it has received from the public.]

Still others requested the EIS to adopt “excessive conservatism” to compensate for the magnitude and broad range of uncertainties in projecting analyses of the future.

Response
The use of probabilistic modeling accounts for the wide range of uncertainties in the calculations. The 95th-percentile results (which means 95 percent of the analyses would produce a smaller potential impact than that shown) represent a very conservative case. If there was sensitivity and uncertainty, the analysis often biased input distributions with “pessimistic” values. If there was uncertainty about the appropriate model for a process, DOE generally used the model that produced the least favorable result. DOE believes that these analyses present an

appropriately realistic case (the mean value results), and a very conservative case (the 95th-percentile case). DOE believes these results, in conjunction with other information, are sufficient to allow decisionmakers to decide whether to approve the site for development as a repository.

7.3.2 (11403)
Comment - EIS002251 / 0001
I appreciate the opportunity to ask a question earlier. I feel like it wasn't thoroughly answered, but the answer I did get that the science errs to the side of conservatism tells me that it is not science being used to study Yucca Mountain, and that it is influenced by the scientists. Because if it wasn't, the answer should have been that it is science. There's no possibility of either erring conservatively or otherwise.

Response
Science is a disciplined way of studying nature. However, every aspect of applied science requires some judgment by the scientist. Science is not always as exact and definitive as a scientist could hope. Scientific problems often require judgment and interpretation using the insights gained from similar processes observed in nature and compiling and judging evidence from the past. Because there is uncertainty in the science applied in the study of the proposed Yucca Mountain Repository, the scientists have provided, where possible, ranges of possible conditions and results, rather than a single most likely value. Where there is insufficient data to provide this range, a single conservative estimate is used, so as to err on the side of overestimating consequences rather than underestimating.

Yucca Mountain scientists have carefully documented the bases for their judgments so that others can follow the development of their data and modeling. External and internal reviews by subject-matter experts have been conducted. These reviews have resulted in the evolution of the repository design.

7.3.2 (12109)
Comment - EIS001887 / 0408
Apprehension for future environmental quality has been aroused by concerns such as global warming and accumulations of radioactivity. Adverse consequences of increased environmental perturbations, however, have not always been recognized by the public. Government agencies should educate the public rather than fostering further development at the risk of unexpected environmental impacts. Accomplishing this is a role of the federal government. Means must be found to bring the political will and the missions of agencies closer to implementing the values expressed in NEPA's [National Environmental Policy Act] intent. NEPA is meant to assure achievement of high environmental quality far into the future. The full range of uncertain adverse impacts of the YMP [Yucca Mountain Project] that are meaningful in the context of future generations is missing from the DEIS and must be corrected to meet NEPA's purpose for sufficient EIA [environmental impact assessment]. This applies in particular to the interactions between global climate change and future releases of radionuclides into the regional and global environment from the YMP.

Response
The regulations of the Council on Environmental Quality (40 CFR Parts 1500 to 1508) direct Federal agencies to use the process established by the National Environmental Policy Act to identify and assess reasonable alternatives to the proposed actions that could have effects on the quality of the human environment. DOE has prepared this EIS consistent with those regulations and 10 CFR 1021. Additionally, DOE has adhered to the directions of the NWPA. As part of that process DOE has hosted public scoping meetings, informational sessions, and solicited comments. While DOE has taken steps to consider the pertinent long-term impacts of its action, uncertainties remain and are discussed (pursuant to 40 CFR 1502.22) in Section 5.2.4 of the EIS.

The potential long-term impacts presented in Chapter 5 and Appendix I of the Draft EIS do account for future climate change. However, DOE improved the future climate model for the Final EIS to reduce the uncertainty in climatic effects on the repository. The climate change scenarios are provided in reports referenced in the EIS. The impacts estimated for a 1-million-year period after closure of the repository were based on a careful evaluation of any releases of radionuclides as well as other hazardous materials. The range of possible impacts reported is based on probabilistic analyses.

The commenter indicates that further development should not be fostered at the risk of unexpected environmental impacts. The situation, however, is that the materials that would be placed in the proposed repository exist now.

The requirement for an ultimate permanent solution to the waste problem would remain even if the Proposed Action was not carried out. Chapter 7 of the EIS discusses the potential environmental impacts of the No-Action Alternative.

7.4 Repository Accidents

7.4 (41)
Comment - 3 comments summarized
Commenters stated that human error is a common initiator for accidents, citing examples of the recent nuclear accident at the Tokaimura nuclear fuel plant in Japan and past accidents in Russia and elsewhere. Commenters suggested that DOE has completely ignored human error as an accident initiator for any stage of repository construction, operation, monitoring and closure.

Response
DOE agrees that human error is a potential accident initiator and has considered human error in the EIS in the analyses of potential accidents. Appendix H of the EIS documents an analysis of potential accidents that could happen at a repository. The range of accidents considered includes events that could be initiated from both human error (for example, fuel assembly drop accidents) and external events (for example, earthquakes and volcanoes). Appendix H and its references describe the applicable analyses and the results. The results of a set of 10 potential accidents (based on screening described in Appendix H) are shown in Tables 4-36 and 4-37 of the EIS. Impacts to any member of the public resulting from the complete spectrum of credible events (those having an annual probability of 1 chance in 10 million or greater) would result in a radiation dose of no more than a few millirem even if no action was taken to avoid exposure after an accident occurred. Spent nuclear fuel handling and transportation operations would be designed so that the consequences of accidents caused by human error are limited and localized. For example, during transfer operations, lifting heights would be limited so that accidental drops of radioactive material would not be expected to result in an uncontained release of radioactive material.

7.4 (67)
Comment - 3 comments summarized
Commenters expressed concern over the selection of older fuel for accident analysis in the DEIS and the fact that the Supplement did not consider transportation analysis.

Response
As a result of similar comments on the Draft EIS, DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A. 2.1.5. The revised fuel used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel to be received at the repository (5 years old) would produce impacts about 3 times higher than the representative fuel selected for the analysis. Accidents involving transportation casks and waste packages would not involve only the hottest fuel because licensing limitations preclude loading these containers with only the hottest fuel.

Transportation analysis is beyond the scope of the Supplement to the Draft EIS. As indicated in Section 1.2 of the Supplement, the scope was limited to changes in the proposed repository design and operating modes. The transportation analysis has been extensively revised for the Final EIS to incorporate the new fuel characteristics and other relevant information (See Chapter 6 and Appendix J).

7.4 (87)
Comment - 10 comments summarized
Commenters were concerned about the potential impact of catastrophic accidents at Yucca Mountain. Such catastrophic event cited included seismic events, a nuclear meltdown, meteor strikes, and impact from aerospace objects originating from proposed launch facilities at the Nevada Test Site. Some commenters stated that the impacts of such events would be compounded by concentrating the nuclear waste at one repository as opposed to scattered storage locations.

The requirement for an ultimate permanent solution to the waste problem would remain even if the Proposed Action was not carried out. Chapter 7 of the EIS discusses the potential environmental impacts of the No-Action Alternative.

7.4 Repository Accidents

7.4 (41)
Comment - 3 comments summarized
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Response
DOE agrees that human error is a potential accident initiator and has considered human error in the EIS in the analyses of potential accidents. Appendix H of the EIS documents an analysis of potential accidents that could happen at a repository. The range of accidents considered includes events that could be initiated from both human error (for example, fuel assembly drop accidents) and external events (for example, earthquakes and volcanoes). Appendix H and its references describe the applicable analyses and the results. The results of a set of 10 potential accidents (based on screening described in Appendix H) are shown in Tables 4-36 and 4-37 of the EIS. Impacts to any member of the public resulting from the complete spectrum of credible events (those having an annual probability of 1 chance in 10 million or greater) would result in a radiation dose of no more than a few millirem even if no action was taken to avoid exposure after an accident occurred. Spent nuclear fuel handling and transportation operations would be designed so that the consequences of accidents caused by human error are limited and localized. For example, during transfer operations, lifting heights would be limited so that accidental drops of radioactive material would not be expected to result in an uncontained release of radioactive material.

7.4 (67)
Comment - 3 comments summarized
Commenters expressed concern over the selection of older fuel for accident analysis in the DEIS and the fact that the Supplement did not consider transportation analysis.

Response
As a result of similar comments on the Draft EIS, DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A. 2.1.5. The revised fuel used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel to be received at the repository (5 years old) would produce impacts about 3 times higher than the representative fuel selected for the analysis. Accidents involving transportation casks and waste packages would not involve only the hottest fuel because licensing limitations preclude loading these containers with only the hottest fuel.

Transportation analysis is beyond the scope of the Supplement to the Draft EIS. As indicated in Section 1.2 of the Supplement, the scope was limited to changes in the proposed repository design and operating modes. The transportation analysis has been extensively revised for the Final EIS to incorporate the new fuel characteristics and other relevant information (See Chapter 6 and Appendix J).

7.4 (87)
Comment - 10 comments summarized
Commenters were concerned about the potential impact of catastrophic accidents at Yucca Mountain. Such catastrophic event cited included seismic events, a nuclear meltdown, meteor strikes, and impact from aerospace objects originating from proposed launch facilities at the Nevada Test Site. Some commenters stated that the impacts of such events would be compounded by concentrating the nuclear waste at one repository as opposed to scattered storage locations.

Response
The EIS evaluates impacts from a spectrum of potential accident scenarios, from minor events to highly improbable natural phenomena such as beyond-design-basis earthquakes (1 chance in 50,000 per year). Appendixes H and I of the EIS describe the results of these evaluations for repository operations (preclosure), and long-term impacts (postclosure), respectively. Because of the nature of the waste and its confinement in strong corrosion-proof containers in underground drifts (tunnels), the proposed repository would offer considerable protection to the environment from any credible event (a probability of 1 chance in 10 million per year or higher). A nuclear meltdown from heat generated by the waste would not be possible. The temperature of the waste would be strictly controlled by waste package spacing and ventilation. If the forced ventilation system failed, ample time would be available to restore ventilation capability because heat-up of the waste packages would be very slow and several years would be available before waste package temperatures would approach levels that could result in a radionuclide release.

With regard to aerospace activities, DOE examined both existing activities and the potential for future activities that could pose a threat to the repository (see Section H.2.1.3 of the EIS). Two such activities were determined to be potential threats; the Kistler Aerospace activities and the Wahmonie rocket launch facility could initiate accidents at the repository from rocket impacts. The Wahmonie activities, which involved rocket launches from a location several miles east of the repository site, have ended (DIRS 104722-Wade 1998), so this facility would pose no risk to the repository. The Kistler Aerospace activities would involve launching rockets from the Nevada Test Site to place satellites in orbit (DIRS 101811-DOE 1996). However, the Kistler Aerospace activity is currently on hold (DIRS 157108-Jason 2001), and there is insufficient information to determine if this activity could pose a threat to the repository. If the project moved forward, DOE would evaluate its potential to become an external accident-initiating event.

DOE also examined the potential for a meteorite strike on both the Waste Handling Building and the surface aging facility and found such an event to be noncredible (probability less than one in 10 million). This analysis is provided in Section H.2.1.3 of the EIS.

7.4 (103)
Comment - 2 comments summarized
Commenters were concerned that any possible resumption of underground nuclear weapons testing at Nevada Test Site could adversely affect repository operations or long-term isolation of spent nuclear fuel and high-level radioactive waste.

Response
Potential impacts from underground testing at the Nevada Test Site were evaluated in 1996 in the *Nevada Test Site Environmental Impact Statement* (DIRS 101811-DOE 1996). The evaluation concluded that the only impact such testing could impose on the repository would be ground motion associated with the energy released from the detonation of the weapon. These ground motion effects were determined to be not limiting for the seismic design criteria. In other words, the design-basis earthquake for the repository was determined to provide the greatest ground motion effects. Therefore, because the repository has been designed to survive the design-basis earthquake with minimal damage, ground motion resulting from any resumption of underground testing would be unlikely to result in any substantial damage to the repository or its contents. Section H.2.1.3 of the EIS provides a discussion of external events including those that could occur from military activity such as resumed nuclear testing on the Nevada Test Site.

7.4 (125)
Comment - 17 comments summarized
Commenters stated that the dry spent fuel surface aging facility should be evaluated for accidents. Commenters also suggested that the facility could not be licensed because of the local seismic conditions.

Response
Accidents involving the spent nuclear fuel storage modules in the surface aging facility and the Waste Handling Building are evaluated in Section H.2.1.3 of the Final EIS. Aircraft crashes and beyond design basis earthquake events are explicitly considered. As noted in Section H.2.1.3, a significant earthquake event could cause the modules to tip over, but the storage canisters and welded seams would withstand such events without damage.

Regional volcanoes were found to be credible, but the only consequence of such an event would be minor ashfall at the repository which would have no effect on the storage modules. Because there would be only very small quantities of surface contamination on the storage modules or casks, storm runoff would not represent a substantial source of radioactive contamination. The fuel storage facility would comply with all applicable Nuclear Regulatory Commission licensing requirements, which would include seismic design criteria specific to the repository and therefore would be licensable by the Commission.

7.4 (207)
Comment - 4 comments summarized
Commenters indicated that they believe that an aircraft crash could cause a real problem if it crashed into repository surface facilities. Commenters also expressed concern that an aircraft crash on the surface could result in immediate or delayed subsurface impacts such as exploding ordnance or rock fracturing. Some stated that DOE had not analyzed this possibility well enough.

Response
During normal operations, shipping casks that arrive at the repository would be unloaded and the contents moved either to a dry storage staging (surface aging) area or into the Waste Handling Building. Although dry storage staging (surface aging) was not evaluated at the Yucca Mountain site in the initial Draft EIS, the potential consequences of an aircraft crash into dry storage facilities were evaluated at the generator sites for the No-Action Alternative (Section 7.2.1.8) and for the repository retrieval scenario (Section 4.2.1.2.8). In both cases penetration potential of above-ground storage facilities by aircraft components was determined not to be sufficient to breach the containers. The EIS has been updated to specifically address the potential consequences of an aircraft crash into dry storage staging (surface aging) facilities at Yucca Mountain. The analysis results continue to show that no breach of waste containers or release of radioactive materials would occur.

Some military aircraft from Nellis Air Force Base carry explosive ordnance. However, this ordnance is not armed until the aircraft arrives at the Nellis Air Force Range (now called the Nevada Test and Training Range), north of the proposed repository location. As a consequence, an aircraft mishap near the proposed repository would be unlikely to detonate any ordnance carried by the aircraft. In the Safety Evaluation Report for the Private Fuel Storage project in Utah, the probability of unarmed live ordnance exploding while being carried on board a crashing aircraft was conservatively estimated to be 1 percent (0.01) (DIRS 154930-NRC 2000). Because the crash probability onto dry storage modules is only slightly above the 1 chance in 10 million, the probability that a crash would involve a plane carrying live ordnance that explodes would be about 1 chance in 1 billion per year. DOE regards such a scenario as not reasonably foreseeable.

As indicated in Section H.2.1.3 of the EIS, aircraft crash impacts into the Waste Handling Building that could cause damage to the stored fuel are not credible (a probability of less than 1 chance in 10 million per year). However, DOE decided to evaluate an aircraft crash into the repository due to the potential for large impacts. The results are provided in Section H.2.1.5.1.

The repository design calls for the subsurface structures, including waste packages and support systems for the emplacement drifts, to withstand the effects of a large earthquake (a once-in-10,000-year event) without a release of radioactivity. The waste packages in the drifts would be under at least 200 meters (660 feet) of rock overburden. As a consequence, the impact of a jet aircraft crash on the surface, with a relatively small energy input to the mountain compared to an earthquake, would be unlikely to cause any disruption in the emplacement drifts. Furthermore, a recent analysis (DIRS 150276-CRWMS M&O 2000) evaluated the impact of a hypothetical failure of an underground waste package with damage to all fuel assemblies and concluded that the dose to a member of the public at the nearest repository land withdrawal boundary would be small (2.66 millirem).

7.4 (241)
Comment - 26 comments summarized
Commenters stated that the blending pools had not been considered in the accident analysis, particularly with respect to the beyond design basis earthquake evaluated in the DEIS. Also of concern was the potential for criticality and the potential for heatup of the fuel stored in the blending pools if water were lost, and contamination of surface water and groundwater from the pool water. Commenters were concerned about the effects of an earthquake

occurring during the blending process as well as the effect of incorrect record keeping. Others were concerned that the design detail was not sufficient to allow an adequate safety analysis.

Response

DOE agrees that it is likely that the portion of the Waste Handling Building that encloses the fuel pools would also collapse in the beyond-design-basis seismic event evaluated in the EIS. However, this portion of the Waste Handling Building would be a type of construction that would not result in heavy construction debris that could fall into the fuel pools and cause extensive damage to the stored fuel assemblies. The 15-meter (50-foot) depth of the fuel pool would also limit the velocity of impact (and, therefore, assembly damage) of any debris that could enter the pool from the postulated earthquake. Furthermore, if a radionuclide release occurred from damage to fuel assemblies, the release would be very small because the radionuclides contained in fuel pellet particles would be retained in the pool water. In the Final EIS accident analysis, such releases were postulated to occur from fuel assembly handling accidents in the pool, and only minimal releases were estimated (see Appendix H of the EIS for further discussion). The earthquake could damage the walls and floor of the fuel pools, although a recent assessment for similar pools at nuclear powerplants concluded that the pool enclosures have significant capacity to resist seismic loads. Because the pools would be below ground level, the compact geologic media that surrounds the pool walls and floor would limit the leakage rate from the pool. The steel liner in the pools would also assist in limiting leakage. Since the fuel assemblies would have been aged at least 5 years prior to arrival at the repository, rapid heatup would not be possible. The assemblies could be stored in dry surface storage with no active cooling required. A recent evaluation by the Nuclear Regulatory Commission determined that the maximum cooling time to prevent radionuclide release from overheated fuel in a storage pool after loss of water could be as much as 5 years under conservative adverse circumstances (all surrounding fuel cooled 5 years or less, high density storage, impaired ventilation). All of the fuel in the pools would be cooled at least 5 years (the estimated maximum average cooling time would be 11 years), and the conservative circumstances cited in the Nuclear Regulatory Commission analysis would be unlikely to exist.

The water handling and treatment systems for the inventory (blending) pools and safety measures planned are described in the Science and Engineering Report (DIRS 153849-DOE 2001). With respect to the source of water for repository operations, including the pools, DOE filed suits on March 2, 2000, in the U.S. District Court for the District of Nevada, and on March 3, 2000, in Nevada’s Fifth Judicial District Court for injunctive relief to overturn the Nevada State Engineer’s Ruling No. 4848, dated February 2, 2000, denying DOE’s water-appropriation request for 430 acre-feet per year for repository construction and operation. The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest. On September 21, 2000, the U.S. District Court Judge granted the State’s motions to dismiss the DOE lawsuit. DOE appealed this ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE’s suit. The case is pending. DOE has not developed any other plans to acquire water for the proposed repository. Depending on the final ruling of the State Court, DOE might consider other options to carry out its responsibilities under the NWPA.

As discussed in Section H.2.1.3 of the EIS, flash floods could occur in the vicinity of the repository (DIRS 100204-CRWMS M&O 1996). However, an earlier assessment (DIRS 103237-CRWMS M&O 1998) screened out severe weather events as potential accident-initiating events primarily by assuming that operational rules would preclude transport and emplacement operations whenever there are local forecasts of severe weather. A quantitative analysis of flood events (DIRS 104699-Jackson et al. 1984) concluded that the only radioactive material that extreme flooding would disperse to the environment would be decontamination sludge from the waste treatment complex. The doses resulting from such dispersion would be limited to workers, and would be very small (DIRS 104699-Jackson et al. 1984). A more recent study reached a similar conclusion (DIRS 101930-Ma et al. 1992).

Less severe storm flooding events would not be expected to carry contaminated water into nearby rivers because the design would include a storm drainage control and collection system to contain water runoff and prevent spillage over the fill slopes. A retention pond would be built to prevent stormwater pollution. Further, there are no rivers in the vicinity of the repository to transport contaminated water. Casks in the aging facility would not contain significant amounts of radioactive contamination on their surfaces, and casks would be monitored for leakage and repaired if leakage was detected. Accidents involving the surface aging facility are considered in Section H.2.1 of the EIS.

The criticality potential resulting from displaced, crushed, and damaged fuel assemblies has been evaluated by the Nuclear Regulatory Commission for spent nuclear fuel storage at nuclear power plants (DIRS 156712-NRC 2001). The conclusion reached by the Commission was that spent nuclear fuel pool criticality would pose no meaningful risk to the public. This conclusion is considered applicable to the fuel pools because they would be designed and operated consistent with Commission regulations. Additional consideration of the likelihood and consequences of criticality events is provided in Section H.2.1 of the EIS. DOE intends to continue to evaluate criticality potential in the pools.

Blending is merely the selective loading of disposal containers to control waste package temperature. Accidental assembly drops during handling and loading operations are evaluated in Appendix H of the EIS and impacts from such accidents are provided in Section H.2.1.5. Releases from assembly drop accidents in the pool would be mitigated by retention in the pool water, and all accidents within the confines of the Waste Handling Building would be mitigated by the ventilation system, which would control the flow of any radioactive release and filter any airborne discharge to the atmosphere. Misloading of a waste package could occur, and such events could result in excessive temperatures. The possibility of such events has been considered, and it is expected that disposal container loading procedures would be developed based on thermal analyses of the various waste package configurations such that sufficient margin would be available to ensure that temperature criterion would not be violated for any credible misload (DIRS 150198-CRWMS M&O 2000).

The processes planned for the blending commercial spent nuclear fuel are the same as those being used successfully for fuel management at nuclear plants throughout the United States. The nuclear industry has been using historical data for many years as the basis for performing core reload and criticality calculations and has an excellent record for accurately predicting the response of the reactor. The records and data that would be used for fuel blending are the same records that the utilities have used to calculate core reloads and criticality.

With regard to the completeness of facility design, the level of discussion in the EIS is similar to the description of the other operational characteristics of the waste handling process. As described in the Science and Engineering Report (DIRS 153849-DOE 2001) and the Preliminary Site Suitability Evaluation (DIRS 155950- and 154659-BSC 2001), DOE believes that the engineering design of the Waste Handling Building has been developed to the extent necessary to allow estimation of potential accidents and resulting environmental impacts, consistent with the National Environmental Policy Act.

7.4 (2943)
Comment - EIS001051 / 0002
This information is inadequate and doesn't address accident exposure as a result of accidents nor does it address downwind effects of radiation exposure, potential ground water contamination or the risk of exposure to health professionals in the Las Vegas area.

Response
The EIS addresses both the probability and potential consequences of accidents. Section 6.2.4 and Appendix J of the EIS discusses potential consequences of transportation accidents. Section 4.1.8 and Appendix H address potential accidents during preclosure repository operations, and Chapter 5 analyzes the potential for groundwater contamination thousands of years after the emplacement of spent nuclear fuel and high-level radioactive waste in the proposed repository. To ensure that the analyses did not underestimate the impacts, they assumed no implementation of intervention or institutional controls to mitigate the consequences. Even in the most severe accidents (annual probability of less than 1 chance in 5 million), DOE expects negligible radiation exposure to anyone not directly involved in the accident, including health care professionals.

In response to public comments, the EIS contains additional information on Federal, state, Native American tribal, and local responsibilities and preparedness for emergency response to accidents involving radioactive material shipments (see Section M.6). Section M.8 discusses the Price-Anderson Act, which provides for liability insurance to redress costs of accidents involving releases of radioactive materials to the environment. In addition, Sections J.1.4.2.5 and H.2.1.5 include a range of cost estimates for cleanup and restoration following transportation and repository accidents, respectively.

7.4 (3363)

Comment - EIS001242 / 0012

If an accident happens, who will be contaminated downwind/how far will the contamination reach in the air?

Response

The maximum reasonably foreseeable accident at the repository would be a large earthquake that collapsed the Waste Handling Building and damaged fuel assemblies inside the building in dry storage. For such an event, very little contamination would occur beyond the site boundary (controlled area), even under the worst weather conditions (see Table 4-37 of the EIS). The accident analysis considered dispersion of radioactive materials to a distance of 80 kilometers (50 miles). However, as listed in Table 4-37, the total exposure to the population within this distance would be very low.

7.4 (3733)

Comment - EIS001160 / 0122

[Section 4.1.7] does not appear to consider off-site exposure potential associated with volcanism. Although volcanism is a low probability event, it would have a potentially high degree of consequence. The health risk associated with a low probability volcanism event should be estimated so as to determine whether some manner of related mitigation is warranted.

Response

Section 4.1.7 of the EIS discusses the potential occupational and public health and safety impacts associated with short-term (prior to the completion of repository closure) impacts. The events considered are limited to those with an annual probability of 1 chance in 10 million or greater. A volcanic event at Yucca Mountain is estimated to have a lower annual probability (approximately 1 chance in 70 million). However, Section 5.7.2 of the EIS discusses the possibility of volcanic disruption of a Yucca Mountain Repository. This analysis presents the long-term (postclosure) estimated annual risk from potential volcanic activity and has been updated from the analysis in the Draft EIS. The peak annual risk is estimated to be a small fraction of the individual protection standard for annual dose to a member of the public [15 millirem in Environmental Protection Agency regulations at 40 CFR 197.20 and Nuclear Regulatory Commission regulations at 10 CFR 63.102(j)].

7.4 (3755)

Comment - EIS001029 / 0003

Transportation and disposition of radioactive materials will take at least 30 years. What happens if an earthquake occurs before the wastes are completely buried underground? There may be aftershocks and other earthquakes following the first. Is there a contingency plan? Could one even work? How many systems such as communication, transportation, computers, must work properly? How many people must be involved? How much of the surface area would be damaged around Yucca Mountain.

Response

DOE would design repository surface and subsurface facilities to withstand a very severe earthquake with no substantial damage. The EIS analysis estimates that a major earthquake sufficient to destroy the Waste Handling Building, beyond the design basis required by the Nuclear Regulatory Commission, would have a probability of 1 in 50,000 per year. Appendix H of the EIS evaluates the potential impacts of such a major earthquake during repository operations. If it occurred, the analysis assumes that this event would cause a complete collapse of the Waste Handling Building and damage to fuel assemblies that would be out of the storage pools in the building during normal operations. The damage to the assemblies and the building would result in a release of radioactive material.

Conservatively assuming no evacuation of the public following the event and that exposure to the public from material deposited on the ground and consumed in food crops would continue with no intervention, the EIS lists potential consequences in Tables 4-36 and 4-37. Based on these consequences, DOE anticipates no adverse health effects to the public.

Even though the analysis identified no scenarios that would result in health effects to the public, DOE would put emergency plans in place that the Nuclear Regulatory Commission would have to approve before the repository could meet licensing requirements. Periodic emergency drills graded by the Commission would ensure appropriate preparedness and that DOE would take appropriate actions if such an unlikely event occurred.

7.4 (3812)
<u>Comment</u> - EIS001325 / 0003
Another downside is that all the waste is in one single area and if something goes wrong, everything there will be ruined and the people there could be hurt.

<u>Response</u>
The EIS evaluates a full range of credible accidents from high probability/low consequence to low probability/high consequence. Credible accident scenarios (those having an annual probability of 1 chance in 10 million or higher) at a repository operations facility at Yucca Mountain are discussed in Section 4.1.8 of the EIS and summarized in Tables 4-36 and 4-37. Accidents involving transportation of the shipping casks, which would contain only solid materials, are evaluated in Section 6.2.4.

7.4 (4039)
<u>Comment</u> - EIS001513 / 0002
The risks and hazards of transport and disposal are dangerously high. The consequences of an accident are deadly. The minor consequences include cancer and sterility. The risks are also long lasting. The waste will remain radioactive and hazardous to human health and the environment for over 10,000 years. There are so many different situations involved, including transport and the transfer at Yucca Mountain into temporary or permanent storage. If Yucca Mountain is deemed unacceptable, there could also be transport out of Yucca Mountain. Many things could happen, such as highway accidents, terrorism, or earthquake. Are we prepared to deal with the effects of these events? Millions of people could be affected by these accidents.

<u>Response</u>
The EIS considers all the events mentioned in the comment [highway accidents, terrorism (sabotage), and earthquakes] and evaluates impacts from such events. Appendixes H and J evaluate repository and transportation accidents, respectively.

7.4 (4289)
<u>Comment</u> - EIS001160 / 0097
Page 4-60, Paragraph 2 of Section 4.1.8, Accident Scenario Impacts, states, "The impacts to offsite individuals from repository accidents would be small etc..." This statement appears unsubstantiated in as much as no appendices are listed where the reader can obtain the underlying data used to compute dosages and confirm or dispute the conclusions. The 0.013 rem threshold seems very small as it is significantly less that background radiation levels (background radiation levels as much as 0.15 rem, Source Book on Atomic Energy, Glasstone et al, 18.38 pp 745) and would be difficult to determine or quantify. The bounded worse case scenario for the noninvolved worker seems extremely low at 31 rem given nature of material being handled. Perhaps the drafters of the DEIS here assume safety measures for containment that are not otherwise described within the DEIS. Again this statement should reference the data used to compute it and what bounding criteria was utilized.

<u>Response</u>
Appendix H of the EIS describes the analytical methods and associated assumptions DOE used to calculate doses to offsite individuals, as indicated in Section 4.1.8.1. The maximum estimated doses listed in Tables 4-36 and 4-37 conservatively do not assume the implementation of safety measures after the accident occurred. If a real event occurred, appropriate safety and emergency response would occur. The noninvolved worker doses would be limited by the small amount of material available for release. Release fractions would be very small because large energy sources necessary to fragment and disperse significant amounts of the radioactive material would not be available.

7.4 (4292)
<u>Comment</u> - EIS001160 / 0100
Page 5-6: The sequence of events described in the first paragraph of Section 5.2 should also include volcanism and human intrusion as initiating events.

Page 5-16: The third paragraph of this page should also consider nuclear materials brought to the surface as a result of drilling.

Response
The text cited in the first comment discusses groundwater pathways as being "the primary means for the radioactive and chemically toxic materials to contact the biosphere." Sections 5.7.1 and 5.7.2 of the EIS discuss the suggested topics.

Section 5.7.1 also discusses drilling intrusions as a potential disruptive event. In the first paragraph of that section, DOE analyzed only the long-term doses associated with such an event based on a National Academy of Sciences recommendation that the long-term repository performance assessment not consider direct impacts of human intrusion. The last two sentences of the section address potential impacts to the drilling crew if activities associated with drilling through a waste package carried contaminated drilling mud to the surface. The text concludes, "The exposure to the drilling crew probably would result in lethal doses to those workers."

7.4 (4515)
Comment - EIS001410 / 0004
If all the nuclear waste reaches the site safely, the issue of long term storage remains. The government's construction plans are incomplete and unsafe. The government calls for nuclear waste disposal to begin prior to the completion of the site. However, Section 4.1.8.1 does not consider accidents that may occur during the construction phase, and cannot draw applicable conclusions because it uses conceptual models and "final facility design details are not available." The possibility of an incident due to a construction mishap must be taken into account in any complete safety analysis.

Response
As described in Section 2.1.2.2.1 of the EIS, underground construction on the development side of the repository would continue during the transfer of waste packages to the drifts on the emplacement side. The underground waste emplacement activities would be isolated from the construction activities, as described in Section H.2.1.3. The underground facility would be completed in phases. A thorough commissioning process would be employed before the newly constructed tunnels were appended to the repository. The isolation barriers would be moved to maintain the separations. Therefore, construction accidents would not affect the waste packages. Appendix F describes potential impacts to workers from construction accidents. DOE has updated Chapter 2, Chapter 4, and Appendix F to recognize the possibility of surface dry storage of waste concurrent with emplacement activities.

7.4 (5772)
Comment - EIS001887 / 0374
APPENDIX H. POTENTIAL REPOSITORY ACCIDENT SCENARIOS: ANALYTICAL METHODS AND RESULTS

In the Draft EIS, DOE analyzes the likelihood and consequences of potential air crashes at the repository. The formula used to estimate crash frequency is standard. Primary factors that must be taken into account is the crash rate for small aircraft (F-15, F-16) and the effective area of the target. The crash rate for small aircraft (page H-11) is provided by the Air Force and is standard; it is the long-term crash rate rather than the crash rate from the last 5 or 10 years.

The effective target area is greatly underestimated. It assumes a major accident would only affect the roof of the Waste Handling Building, since the walls of the Waste Handling Building are five feet thick. The analysis also assumes a jet engine will not penetrate a shipping cask. This is discussed further in Appendix H. Thus, the rail yard is not considered an area that is subject to radiological consequences. Conclusions regarding the consequences of a jet crash into a rail cask are based on assumptions about the air speed of an F-15 and the cross-section of a jet engine. The penetration depth is inversely proportional to the diameter of the penetrating object.

If the object impacting the facility is not a jet engine but a hanging bomb, this assertion by DOE can be disputed. Since Nellis is a bombing range, one must consider hanging bombs, either armed or dummy. Dummies weigh one ton, are made of concrete, and are conical-shaped. They could easily penetrate a cask at speeds of 500 fps. For example, inert bombs were used in Iraq to penetrate fortified bunkers, without "collateral damage." In addition, we do not know whether Cruise missiles are flown at Nellis. For these reasons, the entire Waste Handling Building and repository freight yard, which would have a large number of shipping casks awaiting processing, must be included in the effective target area, Aeff. This dramatically alters the likelihood of an air crash accident.

According to DOE, the effective roof area of the Waste Handling Building is 27,000 m^2, whereas the rail yard plus Waste Handling Building is 0.6 km^2. (Fig. 2-11) Just considering the footprint, the probability of an air crash increases by a factor of 22, from 5.6×10^{-8}/y to 1.2×10^{-6}/y. If one expands the effective area to include the skid zone and the height of horizontal casks on rail cars, the effective area and probability would increase further. Since the probability is greater than 10^{-6}, under DOE regulations, the rail yard must be redesigned to bring the probability down to 10^{-6}/yr.

Potential source terms

The EIS considers a "typical" Pressurized Water Reactor (PWR) assembly as one that has cooled for 25.9 years. (page H-17) The State believes this could be an underestimate. However, even if one accepts this average age of 25.9 years, it is quite likely that fuels cooled both less than and more than 25 years would be transported to the proposed repository. Therefore, the accident consequences would be greater than estimated by DOE simply because radionuclides decay exponentially. Co-60, one of the bad actors, since it is located on the outside of fuel cladding, has a half-life of 5.25 years and decays exponentially. The EIS states that the average age of shipped fuel is used for estimates of Co-60 crud. (page H-19).

Consider the following scenario. PFS, a proposed private nuclear waste storage facility in Utah, operates until the repository begins operation (supposedly the year 2010) with much of the older spent fuel in the U.S. being shipped first to PFS or being stored at reactor sites in storage casks. For reactors still operating in the year 2010, it is likely that more recent spent fuel would be shipped directly to the repository. The entire cost of loading and shipping this fresher fuel would be borne by DOE, whereas for fuel already stored in casks, costs are already sunk and the incremental cost to the utility is small. Thus, contrary to DOE's view that oldest fuel will be shipped first, it is more likely that older fuel would first be shipped to PFS and newer fuel would be shipped first to the proposed repository, followed at a later time by very old spent fuel. In the end, the average age of fuel shipped might be 25.9 years, but in terms of accident impacts, one cannot take the average age of fuel, since it is not a linear, but exponential, decay.

As an example of the inherent error in considering only the characteristics of an "average age" fuel shipment, consider a dichotomous distribution of fuel ages, with ½ of the spent fuel being shipped after cooling for five years (the minimum cooling time required by law) and the other half being shipped after cooling for forty-seven years (perhaps cooling at the PFS facility while the newer fuel is shipped to the geologic repository). The average age of the spent fuel shipments is twenty-six years. If we assume there were two curies of Co-60 initially in the spent fuel, we obtain the following estimates for activity using: (1) only the average age of the fuel shipments (26 years); and (2) five years of decay for one curie of Co-60 and forty-seven years of decay for 1 curie of Co-60.

(1): half-life = 5.25 years
decay coefficient = ln(2)/5.25 = .13203 years^{-1}
$[\text{Co-60}]_{t=26 \text{ years}} = (2 \text{ Curies})e^{-.13203 \times 26} = .065$ Curies

(2): $[\text{Co-60}] = [\text{Co-60}]_{=5 \text{ years}} + [\text{Co-60}]_{t=47 \text{ years}}$
$[\text{Co-60}]_{t=5 \text{ years}} = (1 \text{ Curie})e^{-.13203 \times 5} = .517$ Curies
$[\text{Co-60}]_{t=47 \text{ years}} (1 \text{ Curie})e^{-.13203 \times 47} = .002$ Curies
$[\text{Co-60}] = .517 + .002 = .519$ Curies

This simple calculation shows that using only the "average" fuel characteristics results in a gross underestimate of the impact of this short-lived radionuclide. Under the scenario involving PFS operation, waste characteristics will likely conform more to the dichotomous distribution used above than to a normal distribution. This leads to underestimates of the impacts of releases from these containers.

Response
The second paragraph of the comment disputes the target area assumed for the Waste Handling Building. Based on a change in design for the Waste Handling Building and refinements to the aircraft crash model, DOE has revised

the analysis of the aircraft crash into the vulnerable portions of the Waste Handling Building and determined it to be an incredible event. This result includes the assumption that both the walls and ceiling of the Waste Handling Building would be included in the impact area. The Waste Handling Building has been decreased in size based on the decision to reduce the number of transfer lines from five to three. Details of this analysis are included in Section H.2.1.3 of the EIS.

The third paragraph of the comment relates to the potential for hanging bombs, either armed or dummy, to penetrate the Waste Handling Building and transportation casks in the freight yard. DOE has determined that the dummy bombs (which are carried on only 10 percent of the flights out of Nellis) would not penetrate transportation casks at impact speeds up to 550 kilometers per hour (500 feet per second). (As mentioned previously, DOE evaluated aircraft crashes onto the Waste Handling Building and found them to not be credible). This assessment is based on the steel penetrating formula in *DOE Standard, Accident Analysis for Aircraft Crash into Hazardous Facilities* (DIRS 101810-DOE 1996). Using the dummy bomb weight and diameter [910 kilograms (2,000 pounds) and 0.49 meter (1.6 feet)], the formula calculated that the bomb would penetrate up to 0.89 meter (2.9 feet) of concrete or 7.6 centimeters (3 inches) of steel. Because the shipping cask walls would be made of steel more than or 7.6 centimeters thick, penetration would be unlikely to occur. Further, because only 10 percent of the flights carry such bombs, the event is below the credible level of 1 chance in 10 million. DOE has determined that Cruise missiles are not currently flown out of Nellis Air Force Base.

During normal operations, shipping casks that arrive at the repository would be moved either to a dry surface aging area or into the Waste Handling Building. Although surface aging was not evaluated in the Draft EIS, the potential consequences of aircraft crash into dry storage facilities were evaluated for the No-Action Alternative (Section 7.2.1.8) and for the repository retrieval scenario (Section 4.2.1.2.8). In both cases, penetration potential of above-ground storage facilities by aircraft components was determined not to be sufficient to breach the containers. The EIS has been updated to specifically address the potential consequences of an aircraft crash into surface aging facilities (see Appendix H, Section H.2.1.3). The analysis results continue to show that no breach of waste containers or release of radioactive materials would occur. Although an aircraft crash into the Waste Handling Building was found to be not credible, DOE decided to evaluate the impacts of such an event due to the potential for large impacts. The results are provided in Section H.2.1.5.1 of the EIS.

The second part of the comment deals with the characteristics of the fuel that DOE used to analyze accidents at the repository. DOE agrees that the fuel characteristics used in the Draft EIS needs to be revised to account for what is currently expected to be the shipping campaign for commercial spent nuclear fuel and also to account for the potential hazard of the fuel. DOE has reevaluated the appropriate characteristics to use for representative fuel involved in accidents and the results are given in the Final EIS, along with revised impacts associated with accidents involving the representative fuel.

7.4 (5877)
<u>Comment</u> - 010253 / 0002
Such a large concentration of waste in one place. 11,000 to 17,000 waste packages containing about 70,000 metric tons of uranium and plutonium--magnifies the risk of calamity from natural or human causes even what might be a small and manageable misfortune can become a colossal tragedy when this much radioactivity is in one place.

<u>Response</u>
Accidents during repository operations involving the handling of all the waste are examined in Appendix H. Long term performance of the repository, including the effects of natural and human-caused events on the waste package inventory, is evaluated in Chapter 5.

7.4 (6399)
<u>Comment</u> - EIS001605 / 0003
I wonder what the environmental impact statement says to the issue of safety in the depository itself. I would wonder what the environmental impact statement says on the issue of criticality. How are you going to monitor the site for criticality in the event that, and how are you going to deal with criticality if the issue arises?

Can this create an explosion? And can this create a disastrous situation of radioactive leaks into the environment?

Response

Appendix H of the EIS examines repository safety by evaluating a spectrum of credible radiological accidents and estimating their impacts. Design criteria, codes and standards, and operational controls would be incorporated to prevent criticality. A criticality could occur only if there were multiple failures of highly reliable controls. Sections H.2.1.1 and 5.8 specifically address the issue of criticality for repository operations and after repository closure, respectively. In both cases, the analysis concluded that criticality accidents would be extremely unlikely and, if they occurred, the impacts would not be significant. In Section 5.8 of the EIS, the potential for an explosive criticality was considered and found to be not credible.

7.4 (6587)

Comment - EIS001380 / 0012

On page H-28 there is a ridiculous assumption in the second paragraph that if a cask were breached, a worker would within 10 seconds "immediately vacate the area after observing that the cask had ruptured" implies cask rupture "out of the blue." While possible, it seems much more likely that cask breaching will be more likely to occur during a major accident in which it seems likely, or certainly possible, the worker will also be injured and not be able to escape to safety immediately. In this scenario, safety may be a long way away! Again, such simplistic assumptions cast doubt on the seriousness and medical competence of the people who prepared this draft document. I feel compelled to use such language because the assumptions insult my intelligence and this is very serious business indeed.

Response

Based on updated analyses (DIRS 150276-CRWMS M&O 2000; DIRS 152476-Sprung et al. 2000), the potential for the breach of a transportation cask during repository operations is not a credible scenario. The EIS has been revised to reflect this analysis and provide details for this conclusion. Therefore, DOE no longer considers this accident scenario as a credible event (a probability of greater than 1 chance in 10 million per year).

7.4 (6589)

Comment - EIS001380 / 0013

Page H-31. I challenge the statement that 3,500 drums of solid hazardous wastes and 1,700 gallons of hazardous liquid waste "would pose a very small potential for accidental releases and exposures of workers" defies common sense. These barrels in time all leak, so I would say the potential is almost 100% that some leakage will occur and therefore the risk is proportional to how many barrels degrade how quickly and what they contain. There is a lot of data on these points at Superfund and FUSRAP sites, so why not be more specific and include some meaningful data here. Because these barrels might leak into the Yucca Mountain aquifer, the public and workers and soldiers at Nellis would be at significant risk.

Response

Section H.2.1.2 of the EIS discusses how DOE would generate low-level radioactive waste during the repository construction, emplacement, operations, maintenance, and closure phases of the project. Section H.2.1.2 also discusses that during this time the Department would accumulate the waste in accordance with regulations of the Resource Conservation and Recovery Act. Hazardous wastes would be shipped off the site for treatment and disposal to appropriately permitted facilities. The actual amount of waste on the site at one time would be small and DOE would exercise appropriate controls during waste generation, accumulation, packaging, and shipment. The potential for accidents and impacts would be small.

The comparison to Superfund and Formerly Utilized Sites Remedial Action Program (FUSRAP) sites is not appropriate. Superfund and FUSRAP sites are sites where disposal or long term inappropriate storage of wastes has occurred. Low-level radioactive or chemical hazardous wastes would not be stored long term or disposed of at Yucca Mountain.

7.4 (6757)

Comment - EIS001522 / 0006

Consider several examples of this logically-invalid, question-begging character of the DOE's analysis. When the DOE says, for instance, that "Sixteen accident scenarios…bound the consequences of credible accidents at the repository" (DEIS, 1999, 4-61), this claim begs the question because it presupposes, ahead of time, what accidents are credible, and then after this presupposition, concludes that the accidents will be minor. DOE begs the whole question of the accidents that Yucca Mountain would be likely to cause because it sets up the problem in a question-begging way. It prescribes what accidents are “reasonably foreseeable” (DEIS, 1999, 6-41), despite the fact that it is impossible to predict human error, especially so far into the future, as the National Academy noted (NRC, 1995). After assessing only these question-begging accidents, the DOE then concludes that the risks are small. The “reasonably foreseeable” accidents that the DOE proposes, however, are quite different from those that the State of Nevada, where most such accidents would occur, alleges. Thus there are strong grounds for believing not only that DOE has “stacked the deck” in the material it considers, but also that its resultant conclusions are little more than begging the question.

Response
Appendix H of the EIS describes the methodology for selecting accidents for analysis and the impacts from such accidents and provides references to detailed supporting analyses. The analyses are based on well-founded methods of system safety analysis accepted by DOE and the Nuclear Regulatory Commission. The maximum credible accident would be a complete collapse of the Waste Handling Building during a severe seismic event that would be beyond the design basis of the building, with an estimated probability of 1 in 50,000 years. The analysis assumed that the collapse of the building would damage fuel assemblies in dry storage in the building. DOE included human error in the accident probabilities by accounting for such errors in the accident sequences analyzed in Appendix H.

7.4 (6930)
Comment - EIS001804 / 0003
Let me go back to my talk here. Every other storage system has been found to have major flaws. New answer follows new answer and we’re back to burying atomic waste in a deep hole in the ground such as Russia did in the Kyzytkum Ural Mountains that reached critical mass in 1958 and exploded and contaminated hundreds of square miles. Nobody brought that up. Maybe they’re not that old, but that’s what happened in Russia and this is documented.

Response
DOE has stored high-level radioactive materials, including spent nuclear fuel, at several sites in the United States for several decades without significant release of radioactive material. Commercial utilities have stored spent nuclear fuel at generating sites for several decades without a significant release of radioactive material. Section H.2.1.1 of the EIS discusses criticality potential during repository operations. Section 5.8 discusses potential postclosure criticality. In both cases, the conclusion is that criticality accidents would be extremely unlikely and, if they occurred, impacts would be minor.

There have been a number of criticality accidents in Russia since 1953 resulting in a total of seven worker deaths (no deaths to members of the public). However, none of these involved handling or burial of radioactive waste. The commenter is apparently referring to a September 29, 1957, event that was not a criticality accident but a chemical explosion involving a radioactive liquid waste storage tank. The event occurred at the Mayak Chemical Complex near Kyshtym, Russia in the Ural Mountains. This event resulted in a large release of radioactive material and extensive land contamination. The waste tank that exploded was not in a geologic repository, but was one of 16 similar tanks placed in a concrete trench with a 10-inch concrete cover. The tanks contained high-level liquid waste. In the tank that exploded, explosive nitrate salts and acetate had dried and concentrated on the surface of the waste and eventually detonated. There are no liquid radioactive wastes or explosive chemicals allowed for disposal at the proposed Yucca Mountain Repository. Therefore, events similar to this one are not possible at Yucca Mountain and this event is not relevant to the safety or environmental impact analysis of the proposed repository.

7.4 (7266)
Comment - EIS001832 / 0014
In its analysis of radiological consequences for repository operations accident scenarios, DOE again considers accidents with probabilities of 1 in 10 million, thereby increasing the calculated worker and public health effects associated with such an accident above and beyond what is credible.

If DOE believes it is required to leave analyses in the FEIS that consider 1 in 10 million events, the FEIS should, at a minimum, also describe the effects at higher, more realistic probabilities.

Response
It is true that DOE considers accidents with a frequency of 1 in 10 million or greater per year to be credible. This belief is based on a conservative interpretation of the National Environmental Policy Act, which requires consideration of "reasonably foreseeable" events. In addition, the EIS examines more probable accidents, with the highest probability being greater than once in 2 years. Appendix H discusses the impacts of all accidents, and their probability estimates.

7.4 (7561)
Comment - EIS001912 / 0066
Table 4-35 what does the information in this table mean? Are the results adverse?

Response
Table 4-36 (previously 4-35) of the EIS presents the potential range of credible accidents (annual probability of 1 chance in 10 million or greater) that could occur at a repository operations facility. This table also presents potential radiation dose and impacts from such events to the maximally exposed offsite individual, the population surrounding the repository, and to repository workers. The most severe credible accident is estimated to initiate because an earthquake beyond the facility design basis (an annual probability of 1 chance in 55,000) occurred and caused the Waste Handling Building to collapse. The impacts from this accident are evaluated in Section H.2.1.5.

7.4 (7610)
Comment - EIS002027 / 0001
I am worried about all the nuclear waste going to be stored in Yucca Mountain. The reason why I am worried is what about the possibility of a big spill of nuclear waste. I have seen records of the test done on the casks but nothing is impossible.

Response
No liquids would be shipped to Yucca Mountain for disposal, so liquid spills of waste would not be possible. It would be possible for small amounts of solid radioactive materials to be released in a serious accident.

The EIS evaluates a full range of credible accidents from high probability/low consequence to low probability/high consequence. Credible accident scenarios (those having an annual probability of 1 chance in 10 million or higher) at a repository operations facility at Yucca Mountain are discussed in Section 4.1.8 and summarized in Tables 4-36 and 4-37. Accidents involving transportation of the shipping casks, which would contain only solid materials, are evaluated in Chapter 6.

7.4 (8365)
Comment - EIS001873 / 0049
P. 4-63. DOE assumes that a seriously injured worker would not be concerned about radiation exposure. That does not make sense. DOE should show the radiation consequences to involved workers under scenarios 13-15.

Response
The accidents listed in Table 4-36 of the EIS would involve extensive physical damage, and a worker in the immediate vicinity would be likely to experience serious injury or death. The health impacts of radiation exposure for involved workers, which would include only momentary exposure from inhalation and immersion in a radioactive cloud (with no ingestion of radioactive material), would be minimal in comparison to the physical trauma.

7.4 (8587)
Comment - EIS000817 / 0187
P. H-19. I've always been interested in CRUD. It hasn't received enough study at all. As it says here "there are very few data for the accident of interest" and "the physical condition of crud can be highly variable" -- and I may add can cause lots of problems if it falls off the cladding! It could jam in the basket sleeves preventing removal of the assemblies. It could fall to the bottom of the cask. It could cloud pool water and clog water filters. It could pollute the air in unloading. It could reveal pits and cracks when it falls off or is scraped off when dry. What else?

Response
Crud deposits on fuel rods have been measured (DIRS 152476-Sprung et al. 2000) and determined to be agglomerates, rather than solid films, comprised of irregularly shaped particles with diameters ranging from (0.000001 to 0.0001 millimeter) (0.000004 to 0.0004 inch), compared to a fuel rod cladding thickness of about 0.025 inches for typical pressurized-water reactor fuel. Thus, crud particles would be very small and would be unlikely to jam in the basket sleeves preventing assembly removal. The pool water would be continuously circulated through filters, which would remove the particles. The filters would be replaced when they became loaded with particulate material. Any crud particles released during unloading would be confined to the Waste Handling Building and would be filtered out of the air by the ventilation system. Crud releases for accidents that were not confined by the Waste Handling Building are considered in dose calculations.

7.4 (8592)
Comment - EIS000817 / 0188
P. H-20 Fuel Rod Gaps -- Tritium and krypton, etc. -- when the pressure in the rod is released and gases go out, I predict more problems that we are considering now. Airborne particulates could be a real problem. You say, “No specific reference could be found to the volatile materials in the gap.” Why not? Do some tests then.

Response
The statement referred to in this comment (“no specific reference could be found to the volatile materials in the gap”) refers to information regarding the amount of respirable particles in the gap. Absent specific information on the amount of respirable particles, DOE made a conservative assumption (for the purposes of analysis) that all the particulate material in the gap would be respirable. This assumption is discussed later in Section H.2.1.4.1.2 of the EIS.

7.4 (8593)
Comment - EIS000817 / 0189
P. H-21. I’m confused, I thought 21 was the number, but on p. H-5 you said 4.

Response
Both values are correct. The value of 21 assemblies refers to the maximum number of pressurized-water reactor assemblies in a fully loaded waste package. The value of four assemblies refers to the maximum number of pressurized-water reactor assemblies that can be loaded into a transfer basket, which is used for waste package loading operations within the Waste Handling Building.

7.4 (8595)
Comment - EIS000817 / 0190
P. H-31. Be careful here -- I doubt it’s as easy at that. -- Retrieval is not just “essentially the reverse of waste package emplacement.” Think this through in detail. How will it really work? And maybe you will have to open some packages for an unexpected reason. Accidents may be very different.

Response
The concept of retrieval being the reverse of emplacement refers only to subsurface operations. Subsurface retrieval operations are expected to involve the same equipment and the same routing as emplacement. A description of potential retrieval activities, and associated impacts are described in Section 4.2 of this EIS. Surface operations would be somewhat different, as described in Section H.3. The most conservative accident would be the transporter runaway event analyzed in the Draft EIS in which a waste package failed and released airborne radioactive material.

7.4 (8834)
Comment - EIS000869 / 0011
The highest radiation risk to the public is stated as being caused by Radon-222. There has never been, in the history of mankind, so much radioactive material in one site as is proposed for Yucca Mountain. We have seen what happened at Three Mile Island in 1979, Chernobyl in 1986, and just recently in Japan with markedly lower amounts of radioactive material. The numbers quoted for an accident in S.4.1.9, paragraph two, are optimistic at best. Paragraph three sums up this issue. “In any event, because of the large quantities of radioactive material, radiological considerations would outweigh nonradiological concerns under most accident conditions.”

Response
Naturally occurring radon-222 and its decay products released in ventilation exhaust would be the main contributors to public radiological risk from routine operations at the repository, as discussed in Section 4.1.2, with results summarized in Section 4.1.7 of the EIS. Hypothetical accidents at the repository, discussed in Section 4.1.8, could result in releases of radionuclides from the spent nuclear fuel assemblies. The radionuclides that could contribute to dose (and radiological risk) from accidents include such radionuclides as cobalt-60, strontium-90, and cesium-137. Appendix H of the EIS contains additional information.

Both the Three Mile Island and the Tokaimura (Japan) accidents resulted in no health impacts to members of the public. The Chernobyl accident was a much different case, which illustrates some of the important considerations in evaluating hypothetical accidents. The quantity of radioactive material, as mentioned by the commenter, is just one of the factors that must be considered. Three other very important factors are:

- The availability of a source of energy to cause a release and transport of radioactive material
- The fraction of the radionuclide inventory released, which would depend on the physical form (that is, solid, powder, liquid, gas)
- The specific radionuclides involved in the release

At the end of the emplacement period, the proposed Yucca Mountain Repository would have a very large inventory of radioactive material. However, during spent nuclear fuel handling operations only relatively small quantities of fuel would be handled at one time, limiting the quantity that could be involved in a handling accident. Once emplaced, the radioactive material inventory would be isolated from most external energy sources (a very low probability volcanic event would be an exception) that could cause a release and there would not be a high-energy source to drive a release as there was at Chernobyl. Furthermore, nearly all of the material to be emplaced at Yucca Mountain would be in a bulk solid form, making the potential for release much smaller than such physical forms as liquid, gas, or powder. Other important factors in evaluating accidents are the types of radionuclides present (not just the quantity), atmospheric transport and dispersion, and exposure pathways (all of which would affect both the radiation dose that could be received and the potential radiological risk). For example, all of the radioactive material emplaced at the repository would have been aged at least several years, limiting the quantity of short-lived, highly radioactive nuclides that could produce significant health detriments. When all these factors are taken into consideration, the radiological risk of accidents at the Yucca Mountain Repository would be small, as presented in Section 4.1.8 and Appendix H of the EIS.

7.4 (9086)
Comment - 010151 / 0004
The blending thing blows my mind. We have a DOE facility near us called the Savannah River Site, which rivals Hanford in Washington as the most contaminated place on earth.

And this blending thing, you know, DOE is not famous for its accounting ability. And so they could screw up. They think they got a cool thing and a hot thing, but they got two hot things and you've got a criticality. It's risky.

Response
A misload event involving excessive hot fuel assemblies would not cause a criticality. Hot fuel assemblies are those that have higher heating rates due to shorter aging times. They do not contain more fissile material than colder assemblies. Further, a moderator (water) must be present to cause a criticality. No water would be present in or around the waste packages during the loading, transportation, and emplacement of the waste, and blending and storage pools containing water would be designed so that criticality would not be a credible event. Utilities with commercial nuclear powerplants licensed by the Nuclear Regulatory Commission have a history of safe storage-pool operations. Storage and blending facilities at the proposed repository also would be licensed by the Nuclear Regulatory Commission.

7.4 (9219)
Comment - 010294 / 0003
No design basis given for differential ground displacement from one of the faults going through the underground repository. Provide accident analysis for this Design Basis Accident, where a major tunnel was damaged.

Response
No active faults would intersect the emplacement drifts, so differential ground displacement from an earthquake would be unlikely. The effects of seismic disturbances, including the possibility of a new fault displacement intersecting the repository, are evaluated in *Preclosure Design Basis Events Related to Waste Packages* (DIRS 150198-CRWMS M&O 2000). The evaluation concluded that such events are not credible.

7.4 (9710)
Comment - EIS002154 / 0007
The people in Congress should realize what they're doing to this state, what they're doing to this area. If they have one nuclear accident, something leak through under those casings and explodes, Las Vegas will be wiped off the map. Boulder, Hoover Dam won't be here anymore and half of California will be in the Pacific Ocean at the San Andreas Fault. That's the possibility and the probability if you don't disperse this stuff, and don't park it at one place. It's high-level nuclear material and will devastate the whole area.

Response
If the proposed repository became operational, DOE would place the waste containers in emplacement drifts that would be separated by several hundred feet of rock. The material in the containers could not explode, even if it leaked from the containers and accumulated. DOE examined the potential for explosions from repository operations and found it to be noncredible, as indicated in the material referenced in Appendix H of the EIS. No liquids or explosive materials would be shipped to the proposed repository.

7.4 (9850)
Comment - EIS001888 / 0414
[Clark County summary of a comment it received from a member of the public.]

One commenter requested that the EIS indicate whether all lands would be cleaned up to the same standards after an accident, regardless of ownership.

Response
DOE is confident that operation of the proposed Yucca Mountain Repository and transportation of spent nuclear fuel and high-level radioactive waste to the repository could be accomplished without serious accidents or radionuclide releases that would lead to contamination of nearby land. In the unlikely event that a release of radionuclides occurred and land was contaminated, it is possible that different standards for cleanup would be applied. For example, residential and agricultural land would likely be remediated to a higher standard (lower allowable level of remaining radionuclide concentration) than unoccupied or nonagricultural land. For some types of land, remediation could be more ecologically damaging than the radionuclide contamination. In such cases, public access and use of products could be restricted. There would probably be differences between publicly and privately owned land, and issues of private compensation would arise. Any such cases would have to be carefully evaluated for cost and risk implications. The EIS indicates in Section 4.1.8 that all lands would be cleaned up at the time of the accident to existing applicable standards.

7.4 (9881)
Comment - EIS001888 / 0427
[Clark County summary of comments it has received from the public.]

Commenters expressed the need for the repository EIS to evaluate events and processes, including those having low-probabilities of occurrence, but resulting in high consequences. Others requested the analysis of credible events and processes, and worst case events and processes (regardless of probability).

Response
Appendix H of the EIS presents impact estimates from both low-probability/high-consequence events and high-probability/low-consequence events. The worst-case accident would be a beyond-design-basis seismic event that would collapse the Waste Handling Building and damage fuel assemblies in dry storage. The EIS does not examine accidents that have a probability of less than 1 in 10 million per year. Such events are not credible based on DOE guidance on the implementation of the National Environmental Policy Act, which states that EISs should examine environmental impacts that are "reasonably foreseeable". Tables 4-36 and 4-37 list the results of the EIS analysis of

reasonably foreseeable accidents. DOE anticipates no adverse health effects to the public from any reasonably foreseeable repository accident.

7.4 (10313)

Comment - EIS002099 / 0004

They can build all these casks and all these things. What about all the accidents when they start emptying those casks and they have to transport shipment after shipment after shipment 30, 40, 70,000 times they have to take some kind of machine and pull this stuff out of these casks and transport it down into these tunnels. What about if there's a mistake. What about if there's an accident? Then you have all of this waste being traveled -- transporting through all these roads. One accident could cause environmental impact that could cause generations and generations of health problems for our people.

Response

Section 4.1.8 and Appendix H of the EIS discuss the potential for occurrence and impacts of these types of accidents. Section 2.1.2 presents a description of repository operations. Material to be disposed of in the repository could be removed from shipping casks, depending on the packaging option selected. Because this material would be solid metal spent nuclear fuel and vitrified or otherwise immobilized high-level radioactive waste with very little potential for dispersible material, the potential for release and human health impacts would be very low. Even for an earthquake that could affect all fuel assemblies in dry storage in the Waste Handling Building, the potential for a latent cancer fatality in the hypothetical maximally exposed individual within 80 kilometers (50 miles) of the repository would be very low (see Section H.2.1.5).

Sections 6.2 and 6.3 and Appendix J of the EIS discuss the potential for transportation accidents. While DOE acknowledges that transportation accidents would probably occur, the probability for an accident with release of radioactive material and exposure of the public would be very low, as discussed in Chapter 6.

With regard to impacts, the risk of a latent cancer fatality is the principal risk from exposure to ionizing radiation. The potential for other types of health effects is recognized, namely nonfatal cancer and hereditary disorders. The International Commission on Radiological Protection and National Council on Radiation Protection and Measurements state that the risk factors for nonfatal cancer and hereditary disorders are 20 percent and up to 26 percent, respectively, of the fatal cancer risk. Section F.1.1.5 of the EIS discusses the potential for these other effects. Because the risk of these stochastic, nonfatal effects would be less than one-half of the fatal cancer risk, DOE has chosen to present only the estimates of fatal cancer risk.

7.4 (10399)

Comment - EIS002192 / 0005

Now in the 1,600 pages of the EIS that I commented on, I said there's one line in there that really gets to me, and the DOE says if we have a flood, we are in big trouble, one line.

Response

Section H.2.1.3 of the EIS examines flooding. This section discusses the fact that although flash floods could occur in the vicinity of the repository, earlier assessments screened out severe weather events as potential accident-initiating events. The potential for dispersion of radioactive material in the event of a flood would be very limited. Therefore, DOE did not conduct detailed evaluations of impacts from flooding. Potential site flooding is discussed in Section 3.1.4.1.2 of the EIS.

7.4 (10744)

Comment - EIS002101 / 0006

You know, we're humans. We saw it over in Japan. Human beings make errors. You have not counted that factor into your DEIS and you need to factor that in way, way more. Take the note of that because I really appreciate that you would do that and think about it. I mean, for example, right here, there's like fifty people outside couldn't get into your room. Come on. You know, maybe that's scientific calculations as far as how many square inches a human being occupied took, but it's a factor. I'm not blaming you as a person. I'm saying humans make mistakes.

Response
As indicated in Section H.2 of the EIS, the evaluation of repository accidents considered human errors. Specifically, the estimates of accident sequence probabilities include contributions from human errors in both the initiating events (for example, handling operations) and the mitigating systems (for example, failure to stop a runaway waste package transporter). The documents referenced in Appendix H contain details of these evaluations.

7.4 (10782)
Comment - 010322 / 0004
Does placing the waste packages closer together create more of a hazard, a higher combustibility, and does it create more of a terrorist target? And that I didn't see at all evaluated in the Supplement, the idea of terrorism out at the mountain, and so I'm concerned about that.

Response
Waste package spacing does not influence the potential for combustion, criticality, or an enhanced target. None of the waste packages would contain combustible material. Further, the temperature of the waste packages would be monitored and maintained below limits that would create a potential for any release. The temperature of the waste packages would be controlled by ventilation, fuel assembly blending, and spacing. Acts of sabotage would be minimized by physical and administrative barriers that would prevent human access to the emplacement drifts. Potential acts of sabotage during operation are discussed in Section H.2.1.3 of the EIS. Criticality events would be precluded by the use of neutron absorbers, where necessary, in each storage package.

7.4 (11023)
Comment - EIS001896 / 0020
Section 4.1.8 [Repository Accidents]

The DEIS identifies the radiological results of the Maximum Reasonably Foreseeable Accident [MRFA], but does NOT identify what the actual MRFA is in the body of the DEIS. A detailed description of the MRFA is necessary for any reasonable planning effort. Furthermore, a description of other accident/ incidents that are less than the MRFA, but which affect and impact the emergency response system, are necessary.

Response
Section 4.1.8 of the EIS identifies the most severe credible accident scenario as an earthquake, and lists the consequences for such an event in Table 4-36. Appendix H provides a detailed description of this event. In addition, the EIS considers a number of other accidents that could produce smaller offsite consequences than this maximum event. Table 4-36 also provides consequences for these events and Appendix H provides detailed descriptions of the events. For all accidents analyzed, no emergency response activities were assumed to occur. DOE intends, however, to develop and implement emergency response plans prior to repository operations to mitigate impacts to the workers and to the public in the event of an accident.

7.4 (11261)
Comment - EIS001337 / 0123
Lincoln County and the City of Caliente also provided information during scoping which demonstrated given average wind speeds in the vicinity of Yucca Mountain of 7.4 miles per hour (mph) and peak recorded gusts of 60 mph, it is possible that airborne radioisotopes could be transported to the proximity of Lincoln County communities within 1.5 to 8 hours.* The City and County pointed out that the short airborne emission travel time is in part why DOE has previously declared portions of Lincoln County as within the "Off-site Uncontrollable Area" (OSUA). The County and City urged DOE to assess the potential for and related impacts of off-site exposures to residents and the economy of the County. The DEIS does not consider off-site exposure of communities within Lincoln County.

*U.S. Department of Energy, Draft Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, Office of Civilian Radioactive Waste Management, December 1984.

Response
The highest potential for impacts from accidental releases would be at locations closest to the release point, under conditions of very stable meteorology, which have very low wind speeds [typically 2 meters per second (about 4 miles per hour) or less] and stable atmospheric conditions such as inversions. The high wind speeds and concurrent

very unstable meteorological conditions mentioned by the commenter would result in lower health impacts but would spread contamination over a greater area during a potential accident. Section 4.1.8 and Appendix H of the EIS indicate that the potential for impacts to the maximally exposed individual and the population within 80 kilometers (50 miles) even under unfavorable accident conditions would be very low, with no radiation-related health impacts. Impacts to occupied portions of Lincoln County and the City of Caliente [about 190 kilometers (120 miles) distant] would be much lower. Therefore, repository accident evaluations do not include these locations.

7.4 (11754)
Comment - 010320 / 0003
Although the Science and Engineering Report discloses that normal events could occur at the surface aging facility and waste handling building, there is no discussion of the types of normal events, their probability of occurrence or the potential consequences to workers, the public or the environment. The DEIS needs to identify these possibly events and their consequences.

Response
Appendix H of the Final EIS provides an identification of accidental events and their impacts that could occur during repository operations.

7.4 (11833)
Comment - 010026 / 0003
And what about fuel blending? The process of mixing fuel assemblies of different temperatures to lower a waste package temperature has never been done before. Human error could have unknown consequences.

Response
Fuel assembly blending has been done in shipments and storage of commercial fuel at commercial power plants to maintain the casks within licensing parameters that restrict cask temperature and external dose rate. Accidents involving blending operations are evaluated and impacts presented in Appendix H of the EIS. The accident sequence probabilities include accidents initiated by human error.

7.4 (12016)
Comment - 010080 / 0002
The nuclear lobby would disagree because they know that the DOE pays little attention to plans for accidents, electrical or mechanical malfunctions at Yucca Mountain.

Response
The EIS evaluates impacts from a spectrum of potential accident scenarios, from minor events to highly improbable natural phenomena such as beyond-design-basis earthquakes (1 chance in 50,000 per year). Appendixes H and I of the EIS describe the results of these evaluations for repository operations (preclosure), and long-term impacts (postclosure), respectively.

While accidents and malfunctions were not discussed in the Supplement to the Draft EIS, other project documents do discuss them. See, for example, the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001), which discusses off-normal retrieval procedures and equipment. During the preclosure period, which could last more than 300 years, the repository would be open and subject to inspection and maintenance. Should problems with corrosion of rails, switches, etc., be detected, repairs or replacements would be made.

7.4 (12203)
Comment - EIS002263 / 0001
I noticed one thing in the presentation. There was 1.4 in ten million chance of an accident. I recall it was these same people that told us – I forget, how many, one in how many thousands reactor years that there will be an accident the size of Three-Mile-Island. And when Three-Mile-Island came along, why suddenly those statistics were no longer quoted.

I have a feeling that the estimate of their chances of accident is off by an equal amount. Part of the plan of the DOE places a lot of emphasis on the strength of their canisters. Canister strength is based on the crystalline structure of metals and possibly plastics. However, over a period of time, reactivity will destroy the strength of these metallic crystals and also of plastics or whatever other materials is used to strengthen these canisters. Also, these canisters will not be monitored, as they cannot be, as the temperature in the tunnels will exceed 200 to possibly 400°. They will eventually rupture, and vast quantities of radioactivity will then fall through the fault in the mountain and into the aquifer before it is detected.

This would then immediately change the estimate of approximately two millirems at 40 kilometers, to something very substantially higher than this. Even though the aquifer flows mostly to the west from Yucca Mountain, the scenario of such a leakage could easily render Las Vegas uninhabitable within 50 to 100 years.

Downstream from Yucca Mountain is Amargosa Valley. There is a dairy there that ships 35,000 gallons of milk per day to Los Angeles market. If these canisters do leak and discharge their radioactivity into the aquifer, the water would very quickly be picked up and passed along in the milk to millions of people to Los Angeles. And I have not seen this issue addressed in the Environmental Impact Statement.

Response
The occurrence of a single event (such as the Three Mile Island accident) that has a low estimated probability of occurrence does not prove or disprove the validity of the probability estimate. The *Reactor Safety Study* (DIRS 107799-NRC 1975), which the Nuclear Regulatory Commission published in 1975, before the Three Mile Island event, estimated that the probability of a core melt accident would be about 1×10^{-4} per reactor year, or 1 chance in 10,000 per year for a U.S. reactor. At present, worldwide commercial operating experience with the population of commercial nuclear reactors similar to the type operated in the United States totals at least 5,000 reactor-years. The Three Mile Island accident represents the only partial core melt accident in 5,000 reactor-years of experience, which is a frequency of 2×10^{-4} such accidents per reactor year. Thus, the commercial nuclear reactor experience with one core melt accident is not inconsistent with an estimate of 1×10^{-4} per reactor year. The Three Mile Island experience, which resulted in no significant radioactive release, was the driver for many changes to commercial nuclear reactor designs and operations that have reduced the probability of such events even further.

The EIS results for groundwater contamination are based on a probabilistic analysis in which much of the input data is in the form of a probability distribution of a range of values, and the outcome is a distribution of possible results. In the case of canister degradation, the analysis considered such factors as gamma-ray effects on the metals, high temperatures [which would never reach 204°C (400°F) by design], and adverse chemical environments. Waste package failure would occur slowly over thousands of years. The extreme case discussed in the comment would be reflected in the results as a high percentile occurrence, such as the 95th percentile that is reported. Even the most pessimistic end of this range estimates that most waste packages would last for thousands, not hundreds, of years. Furthermore, catastrophic failure of the waste packages would not be a credible event.

The groundwater under Yucca Mountain flows to the south toward Death Valley. There is no evidence that any of that groundwater reaches any area of high population such as Las Vegas or Pahrump (see Chapter 3 of the EIS). Thus, material that could eventually be released into the mountain from the waste packages would not flow to these population areas. Furthermore, groundwater travel times are so slow that it would take thousands of years after release from a waste package for the material to move to the nearest discharge point.

DOE has incorporated milk production and shipments from the Amargosa Valley dairy and the effect on milk consumption in the analysis in Chapter 5 of the Final EIS.

7.4 (12332)
Comment - 010165 / 0005
Also the radiological impacts under accidents at the surface facility, so accidents that happened on the surface facility. It seems to be limited to the general public, as I think the figures were quoted in terms of exposure to the public. And I was wondering where the workers figure in on that one. What would be the impacts on people that are actually working there? I didn't see that in the document either. Again, that's sort of a quick review.

Response
Section 4.1.8.1 of the EIS describes worker doses from accidents in the Waste Handling Building. Appendix H describes the analysis of repository accidents.

7.4 (12568)

Comment - 010174 / 0007

Yucca Mountain is in the 3rd most active earthquake zone in the United States. We believe the effects of possible earthquakes have not been adequately studied, in relation to causing seepage in the underground repository, disrupting the inventory pools, or disrupting the 200 acre above-ground storage facility for 4500 dry casks. In fact, there have been no site suitability studies for the above-ground storage facility.

Response

Earthquake effects in relation to causing seepage in the underground repository were screened out in the Total System Performance Assessment model due to low consequences. Accidents involving the spent nuclear fuel storage modules in the surface aging facility and the Waste Handling Building (which includes the fuel blending facility) are evaluated in Section H.2 of the Final EIS. These facilities would be designed and constructed to comply with all applicable Nuclear Regulatory Commission licensing requirements which include seismic design criteria specific to the repository.

7.4 (12656)

Comment - 010381 / 0010

The EIS lacks treatment of cumulative effects from both Yucca Mountain and the Nevada Test Site. Surface water from both these projects comes into the Amargosa Valley and beyond, all the way to Death Valley. The new design requires aboveground storage of large quantities of spent nuclear fuel in pools and in casks. This surface storage is being proposed to take place over a period of decades -- these facilities themselves are obviously a risk to surface water. There is a real possibility of earthquake damage to the site. Tecopa is considered Seismic Zone 3, and Yucca Mountain is considered potentially more active than Tecopa.

Response

Repository facilities would be designed to withstand the probable maximum flood. As discussed in Section H.2.1.3 of the EIS, flash floods, while unlikely, could occur in the vicinity of the proposed repository (DIRS 100204-CRWMS M&O 1996). However, an earlier assessment (DIRS 103237-CRWMS M&O 1998) screened out severe weather events as potential accident-initiating events primarily due to flood design criteria and by assumptions that operational rules would preclude transport and emplacement operations whenever there were local forecasts of severe weather. A quantitative analysis of flood events (DIRS 104699-Jackson et al. 1984) concluded that the only radioactive material that extreme flooding could disperse to the environment would be decontamination sludge from the waste treatment complex. The doses resulting from such dispersion would be limited to workers, and would be very small (DIRS 104699-Jackson et al. 1984). A more recent study reached a similar conclusion (DIRS 101930-Ma et al. 1992).

Less severe storm flooding events would not carry contaminated water into nearby rivers because the repository design would include a storm drainage control and collection system to contain water runoff and prevent spillage over the fill slopes. A retention pond would be built to prevent stormwater pollution. Further, there are no rivers in the vicinity of the proposed repository to transport contaminated water. Casks in the aging facility would not contain significant amounts of radioactive contamination on surfaces, and casks would be monitored for leakage and repaired if leakage was detected.

Because there would be only very small quantities of surface contamination on the storage modules or casks at the fuel aging facility, stormwater runoff would not represent a substantial source of radioactive contamination. Impacts from an accident initiated by a beyond-design-basis earthquake are reported in Appendix H of the EIS.

7.4 (12842)

Comment - 010307 / 0008

Nuclear fuel blending inventory pools, which would store up to 12,000 fuel assemblies are barely mentioned and there is only one limited diagram (Figure 2-5). There is no detail on the design, water source, water circulation and treatment, or safety features. One sentence in the Wastewater section (2.3.4.2 [2.3.2.4.2]) mentions the 10% increase in evaporation pools from this source.

Response
The level of discussion in the EIS is similar to the description of the other operational characteristics of the waste handling process. DOE based the analyses in the Draft EIS, Supplement to the Draft EIS, and Final EIS on the Viability Assessment, (DIRS 101779-DOE 1998), Science and Engineering Report (DIRS 153849-DOE 2001), and Preliminary Site Suitability Evaluation (DIRS 155734-DOE 2001), which provide more detailed engineering descriptions. See those documents and the other references for more detail about blending and other aspects of the design.

7.4 (13088)
Comment - 010227 / 0006
The SDEIS also does not talk about what could happen if the area of the waste ponds flood, or are damaged by earthquakes.

Response
The repository design does not include waste ponds, but does include stormwater retention ponds and evaporation ponds. The evaporation ponds are designed for nonhazardous and nonradioactive wastewaters. In the unlikely event that an evaporation pond overflowed, the environmental consequences of such an event would be minimal. Liquid radioactive waste would be processed to solid waste and shipped off the site.

Flooding events are discussed in Section H.2.1.3 of the EIS and were screened out as potential accident-initiating events because of design criteria to accommodate the probable maximum flood and because of the assumption that operational rules would preclude transport and emplacement operations whenever there were local forecasts of severe weather. A quantitative analysis of flood events (DIRS 104699-Jackson et al. 1984) concluded that the only radioactive material that extreme flooding could disperse to the environment would be decontamination sludge from the waste treatment complex. The doses resulting from such dispersion would be limited to workers, and would be very small (DIRS 104699-Jackson et al. 1984). A more recent study reached a similar conclusion (DIRS 101930-Ma et al. 1992). The effects of a beyond-design-basis earthquake are evaluated in Appendix H.

7.4 (13104)
Comment - 010227 / 0022
There are several new elements described in the SDEIS that have never been brought into the Yucca Mountain discussion before: on-site fuel cooling, and fuel blending pools. These surface facilities, as described, would not be able to get a license under NRC part 72 [10 CFR Part 72], due to seismicity. If they cannot meet those standards, already in place, how are they expected to protect public health and safety?

Response
Accidents involving the spent nuclear fuel storage modules in the surface aging facility and the Waste Handling Building (which includes the fuel blending facility) are evaluated in Section H.2 of the Final EIS. These facilities would be designed and constructed to comply with all applicable Nuclear Regulatory Commission licensing requirements that would include seismic design criteria specific to the repository.

7.4 (13177)
Comment - 010243 / 0024
Cleanup after accidents [fuel blending facility] will likely increase worker exposures and generate additional streams of LLW, Mixed Wastes, and possibly HLW.

Response
The same types of operations assumed in the Draft EIS would be involved in the blending process. Postulated accidents involving leakage or draining of the blending pools could produce larger amounts of contaminated water. However, the contamination levels in the water would be very low and such events would be accommodated with existing waste handling processes and equipment.

7.4 (13276)

Comment - 010231 / 0010

Page 3-l1, Section 3.1.8. Accidents. All of the doses to the maximally exposed individuals exceed by 2.5 to 3.2 times the current radionuclide NESHAPs [National Emission Standards for Hazardous Air Pollutants] standards. The information to determine these results should be provided.

Response

The information and analyses used to estimate the reasonably maximally exposed individual doses are provided in Appendix H. National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61) are applicable only to routine or permitted releases. They do not apply to accidents. Since publication of the Draft EIS, the Environmental Protection Agency promulgated *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada,* at 40 CFR Part 197, which included an annual dose limit to a member of the public of 15 millirem (40 CFR 197.4). In accordance with requirements of the Energy Policy Act, the Nuclear Regulatory Commission subsequently promulgated Yucca Mountain licensing criteria, which includes a Preclosure Public Health and Environmental Standard at 10 CFR 63.204 of 15 millirem per year to a member of the public. The appropriate sections of the EIS (including those mentioned in Chapter 8) have been updated to reflect a comparison to the recently promulgated standard of 15 millirem.

7.4 (13278)

Comment - 010143 / 0002

One of the things we're taking a look at, of course everybody has commented on this tonight at one time or another, is the introduction of a surface aging facility that will increase the complexity of waste handling, increase bare fuel handling activities, increase radioactivity waste generation, and one would expect increased both worker and public risk.

Somehow these additional risks, since the risks are in total, is predicted to decrease in new design. I haven't been able to figure that one out yet. The FEIS needs to explain how this risk is decreased.

Response

Accidental assembly drops during handling and loading operations are evaluated in Appendix H of the EIS, and impacts from such accidents are discussed in Section H.2.1.5. Releases from assembly drop accidents in the pool would be mitigated by retention of the pool water, and all accidents within the confines of the Waste Handling Building would be mitigated by the ventilation system, which would control the flow of any radioactive release and would filter any airborne discharge to the atmosphere. Misloading of a waste package could occur, and such an event could result in excessive temperatures. The possibility of such event has been considered, and it is expected that disposal container loading procedures would be developed based on thermal analyses of the various waste package configurations such that sufficient margin would be available to ensure that temperature criterion would not be violated for any credible misload (DIRS 150198-CRWMS M&O 2000).

It is true that, under higher- and lower-temperature operating modes, some impacts are predicted to be higher or lower than those presented in the Draft EIS for the three thermal load scenarios. Without more information, DOE cannot respond in more detail to the commenter's question. However, DOE believes that the estimated impacts presented in the Final EIS for the higher- and lower-temperature operating modes represent a range of environmental impacts that could occur.

Some accident impacts have decreased from those reported in the Draft EIS assessment due to the smaller amount of radioactive material that would be in the Waste Handling Building, a lower probability of failure estimated for the filtration system, and other factors. Section H.2.1.1 of the EIS describes these changes.

7.4 (13321)

Comment - 010318 / 0002

Radioactive waste should not be stored temporarily prior to approval of a permanent disposal site. Should an accident or sabotage occur, concentrating all the waste together at a temporary location will increase the danger to catastrophic proportions. The western states would be covered with radioactive contamination first, and it would spread across the midwest and to the east coast. The entire United States would be devastated.

Response
DOE does not intend to store all the waste temporarily at Yucca Mountain or any other location prior to approval of the proposed repository. Accidents during repository operations involving the spent nuclear fuel surface aging facility are examined in Section H.2.1, and long-term performance of the repository, including the effects of natural and human caused events on the entire waste package inventory, is evaluated in Chapter 5.

7.4 (13369)
Comment - 010182 / 0015
The SDEIS increases the number of ventilation shafts from 5 in the DEIS to a possible maximum of 17. Also, forced air is increased from 3.5 cubic feet to 530 cubic feet. "Fans at the surface ends of the exhaust shafts would provide the moving force for the subsurface repository airflow" (Page 2-22, Para 2). The SDEIS should consider the extent to which increased ventilation results in an enhanced exposure pathway. The SDEIS fails to consider that if the surface facilities and equipment were to fail, i.e., due to seismic activity, the electric power would be terminated and the ability to cool the repository would fail.

Response
Ventilation would be active to help remove heat from the emplacement drifts during the preclosure period. In the event of a ventilation failure, a very slow buildup of heat would begin in the repository. There would be no adverse consequences from this heat. For example, DOE evaluated other repository designs without active ventilation and results showed that repository performance would be acceptable. DOE has added the forced-cooling ventilation system as a conservative defense-in-depth feature to maintain a lower drift-wall temperature (described in the Supplement to the Draft EIS). If a fan failed, it could be repaired or replaced within several weeks; this would not cause any detectable impacts.

The exhaust system would be designed to prohibit the exhaust of radioactively contaminated air. Design of the repository ventilation system would include air monitoring for radioactivity and a feature to divert exhaust through high-efficiency particulate air filtration prior to exhausting if any radioactivity was detected.

The design of the repository ventilation system is still evolving. DOE would ensure that the final design met all requirements (including development of adequate maintenance and inspection programs) and received necessary peer reviews. In addition, the Nuclear Regulatory Commission would review the design before licensing a repository.

Although a greater amount of air would be moved through the repository with the increased ventilation for some of the flexible design repository operating modes, the source of pollutants would not increase proportionally. The source of pollutants would remain approximately the same, slightly larger, between the low ventilation rate [0.1 cubic meter per second (210 cubic feet per minute)] and the higher ventilation rate [15 cubic meters per second (32,000 cubic feet per minute) per drift]. As a result, the risk would only increase a small amount.

If the surface facilities failed and forced ventilation could not be maintained, the heat-up of the repository and disposal packages would be very slow. In a recent assessment, it was determined that the peak temperature of the waste package outer surface [ranging from 369° to 454°C (696°F to 849°F), depending on the assumptions made] would not occur until 15 years after a ventilation loss that took place immediately after emplacement. Thus, there would be ample time to restore ventilation prior to any significant waste package degradation from overheating. In addition, current plans include provisions for a high-efficiency particulate filtration system that could be used to filter the ventilation flow and eliminate most of the radionuclide particulate release to the atmosphere if any radionuclide releases occurred in the underground.

7.4 (13390)
Comment - 010182 / 0030
The SDEIS should analyze alternatives if the surface facilities and support should fail.

Response
If the surface facilities failed and forced ventilation could not be maintained, the heat-up of the repository and disposal packages would be very slow. Recent assessment, (DIRS 148608, CRWMS M&O 2000) determined that the peak temperature of the waste package outer surface [ranging from 369°C to 454°C (696°F to 849°F), depending

on the assumptions made] would not occur until 15 years after a ventilation loss that took place immediately after emplacement. Thus, there would be ample time to restore ventilation prior to any significant waste package degradation from overheating. In addition, current plans include provisions for a high-efficiency particulate filtration system that could be used to filter the ventilation flow and eliminate most of the radionuclide particulate releases to the atmosphere if any radionuclide releases were to occur in the underground.

7.4.1 SABOTAGE

7.4.1 (61)
Comment - 22 comments summarized
Commenters expressed concern that a repository would represent an attractive target for sabotage. These concerns included the accumulation of all of the waste material at one location and extended to both during the active operation of the repository, monitoring, and the period after closure of the repository.

Response
The intent of the Nuclear Waste Policy Act of 1982 is to provide for the siting, construction, and operation of a deep geologic repository for spent nuclear fuel and high-level radioactive waste that would protect the public and the environment from the hazards of these materials. Over the long term (after closure), deep geologic disposal of spent nuclear fuel and high-level radioactive waste would provide optimal security by emplacing the material in a geologic formation that would provide protection from inadvertent and advertent human intrusion, including potential terrorist activities. The use of robust metal waste packages to contain the spent nuclear fuel and high-level radioactive waste more than 200 meters (660 feet) below the surface would offer significant impediments to any attempt to retrieve or otherwise disturb the emplaced materials.

In the short term (prior to closure), the proposed repository at Yucca Mountain would offer certain unique features from a safeguards perspective: a remote location, restricted access afforded by Federal land ownership and proximity to the Nevada Test Site, restricted airspace above the site, and access to a highly effective rapid-response security force. Refer to Section 4.1.8.43 of the EIS for additional information.

Excavation of emplaced materials after closure of a repository would take approximately the same level of effort it has taken DOE to excavate the current Exploratory Studies Facility. In other words, it would take years with sophisticated excavation equipment, a large workforce, and significant expenditure of funds — all unlikely to happen without being highly visible to the Government and the public. For this reason, it is unlikely that such activity would ever take place. Even if terrorists were able to penetrate to repository depth, the spent nuclear fuel and high-level radioactive waste would be in waste packages weighing between 32 and 82 metric tons (35 and 90 tons), each made of thick solid metal (stainless steel and Alloy-22). Without the ventilation systems and remotely operated emplacement equipment used for handling of the waste packages, potential terrorists probably would not survive the high temperatures and high radiation fields that would exist. Therefore, it is unlikely that terrorists could remove or cause major damage to a waste package.

DOE believes that the repository would also not be an attractive target for saboteurs during operation. Based on experience at other DOE facilities, sabotage attempts would be unlikely. In addition, impacts from such events would be unlikely to exceed impacts from the severe seismic event considered in Appendix H of the EIS, which would cause total collapse of the Waste Handling Building and the Waste Treatment Building and damage to fuel assemblies out of the storage pools. Due primarily to the remoteness of the site, DOE believes that the likelihood and consequences of sabotage events would be greater during transportation to the repository (see Section H.2.1.3). Appendix J discusses such impacts. Furthermore, DOE intends to fully comply with Nuclear Regulatory Commission regulations that require the protection of spent nuclear fuel and high-level radioactive waste from radiological sabotage.

With respect to the impact of nuclear warheads directed at the repository, it is unlikely that the detonation of such weapons at or above the surface of the repository would significantly enhance the release of radiation associated with the weapon itself. The average 300-meter (1,000-foot) rock overburden plus the very robust waste packages and ground support structures would minimize the potential for release from the waste packages following such an event.

7.4.1 (10862)

Comment - 010062 / 0001

First, I am concerned about human intervention in safe storage. Primarily, I worry about warfare between nations as a source of disruption of a 10,000-year safe storage forecast. I do not believe we can protect more than a few days at a time globally. I do believe that thousands of strategic nuclear warheads capable of penetrating and destroying Yucca Mountain's facilities currently are deployed by China, France, Israel, India, Pakistan, Russia, and the United Kingdom. My knowledge of chemical, biological, and laser weaponry is far less developed, but I would suggest scenarios for each type of weapon could be devised which might successfully breach the defenses planned for Yucca Mountain's facility.

I see Yucca Mountain as a logical target for opponents of the United States in coming years if the project gets approval and recommendation from the President. The aim of an opponent at war with the United States would be to employ an attack upon the waste storage facility to foul or contaminate large portions of the United States with radioactivity, thereby harming our population with air and water pollution.

Has anyone studied the size of nuclear warhead necessary to penetrate Yucca Mountain to repository depth? The potential for laser weapons would seem to be another source of concern for transportation packages, if eco-terrorists were in control of such a device. Please examine the threats existing weaponry could pose to the project and publicize your resulting analysis before agreeing to sign off on such a facility.

Terrorist activity by political opponents of waste emplacement at Yucca Mountain is a further concern—domestic opposition has a history of ability to mobilize thousands for protests. I would anticipate such opposition for the transportation schedule particularly in the northeast. The question is how far would opponents go to make the facility unusable? Would they:

A. Detonate explosives to foul the rail/truck vehicles or freeways/rail routes?
B. Attack a transport vehicle to prevent successful transport?
C. Seek to damage entry portal facilities?
D. Seek to detonate bomb(s) in the repository area?
E. Try to sabotage transport vehicles, routes, or the Yucca Mountain facility in other ways?

The domestic opposition has a history of more than 30 years. I used to be part of that sentiment. My conversion came as a result of reading, study, and monitoring about cask technology and performance of ISFSIs [independent spent fuel storage installations], especially at Prairie Island 1 and 2 near Red Wing, Minnesota. I would have advised broad public education as the strongest deterrent to domestic opposition.

International terrorists represent a whole different level of threat to such a waste repository. I could conceive of people within Iraq, for instance, who might try to bomb the north portal to prevent waste emplacement. If such people were to wait their attack until significant waste was at repository level and used an atomic bomb placed at repository level, would the resulting blast be capable of breaching casks and enhancing radioactive pollution of air quality in the United States?

Recently a news broadcast suggested Vladimir Putin of Russia was offering Russian facilities for nuclear waste storage generated by other nations. That puts the United States in a competition mode, conceivably, for access to waste produced elsewhere. Is this an attempt to gain materials for reprocessing to expand weapon arsenals with more reliable warheads?

Does the concentration of nuclear waste in one area commit the United States to a military defense of that facility? Has DOE covered that contingency or is that a DoD [Department of Defense] policy/providence?

Response

DOE believes that it is unlikely the detonation of nuclear weapons at or above the surface of the repository would significantly enhance the release of radiation associated with the weapon itself. The average 300-meter (1,000-foot) rock overburden plus the very robust waste packages and ground support structures would minimize the potential for release from the waste packages following such an event. Furthermore, due to the remoteness and nonstrategic nature of the facility, it is unlikely that the repository would represent a favorable target to foreign aggressors. DOE has examined sabotage events involving shipment of spent nuclear fuel and high-level radioactive waste to the repository. The impacts of this event are provided in Sections 6.2.4.2.3 of the EIS. Sabotage events at the repository would be unlikely due to access control, and would result in diminished impacts due to the remoteness of the facility (see Section H.2.1.3).

With respect to the comment regarding competition with Russia for nuclear waste storage facilities, DOE does not intend to emplace any waste other than that considered in the EIS.

DOE has not committed to a military defense of the facility, but the proposed repository at Yucca Mountain would offer certain unique features from a safeguards perspective: a remote location, restricted access afforded by Federal land ownership and proximity to the Nevada Test Site, restricted airspace above the site, and access to a highly effective rapid-response security force. During operations, security measures would deter human intervention, and the deep geologic emplacement would preclude the necessity for military defense after emplacement.

7.4.1 (13176)
Comment - 010243 / 0023
Deliberate sabotage also becomes easier and more likely with the additional step of fuel handling.

Response
Blending is the selective loading of fuel assemblies to control waste package temperatures. Blending operations would be performed within security controlled areas, so sabotage would be unlikely. Blending operations would involve basically the same handling operations that would occur without blending. Fuel assembly drops, which could occur during blending operations, are considered in the accident analyses in Appendix H of the EIS.

DOE believes that the safeguards applied to the proposed repository should involve a dynamic process of enhancement to meet threats, which could change over time. Repository planning activities would continue to identify safeguards and security measures that would further protect fixed facilities from terrorist attack and other forms of sabotage.

7.4.2 EMERGENCY RESPONSE

7.4.2 (399)
Comment - EIS000067 / 0001
Table 6-20 (Pg. 6-57) identifies impacts to workers from industrial hazards during construction and operation. In Esmeralda County and the nearby sections of Nye County along U.S. 95 there are no medical facilities. Esmeralda County needs to have assistance from DOE to be able to have the facilities in order to provide the medical help for ill or injured workers.

Response
Section 116(c) of the NWPA states that "the Secretary shall provide financial and technical assistance to [an affected unit of local government or the State of Nevada]…to mitigate the impact on such [an affected unit of local government or the State of Nevada] of the development of [a] repository and the characterization of [the Yucca Mountain] site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

Under the NWPA, the Section 116 impact assistance review process and the EIS process are distinct from one another, and the implementation of one would not depend on the implementation of the other. Thus, the provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 would be based on an evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 that documented likely economic, social, public health and safety, and environmental impacts. DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

After a decision on the proposed repository and transportation modes and routes, local jurisdictions would be better able to identify the likely economic, social, public health and safety, and environmental impacts that would be the basis for a request for economic assistance, which might include assistance in providing additional medical and emergency response facilities, under Section 116(c) of the NWPA.

Further, as required by Section 180(c) of the NWPA, DOE would provide technical assistance and funds to states for training public safety officials of appropriate units of local government and Native American tribes through whose jurisdictions the DOE would transport spent nuclear fuel and high-level radioactive waste. Training would cover procedures required for safe routine transportation of these materials, as well as procedures for dealing with emergency response situations. In addition, Sections 116(a) and 117(c)(5) of the NWPA set forth assistance guidelines covering a number of issues, including emergency preparedness and response, state liability arising from accidents, and necessary road upgrading.

7.4.2 (432)
Comment - EIS000080 / 0003
Nye County must, as a mitigation measure, be given the wherewithal to implement and comprehend a wellhead protection program in the communities of Beatty, Amargosa Valley and Pahrump where these wastes are going to be traveling through.

These same mitigation measures would carry over to our neighboring counties like Goldfield along the route and White Pine County and Lincoln County, as well.

Part of wellhead protection is providing an emergency response capability if there is an accident. No matter how much you plan, no matter how well prepared you are, things still happen.

Nye County must be in the position to be prepared for it when it happens, not react to it after it happens.

Response
The EIS evaluates the potential for repository activities to affect both water availability and water quality. The updated analysis in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure (thousands of times less than the individual protection standard set by 40 CFR Part 197). However, DOE does not believe a well head protection program would be appropriate because the possibility of a transportation accident affecting groundwater would be remote. A paper by R. M. Ostmeyer (DIRS 157052-Ostmeyer 1986) analyzed the potential importance of water pathway contamination for spent nuclear fuel transportation risk using a “worst-case” water contamination scenario. The analysis showed that the impacts of the water contamination scenario might also affect groundwater resources, but to much lower levels of contamination than surface water because of the delay associated with the infiltration of meteoric water to groundwater. Therefore, the results of the analysis indicate that water-pathway contamination would not be a significant contributor to the radiological risks of transporting spent nuclear fuel. In the unlikely event of a transportation accident that involved contamination of surface water or groundwater, DOE would cooperate with other responding agencies in implementing all appropriate remedial actions.

7.4.2 (807)
Comment - EIS000103 / 0005
There are again -- the most important thing here. There are no medical county facilities in Nye County or Nellis Air Force Base or NTS [Nevada Test Site] or the Tonopah Test Site.

There is nothing on [I] 95 or [I] 160 to handle emergencies or what have you for our soon to be 60,000 to 120,000 people in Pahrump, and therefore I’ve asked Senator Reid to call in our markers and I’ve submitted a report and asked Nevada Bell who has overcharged us patrons down here and throughout the northern Nevada 5.4 million and they’re putting into the rural community so they can make money for virtual schools, virtual libraries and virtual medicine 4.3 million.

At the last NWTRB [Nuclear Waste Technical Review Board] meeting, I asked Lake Barrett if he would put 50 million into his budget, and he said he would for next year.

I of course then attacked Carl Gertz and his M&O [Management and Operating Contractor] man working and asked him for 50 million, and so now it's quite up to Senator Reid to get us a hundred million for virtual medicine throughout Nye County, and as you know, we're the third largest in the world.

We have nothing, we will have nothing and this has never been considered, and so it's up to our brave senator not only to get this money or from private sources like Iowa did, 17 million and the whole state has virtual medicine.

Response
Section 116(c)(2) of the NWPA requires the Secretary of Energy to provide financial assistance to the State of Nevada and any affected unit of local government requesting such assistance to mitigate the impacts of the development of a repository and characterization of the site. The State and any affected unit of local government may request such assistance by preparing and submitting a report on the likely economic, social, public health and safety, and environmental impacts. After a decision was made regarding the proposed repository and transportation modes and routes, local jurisdictions would be better able to identify the likely economic, social, public health and safety, and environmental impacts that would be the basis for a request for economic assistance, which could include assistance in providing additional medical and emergency response facilities under Section 116(c) of the Act. DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

7.4.2 (1262)
Comment - EIS000228 / 0006
The description of emergency management impacts is of critical concern to Clark County. The NEPA [National Environmental Policy Act] obliges Federal agencies to examine the direct effects of their programs. The DEIS fails to accomplish this by providing a thorough description of the emergency response system necessary to respond to the Maximum Reasonably Foreseeable Accident (MRFA). Discussion of the MRFA is so sparse that emergency response professionals do not have sufficient information to define their response requirements. The DEIS should have provided a more thorough description of the communications, security, packaging, and transportation systems deployed to mitigate accidents as well as the MRFA. No description of how the DOE will implement the emergency response sections of the Nuclear Waste Policy Act (section 180c) is provided.

Response
DOE intends to fully implement the provisions of Section 180(c) of the NWPA, which requires the Secretary of Energy to provide technical assistance and funds to public safety officials of appropriate units of local government and Native American tribes through whose jurisdictions transportation of spent nuclear fuel and high-level radioactive waste would occur. However, it is not the purpose of the EIS to provide all of the information necessary to develop the procedures and training necessary for safe routine transportation of these materials and for dealing with emergency response situations.

The Final EIS identifies mostly rail as the preferred mode of transportation nationally and in Nevada, but does not identify a preferred route. If the repository was approved and further work is done on the selection of the branch rail line from among the alternatives identified, and the specific alignment of the branch rail line, additional information would become available that would allow for better identification of the maximum reasonably foreseeable accidents and the necessary emergency response procedures and capabilities to deal with such accidents.

7.4.2 (2405)
Comment - EIS000653 / 0002
One of these gaps in particular is the description of the emergency management impacts. These are of critical concern to Clark County. NEPA [National Environmental Policy Act] obliges Federal agencies to examine the direct effects of their programs on local communities. The DEIS fails to accomplish this by failing to provide a thorough description of the emergency response system necessary to respond to the maximum reasonably foreseeable acts of the MRFA [Maximum Reasonably Foreseeable Accident]. Discussion to have MRFA is so sparse that our emergency response professionals did not feel they had enough information to define their response requirements.

The DEIS should have provided a more thorough description of the communications, security, packaging and transportation systems deployed to mitigate accidents as well as the MRFA.

No description of how the DOE will implement emergency response sections of the Nuclear Waste Policy Act, Section 180c is provided.

Response
DOE intends to fully implement the provisions of Section 180(c) of the NWPA, which requires the Secretary to provide technical assistance and funds to public safety officials of appropriate units of local government and Native American tribes through whose jurisdictions transportation of spent nuclear fuel and high-level radioactive waste would occur. However, it is not the purpose of the EIS to provide all of the information necessary to develop the procedures and training necessary for safe routine transportation of these materials and for dealing with emergency response situations.

The Final EIS identifies mostly rail as the preferred mode for both national and Nevada transportation, but does not identify a preferred route. Assuming that the site was designated and DOE selected the mostly rail mode, as further work is done on the selection of the branch rail line from among the alternatives identified, and the specific alignment of the branch rail line, additional information would become available that would allow for better identification of the maximum reasonably foreseeable accidents and the necessary emergency response procedures and capabilities to deal with such accidents.

7.4.2 (6149)
Comment - EIS001654 / 0024
Page S-51. Emergency Services Adequacy Questioned

The conclusion that "a large impact on the emergency services of surrounding communities or counties would be unlikely" needs to be demonstrated. The statement suggests that the repository site will be managed largely on a self-sufficient basis. That will be necessary because of the nature of the facility and its pre-closure construction and operations (we also would expect this to be a requirement of the operating license.) From our observations, the resources in Nye County for this kind of support are meager and the resources in Las Vegas metropolitan area are mal-positioned to be of value in emergency situations at the site.

Response
This comment is correct that repository operations would be largely self-sufficient with respect to emergency services, which DOE would coordinate with emergency services at the Nevada Test Site. Because of the distances involved, Clark County would not be well positioned to provide emergency services. Further, some of the types of emergency services would not be available from Nye County (for example, mine rescue or radiological response).

Outside the National Environmental Policy Act framework, the NWPA establishes a process by which DOE can assist the State of Nevada and affected units of local government in funding emergency response capabilities. Section 116(c) of the NWPA states that "the Secretary shall provide financial and technical assistance to [an affected unit of local government or the State of Nevada]… to mitigate the impact on such [an affected unit of local government or the State of Nevada] of the development of [a] repository and the characterization of [the Yucca Mountain] site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the Act limits the potential scope of impacts that are appropriate for consideration under Section 116 to the environmental impacts considered in this EIS.

Beside the Payments-Equal-to-Taxes program already being implemented under Section 116(c)(3) of the NWPA, any decision to provide other assistance under Section 116(c) would be based on an evaluation of requests from affected units of local government or the State of Nevada pursuant to Section 116(c)(2) that document likely economic, social, public health and safety, and environmental impacts.

7.4.2 (7241)
Comment - EIS001337 / 0112
Page 6-57 Table 6-20 identifies impacts to workers from industrial hazards during construction and operation. In rural Nevada, access to emergency medical care is limited and challenging. These communities need financial assistance from DOE to be able to have the appropriate facilities and personnel to provide proper medical help for ill or injured workers and their families.

Response
DOE would initiate discussions with potentially affected units of local government and consider appropriate support and mitigation measures. Further, under the NWPA, Congress has established an impact assistance review process that is distinct from the Yucca Mountain Repository EIS process. The implementation of one process would not depend on implementation of the other. Thus, the impact findings identified in this EIS would not bar the provision of assistance under Section 116 of the NWPA. A decision to provide assistance would be based on evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 that documented likely economic, social, public health and safety, and environmental impacts.

7.4.2 (9779)
Comment - EIS001888 / 0363
[Clark County summary of comments it has received from the public.]

Although some ER [emergency response] management activities are in place, the ability to get special equipment on site quickly is not resolved. Also, the substance, timing, and magnitude of federal assistance to local government is uncertain.

Response
The ability to get special equipment on site quickly is not required at present. Even if approved by Congress, repository construction would not begin for a number of years and transportation of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain site and placement in the repository would not begin before 2010. The type of special equipment needed would depend on the selected mode of transportation. DOE would work with the appropriate government agencies to ensure adequate planning, equipment, and trained personnel for any circumstances that would call for emergency response.

Under the NWPA, DOE has various means to evaluate the merits of providing compensation to the State of Nevada and affected units of local government on behalf of their citizens. For example, under Section 116(c) of the Act, the State or affected unit of local government can request financial assistance from DOE. Such assistance "shall be designed to mitigate the impact on such State or affected unit of local government of the development of such repository and the characterization of such site." In addition, under Section 114(a)(1) of the Act, the State or affected unit of local government can prepare a report on the likely economic, social, public health and safety, and environmental impacts that could result from a repository, which DOE can consider as part of its site recommendation process. Section 180(c) of the NWPA requires the Secretary of Energy to provide technical assistance and funds to states for training public safety officials of units of local government and Native American tribes through whose jurisdictions DOE would transport spent nuclear fuel and high-level radioactive waste.

7.4.2 (9948)
Comment - EIS001888 / 0474
[Clark County summary of comments it has received from the public.]

Expansion of use of NTS [Nevada Test Site] will result in additional ER [emergency response] costs for county and local government. This should be included in EIS and paid for by DOE.

Response
Chapter 9 of the EIS describes mitigation measures that DOE could undertake to reduce the potential impacts of the repository. In addition, Section 116(c) of the NWPA states that "the Secretary shall provide financial and technical assistance to [an affected unit of local government or the State of Nevada]…to mitigate the impact on such [an affected unit of local government or the State of Nevada] of the development of [a] repository and the characterization of [the Yucca Mountain] site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

Under the NWPA, the Section 116 impact assistance review process and the EIS process are distinct from one another, and the implementation of one would not depend on the implementation of the other. Thus, the provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 would be based on an evaluation of requests for assistance from affected units of local government or the State of Nevada pursuant to Section 116 that documented likely economic, social, public health and safety, and environmental impacts. DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

Assuming the proposed repository site was designated and transportation modes and routes were determined, local jurisdictions would be better able to identify the likely economic, social, public health and safety, and environmental impacts that would be the basis for a request for economic assistance, which could include assistance in providing additional medical and emergency response facilities, under Section 116(c) of the NWPA.

7.4.2 (11982)
Comment - EIS000235 / 0008
The Final EIS should consider implementation of the Radiological Emergency Response Plan for the Grover C. Dils Medical Center as a possible mitigation measure.

Response
It is premature to commit to specific mitigation measures related to transportation until decisions regarding the proposed repository and specific modes and routes of transportation, if appropriate, have been made.

Closer to the time that transportation would occur, DOE would provide technical assistance and funds to states for training for public safety officials of appropriate units of local government and Native American tribes through whose jurisdictions transportation of spent nuclear fuel or high-level radioactive waste would occur. This assistance is required by Section 180(c) of the NWPA, and is required to cover procedures for safe routine transportation and also for dealing with emergency response situations.

In addition, Section 116(c) of the NWPA allows the Secretary of Energy to provide financial and technical assistance to the State of Nevada and any affected unit of local government requesting assistance to mitigate impacts of the development of the repository.

7.5 Repository Affected Environment and Impacts

7.5.1 LAND USE

7.5.1 (106)
Comment - 32 comments summarized
Commenters are concerned that the size of the land withdrawal area would result in too much land taken away from the public and Native Americans. Commenters felt the EIS should provide a justification for such a large area and address the impacts of removing such a large piece of public land. Issues included: basis of 12-mile distance to southern boundary, status of current land ownership, intrusion onto the town boundaries of Amargosa Valley, ability to maintain the withdrawal area after repository closure, existence of environmental management sites within the proposed withdrawal area, and impacts on current land uses.

Response
As discussed in Sections 3.1.1.3 and 4.1.1.1 of the EIS, regulations issued by the Nuclear Regulatory Commission require that land for the repository be either under the jurisdiction and control of DOE or permanently withdrawn and reserved for its use (10 CFR 63.120). Furthermore, the Nuclear Regulatory Commission regulations require the repository operations areas and postclosure controlled areas to be free and clear of encumbrances such as (1) rights arising under the general mining laws, (2) easements or right-of-ways, and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, and appropriation or prescription. Only Congress has the power to withdraw Federal lands permanently for the exclusive purpose of a specific agency and any other uses of the lands would be subject to conditions of the withdrawal. As a practical matter, DOE control of the surface and subsurface estates would reduce the potential for human actions that could adversely affect the repository's ability to isolate the waste.

findings on such impacts. Any decision to provide assistance under Section 116 would be based on an evaluation of requests for assistance from affected units of local government or the State of Nevada pursuant to Section 116 that documented likely economic, social, public health and safety, and environmental impacts. DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

Assuming the proposed repository site was designated and transportation modes and routes were determined, local jurisdictions would be better able to identify the likely economic, social, public health and safety, and environmental impacts that would be the basis for a request for economic assistance, which could include assistance in providing additional medical and emergency response facilities, under Section 116(c) of the NWPA.

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In addition, Section 116(c) of the NWPA allows the Secretary of Energy to provide financial and technical assistance to the State of Nevada and any affected unit of local government requesting assistance to mitigate impacts of the development of the repository.

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Comment - 32 comments summarized
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Response
As discussed in Sections 3.1.1.3 and 4.1.1.1 of the EIS, regulations issued by the Nuclear Regulatory Commission require that land for the repository be either under the jurisdiction and control of DOE or permanently withdrawn and reserved for its use (10 CFR 63.120). Furthermore, the Nuclear Regulatory Commission regulations require the repository operations areas and postclosure controlled areas to be free and clear of encumbrances such as (1) rights arising under the general mining laws, (2) easements or right-of-ways, and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, and appropriation or prescription. Only Congress has the power to withdraw Federal lands permanently for the exclusive purpose of a specific agency and any other uses of the lands would be subject to conditions of the withdrawal. As a practical matter, DOE control of the surface and subsurface estates would reduce the potential for human actions that could adversely affect the repository's ability to isolate the waste.

As noted by the commenters, the anticipated land withdrawal area is large compared to the size of the proposed repository. This would allow for the protection of the repository itself, its surface transportation and other handling facilities, its waste packaging, its offices, and its transport decontamination facilities.

The approximately 18-kilometer (11-mile) distance prescribed by the regulators for calculating potential doses to hypothetical recipients (the reasonably maximally exposed individual) was defined as the southern boundary of the Nevada Test Site. The potential dose receptor location was based on estimating the likely future location of a small community of persons and farms given the physical setting of the affected areas and the depth of water in that setting. The southern boundary of the controlled area is defined at 40 CFR Part 197. As mandated by the Environmental Protection Agency, DOE used a conservative controlled area (a subset of the land withdrawal area) to extend control toward the closest populated area, the Town of Amargosa Valley, thus preventing future encroachment as the basis for analysis in this EIS. The final identification of either a restricted or controlled area boundary would be defined during the licensing process conducted by the Nuclear Regulatory Commission if there was a decision to construct a repository at Yucca Mountain. DOE has revised Section 3.1.1.3 of the EIS to provide a clearer explanation of the rationale for the size of the potential land withdrawal area, including a discussion of the controlled area.

As described in Section 3.1.1.3 of the EIS, the size of the potential land withdrawal area is about 600 square kilometers (230 square miles or 150,000 acres). All but 1 square kilometer are under the control of three Federal agencies: DOE, the U.S. Department of Defense, and the U.S. Department of the Interior. The remaining 1 square kilometer (0.39 square mile or 250 acres) is private land at the southern end of the withdrawal area. There are no State or tribal lands within the withdrawal area.

About two-thirds of the withdrawal area is already withdrawn from use by the general public for DOE operations at the Nevada Test Site and for U.S. Air Force operations at the Nellis Air Force Range. The remaining one-third of the withdrawal area is public land administered by the Bureau of Land Management. As described in Section 3.1.1.3 of the EIS, DOE was issued a right-of-way reservation by the Bureau to use these public lands and Air Force lands for site characterization of Yucca Mountain. The Bureau has also withdrawn a small area at Yucca Mountain (about 4,300 acres) from the general mining and mineral leasing laws to preclude inadvertent or deliberate drilling into the repository block by prospectors.

DOE understands that the Western Shoshone people maintain that the Ruby Valley Treaty of 1863 gives them rights to certain lands in Nevada, including the Yucca Mountain region, as discussed in Section 3.1.1.4 of the EIS. DOE must nevertheless abide by decisions of the U.S. Supreme Court that have ruled that the United States has met its obligations with the Indian Claims Commission, and that the aboriginal title of the land has been extinguished.

The overlap between the withdrawal area and the unincorporated Town of Amargosa Valley referred to by commenters is public land administered by the Bureau of Land Management. The Bureau, under the principles of multiple use, manages this land; the Federal Government has not conveyed it to any municipality. Nye County Ordinance 139 created the unincorporated Town of Amargosa Valley, a taxing district of about 1,295 square kilometers (500 square miles) that overlaps the southern part of the withdrawal area by about 202 square kilometers (78 square miles). DOE has revised Section 3.1.1.3 of the EIS to recognize this overlap.

Known uses of the public land within the withdrawal area include mining from a patented mining claim, occasional mineral prospecting, and occasional recreational use (for example, an annual off-highway vehicle race). A water well in the withdrawal area supplies water to a nearby mine, and the Bureau of Land Management has designated part of this area as a utility corridor. In addition, Nye County monitors numerous wells in this area as part of the County's Early Warning Drilling Program. Some of these activities could be adversely impacted by a land withdrawal, depending on its size and any congressional land-use restrictions contained in the withdrawal legislation. Depending on the specifics of the withdrawal legislation, the patented mining claim could be adversely impacted after repository closure, but by that time the mineral resources of the claim would likely have been depleted. DOE has revised Section 4.1.1 of the EIS to describe potential impacts to activities such as restrictions on hiking, camping, off-road vehicle use, and mineral exploration and development if the land area identified in the EIS were withdrawn by Congress. There are no environmental management sites within the land withdrawal area.

If Congress withdrew the land for repository purposes, as discussed in Section 4.1.1.1 of the EIS, conditions for nonrepository land uses could be specified in the withdrawal legislation, thereby minimizing the impacts to current users.

7.5.1 (444)
Comment - EIS000090 / 0001
A lot of people aren't aware of the DOE controls Yucca Mountain and controls the test sites, but in fact the Defense Department that's taking over control of both of those facilities.

I have the paperwork. It's no big secret.

The defense programs, institutional controls, land withdrawal restrictions. The Defense Department is the landlord at the Nevada Test Site.

Response
The land withdrawal area is Federal land administered by three agencies: the U.S. Department of the Interior, Bureau of Land Management; the U.S. Air Force; and DOE. Approximately 315 square kilometers (78,000 acres; 53 percent) of the area is withdrawn for DOE by Public Land Order 2586 for the Nevada Test Site. About 100 square kilometers (24,000 acres; 16 percent) of the area is withdrawn for the Air Force by Public Law 99-606 for the Nellis Air Force Range. The remainder of the land withdrawal area is public land administered by the Bureau of Land Management under a multiple-use classification. The Bureau of Land Management issued a right-of-way reservation for the site characterization of Yucca Mountain. DOE also has a small withdrawal [about 17 square kilometers (4,300 acres), Public Land Order 6802] from the general mining and mineral leasing laws to preclude inadvertent drilling by prospectors into the repository geologic formation. DOE obtained the information used for land ownership in the EIS from Master Title Plats provided by the Bureau of Land Management. DOE is not aware of any impending change in control by the Department of Defense of the land withdrawal area associated with the Yucca Mountain Project.

7.5.1 (5470)
Comment - EIS001887 / 0152
Page 3-9; Table 3-4 - Current land ownership and public accessibility to the analyzed land withdrawal area.

Except for the one patented mining claim referenced in this table, the title of the table is incorrect and misleading. While the patented mining claim may be "owned" by a private party, none of the remaining lands given in the table are under federal ownership. All of the lands defined in the table, except for the one mining claim, are public lands. The title of the table should be changed to reflect the lands under public ownership, albeit temporarily withdrawn for federal use.

Response
DOE has revised the title of Table 3-4 in response to this comment.

7.5.1 (5857)
Comment - 010422 / 0001
Have full disclosure of: the present ownership of the properties and previous owner, if now owned by the federal government, and purchased by the government in the previous five years. Actual ownership, not just a corporate or partnership name, but those who are the actual owners and the consideration paid or proposed to be paid by the federal government for the property.

Response
It is not clear to what properties the commenter is referring. However, with regard to proposed repository properties, existing easements and information on land that could be included in the potential land withdrawal area are a matter of public record. Historic ownership, acquisition costs, etc., are not presented in the EIS because it would provide no discriminating information for decisionmakers. With regard to lands within the transportation corridors, no definitive information is available about which specific tracts of land would be impacted. Should lands require acquisition by the Federal Government, the purchase price or the exercise of eminent domain provisions would be established pursuant to Federal regulations.

7.5.1 (6067)
Comment - EIS001898 / 0010
Although flexibility exists in the amount of land that is to be withdrawn for the geologic repository operations area and the post-closure controlled area, the extent of the land withdrawal influences the type and magnitude of impacts that should be considered in the impact statement. The DEIS does not provide a clear basis for determining the extent of the proposed land withdrawal nor does it assess the full range of impacts associated with the land withdrawal (e.g., socioeconomic, water use, cultural).

Basis:

According to DEIS Section 1.4.1 (Purpose and Need for Agency Action-Yucca Mountain Site), the area needed for development of the surface repository is approximately 3.5km^2 with up to approximately another 600 km2 set aside as a buffer zone. However, the severity of impacts is dependent on the area to be withdrawn.

The FEIS should include an assessment of the potential impacts of removing a large area (e.g., 600 km2 is used as the size of the potential land withdrawal on pages 2-1 and 2-2 of the DEIS) from other possible uses. The withdrawal would preclude or limit use of the land at any time for other purposes by the public or by Native Americans. Development of water resources on this land by private individuals, businesses, industry, or the State of Nevada might also be prohibited. These impacts are not fully assessed in the DEIS.

Recommendation:

The impacts associated with the land withdrawal should be discussed systematically in the FEIS, including impacts on cultural resources and land use.

Response
The EIS identified a land withdrawal area in Section 3.1.1.3 to comply with regulations issued by the Nuclear Regulatory Commission concerning land ownership and control for a repository at Yucca Mountain (10 CFR Part 63). The safety of the repository requires DOE to demonstrate with a reasonable expectation that the long-term performance of the repository can meet the environmental radiation-protection standards established by the Environmental Protection Agency (40 CFR Part 197). Essentially all of the land identified for withdrawal (that is, about 229 out of 230 square miles) is Federal land. About 1 square kilometer at the southern end is private land. There is no State land or tribal land within the withdrawal area. If Congress withdrew the land for a repository as discussed in Section 4.1.1.1 of the EIS, it could specify conditions for other land uses as part of the withdrawal. The land withdrawal could eliminate currently existing opportunities for multiple use, including recreation, mineral exploration and mining. Because the lands within the withdrawal area do not have unique characteristics that have historically attracted the public, and because large tracts of public land occur nearby, DOE believes that the impacts to people who use this land would be negligible. DOE acknowledges in the EIS that Native Americans consider the intrusive nature of the repository to be an adverse impact to all elements of the natural and physical environment.

7.5.1 (6153)
Comment - EIS001654 / 0032
Page S-63. Unavoidable Adverse Impacts Should be Compared with the Much Greater Impacts of No Action Alternatives

We recognize this section is a requirement of NEPA [National Environmental Policy Act], but to the reader it could be misinterpreted in terms of comparative risks and consequences. For example, the first bullet on page S-63 states that the permanent withdrawal of approximately 230 square miles of land for the repository would likely prevent human use for other purposes. To someone living in urbanized areas and unfamiliar with the character of the land in question, that seems like a large quantity of land to be "lost." Yet, page 10-1 states the land "has a low resource value, is remote, and is partly withdrawn, the *resultant impact would be small*." (emphasis added.)

If a similar comparison were to be provided of consequences of similar sized 'withdrawal' from use adjacent to the 77 current storage sites over the 10,000-year period under the No Action Alternatives, the adverse impacts would be profound and unacceptable.

Response
DOE agrees that the land surrounding existing nuclear facilities would likely be less remote than the land surrounding the proposed geologic repository at the Yucca Mountain site. However, the regulations that apply to the construction and operation of a geologic repository at Yucca Mountain are different than those that apply to the operation of nuclear powerplants. Therefore, the suggested comparison would be inappropriate. In addition, because there is substantial uncertainty about the locations and identity of future landowners, and/or the nature of future land uses, in the vicinity of commercial nuclear powerplants, it would be inappropriate for DOE to speculate on these matters. However, if the decision were made to construct the repository, this could eventually free up land at the commercial sites for other uses. As noted in Section 3.1.1.3 of the EIS, the proposed repository withdrawal is located almost on Federal land (with the exception of a private patented mining claim at the southern end of the withdrawal area.). Storage facilities for spent nuclear fuel and high-level radioactive waste in the No-Action Alternative analysis would be on existing commercial nuclear reactor sites and DOE sites or on the lands that are either owned by the utility (for commercial reactors) or controlled by the Federal Government (DOE and other government sites). The land required for a storage facility at a nuclear powerplant is typically a few acres, which is a small percentage of the land available at these current sites. The operation of a typical independent spent fuel storage facility at a Nuclear Regulatory Commission-licensed installation would probably require no more land than that already disturbed at the existing facility. The analysis of the No Action Alternative in the EIS alternated the location of the storage facility between two adjacent locations on the existing sites every 100 years; therefore, no new land would be disturbed.

7.5.1 (7122)
Comment - EIS001106 / 0014
An intention of NEPA [National Environmental Policy Act] is to bring all the environmental acts together for an individual major action. Typically most federal agencies succeed in this instance, as is the case for the Yucca Mountain DEIS. Where the DEIS does fall short is in regard to joint regional land use planning with other agencies, citizens, and private stakeholders.

Response
As described in Section 3.1.1 of the EIS, the Yucca Mountain Project (YMP) is a tenant on land under the administration of three Federal agencies: the U.S. Department of the Interior, Bureau of Land Management for public land; the U.S. Air Force for the Nellis Range; and DOE for the Nevada Test Site. Use of the Nevada Test Site area by the YMP is controlled by an intra-agency Memorandum of Agreement with DOE's Nevada Operations Office that allows the use of about 230 square kilometers (89 square miles) of the Nevada Test Site (NTS) for site characterization activities. Through the Memorandum of Agreement, the YMP is accountable for conducting its activities in accordance with the same environmental requirements as the NTS. The Memorandum of Agreement gives the YMP technical responsibility independent of, but in coordination with, environmental activities of the NTS. In addition, DOE was issued right-of-way reservations by the Bureau of Land Management for access to the portions of public land and the Nellis Range for site characterization activities by the YMP (the Nellis right-of-way was recently renewed until April 2004 and the public land right-of-way was recently renewed until January 2008). These agreements also contain environmental requirements. Therefore, as a tenant, the YMP falls under agreements with the Bureau of Land Management, the Air Force, and the DOE Nevada Operations Office.

For the part of the site on the Nevada Test Site, the YMP falls under the Resource Management Plan of DOE's Nevada Operations Office. If Congress authorized a land withdrawal for the proposed repository at Yucca Mountain, DOE would re-evaluate the need for a site-specific land-use plan to ensure compliance with all applicable requirements. That plan, based on the principles of ecosystem management and sustainable development would formally synthesize the YMP policies and procedures already in place; draw on the successes of the Resource Management Plan for the Nevada Test Site; and solicit input from Federal and State agencies, stakeholders, and the general public.

7.5.1 (7348)
Comment - EIS001106 / 0024
Impact assessment under NEPA [National Environmental Policy Act] is meant to be a substantive learning process such that agencies can see how to coordinate and integrate proposed actions. The Yucca Mountain DEIS fails to accomplish this in one notably significant instance, the so-called Five-Party Interagency Agreement. The interagency agreement calls for integrated and coordinated land use planning in accordance with the tenets of

ecosystem management in the Yucca Mountain region. This is missing from the DEIS, setting the Yucca Mountain site apart from all contiguous land use plans.

Response
The five-party Cooperative Agreement coordinates and enhances management of natural resources in the Great Basin and Mojave Desert ecosystems on the Nellis Air Force Range, Desert National Wildlife Range, and the Nevada Test Site. The five agencies are DOE's Nevada Operations Office (operator of the Nevada Test Site), the U.S. Air Force (operator of the Nellis Air Force Base), the Bureau of Land Management's Las Vegas Field Office, the U.S. Fish and Wildlife Service, and the State of Nevada. If a repository was developed at Yucca Mountain, DOE would consider including the Yucca Mountain Project in the Cooperative Agreement.

At present, the Yucca Mountain DOE site is a tenant on land under the administration of three Federal agencies: the U.S. Department of the Interior, Bureau of Land Management; the U.S. Air Force for the Nellis Range; and DOE for the Nevada Test Site. These agencies are parties to the Five-Party Cooperative Agreement. The DOE Nevada Operations Office is the responsible landlord of the Nevada Test Site portion of the Yucca Mountain site. Use of that site by the Yucca Mountain Project is controlled by an intra-agency Memorandum of Agreement with the Nevada Operations Office that allows the use of about 230 square kilometers (89 square miles) of the Nevada Test Site for characterization activities. Through the Memorandum of Agreement, the Yucca Mountain Project is accountable for conducting its activities in accordance with the same environmental requirements as the Nevada Test Site. The Memorandum of Agreement gives the Yucca Mountain Project technical responsibility independent of, but in coordination with, the environmental activities of the Nevada Test Site. In addition, the Bureau of Land Management issued DOE right-of-way reservations for access to portions of public land and the Nellis Range for site characterization activities by the Yucca Mountain Project. These reservations contain environmental stipulations that conform to the understandings of the Five-Party Agreement. Therefore, as a tenant, the Yucca Mountain Project falls under the respective agreements with the Bureau of Land Management, the Air Force, and the DOE Nevada Operations Office.

DOE did not adopt an ecosystem approach for biological analysis in this EIS. An "ecosystem" approach is one method for analyzing potential impacts on biological resources. DOE discusses its evaluation of the ecosystem approach and its reasons for choosing other analytical tools in Section 3.1.5 of the EIS.

7.5.1 (9852)
Comment - EIS001888 / 0417
[Clark County summary of comments it has received from the public.]

Commenters requested that the EIS examine the effects of construction and operation of the repository and its transportation systems on federal, state, and county existing land uses (e.g., land quality, agriculture, livestock use, mineral/oil exploration, protected or otherwise sensitive lands, withdrawn areas, availability of water resources) and land use plans, policies, and controls.

Response
DOE structured the cumulative impact assessments presented in Chapter 8 of the EIS by identifying actions the effects of which could coincide in time and space with the effects from the proposed repository and associated transportation activities. Consistent with Council on Environmental Quality regulations (40 CFR 1508.7), DOE considered past, present, and reasonable foreseeable actions in its assessment of cumulative impacts and has reviewed a number of actions, both current and proposed, to determine relevance. The expression "reasonably foreseeable" refers to future actions for which there is reasonable expectation that the action could occur, such as a proposed action under analysis, a project that has already started, or a future action that has obligated funding.

The identification of the relevant actions was based on reviews of resource, policy, development, and land use plans prepared by agencies at all levels of government and from private organizations, other environmental impact statements, environmental assessments, and tribal meeting records. Pursuant to Council on Environmental Quality regulations [1502.16 (c) and 1506.2], in addition to the assessment of potential environmental impacts, potential conflicts with plans issued by various governmental entities were considered to the extent practicable and to the extent they provided relevant information. If the repository was authorized, after DOE selected a transportation mode and specific transportation corridor, more definitive information could be developed on conflicts with land uses and various agency plans and policies, and ultimately the mitigation measures that could be needed to resolve conflicts and impacts on a given area.

7.5.1 (10221)
Comment - EIS002209 / 0001
Therefore I challenge the Federal Government to provide the citizens of Nevada with legitimate proof of federal ownership of the property known as Yucca Mountain, proof that meets the test required by the contract of federalism as evidence of your rightful rulemaking powers at Yucca Mountain. I ask you to respond truthfully to the following questions: If you already own Yucca Mountain, why does the contract say you must buy it? If the state doesn't own it, how could they sell it to you?

Response
The Federal Land Policy and Management Act of 1976 (Public Law 94-579) contains the following definition: "The term 'public lands' means any land and interest in land owned by the United States within the several States and administered by the Secretary of the Interior through the Bureau of Land Management, without regard to how the United States acquired ownership, except (1) lands located on the Outer Continental Shelf; and (2) lands held for the benefit of Indians, Aleuts, and Eskimos." All of the Bureau of Land Management land analyzed in the potential land withdrawal area falls within this definition with the exception of the patented mining claim, which is now private land. DOE obtained the information used for land ownership in the EIS from Master Title Plats provided by the Bureau of Land Management. The requirements of the Federal Land Policy and Management Act would be applied to any withdrawal action.

7.5.1 (10555)
Comment - EIS002156 / 0005
In volume 1, impact analysis, chapters 1-15, at 3.1.1.3, the Department of Energy misrepresents the facts of the Nuclear Regulatory Commission licensing criteria for a repository (10 CFR Part 60). The Nuclear Regulatory Commission requires site ownership and control, not ownership, or permanent control, which is presented in the Department of Energy's DEIS 7, affected environment, page 3-7.

Response
The Nuclear Regulatory Commission licensing criteria for disposal of spent nuclear fuel and high-level radioactive wastes in the proposed geologic repository at the Yucca Mountain site are contained in 10 CFR Part 63, *Disposal of High-Level Radioactive Wastes in a Geological Repository at Yucca Mountain, Nevada*. Under 10 CFR 63.121, "Requirements for ownership and control of interests in land," the regulations state, "(a) Ownership of land. (1) Both the geologic repository operations area and the controlled area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. (2) These lands shall be held free and clear of all encumbrances, if significant, such as: (i) rights arising under the general mining laws; (ii) easements for right-of-way; and (iii) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise."

In other words, the proposed repository must be on land that is either under the jurisdiction and control of DOE or permanently withdrawn and reserved for its use by DOE.

7.5.1 (11230)
Comment - EIS000085 / 0004
The land belongs to the government. Now they asked us that when the nuclear weapons went on. For a long time, and will never come back to the state.

If they close that down tomorrow, as far as any part of nuclear, they'll never open it up back to public land. They couldn't afford to, because there are hot spots out there. There's things that people could get into.

So that land is paid and bought -- bought and paid for -- not necessarily paid for, but it's been bought.

But why not let the government use the land instead of looking for other places where we will have to take more land away from the public?

It don't matter where else you go with this thing, some other state. We're going to pay through the nose again, and we paid plenty more here. We have. So does the whole nation.

Response
Thank you for your comment.

7.5.1 (12192)
Comment - EIS001888 / 0416
[Clark County summary of comments it has received from the public.]

One commenter requested that the EIS discuss how the repository program will be consistent with DOE's Land Facility Use Management Policy on ecosystem management, sustainable development, and stakeholder participation in decisionmaking. The commenter also requested an explanation of how the Yucca Mountain Site Characterization Project (YMP) will be consistent with the Resource Management Plan being developed for the Nevada Test site (NTS) and how DOE (NTS and the YMP) will interface with the Bureau of Land Management's Mojave-Southern Great Basin Regional Advisory Council, as well as take into account the rangeland health standards and guidelines. Another commenter stated that the EIS must address any conflicts between DOE's Proposed Action and the plans, policies, and controls of Indian Tribes.

Response
At present, the Yucca Mountain Project is a tenant on land under the administration of three Federal agencies: the Department of the Interior, Bureau of Land Management; the U.S. Air Force for the Nellis Range; and DOE for the Nevada Test Site (NTS). The DOE Nevada Operations Office is the responsible landlord of the NTS portion of the Yucca Mountain site. Use of that site by the Yucca Mountain Project is controlled by an intra-agency Memorandum of Agreement with the Nevada Operations Office that allows the use of about 230 square kilometers (89 square miles) of the NTS for site characterization activities. Through the Memorandum of Agreement, the Yucca Mountain Project is accountable for conducting its activities in accordance with the same environmental requirements as those that apply to the NTS. The Memorandum of Agreement gives the Yucca Mountain Project technical responsibility independent of, but in coordination with, environmental activities of the NTS. Section 3.1.1.2 of the EIS describes the current land ownership at Yucca Mountain. DOE has modified that section to clarify that it is achieving compliance with its Land Facility Use Management Policy under the Memorandum of Agreement with the Nevada Operations Office.

In addition, as a tenant on the NTS, the Yucca Mountain Project falls under the DOE Nevada Operations Office Resource Management Plan. If Congress authorized a land withdrawal for the repository at Yucca Mountain, DOE would reevaluate the need for a site-specific land use plan to ensure compliance with all applicable requirements. That plan, based on the principles of ecosystem management and sustainable development, would formally synthesize Yucca Mountain Project policies and procedures; draw on the successes of the Nevada Test Site Resource Management Plan; and solicit input from Federal and State agencies, stakeholders, and the general public, which would include the Mojave-Southern Great Basin Regional Advisory Council through its role as an advisory group to the Bureau of Land Management.

As stated in Section 4.1.1.1 of the EIS, Congress must withdraw land for the repository to meet the permanency requirements of 10 CFR 63.121. If Congress withdrew all the land analyzed in the EIS for the withdrawal area, the approximately 600 square kilometers (150,000 acres) would come under DOE control. If Congress withdrew the land for the repository, it would specify nonrepository land uses. Other uses of the land could be adversely affected by the land withdrawal; however, the actual impacts would depend on the exact area of the withdrawal and any use restrictions imposed by Congress. DOE has revised the EIS to indicate the potential impacts if the recommended area was withdrawn.

7.5.1 (13014)
Comment - 010334 / 0011
With respect to the ground-disturbing activities, there was the mention of additional land that would be needed and that's on 3-8 and 9 talking about additional acreage that would be potentially impacted for a total of 1600 acres and some of that has to do with the solar facilities and things that are beside it.

We believe that in our opposition to the project there is also the opposition of ground-disturbing activities. So we would suggest that any activities that are proposed regardless of nature always consider what has the least disturbance to the land. As such there is under the long term -- I'm sorry -- the high heat mode I believe is what it's called. I'm trying to get the term. I'm sorry. The higher temperature repository operating mode.

In looking at those various options, there is one that -- one of the options would consider least disturbance to the ground and that's what we would be proposing.

Response
Thank you for your comment. DOE will continue to evaluate design features and operating modes that would reduce uncertainties or improve long-term performance and improve operational safety and efficiency. Design features will continue to evolve in response to additional as described in Section 4.1.1.2 of the EIS the higher-temperature operating mode would disturb less land than the lower-temperature operating mode.

7.5.1 (13361)
Comment - 010182 / 0009
Land Area -- Expanding the capability of the Waste Handling Building to use for blending hotter and cooler waste packages, and surface aging; adding flexibility to include subsurface design to enable a cooler repository, including increased ventilation; adding a solar power generating facility to reduce the need for power from off the site; revising the emplacement drift layout to include increasing spacing between emplacement drifts to allow a moisture pathway between drift, and providing access to roads, all contribute to a much larger repository design than was originally estimated (and which an associated design and controls were set to "minimize impacts to drainage channels, potential for increased erosion and impacts from flash flooding" -- SDEIS, p3-7, para 3.1.3.2). Will this be a never-ending process? The DOE has expanded the land area which will be disturbed, but, the SDEIS provides no analysis of the additional disturbed land. The DOE assumes all land in the Yucca Mountain area is the same in terms of topography.

Response
Section 3.1.3.2 of the Supplement to the Draft EIS discusses the land area that would be disturbed if either a higher-temperature operating mode or lower-temperature operating mode for the flexible design was implemented. This information was carried forward to the Final EIS. The Supplement focused on the primary impact indicators, the most important contributors or parameters used to determine the impacts in a particular environmental resource area. These primary impact indicators are identified in Table 3-1 of the Supplement and compared to those quantified in the Draft EIS. Subsequent sections of Chapter 3 discuss the primary impact indicators by environmental resource area. For example, Section 3.1.5 of the Supplement discusses potential impacts to cultural resources and acknowledges that impacts to cultural resources could occur in areas where ground-disturbing activities would take place including the construction of a surface aging facility, the solar power generating facility, and access roads and transmission cables. If important cultural resources are present in or adjacent to the areas to be disturbed by construction activities, DOE would undertake appropriate mitigative actions plan to reduce adverse effects to the resources.

7.5.2 AIR QUALITY/CLIMATE

7.5.2 (383)
Comment - EIS000048 / 0003
The surrounding areas have no protection from particulates vented from the repository.

Response
The impacts of particulate and gaseous releases from naturally occurring radon-222 at the proposed repository were analyzed in the EIS. Normal activities during construction, operation and monitoring, and closure would release small amounts of naturally occurring radon-222 (a noble gas) and its decay products from the subsurface. DOE examined the potential health impacts to members of the public from exposure to radon-222 and its decay products released from the repository. Section 4.1.2 of the EIS discusses the estimated radiation doses to maximally exposed individuals and populations from subsurface radon-222 releases. Section 4.1.7 describes short-term health and safety impacts to workers (occupational impacts) and to members of the public. DOE estimated that the maximally exposed individual would have no more than a 0.000031 (3.1 in 100,000) probability of a latent cancer fatality over

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a 70-year lifetime from construction, operation and monitoring, and closure of the repository. Over the 115 to 341-year duration of project operations, the population within 80 kilometers (50 miles) of Yucca Mountain would have an estimated 0.46 to 2.0 latent cancer fatalities.

Tables 4-36 and 4-37 summarize of the EIS the impacts of a range of potential accidents that could occur during repository operations and result in a dose to the maximally exposed individual in for different meteorological conditions. These results show that this individual would have a likelihood of 0.000019 (1.9 chances in 100,000) of incurring a latent cancer fatality.

7.5.2 (601)
Comment - EIS000127 / 0018
Rainfall. This thing says we get about four to ten inches of rain a year. That might be true. How many remember getting four inches of rain in one morning this year? And that storm swept straight north to Yucca Mountain.

Response
Section 3.1.2.2 of the EIS discusses the average precipitation at the Yucca Mountain region, which ranges from 10 to 25 centimeters (4 to 10 inches) per year. DOE believes this is an accurate representation of the long-term annual precipitation range for the region. In relation to unusually heavy rainfalls, Section 3.1.2.2 also discusses the occasional periods of monsoon thunderstorms. Such storms can produce more than 2.5 centimeters (1 inch) of rain in a matter of hours. Two storms in mid-July 1999 produced 8.4 centimeters (3.3 inches) of precipitation in the Yucca Mountain site area. The maximum 1-hour amount during that month was 3.15 centimeters (1.24 inches). However, such occasional heavy rainfalls would not cause a deviation from the long-term prediction of precipitation at the site. Global climate change is addressed in the Total System Performance Assessment in Appendix I.2.1.

Section 3.1.4.1.2 of the EIS discusses the flood potential at Yucca Mountain. DOE used the probable maximum flood values to predict the areal extent of flooding and to determine if facilities and operations would be at risk of flood damage. The results of this analysis showed that flood levels would not reach either the North or South Portal openings to the subsurface facilities. Flooding was also considered as an accident-initiating event in Section H.2.1.3.

Section 3.1.4.2.2 of the EIS discusses groundwater at the Yucca Mountain site and acknowledges the variability of infiltration rates with time and location because of the sporadic nature of storms in the region. In addition, the EIS evaluates potential changes in climate over time to provide a range of conditions that determine how much water could fall onto and infiltrate the ground surface. Section I.2.2 discusses the future climate scenarios evaluated in the EIS long-term performance assessment.

7.5.2 (796)
Comment - EIS000197 / 0003
You have a discussion of radionuclide releases of radon 222 through the ventilation system during construction. Wouldn’t you install the special filters used in power plants to filter the radioactivity out of the air? We feel that this is necessary to protect people that are downwind. In this part of Nevada where wind blows in any direction, we could be downwind from the proposed repository site.

Response
Radon-222 removal would not be practical because it is a noble gas and would pass through any filter. The estimated potential radiation doses to the public from naturally occurring radon-222 and its decay products due to repository-related operations would be very small, with the highest annual exposure estimated at 1.3 millirem per year. For comparison, the average person in the United States and the people in the Amargosa Valley near the Yucca Mountain site are exposed to approximately 200 millirem per year from naturally occurring radon-222 and its decay products (see Table 3-30 of the Final EIS). Since the publication of the Draft EIS, the Environmental Protection Agency promulgated *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (40 CFR Part 197), which included an annual dose limit to a member of the public of 15 millirem (40 CFR 197.4). In accordance with requirements of the Energy Policy Act, the Nuclear Regulatory Commission subsequently promulgated Yucca Mountain licensing criteria, which includes a Preclosure Public Health and Environmental Standard at 10 CFR 63.204 of 15 millirem per year to a member of the public. The appropriate sections of the EIS (including those mentioned in Chapter 8) have been updated to reflect a comparison to the

recently promulgated standard of 15 millirem. Because the potential dose from radon-222 emissions during repository operations would be so low and below relevant standards, installing additional equipment or processes to further reduce radon-222 gaseous emissions would not be warranted.

The special filters used for nuclear powerplants are for very limited, short-term applications or are effective only for specific radionuclides. They would not be effective for repository applications. For example, high-efficiency particulate air filters are effective in clean-air applications, but not where significant dust loading on the filter could occur, as it could at the proposed repository. In addition, filtering is not an effective method for reducing atmospheric releases of the naturally occurring radon-222 and its decay products because radon-222 is a gas and not a solid particle.

7.5.2 (971)
Comment - EIS000023 / 0003
Our region [southern California] may further be affected if the Yucca Mountain facility fails in its mission to secure highly toxic waste for 10,000 years. Santa Ana winds regularly drive Great Basin air into our region.

Response
The consequences of air release are inversely related to the distance from the release point; that is, for a given release, the consequences are less the farther one is from the release point. Section 4.1.7.5.3 of the EIS discusses the maximum impacts from a release during construction, operation and monitoring and closure phases of the proposed repository. Table 4-35 indicates that the dose to the maximally exposed individual would be less than 62 millirem over the 70-year lifetime of exposure, with a corresponding probability of latent cancer fatality being less than 0.000031. The highest annual dose to a member of the public from repository operations would be about 1.5 millirem or less. This dose is less than the applicable standards. Because southern California is approximately 100 kilometers (60 miles) south of Yucca Mountain, atmospheric dispersion would result in an even smaller radiation dose to that area.

Sections 5.5 and I.7 of the EIS discuss the potential consequences from release of radionuclides from the repository into the atmosphere following closure. There is limited potential for release to air because the waste would be isolated far below the Earth's surface. The EIS determined that radon-222 is the substance with the greatest potential impact from a release to air during the postclosure period. An estimated maximum annual release rate of about one-tenth of a microcurie would occur during about 19,000 years after repository closure. The estimated human health impacts to the population within 80 kilometers (50 miles) of the repository would be negligible, with no latent cancer fatalities expected. The reasonably maximally exposed individual would have very small risk of latent cancer fatality over a 70-year lifetime, about 0.00000000001. Potential impacts to individuals in southern California-would be even smaller than those for the region around Yucca Mountain because of their distance from the Yucca Mountain site.

7.5.2 (1374)
Comment - EIS000432 / 0002
The Hanford site caused many problems and I think the potential hazards would be even greater in storing the entire countries radioactive waste. Not just these farmers or residents are in potentially hazardous area, the animals and environment as well is at risk. It took a Federal courts appeal to change the air quality standards set by the new U.S. Environment Protection Agency National Ambient Air Quality Standard for the DOE to be able to operate its proposed site.

Response
The EIS analyzes the hazards of radionuclide releases from the Yucca Mountain site. Chapter 4 analyzes the impacts of repository operations and Chapter 5 analyzes the impacts of repository long-term performance. The potential doses to reasonably maximally exposed individuals would be small (see Sections 4.1.2, 4.1.7, and 5.4). At these levels the repository would meet all Federal regulations, and would be unlikely to result in any adverse health consequences.

The proposed repository would operate under and comply with stringent Federal regulations that are specific to the Yucca Mountain site, and under National and State of Nevada environmental protection requirements that could apply to a repository at Yucca Mountain. Chapter 11 of the EIS describes the statutory and other applicable requirements that could apply to the Proposed Action. Section 11.2.7 discusses these environmental protection requirements, which include those applicable to animals. The type and quantity of radionuclides released to the environment as a result of the Yucca Mountain Repository and the regulatory requirements would be substantially different from those that applied at the Hanford Site.

7.5.2 (2007)
Comment - EIS000535 / 0001
I am vehemently opposed to being downwind of a radioactive dump site--not another one! When the Santa Ana winds blow out of the east, over the San Bernardino County area in Southern California, that puts me and many others downwind of wind-carried radiation from such dumps.

Response
The proposed Yucca Mountain Repository would be a highly engineered, state-of-the-art deep geologic disposal facility, designed specifically for safe, long-term disposal of spent nuclear fuel and high-level radioactive waste.

The consequences of air releases are inversely related to the distance from the release point; that is, for a given release, the consequences are less the farther the location from the release point. Section 4.1.2 of the EIS discusses releases of radionuclides during operations. The dose to the maximally exposed individual, someone living continuously at the southern boundary of the Land Withdrawal Area would be 1.3 millirem or less during the year of highest exposure. This dose would be mainly from naturally occurring radon-222 and its decay products. For comparison, Table 3-30 lists annual doses from natural background radiation to a resident of Amargosa Valley and at other locations, which are in the range of 300 millirem per year (200 of which is from radon).

Because the nearest point in San Bernardino County is about 120 kilometers (75 miles) south of Yucca Mountain, the potential radiation dose there would be even smaller than the 1.8 millirem calculated for the maximally exposed individual because of atmospheric dispersion over the additional distance. The concentration of radionuclides from potential releases at the Yucca Mountain site would be undetectable.

7.5.2 (3313)
Comment - EIS001085 / 0003
Radon monitoring data in the ESF [Exploratory Studies Facility] under current operating condition was used to estimate the amount of radon release from the site and the potential inhalation dose to workers. Since radon release from rock surfaces depends on various environmental and operational conditions of the MGR [monitored geologic repository] and since MGR operation would be different from the current ESF conditions, these release estimates should be reassessed in the FEIS. The effect of ventilation induced radon release due to pressure differences, the effect of heating of the rocks by waste packages, and other physical and environmental factors on radon release should be re-evaluated and included in the final assessment. All these factors could substantially increase the radon releases as well as the worker inhalation doses.

Response
The analysis of potential doses from exposure to radon and its decay products in the Final EIS used updated radon monitoring data from the Exploratory Studies Facility, updated design parameters and operational conditions as appropriate, and updated calculations. The analysis considered the effects of changes in ventilation rate, barometric pressure, and temperature. An updated Yucca Mountain report uses this information to model radon emanation and radon release from the repository under operating conditions of the flexible design operating modes. Section G.2.3 discusses this new information.

7.5.2 (5471)
Comment - EIS001887 / 0153
Page 3-12; Section 3.1.2.1 -- Air Quality

Were data collected since 1995 on air quality? If so, why wasn't it presented here? If not, why not?

Response
The gaseous criteria pollutant monitoring program ran from October 1991 through September 1995. It was discontinued because the baseline near-zero values of most pollutants were well established during the 4-year

program. Since then, only minor additional sources of gaseous pollutants have been added at Yucca Mountain. The analyses in Sections 4.1.2 and G.1 of the EIS confirm there would be minor releases of gaseous criteria pollutants -- concentrations at the location of the maximally exposed individual would be less than 1 percent or less of applicable National Ambient Air Quality Standards in every case. The particulate matter (as PM_{10}) monitoring program began in 1989, and continues to operate. The results of both the PM_{10} (through 1997) and the gaseous monitoring programs were presented in the *Environmental Baseline File for Meteorology and Air Quality* (DIRS 102877-CRWMS M&O 1999). The results of post-1995 air-quality monitoring required for compliance with the Air Quality Operating Permit (issued to DOE by the State of Nevada for site characterization) are discussed in the annual Site Environmental Reports from 1991 through 2000. These reports are available for review in DOE reading rooms or at the following Internet site: *http://www.ymp.gov* (search "Site Environmental Report").

7.5.2 (5589)
Comment - EIS001887 / 0214
Page 4-6; Section 4.1.2 - Impacts to Air Quality

This section uses the boundary of the proposed land withdrawal area as the basis for calculation of impacts to the maximally exposed member of the public. The proposed land withdrawal area is extraordinarily large compared to the repository operations area. This provides a large dilution factor for air quality analyses. The impact calculations in this section should be provided for the boundary of the operations area, rather than a distance of nearly 20 km from the operations area. This comment applies to all relevant analyses provided in Section 4. It also applies to Section 4.1.8.1, Radiological Accidents, where the maximally exposed offsite individual is placed 11 km west of the repository surface facility. In all cases, the maximally exposed offsite individual should have the characteristics of a subsistence farmer.

Response
DOE would exercise active control over portions of the land withdrawal area to prevent uncontrolled access by members of the public during the construction, operation and monitoring, and closure phases and any additional period of administrative control. Therefore, the Department used this boundary to calculate impacts to the reasonably maximally exposed individual. DOE would have to show that potential operational and accidental releases would be within Environmental Protection Agency regulatory limits. During the operation and monitoring phase of the Proposed Action, the most important release pathway would be the air pathway and the most important pathways for human exposure to airborne releases would be direct external radiation and ingestion of food and soil (40 CFR Part 197). The analysis considered all exposure pathways, including inhalation, ingestion, and direct external radiation from radionuclides in the air and on the ground. Based on published screening dose factors, direct external radiation from radionuclides deposited on the ground would account for about 40 percent of the dose; ingestion of decay products in foodstuffs and inadvertently consumed soil would account for 60 percent of the dose. Inhalation and external irradiation from radionuclides in the air would be minor exposure pathways.

7.5.2 (5593)
Comment - EIS001887 / 0218
Page 4-10; Section 4.1.2.2.2 - Radiological Impacts to Air Quality from Construction

The Draft EIS should be consistent in its use of millirem and person-rem. The definition of person-rem should be given here, not later in the Section.

This section has inconsistencies in reporting dose. This section reports the dose for the maximum exposed individual offsite for a five-year period and the dose of a maximally exposed non-involved worker as an annual dose. This appears to have been done to keep the numbers for the worker low.

Response
DOE believes it has used the terms "millirem" and "person-rem" consistently throughout this section and the EIS. Individual doses are calculated in millirem and population doses are calculated in person-rem. Section 3.1.8.1 of the EIS explains this concept.

Section 4.1.2 of the EIS presents both annual and total doses for repository operating mode and project phases. It reports these results for the maximally exposed member of the public and noninvolved worker, general population within 80 kilometers (50 miles) and noninvolved worker population, and the Nevada Test Site noninvolved worker population.

Chapter 14 of the EIS contains definitions of these of both terms.

7.5.2 (5594)
Comment - EIS001887 / 0219
Page 4-11; Section 4.1.2.3.1 - Nonradiological Impacts to Air Quality from Continuing Construction, and Operation and Monitoring

What analysis supports the value of 10 micrograms per cubic meter used as the concentration for cristobalite?

Response
There is no public exposure limit for cristobalite. Sections G.1 and F.1 of the EIS describe the basis for selecting the 10-microgram-per-cubic-meter value for comparing exposure concentrations. An Environmental Protection Agency health assessment (EPA 1992) states that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 (micrograms per cubic meter) × years. Assuming a 70-year lifetime, the EIS analysis established an approximate annual average concentration of 10 micrograms per cubic meter as a benchmark for comparison. Footnote “d” to Tables 4-1, 4-3, and 4-6 summarizes the estimated maximum criteria pollutant and cristobalite concentrations at the analyzed land withdrawal area boundary during different phases of repository construction, operation and monitoring, and closure.

7.5.2 (5595)
Comment - EIS001887 / 0220
Page 4-13; Section 4.1.2.3.2 - Radiological Impacts to Air Quality from Continuing Construction, and Operation and Monitoring

Define and quantify “very small” releases of other noble gases.
Were any analyses performed for accident scenarios for this section?

Response
As noted in Section 4.1.2.3.2 of the EIS, the main noble gas radionuclide release to the atmosphere from the handling of spent nuclear fuel assemblies would be krypton-85. Approximately 2,600 curies would be released annually. Estimated annual releases of other noble gas radionuclides would be about 1.0×10^{-6} curie of krypton-81, 3.3×10^{-5} curie of radon-219, 5.9×10^{-2} curie of radon-220, 4.6×10^{-6} curie of radon-222, and very small quantities of xenon-127.” The amount of xenon-127 would be smaller than the smallest quantified radionuclide release (4.6 microcuries per year of radon-222).

Appendix H of the EIS describes potential repository accident scenarios, which include scenarios during the construction and operation and monitoring phases, such as accidents at the Waste Handling Building and mishaps that could occur during handling of the transportation casks at the repository.

7.5.2 (6504)
Comment - EIS001632 / 0038
Page 4-30, Section 4.1.4.2: This section states that “routine releases of radioactive materials from the repository would consist of radioactive noble gases, principally isotopes of krypton and radon.” Does DOE have any examples of where these types of releases are currently occurring? If so, are they monitored and have there been any impacts to biologic communities?

Response
Section G.2.3.2 of the EIS discusses releases of noble gases from spent nuclear fuel in repository surface facilities in more detail. Releases of noble gas radionuclides could occur at any commercial nuclear reactor sites that handle spent nuclear fuel. Such releases are documented in annual and semiannual environmental reports and published in a Nuclear Regulatory Commission summary, *Radioactive Materials Released from Nuclear Power Plants* (DIRS 155108-Tichler, Doty, and Lucadamo 1995).

Krypton and other noble gases do not accumulate in environmental or biological media and, therefore, present little hazard to humans or the environment. Radon is somewhat different because of its decay products, but so little radon is released from spent nuclear fuel that it is almost immediately indistinguishable from naturally occurring radon in the environment. As stated in Section 4.1.4.2 of the EIS, estimated doses to plants and animals would be small and impacts from those doses would be unlikely to affect the population of any species because the doses would be much lower than 100-millirad-per-day. The International Atomic Energy Agency has stated that there is no convincing evidence that chronic exposures of 100 milliard per day will harm plant or animal populations. Neither of these noble gases is typically monitored in biologic communities because the potential for impact is so small.

7.5.2 (6663)

Comment - EIS001878 / 0041

Impacts on air quality not adequately addressed. Because the analysis of air quality impacts focuses only on pollutant concentrations at the boundary of the land withdrawal area, the DEIS does not adequately address possible air pollution impacts on Clark County and other areas (pp. 4-6, -7, -102). The DEIS must disclose whether the bulk emissions documented in Appendix G would aggravate existing air quality problems in Clark County and elsewhere. According to newspaper reports in January 2000, Clark County may soon face federal sanctions regarding funding of new transportation projects as a result of continuing problems attaining state and federal air quality standards.

The DEIS must also disclose the predicted downwind concentrations of radiological and nonradiological air pollutants, and the maximum distance at which measurable concentrations could be detected. Eureka County needs to know whether airborne emissions from the repository could be carried to Eureka County and neighboring counties, as they were during nuclear weapons testing in the 1950s and 1960s.

Response

Chapter 6 of the EIS discusses the impacts of the various transportation alternatives. Sections 6.3.2 and 6.3.3 discuss the rail and heavy-haul truck alternatives respectively, including those that would affect Clark County. The EIS notes that the Las Vegas basin airshed is in nonattainment for particulate matter (PM_{10}) and carbon monoxide. The EIS estimates potential air quality impacts from repository construction and operation if a decision was made to implement both rail and heavy-haul truck transportation scenarios.

The EIS presents information on predicted downwind concentrations of nonradiological air constituents and of the dose impact of downwind concentrations of radiological releases. Analyses were at the land withdrawal boundary, because these are the points where the impacts to the public could be the highest.

The predicted concentrations of nonradiological constituents are presented in Section 4.1.2 of the EIS and summarized in Tables 4-1, 4-3, and 4-6. These tables list the maximum concentrations of the criteria pollutants or cristobalite at the accessible land withdrawal boundary regardless of the direction. The projected concentrations would be small fractions of the regulatory limits established to ensure public safety (also listed in the tables). Because Clark and Eureka Counties are farther away, potential impacts from repository activities in these areas would be even smaller. Appendix G describes the methods DOE used to analyze potential impacts to air quality at the proposed Yucca Mountain Repository from releases of nonradiological air pollutants during the construction, operation and monitoring, and closure phases. The bulk emissions in Appendix G were used to calculate the concentrations presented in Chapter 4.

The analysis did not present radiological air pollutant concentrations because they are an intermediate step in the calculation of radiation dose; regulations for exposure to ionizing radiation are presented in units of radiation dose. The radiological doses to the public are summarized in Tables 4-2, 4-4, 4-5, and 4-7. The maximum distance at which radionuclides released from Yucca Mountain could be detected would be highly variable, depending on meteorological conditions. However, it would be very unlikely that radionuclides released from repository operations could be detected or distinguished from natural background outside the 80-kilometer (50-mile) area included in population calculations (all of Eureka County is beyond 80 kilometers).

It is difficult to compare potential releases from the proposed repository at the Yucca Mountain site meaningfully to those that from the above-ground testing conducted during the 1950s and 1960s because of the extreme differences in the quantity and method of radionuclide release. Potential releases for the Yucca Mountain site would be a very small fraction of those from above-ground testing.

7.5.2 (7210)
Comment - EIS001337 / 0089
Page 3-10 Section 3.2. 1. The text should make clear why an 80 km radius was selected around the Yucca Mountain site for air quality impact analysis. Given wind patterns is a consistent radius appropriate for determining potential impacts.

Page 3-12 Section 3.1.2.2. The choice of 60 meters as a maximum for wind measurements (see Figure 3-3) may not be appropriate to determine potential for dispersion under conditions of volcanism. If wind velocities at greater heights were used for atmospheric dispersion modeling, such differing heights should be identified here. This section would also benefit from a table showing dispersion times from the site to community areas offsite (in all directions). The table should indicate how long dispersion from the site would take to reach communities located in all counties surrounding Yucca Mountain.

Response
Eighty kilometers (50 miles) is the long-established precedent for calculating the potential population (collective) dose around a nuclear facility (dating back to 1975). The National Council on Radiation Protection and Measurements Report *Principles and Application of Collective Dose in Radiation Protection* (DIRS 101858-NCRP 1995) contains a brief history of the development of the 80-kilometer application (DIRS 101858-NCRP 1995).

Section 3.1.2.2 of the EIS provides background information on the meteorology of the potentially affected environment around Yucca Mountain. Figure 3-3 shows wind direction and wind speed based on past measurements that can be used in analyzing ground level or stack releases. Appendix G discusses meteorological data and atmospheric dispersion factors. Different meteorological information might be needed to adequately evaluate the potential impacts of volcanic events, depending on the type of event assumed to occur. Disruptive events, including potential volcanic disturbances, are discussed in Section 5.7.2. The ash dispersal model used information on eruption characteristics, wind direction, and velocity, and ash and waste characteristics. The potential impacts of such events or accidents are typically evaluated at the location of the most highly exposed individual and in the direction that would result in the highest exposure to the population. Because volcanic events have extremely low probabilities (estimated at less than 1 in 100 million per year), their associated risk is also very low.

7.5.2 (7227)
Comment - EIS001337 / 0105
Page 4-9 Radiological Impacts to Air Quality from Construction - The DEIS discusses the potential of radionuclide releases of radon-222 through the ventilation system. To provide protection to the people that are down wind from the site, DOE should install adequate filters to remove the radioactive particles from any exhaust release.

Response
Radon-222 removal would not be practical because it is a noble gas and would pass through any filter. The estimated potential radiation doses to the public from naturally occurring radon-222 and its decay products due to repository-related operations would be very small, with the highest annual exposure estimated at 1.3 millirem per year. For comparison, the average person in the United States and people in the Amargosa Valley near the Yucca Mountain site are exposed to approximately 200 millirem per year from naturally occurring radon-222 and its decay products (see Table 3-30 of the EIS). Since publication of the Draft EIS, the Environmental Protection Agency promulgated *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada,* at 40 CFR Part 197, which included an annual dose limit to a member of the public of 15 millirem (40 CFR 197.4). In accordance with requirements of the Energy Policy Act, the Nuclear Regulatory Commission subsequently promulgated Yucca Mountain licensing criteria, which includes a Preclosure Public Health and Environmental Standard at 10 CFR 63.204 of 15 millirem per year to a member of the public. The appropriate sections of the EIS (including those mentioned in Chapter 8) have been updated to reflect a comparison to the recently promulgated standard of 15 millirem. Because the potential dose from radon-222 emissions during repository operations would be so low and below relevant standards, it would neither be practical nor cost-effective to install additional equipment or processes to further reduce such emissions.

7.5.2 (7373)
Comment - EIS001957 / 0013
Section 3.1.2.2, Climate -- This section states that annual precipitation in the area ranges from approximately 4-10 inches. However, no analysis is accorded to potential changes in climate over the next 100-1,000-10,000 years. It is important to note that in the last 10,000 years, there have been substantial, documented changes in climate in this region, including periods of much wetter climate than at present. This significant factor must be assessed in the final EIS (likewise in Section 5, Environmental Consequences of Long-Term Repository Performance).

Response
DOE has revised Section 3.1.2.2 of the EIS to include a discussion of paleoclimatology. The primary assumption associated with paleoclimatology efforts is that climate is cyclical so past climates provide insight into future climates. The analysis group climate regimes believed to have existed in Yucca mountain's past, that, therefore, should occur in its future into four different categories: a warm and dry, modern-like interglacial climate; a warm and wet monsoon climate; an intermediate glacial transition climate; and glacial periods. Characteristics of these climate regimes and postulated future durations are included as input parameters to the long-term performance assessment modeling performed for the site. Section I.2.1 of the Final EIS describes the process considered in the Assessment, including future climate projections. The Total System Performance Assessment addressed global climate change using a climate model based on paleoclimatology information; that is, the record of climate changes in the past was used to predict the expected changes in climate for the future.

7.5.2 (7644)
Comment - EIS001928 / 0008
pg. S-35-6th para., last sentence -- "Releases would vary from 90 to 2,600 curies annually depending on the packaging scenario." That is quite a range. Please explain how those values were determined and which packaging scenario will release the most activity.

Response
The final dose rate would vary depending on the final waste form; that is, whether the spent nuclear fuel is received as a bare intact assembly, in sealed canisters that require being opened and repackaged, or whether the fuel is shipped in disposable canisters. Section A.1.1.3 of the EIS describes the final waste forms that could be received at the proposed repository. Section G.2.3.2 of the EIS discusses the unloading and handling of the fuel at the proposed repository. Uncanistered fuel and fuel in dual-purpose canisters would result in the highest annual releases. During handling, material transfers from shipping casks to disposal containers would allow noble gases to escape from the small percentage of fuel elements that had failed. In contrast, disposable canisters would not be opened during the transfer process. However, under the disposable canister option about 20 percent of the fuel would be uncanistered, accounting for the small amount of release.

7.5.2 (7894)
Comment - EIS001653 / 0048
Section 3.2.2.1.2 There is no climate description for Northern Nye and Lander Counties.

Response
The EIS provides a general climate description for those areas through which potential alignments in rail corridors could pass. These areas include northern Nye and Lander Counties. Since the U.S. Department of Transportation accident and vehicle fatality rate data (which include accident statistics for each state under the full range of climatic, road, and traffic conditions for the period from 1994 to 1996) were used to assess impacts, the effects of weather conditions in Nevada were considered in the EIS analysis. Section 3.2.2.1.2 has been modified to clarify DOE's approach.

7.5.2 (8081)
Comment - EIS001653 / 0061
Pg. 4-12 Section 4.1.2.3.2 Should the analysis consider a possible release scenario at the surface handling facility including the potential for and the consequences thereof?

Response
Appendix H of the EIS considers radiological and nonradiological repository accident scenarios including surface facilities. Section 4.1.8 of the EIS describes potential impacts of off-normal and accidental releases from the surface facilities. Section 4.1.2 considers routine releases.

7.5.2 (8284)
Comment - EIS000817 / 0102
P. 4-72. What is the amount of pollution from all the fossil fuel used to store and dispose of nuclear fuel? What are all the externalities here?

Response
Nonradiological air pollutants at the proposed repository would include nitrogen dioxide, sulfur dioxide, and particulate emissions from fossil fuel consumption. Appendix G of the EIS describes the quantities of pollutants released from various activities at the proposed repository. DOE analyzed potential impacts of such releases by comparing them to National Ambient Air Quality Standards at the location of the maximally exposed individual. Tables 4-1, 4-3, and 4-6 of the EIS summarize nonradiological impacts at the analyzed withdrawal area during different phases of repository operation and show that the concentrations of these constituents would be less than the applicable standards. Because the regulatory standards for comparison are promulgated as either a 1-hour, 3-hour, 8-hour, 24-hour or on an annual basis, the total quantity of pollutants generated over time was not calculated.

7.5.2 (8445)
Comment - EIS001397 / 0013
The Yucca Mountain site for this project was chosen in part for the desert conditions and low average rainfall in the region. However, the DEIS fails to address the fact that often [the] entire annual rainfall occurs in a very few severe storms with flash flood conditions. The addition of "raincoats" or drip shields to the casks does not sound like an adequate solution. The final EIS must address the many inches of rain that can occur in this region in a single hour.

Response
Section 3.1.2.2 of the EIS discusses the Yucca Mountain region average precipitation, which ranges from 10 to 25 centimeters (4 to 10 inches) per year. DOE believes this is an accurate representation of the long-term annual precipitation range for the region. Regarding unusually heavy rainfalls, Section 3.1.2.2 also discusses occasional periods of monsoon thunderstorms that can locally produce more than 2.5 centimeters (1 inch) of rain in a matter of hours. However, such occasional heavy rainfalls would not cause a deviation from the long-term prediction of precipitation at the site. The flash flood and rapid runoff conditions are of little concern because surface runoff by its very nature would not infiltrate the mountain, but would flow over and past the proposed repository. During the operational period, the subsurface portals would be protected from such flooding should it occur. After closure, these portals would be sealed and unavailable for water to enter.

The EIS evaluated climate change and its potential effect on long-term repository performance. Section I.2.2 of the EIS discusses the effects of future shifts to a cooler and wetter climate.

Since the publication of the Draft EIS, DOE has modified the repository design to include titanium drip shields over the waste packages. The drip shields would be placed over the waste packages immediately before closure. The function of the drip shields in the flexible design would not be related to heavy rainfall events; rather, their function would be to divert water that might seep into an emplacement drift. The Final EIS discusses these design changes and the steps DOE would take to close the repository.

7.5.2 (8827)
Comment - EIS000869 / 0008
Regarding S.4.1.2, referencing radiological and nonradiological impacts, the dust suppression techniques used during excavation, i.e., water spraying, could lead to faster and higher levels of water contamination. With the low humidity in the desert areas, it could also vaporize and increase air contamination.

Response
Water spraying is a common dust suppression technique. During the construction of the repository, DOE would spray water on disturbed soil and earth material excavated from the subsurface. This material would not be

contaminated, although one purpose of spraying water would be to limit the mobilization of dust containing the naturally occurring carcinogenic mineral cristobalite, which would be present in some excavated material. There would not be enough sprayed water used for dust suppression to infiltrate to the repository level. Evaporation of the water would not lead to additional air contamination.

7.5.2 (8841)
Comment - EIS000869 / 0014
There is no indication of the estimated number of thermal units to be released into the atmosphere and surrounding environment and what impact it may have on the climate and ecosystems of the area.

Response
DOE has expanded the issue of thermal management to the Final EIS. Exhaust ventilation heat is discussed in Chapter 2, and potential impacts are addressed in Section 4.1.2.3. The revised flexible design (EDA II without backfill) would remove at least 70 percent of the heat generated by the waste inventory during the preclosure period. The peak ventilation air temperature would be 58° Celsius (about 136° Fahrenheit) occurring 10 years into the preclosure period and decreasing thereafter. This is lower than the exhaust air temperature of many industrial processes, such as powerplants and manufacturing facilities. DOE expects no significant impacts from the heat released in ventilation air on either the climate or ecosystems of the area.

7.5.2 (8940)
Comment - EIS001922 / 0009
Air Quality

The DEIS does not adequately address the fact that the site will not meet the current Carbon 14 (C-14) emissions standard for waste facilities, nor does it examine the consequences of such releases.

Response
DOE expects negligible releases of carbon-14 during the repository operations and monitoring and closure phases. Section 5.5.2 of the EIS discusses potential long-term releases of carbon-14 to the atmosphere and the potential atmospheric consequences tot he local population and to an individual receptor. The results of this analysis shows that the dose to the public would be far below applicable dose limits. After DOE closed the repository, carbon-14 in the form of carbon dioxide would have a potential for gas transport.

7.5.2 (9729)
Comment - EIS001887 / 0221
Page 4-15; Section 4.1.2.3.2 - Radiological Impacts to Air Quality from Continuing Construction, and Operation and Monitoring

Define and quantify “minimal” and “very small.”

Response
DOE has clarified the discussion in Section 4.1.2.3.2 of the EIS of the radiological impacts to decontamination workers during the monitoring and maintenance phase. Essentially the only radioactive material released to ambient air during this phase would be naturally occurring radon gas vented from the subsurface. Because there are low levels of naturally occurring radioactivity and because DOE would use high-efficiency particulate air filters for air exhausted to the atmosphere, there would be negligible releases of airborne radioactivity other than radon. The collective dose to the nondecontamination period than during the remainder of the monitoring and maintenance phase because there would be more such workers during decontamination.

7.5.2 (11020)
Comment - EIS001896 / 0017
Section 4.1.2.2.2

There could be radiological impacts on air quality during construction of the facility.

Response
No releases of manmade radionuclides would occur during the construction phase of the proposed repository because such materials would not be present until the repository began operations. Section 4.1.2.2.2 of the EIS discusses potential radiological impacts during repository construction from naturally occurring radionuclides, primarily radon-222 and its decay products, released during construction of the subsurface facilities. Table 4-2 shows that the annual dose to the maximally exposed individual at the southern boundary of the Land Withdrawal Area would be about 0.5 millirem per year during the initial construction phase. This dose would be about 3 percent of the 15-millirem-per-year regulatory limit in 40 CFR 197.4 and 10 CFR 63.204.

7.5.2 (11367)
Comment - EIS002278 / 0004
I see no talk about global warming and the effects that the scientists are talking about now, and how within the next 50 years even, a hundred years, our climate change may be such that that whole mountain might be under water.

Response
Section 3.1.2.2 of the Final EIS includes a discussion of paleoclimatology. Climate regimes believe to have existed in Yucca Mountain's and, therefore, that should occur in the future have been grouped into four different categories, as described in Section 3.1.2.2. Characteristics of these climate regimes and postulated future durations are included as input parameters to the long-term performance assessment modeling for the site. Global climate changes are addressed in the Total System Performance Assessment in Appendix I.2.1, using a climate model based on paleoclimatology information. No credible scenario was identified that could result in Yucca Mountain being submerged under water.

7.5.2 (11705)
Comment - EIS001888 / 0383
[Clark County summary of a comment it has received from a member of the public.]

One commenter noted that the radiation risk to residents (Esmeralda County) of airborne exposure should be included in the EIS.

Response
Environmental impact statements have historically used an area within 80 kilometers (50 miles) for analyzing potential impacts from airborne radiation exposure because this is the established precedent for calculating the potential population (collective) dose around a nuclear facility (DIRS 101858-NCRP 1995). The small portion of Esmeralda County that lies within 80 kilometers (50 miles) of the proposed Yucca Mountain Repository is included in the EIS. As noted in Figure 3-25, about 20 persons in Esmeralda County (26 projected for 2035) live within this area. There would be no meaningful impacts to residents of Esmeralda County more than 80 kilometers away from the activities at Yucca Mountain.

7.5.2 (12404)
Comment - 010242 / 0022
Page 3-4: Section 3.1.2.1 - Radiological Air Quality
There is no basis to calculate radon beginning 20 km from the repository, the proposed boundary of the accessible environment for the repository, since the source of the radon is not the radioactive waste to which repository disposal performance regulations are intended to apply. The public exposure should be calculated at points nearest the source, outside the restricted operations area, since members of the public will frequent these areas and be exposed to the released radon.

Response
Radon emanates from the rock of the subsurface repository, enters the repository drifts, and is exhausted in ventilation air. For purposes of public exposure, the source of the radon is the ventilation shafts and exhaust ducts that would service the subsurface repository, since the radon is being released in the subsurface ventilation air. No members of the public would be routinely exposed within the proposed land withdrawal boundary, since this area would be off-limits to public access. If members of the public would enter this area, it would be for limited periods of time, and not for the continuous yearly exposure considered for people living outside the land withdrawal area. If members of the public do visit the Yucca Mountain operations areas they would be subject to DOE's radiation

protection limits and guidance. Any potential radiation exposure from radon or other sources would be of limited duration and any potential radiation dose would be expected to be very low.

7.5.3 HYDROLOGY/GEOLOGY

7.5.3 (1212)
Comment - EIS000322 / 0003
Besides the deadly threat of transportation of this high-level radioactive waste, the storage of the waste in Yucca Mountain also poses a threat to us all. Yucca Mountain is volcanic, it is seismically active, and it will leak. Studies have been done that indicate Yucca Mountain has been flooded with hot water in the past.

Response
Based on the results of analyses in Chapter 5 of the EIS on the long-term performance of the proposed repository at Yucca Mountain, DOE believes that a repository would operate safely (in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards in 40 CFR Part 197). Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 of the EIS describes the potential impacts from accident scenarios associated with earthquakes during repository operations. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. DOE believes that the EIS adequately describes and analyzes geology, geologic hazards, and the effects of these hazards on the proposed repository.

Section 3.1.4.2.2 of the EIS describes evidence that the elevation of the water table at Yucca Mountain has fluctuated over time. These fluctuations have been due primarily to changes in the climate. DOE examined the cumulative effects on the elevation of the water table from a wetter climate, earthquakes, and a volcanic eruption. Based on the evidence, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate the waste emplacement areas at Yucca Mountain.

There is no evidence to suggest that the water table at Yucca Mountain is slowly rising. Section 3.1.4.2.2 (Saturated Zone) discusses opposing views on fluctuations in the elevation of the water table. A small number of investigators believe that the water table has risen in the past to elevations higher than the waste-emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that past water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than present for the past several million years.

7.5.3 (1376)
Comment - EIS000432 / 0004
Furthermore, there is also surface and ground water that flows near the proposed site at Yucca Mountain. For example, the Fortymile Canyon river/waterway flows just east of Yucca Mountain itself. The Buckboard waterway flows from the north. The [Amargosa] River flowing from the west alongside Yucca Mountain down to the south of Yucca Mountain. The DOE also states that "In the distant future groundwater would contain small quantities of radionuclides and chemical toxic substances." (s-42) Again the DOE says that the impact on plants and animals would be small and "unlikely" to have adverse impacts.

Response
Section 3.1.4.1 of the EIS describes surface water in the area of Yucca Mountain in detail. The Amargosa River and its tributaries (including Fortymile Wash) are dry along most of their lengths most of the time. The Central Death Valley hydrologic subregion consists of three groundwater basins, each with smaller sections. Yucca Mountain is in the Alkali Flat-Furnace Creek groundwater basin. Hydrologic models derived from extensive studies indicate that water infiltrating at Yucca Mountain would join groundwater in the Fortymile Canyon section and flow toward the Amargosa River section (see Figure 3-13). Thus, the small fraction of water of the total in the basin that might move through a repository would be likely to flow toward the south toward Amargosa Valley. Long-term performance assessment (modeling) analyses indicate that the combination of the natural barriers of the repository site and engineered barriers would keep the radionuclides well below the regulatory limits established at 40 CFR Part 197. Sections 3.1.4.2.1 and 5.4 of the EIS contain more information.

protection limits and guidance. Any potential radiation exposure from radon or other sources would be of limited duration and any potential radiation dose would be expected to be very low.

7.5.3 HYDROLOGY/GEOLOGY

7.5.3 (1212)
Comment - EIS000322 / 0003
Besides the deadly threat of transportation of this high-level radioactive waste, the storage of the waste in Yucca Mountain also poses a threat to us all. Yucca Mountain is volcanic, it is seismically active, and it will leak. Studies have been done that indicate Yucca Mountain has been flooded with hot water in the past.

Response
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There is no evidence to suggest that the water table at Yucca Mountain is slowly rising. Section 3.1.4.2.2 (Saturated Zone) discusses opposing views on fluctuations in the elevation of the water table. A small number of investigators believe that the water table has risen in the past to elevations higher than the waste-emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that past water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than present for the past several million years.

7.5.3 (1376)
Comment - EIS000432 / 0004
Furthermore, there is also surface and ground water that flows near the proposed site at Yucca Mountain. For example, the Fortymile Canyon river/waterway flows just east of Yucca Mountain itself. The Buckboard waterway flows from the north. The [Amargosa] River flowing from the west alongside Yucca Mountain down to the south of Yucca Mountain. The DOE also states that "In the distant future groundwater would contain small quantities of radionuclides and chemical toxic substances." (s-42) Again the DOE says that the impact on plants and animals would be small and "unlikely" to have adverse impacts.

Response
Section 3.1.4.1 of the EIS describes surface water in the area of Yucca Mountain in detail. The Amargosa River and its tributaries (including Fortymile Wash) are dry along most of their lengths most of the time. The Central Death Valley hydrologic subregion consists of three groundwater basins, each with smaller sections. Yucca Mountain is in the Alkali Flat-Furnace Creek groundwater basin. Hydrologic models derived from extensive studies indicate that water infiltrating at Yucca Mountain would join groundwater in the Fortymile Canyon section and flow toward the Amargosa River section (see Figure 3-13). Thus, the small fraction of water of the total in the basin that might move through a repository would be likely to flow toward the south toward Amargosa Valley. Long-term performance assessment (modeling) analyses indicate that the combination of the natural barriers of the repository site and engineered barriers would keep the radionuclides well below the regulatory limits established at 40 CFR Part 197. Sections 3.1.4.2.1 and 5.4 of the EIS contain more information.

7.5.3 (1486)
Comment - 010290 / 0004
The SDEIS introduces the concept of fuel pools for blending waste at Yucca Mountain. Fuel pools will introduce new risks that have not been adequate analyzed, particularly in relation to seismicity. Also, fuel pools will require huge quantities of water -- a precious resource in the desert. The SDEIS assumes that water will be available from the State of Nevada, although the State has denied water appropriations for the Yucca Mountain Project. The DOE should assess the feasibility and impact of importing water from another source.

Response
As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring seismic activity and studying the geologic structure at and near Yucca Mountain since 1978. Using these data and the results of these studies, along with input from panels of recognized experts on seismic risks and hazards, DOE would design critical surface facilities at the repository to withstand a magnitude-6.3 earthquake within 5 kilometers (3 miles) of Yucca Mountain (this bounds the effects from a magnitude-7.5+ earthquake in Death Valley within 50 kilometers (31 miles) of Yucca Mountain). Similarly, possible fuel blending in the Waste Handling Building would be designed to withstand such earthquakes.

The highest estimate of water demand for the flexible design described in the Supplement is less than the highest estimate for water for the design described in the Draft EIS (see Table S-2 of the Supplement). On February 2, 2000, the Nevada State Engineer denied DOE's water-appropriation request for 430 acre-feet per year for repository construction and operation (DIRS 144853-Turnipseed 2000). The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest. On March 2 and 3, 2000, DOE filed suits in U.S. District Court for the District of Nevada and in Nevada's Fifth Judicial District Court, respectively, for injunctive relief to overturn this Ruling. On September 21, 2000, the U.S. District Court Judge granted the State's motions to dismiss the DOE lawsuit. DOE appealed this ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE's suit. The case is pending.

DOE has not developed any other plans to acquire water for the proposed repository. Depending on the final ruling of the State Court, DOE might consider other options to carry out its responsibilities under the Nuclear Waste Policy Act, as amended.

7.5.3 (1770)
Comment - EIS000572 / 0002
Everything has been thrown out the window, all their guidelines, everything. I mean, this is like active volcanoes, you know. We have earthquakes, but they are only one, two, three. Still, there are earthquakes, which means there can be bigger ones, you know, that will affect the repository, and it will affect everybody in this area.

Response
DOE has not proposed to amend its general guidelines (10 CFR Part 960) to avoid the elimination of the Yucca Mountain site from consideration. Rather, the purpose of the new Yucca Mountain-specific guidelines (10 CFR Part 963) is to implement the NWPA, given the regulation and criteria of the Environmental Protection Agency (40 CFR Part 197) and the Nuclear Regulatory Commission (10 CFR Part 63) and to provide a technical basis to assess the ability (or performance) of a geologic repository at Yucca Mountain to isolate spent nuclear fuel and high-level radioactive waste from the environment.

The Nuclear Waste Policy Act of 1982 [Section 112(a)] directed the Secretary of Energy (and by extension, DOE) to issue general guidelines for the recommendation of sites for characterization, in consultation with certain Federal agencies and interested Governors, and with the concurrence of the Nuclear Regulatory Commission. These guidelines (issued in 1984 at 10 CFR Part 960) were to include factors related to the comparative advantages among several candidate sites located in various geologic media, and other considerations such as the proximity to storage locations of spent nuclear fuel and high-level radioactive waste, and population density and distribution.

In 1987, amendments to the Nuclear Waste Policy Act specified Yucca Mountain as the only site DOE was to characterize. For this reason, DOE proposed in 1996 to clarify and focus its 10 CFR Part 960 guidelines to apply only to the Yucca Mountain site (draft 10 CFR Part 963), but never issued these guidelines as final. In 1999, DOE proposed further revisions to the draft Part 963 guidelines for three primary reasons:

1. To address comments that criticized the omission of essential details of the criteria and methodology for evaluating the suitability of the Yucca Mountain site.

2. To update the criteria and methodology for assessing site suitability based on the most current technical and scientific understanding of the performance of a proposed repository, as reflected in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998).

3. To be consistent with the then-proposed site-specific licensing criteria for the Yucca Mountain site issued by the Nuclear Regulatory Commission (which has since promulgated these criteria at 10 CFR Part 63), and the then-proposed site-specific radiation protection standards issued by the Environmental Protection Agency (which has since promulgated these standards at 40 CFR Part 197).

In 2001, DOE promulgated its final 10 CFR Part 963 guidelines to establish the methods and criteria for deterring the suitability of the Yucca Mountain site for the location of a geologic repository. These final guidelines are principally the same as those proposed in 1999.

Chapter 5 of the EIS considers the effects of future earthquakes on the long-term performance of the proposed repository at Yucca Mountain. Based on the results of those analyses, DOE believes that a repository would operate safely (in compliance with the radiation protection standards in 40 CFR Part 197). Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes potential impacts from accident scenarios associated with earthquakes during repository operations. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. DOE believes that the EIS adequately describes and analyzes the geology, geologic hazards, and the effects of these hazards on the repository.

7.5.3 (1820)
<u>Comment</u> - EIS000198 / 0001
After seeing some of the pictures put out by the DOE we clearly show the path of groundwater passing under Yucca Mountain with all its geological faults and eventually passing to the inhabitants of Amargosa Valley and being in an earthquake zone. Why are you doing this?

<u>Response</u>
Based on the results of analyses in Chapter 5 of the EIS on the long-term performance of the proposed repository at Yucca Mountain, which considered the effects of existing fractures on groundwater flow and future earthquakes, DOE believes that the repository would operate safely. DOE recognizes that some radionuclides and potentially toxic chemicals would, after long periods, enter the environment outside the repository. Nevertheless, modeling of the long-term performance of the repository indicates that the combination of natural and engineered barriers would keep such releases within the regulatory limits established by 40 CFR Part 197. As described in Chapter 1 of the EIS, Congress determined, through the passage of the Nuclear Waste Policy Act of 1982, that the Federal Government has the responsibility to permanently dispose of spent nuclear fuel and high-level radioactive waste to protect the public health and safety and the environment. In the 1987 amendments to the Act, Congress directed DOE to determine whether Yucca Mountain is suitable for a geologic repository.

7.5.3 (1846)
<u>Comment</u> -- EIS000367 / 0002
I'm not sure what studies have been done on the environment as it changes. People here have mentioned volcanoes, earthquakes. Those are realities, and that's where we live. That's why Inyo is called "Land of Many Spirits," because of all these natural things and the spirits that we call them. That's the natural things of nature.

Those actions that nature has, including volcanoes, earthquakes, storms, ice ages, those are things that we have to consider in all parts of life.

Response
Chapter 5 of the EIS considered the effects of future earthquakes, volcanic eruptions, and changes in the climate on the long-term performance of the proposed repository at Yucca Mountain. Based on the results of those analyses, DOE believes that a repository would operate safely [in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197. Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including volcanoes, earthquakes, and reasonable fluctuations in the climate during the next million years. Section 3.1.2.2 characterizes the climate of the Yucca Mountain area, including the frequency and severity of storms and tornadoes. As described in Section 4.1.3.2 and in Appendix L, DOE would design the site to accommodate the flow of floodwaters safely across the site.

7.5.3 (1894)
Comment - EIS000455 / 0008
Other issues are not adequately discussed in the DEIS, including ground water upswelling, earthquakes at the repository site. Several investigators have suggested that the water table in the vicinity of Yucca Mountain has risen dramatically, as much as 330 feet. All of these things need to be examined and more.

Response
There is no evidence to suggest that the water table at Yucca Mountain is slowly rising. Section 3.1.4.2.2 (saturated zone) discusses opposing views on fluctuations in the elevation of the water table. A small number of investigators believe that the water table has risen in the past to elevations higher than the waste-emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level.

Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes potential impacts from accident scenarios associated with earthquakes during repository operations. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. DOE believes that the EIS adequately describes and analyzes the geology, geologic hazards, and the effects of these hazards on the repository.

7.5.3 (1899)
Comment - EIS000459 / 0002
Not only is Yucca Mountain riddled with earthquake faults but is slowing filling with geothermal waters.

Response
Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults and seismicity. Chapter 5 considers the effects of future earthquakes on the long-term performance of the proposed repository at Yucca Mountain. Based on the results of those analyses, DOE believes that a repository would operate safely [in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197].

There is no evidence to suggest that the water table at Yucca Mountain is slowly rising. Section 3.1.4.2.2 (saturated zone) discusses opposing views on fluctuations in the elevation of the water table. A small number of investigators believe that the water table has risen in the past to elevations higher than the waste-emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described in Section 3.1.4.2.2 of the EIS). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level.

7.5.3 (2261)
Comment - EIS000362 / 0002
I would also encourage you, on your way back, to consider driving north through Bishop and up to Mono Lake. As you approach Mono Lake, you'll see some very young cinder cones that some of them are only 500 years old.

When I looked in your EIS, it talked about volcanism and the basin and range having stopped about 75 thousand years ago. In all of your studies, the potential for a volcano erupting within the Yucca Mountain region seems to be dismissed as something long ago. They thought that the cinder cones around Mono Lake were quite a bit older until very recently, and now they have decided they are only 500 to 750 years old.

The USGS is sitting on volcanic activity in the caldera at Mammoth Lakes. It's my personal hope that, and I would be very disappointed, in fact, if within the next 10 or 20 or 30 years, during my lifetime certainly, we don't get a nice new cinder cone at the intersection of Highways 203 and 395 in the vicinity of the Mammoth Lakes Airport. I would really like to see that. It wouldn't be -- there are a lot of people who wouldn't. But it's not the kind of disaster that's human and manmade. It would be a natural event. It would be an act of God, and that, to me, also is indicative of the kind of activities that are happening in the Yucca Mountain region, but not as you have defined it in the 30-kilometer radius.

Response
As described in Section 3.1.3 of the EIS, the most recent volcanic eruption in the area occurred between 70,000 and 90,000 years ago about 10 miles south of the Yucca Mountain site. The next-youngest eruptions were in Crater Flat west of Yucca Mountain where four northeast-trending cinder cones developed about 1 million years ago. A panel of experts examined the data, models, and related uncertainties, and concluded that the probability of a volcanic dike disrupting the repository during the first 10,000 years after closure is 1 in 7,000 (1 chance in 70 million per year). Although extremely unlikely, a volcanic eruption through the repository could spread ash and entrained waste into the atmosphere and magma into the emplacement drifts. DOE estimated the potential impacts to the nearest population, conservatively assuming the direction and speed of wind transport of an ash plume, and determined that the impacts to public health and safety would be very small (Section 5.7.2 of the EIS). DOE also determined that magma flowing into the emplacement drifts would have minimal impacts on the long-term performance of the repository (Section 5.7.2 of the EIS).

7.5.3 (2512)
Comment - EIS002133 / 0001
This here is water that I had to buy. I buy water because I can't drink the water here. If they bring nuclear waste here for Yucca Mountain, we're definitely not going to be able to drink the water. It's already so bad. What are we going to do?

Response
DOE is very concerned about the safety of the groundwater and surface water in the vicinity of Yucca Mountain. The water quality in the Las Vegas Valley and in the vicinity of the proposed Yucca Mountain repository is safe for all human uses. The choice of whether or not to use this water for drinking is, and always will be, an individual and personal decision, usually based on taste preferences. With respect to a possible repository at Yucca Mountain, Chapter 5 of the EIS estimates the impact on water quality at several locations downgradient from the site. The conclusion of extensive scientific investigations and detailed engineering evaluations is that potential impacts to water quality from a repository at Yucca Mountain would be negligible.

7.5.3 (2625)
Comment - EIS000084 / 0006
The timing is not important. As a national park, they have an obligation to protect in perpetuity, meaning forever.

Yet the NPS (National Park Service) is not complaining. Why? Well, I was told the answer by the assistant superintendent of Death Valley National Park. She said they had been told by the US federal justice system not to file suit against another branch of the Federal Government.

That is the same reason that Death Valley National Park is not protesting the appropriation of new water rights for Yucca Mountain, 450 acre feet annually.

However, Death Valley is currently protesting private individuals' transfers of already appropriated water rights that are permitted and in good standing here in Amargosa Valley.

Where is the justice in this?

Response
The National Park Service has been very active in its oversight of water-permit applications and groundwater withdrawals for the Yucca Mountain Site Characterization Project. The Park Service protested the first Yucca Mountain water permit applications, and this resulted in the implementation of a comprehensive groundwater monitoring program in the region. This monitoring program includes Death Valley National Park and Devils Hole Protective Withdrawal. The Park Service routinely receives and analyzes monitoring data from this program to ensure the protection of water resources in the Park.

The National Park Service also submitted comments on the Draft EIS. Its concerns included possible impacts to Death Valley National Park and Devils Hole Protective Withdrawal from the repository.

7.5.3 (2729)
Comment - EIS000709 / 0002
There are two reasons why the Yucca Mountain repository should not be developed: groundwater intrusion and seismic activity. The EIS references the work of "several investigators" who determined the [that] the water table at Yucca Mountain was much higher than it is now, occasionally even reaching the surface. This work was later discredited, but still later, the discreditors were discredited. The DOE says additional research is needed and is ongoing. This proves that the EIS is inadequate; it cannot be considered complete when there is active research into a critical environmental impact.

The information regarding seismic activity is outdated and incomplete. Just since July, there have been two major earthquakes. The EIS says that the repository should be able to withstand a 5.6 magnitude earthquake, yet the seismic potential in the surrounding faults is on the order of 6.5-7.

Response
Based on analyses described in Section 3.1.4.2.2 (Saturated Zone), DOE does not believe a credible rise of the water table could inundate the waste emplacement areas. The EIS discusses evidence that the elevation of water table at Yucca Mountain has fluctuated over time. These fluctuations have been due largely to changes in the climate. DOE examined the cumulative effects on the elevation of the water table from a wetter climate, earthquakes, and a volcanic eruption. Based on the evidence, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate the waste-emplacement areas at Yucca Mountain.

Section 3.1.4.2.2 also discusses opposing views on fluctuations in the elevation of the water table. A small number of investigators believe that the water table has risen in the past to elevations higher than the waste-emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level. Although DOE disagrees with the central scientific conclusions of these opposing views, it continues to support research in this area, and on other aspects of the geology and hydrology to enhance our understanding of the site.

Chapter 5 of the EIS considers the effects of future earthquakes on the long-term performance of the proposed repository at Yucca Mountain. Based on the results of those analyses, DOE believes that a repository would operate safely (in compliance with the public health and environmental radiation protection standards at 40 CFR Part 197). Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes potential impacts from accident scenarios associated with earthquakes during repository operations. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. DOE believes that the EIS adequately describes and analyzes the geology, geologic hazards, and the effects of these hazards on the repository.

Regarding the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3 (2919)
<u>Comment</u> - EIS001049 / 0005
Nevada has more than paid its debt by providing security to America, by hosting the Nevada Test Site, and should not have to have further nuclear waste stored in the unproven and earthquake vulnerable Yucca Mountain site. As you know, there has been migration of radioactivity in the ground water toward Death Valley from the Nevada Test Site. There is evidence that the water table has risen in Yucca Mountain and any migration of radioactivity in the water table would endanger Las Vegas, the entertainment capital of the world. The proposed lowered radiation standards wouldn’t loosen the risk and are a dishonest attempt to unscientifically present Yucca Mountain as safe.

<u>Response</u>
DOE recognizes that the State of Nevada is home to a number of Federal activities. In particular, the Nellis Air Force Range and the Nevada Test Site occupy large parcels of land in southern Nevada. Sections 8.2 and 8.3.2 of the EIS discuss the short- and long-term cumulative environmental impacts, respectively, posed by these and other Federal actions considered with the Proposed Action. Section 3.1.3.3 discusses modern seismic activity and the seismic hazards associated with the site. That section describes how DOE would construct critical facilities and systems such that they would be able to withstand an earthquake with a return frequency of once in 10,000 years. To support the design of repository facilities, DOE would continue to investigate characteristics of the site and how it would react to an earthquake of such magnitude.

Section 3.1.4.2.2 of the EIS describes the migration of groundwater contamination from the Nevada Test Site (NTS). There is no evidence to indicate NTS activities have contaminated the groundwater beneath Yucca Mountain.

Because groundwater from both Yucca Mountain and the NTS flow toward Amargosa Valley, long-term impacts from NTS activities could be cumulative with those from the Proposed Action (see Section 8.3.2.1).

DOE believes that there is no evidence that groundwater beneath Yucca Mountain would ever rise as high as the level of the proposed repository. As indicated in Section 3.1.4.2.2, DOE believes evidence found during investigations of the site indicates that, during wetter geologic times, groundwater was as much as 120 meters (394 feet) higher than it is today. This is still below the level of the proposed repository emplacement drifts. The same section recognizes that there are viewpoints on the historic groundwater elevations at Yucca Mountain that differ from those supported by DOE. The text summarizes the bases of these opposing viewpoints, the expert reviews established by DOE, and the review results that make DOE believe the opposing viewpoints are based on incorrect interpretations of the data.

Chapter 5 of the EIS discusses the long-term performance of the proposed repository, including potential impacts 10,000 years and more into the future, to people using groundwater that had passed beneath the site. The groundwater flow path is toward Amargosa Valley to the south of the repository site and not, as suggested in the comment, toward Las Vegas, which is to the southeast.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information). The EIS based its analysis of impacts on a state-of-the-art modeling technique that is internationally recognized as an adequate and proper approach. DOE also used this methodology in the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998). Chapter 5 of the EIS indicates that impacts would be low and that health effects would be thousands of times less than natural incidences of health problems in the population. The impacts predicted by the analysis would be much lower than the limits established by the Environmental Protection Agency at 40 CFR Part 197. Appendix I of the EIS and supporting documents contain details of the analysis methodology. See Sections 3.1.4.2.1 and 5.4 for additional information.

7.5.3 (3265)
Comment - EIS000602 / 0006
What happens when you get to the dump, to the site? Is the high level of water in the mountain itself going to cause water contamination? That water ultimately essentially gets to the Colorado River and to the city of Las Vegas.

We have been known in this southern part of the state to have flash flooding. Deserts are known to have flash flooding.

Response
As described at the beginning of Section 3.1.4.2.2 of the EIS, the primary emplacement area for the proposed repository is about 300 meters (984 feet) above the present water table. As described in the Saturated Zone discussion of the same section, the DOE investigation of the Yucca Mountain site has shown that during wetter geologic times over the past hundreds of thousands of years, the water table was as much as 120 meters (390 feet) higher than it is today. This is still well below the level of the proposed repository. Section 3.1.4.2.2 also recognizes that there are viewpoints on the historic groundwater elevations at Yucca Mountain that differ from those supported by DOE. The text summarizes the bases of these opposing viewpoints, the expert reviews established by DOE, and the review results that make DOE believe the opposing viewpoints are incorrect interpretations of the data.

Groundwater beneath Yucca Mountain is part of the Death Valley regional groundwater flow system, which, as described in Section 3.1.4 of the EIS, is a terminal hydrologic basin. That is, there is no natural pathway for water (groundwater or surface water) to leave the basin other than by evaporation or transpiration through plants. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, unless it is removed from the system (for example, by pumping, evaporation, or transpiration) before it gets there. The specific flow pattern in this area is from Yucca Mountain south to the Amargosa Desert and then to the primary discharge area of Alkali Flat (Franklin Lake Playa) not toward areas to the north or east. A small fraction of the groundwater may flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in Furnace Creek area of Death Valley. It does not move toward either Las Vegas or the Colorado River drainage system.

Section 3.1.4.1.2 of the EIS addresses the potential for flash flooding events to occur at the site of the proposed repository. Both the U.S. Bureau of Reclamation and the U.S. Geological Survey have generated flood estimates for drainage channels at Yucca Mountain. The location and design of surface facilities that DOE would build in support of the proposed repository would avoid significant impacts from floods. For facilities in which DOE would manage spent nuclear fuel or high-level radioactive waste, this means design against flood levels considered to be the most severe reasonably possible for that site. None of the flood estimates (including those for the regional and probable maximum floods) predicted water levels high enough to reach the entries to the subsurface facilities. In summary, DOE believes flash flooding would not pose a threat to either surface or subsurface facilities associated with the proposed repository.

7.5.3 (3595)
Comment - EIS000715 / 0005
Groundwater upwelling and earthquakes are two issues not adequately discussed in the DEIS. The DOE notes an opposing viewpoint, stating the "Several investigators have suggested that the water table in the vicinity of Yucca Mountain has risen dramatically higher than 100 meters (330 feet) above the current level, even reaching the land surface in the past (Szymanski, 1989). If such an event occurred, it would affect the performance of the proposed repository" (p. 3-49). DOE even admits, "if such an event occurred, the long-term impacts would probably increase greatly" (p. 5-15). Yet the DEIS dismisses the possibility and does not address the potential impacts of such an event.

DOE notes another opposing viewpoint by Davies and Archambeau which suggests that a moderate earthquake at the site could result in a water table rise of about 150 meters (490 feet) and a severe earthquake could cause a rise of about 240 meters (790 feet) in the water table, which would flood the repository. Nevada ranks third in the nation for current seismic activity. Since 1976, there have been over 600 seismic events of a magnitude greater than 2.5 within a 50-mile radius of Yucca Mountain. The DEIS states that "earthquakes have occurred in the Yucca Mountain geologic region of influence, and are likely to occur in the future" (p. 5-16). Yet, the DOE has repeatedly ignored the potential impacts of future earthquakes at the Yucca Mountain site and refuses to examine how an earthquake might affect the region's groundwater supply.

Response
Section 3.1.4.2.2 of the EIS discusses several opposing views concerning fluctuations in the elevation of the water table at Yucca Mountain. These investigators believe that the water table at Yucca Mountain has risen in the past to elevations that are higher than the subsurface emplacement areas. DOE does not concur with these opposing views, nor did an expert panel that was convened by the National Academy of Sciences to specifically examine this issue [see Section 3.1.4.2.2 of the EIS (Saturated Zone) for details]. DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level. On this basis, DOE did not evaluate the impacts of groundwater inundation of the waste-emplacement areas. This approach is consistent with regulations of the Council on Environmental Quality [40 CFR 1502.1(b)] which state that impacts shall be discussed in proportion to their significance.

Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including seismicity. Section 4.1.8 of the EIS describes the impacts of earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and their effects on the performance of the repository. With the exception of factual changes and clarifications that have been included in the Final EIS, DOE believes that the information on seismic activity in the Draft EIS and the Final EIS adequately describes and analyzes the effects of this activity on the repository.

With regard to the effects of earthquakes on the region's groundwater supply, Section 3.1.4.2.2 of the EIS describes the effects on well-water levels after earthquakes in the region. In brief, water levels have fluctuated by as much as 0.9 meter (3 feet) in response to earthquake events, and confined water pressure deep in wells has fluctuated by as much as 2.2 meters (7 feet) in response to those same events. However, the water levels return to pre-earthquake levels within minutes to hours. An exception was an earthquake in the summer of 1992 that caused water levels in some wells at Yucca Mountain to fluctuate over a few months. Several investigators have speculated that very large fluctuations in water levels can occur during earthquakes. Although the EIS describes these theories in Section 3.1.4.2.2 of the EIS, DOE does not concur with these theories, nor did an expert panel that was convened by the National Academy of Sciences to examine this issue (as described in Section 3.1.4.2.2 of the EIS). In summary, changes to the water table and water supply from earthquakes would not be expected to be large or long-lived.

7.5.3 (3900)
Comment - EIS000654 / 0003
What we do know involves the magnitude earthquakes that have occurred in the region, the fact that it's a seismically highly active region; uncertainties about groundwater movement, but evidence that water has moved within a recent time frame through the rocks surrounding the repository.

Response
DOE recognizes that the effect of earthquakes at the proposed Yucca Mountain Repository is a major concern. The EIS analyzes the probability of occurrence and the potential environmental impacts from earthquakes (Section 4.1.8.1 of the EIS). To support this analysis, DOE and the U.S. Geological Survey completed a comprehensive evaluation of the seismic hazards in the Yucca Mountain region using standard practices of mapping, trenching, age-dating, and monitoring of contemporary seismicity. Then DOE sponsored groups of scientific experts from within and outside the Project used these site data to assess the seismic hazard potential of all significant seismic sources in the Yucca Mountain region. Another group of experts used numerical modeling methods and data from recent earthquakes to estimate ground motion attenuation relationships appropriate for Yucca Mountain.

Using the seismic hazard information described in Section 3.1.3.3 of the EIS, DOE would design repository surface facilities to withstand the effects of earthquakes that could occur during the lifetime of the facilities. The seismic design requirements for the repository specify that the structures, systems, and components important to safety would be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

DOE would build repository subsurface facilities in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less effect on subsurface facilities than on surface facilities. Inspections of tunnels in the Yucca Mountain area reveal little evidence of disturbance following earthquakes. In addition, DOE would design the subsurface facilities to withstand the effects of earthquakes for the long-term performance of the repository.

The 1992 Little Skull Mountain earthquake was the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain, with a Richter magnitude 5.6. With an epicenter 20 kilometers (12 miles) to the southeast, this earthquake caused no damage at Yucca Mountain. It did cause minor damage to the Yucca Mountain field operations center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), which is an old building that was not built to the seismic design specifications planned for the facilities at Yucca Mountain.

Extensive studies at Yucca Mountain show evidence of low infiltration and percolation rates, long groundwater residence times, and a repository horizon that has been hydrologically stable for long periods (see Section 3.1.4 of the EIS for details). The proposed emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Any fault movements or displacements from postemplacement seismic activity probably would occur on existing fault planes. Calculations show that there would be almost no effect on repository performance from rockfall.

A fault-fracture dominant flow system is the basis of the hydrology models derived from extensive studies at Yucca Mountain (see Section 3.1.4 of the EIS for details). The addition of new faults by future seismic events would have a very minor or no effect on the current fault and fracture flow pathways and, therefore, would be unlikely to alter repository performance. Long-term performance assessment analyses show that the combination of the natural barriers of the site and engineered barriers would keep radionuclide releases well below the regulatory limits established at 40 CFR Part 197.

7.5.3 (3969)

Comment - EIS001330 / 0001

Yucca Mountain is not a geologically suitable site for nuclear waste disposal. The proposed repository location is in the Basin and Range Province, one of the most geologically active areas in North America. In recent geologic time, the region has experienced episodes of volcanism as evidenced by the layers of volcanic rock and ash that cover the Great Basin and make up Yucca Mountain itself. Some of these volcanic events occurred less than a million years ago. In addition, the region has experienced recent faulting, including some large magnitude earthquakes within the last century. For seismic hazard, Nevada is rated No. 3, indicating a high earthquake risk. There are several faults that are in very close proximity to Yucca Mountain. For obvious reasons, volcanism and faulting pose a serious threat to the stability of a radioactive waste storage site.

Response

Chapter 5 of the EIS considers the effects of future earthquakes on the long-term performance of the proposed repository at Yucca Mountain. Based on the results of those analyses, DOE believes that a repository would operate safely [in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197]. Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes potential impacts from accident scenarios associated with earthquakes during repository operations. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository.

The State of Nevada ranks third, behind Alaska and California, in seismic activity. Its reputation as a highly active state comes primarily from the occurrence of major historical earthquakes (with a magnitude greater than 7 on the Richter scale) in western Nevada. Yucca Mountain is not in this highly active seismic belt. DOE believes that the EIS adequately describes and analyzes the geology, geologic hazards, and the effects of these hazards on the repository. Regarding the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3 (3971)
Comment - EIS001541 / 0001
Detailed information regarding climate, geology (more specifically physiography), and hydrology reflective of the Yucca Mountain site 10 to 20 thousand years ago should have been included in the DEIS Chapter 3 discussions on each of these physical characteristics. This recent past climate, physiography, and hydrology information would help put into perspective how these specific characteristics for the Yucca Mountain site have changed over this time period.

There is significant detail as to how the geology developed over the past 10 to 14 million years, but nothing is presented for a past time frame similar to the 10,000-year time period associated with future site performance considerations. It seems rather ironic that no factual details for these parameters over the past 10 to 20 thousand years is presented in this Draft EIS, but theoretical predictions as to how numerous repository characteristics may behave during the coming 10 to 100 thousand years is provided!

Response
DOE believes that the information requested by the commenter is contained in the EIS. The geologic history of the Yucca Mountain area over the past several tens-of-thousands of years is described in Section 3.1.3 (at the end of the subsection titled Site Stratigraphy and Lithology). Briefly, the youngest stratigraphic units at Yucca Mountain consist of unconsolidated boulders, sand, silt, and clay deposited by intermittent streams in and near existing dry washes and in valleys, and unconsolidated and unsorted debris at the base of hillslopes. Spring deposits and windblown sand also occur in the area. For more information about these deposits, see DOE (DIRS 100548-1998). Information on recent faulting and seismicity is contained in Sections 3.1.3.2 and 3.1.3.3. Information on recent past climates and groundwater conditions at Yucca Mountain is in Section 3.1.4.2.2, especially in the subsection titled Saturated Zone.

DOE's assessment of surficial geologic processes during the next 10,000 years is based on the surficial deposits and geomorphic surfaces that developed in the area during Quaternary time (last 1.6 million years). These deposits, and the processes that formed them, are described in CRWMS M&O (DIRS 151945-2000). The Quaternary landscape in the Yucca Mountain area has been dominated by physical weathering, colluvial, eolian, and alluvial processes. These processes have responded to varying climates and climatic changes, as well as to the topography of the mountain and adjacent basins.

The surficial deposits and geomorphic features observed today have developed over the past 10,000 years. The preservation of early and middle Quaternary colluvial deposits on many hillslopes has been cited as evidence of ineffective hillslope erosion during colder, pluvial climates. As an alternative, the amount of time that erosional processes dominate the landscape is less than the time during which hillslopes are mostly stable (DIRS 151945-CRWMS M&O 2000). The absence of alluvial fans along the base of tilted fault blocks is a strong indication of very low rates of tectonic activity. The distribution of Quaternary deposits of different ages in Crater Flat appears to reflect the ongoing opening or extension of the basin.

The map units used to describe the Quaternary rock units at and near Yucca Mountain represent nearly 1 million years of paleoenvironmental history. The landscape has experienced many cycles of Quaternary climatic change, and tectonic activity has continued at a slow, almost imperceptible rate (DIRS 151945-CRWMS M&O 2000). A model of landscape response to climatic change in the southern Great Basin is discussed in CRWMS M&O (DIRS 151945-2000).

Displaced or deformed alluvial and colluvial deposits in the Yucca Mountain area record late Quaternary surface displacement along 11 local faults (DIRS 151945-CRWMS M&O 2000). Prehistoric earthquakes are interpreted based on displacement and timing of surface ruptures at specific locations. A total of 52 exploratory trenches and natural exposures have been excavated, cleaned, and logged in the past 20 years as part of seismotectonic investigations in the Yucca Mountain site area. Twenty-eight trenches at the site display clear evidence for displacement of Quaternary deposits across the fault traces (DIRS 151945-CRWMS M&O 2000). An additional 11 trenches were excavated across the nearby Bare Mountain and Rock Valley faults, located within a 20-kilometer (12-mile) radius of the site. All of these trenches exposed displaced Quaternary deposits (see DIRS 137917-CRWMS M&O 2000). Estimates of timing of surface rupture events form the basis for developing earthquake recurrence models, computing fault-slip rates, and correlating displacements along faults in distributive faulting scenarios. The timing of individual events at a given site is constrained by ages of faulted and unfaulted deposits and soils either exposed in trenches excavated across the fault or located adjacent to the surface trace of the fault.

Geochronologic studies have revealed that deposits and soils exposed in trenches vary in age from late Holocene (1,000 to 2,000 years old) to early Pleistocene (1 million years old). For example, trenches have exposed deposits that are as old as 400,000 years along the Windy Wash and Fatigue Wash faults, up to 750,000 years on the Paintbrush Canyon fault, and more than 900,000 years on the Solitario Canyon fault. Estimated maximum and minimum ages for each faulting event at trench sites are included where age control is available. The Quaternary stratigraphy establishes a record of paleoseismic activity for characterization of the long recurrence, low-slip-rate faults at Yucca Mountain. The resolution and completeness of the paleoseismic record of faulting events decreases with increasing age. In particular, in deposits older than 500,000 years old, fewer events are recognizable and the geologic context of those identified is more poorly understood. This situation is due to incompleteness of older stratigraphic records, deformational overprinting by younger events, and commonly poorer resolution in age control for older deposits. The inventory is most complete and the age data are of highest quality for displacements that occurred within the past 150,000 years. Thus, this time interval is emphasized in developing recurrence models and rupture scenarios (DIRS 151945-CRWMS M&O 2000).

Climate change operates over a wide range of time scales. Geologic-scale climate drivers, such as changing configurations of land masses and oceans due to continental drift, occur over millions of years. Conversely, shorter-term climate drivers, such as the Earth's orbital cycle and solar output cycles, occur over decades to thousands of years. These shorter-term changes have the potential to affect the long-term performance of a repository. Section 6.2 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) describes the timing, magnitude, and character of past climate changes in the Yucca Mountain area and establishes the rationale for projecting future changes in the climate. Estimating future hydrologic conditions in the unsaturated zone, saturated zone, and groundwater discharge zone requires an understanding of the timing and types of potential future climates. Wetter and cooler climates that persist for centuries or millennia are of greatest interest, because such climates produce more infiltration, percolation, higher water tables, and more groundwater discharge compared to the present climate.

7.5.3 (4322)
Comment - EIS001222 / 0001
I recommend that this proposal be dropped immediately and permanently for the following reason:

The Yucca Mountain site proposed to hold the nuclear waste is not geologically stable. In 1992 an earthquake of magnitude 5.6 struck within ten miles of the mountain. This suggests that larger quakes are possible in the region. Such larger quakes could damage the containers in which the waste is stored, allowing the waste to leak out and contaminate the surrounding area. Other geological processes known to occur in the vicinity are volcanism and dramatic rises in the level of the water table, either of which can breach container integrity and spread radiation throughout the surrounding area. This is of particular concern because the half-lives of many of the isotopes in the waste are extremely long, in the thousands and millions of years.

Response
Section 3.1.3.1 of the EIS discusses Yucca Mountain as part of a volcanic plateau that formed during explosive silicic eruptions that originated from several calderas north of the site. Over time, this explosive activity began to wane and was replaced by less explosive and much less voluminous basaltic eruptions in the Yucca Mountain region. The last basaltic eruption occurred long ago at Amargosa Valley, about 10 miles south of the site. A panel of outside experts examined the data, models and related uncertainties and concluded that the probability of a volcanic dike disrupting the repository during the first 10,000 years after closure is 1 chance in 7,000 (1 chance in 70 million annually). Section 3.1.3.1 discusses this in more detail. This estimate was recalculated in Section 3.1.3.1

of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

DOE has been monitoring earthquakes in the Nevada Test Site region since 1978. Faults and earthquakes have been investigated as part of the site characterization program to assess seismic hazards at the site. DOE recognizes that the effect of earthquakes on a repository at Yucca Mountain is a major concern and DOE has conducted extensive analyses. The EIS analyzes the probability of earthquake occurrence and the environmental consequences. To support this analysis, DOE and USGS first completed a comprehensive evaluation of the seismic hazards in the Yucca Mountain region using standard practices of mapping, trenching, age dating and monitoring of contemporary seismicity. Then DOE sponsored groups of experts from within and outside the Project used the data to assess the seismic hazard potential of all significant seismic sources in the Yucca Mountain region. Another group of experts used numerical modeling methods and data from recent earthquakes to estimate ground motion attenuation relationships that are appropriate for Yucca Mountain.

Using the seismic hazard information, repository surface facilities would be designed to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

Subsurface facilities would be built in solid rock, and because vibratory ground motion decreases with depth, earthquakes would have less an effect on subsurface facilities than surface facilities. Inspection of existing tunnels in the Yucca Mountain area has revealed little evidence of disturbance following earthquakes. The subsurface facilities would also be designed to withstand the effects of earthquakes for the long-term performance of the repository.

The Little Skull Mountain earthquake of 1992, Richter magnitude 5.6, is the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain. That earthquake, with an epicenter 20 kilometers (12 miles) to the southeast, caused no damage at Yucca Mountain. The event did damage the Yucca Mountain Field Operations Center in Jackass Flats, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic design specifications that are planned for the facilities at Yucca Mountain. Section 3.1.3.3 of the EIS discusses this information in more detail. The results of the probabilistic seismic hazard assessment also indicate that the probability is very small of reactivating faults at the site. Additional fault displacements and associated seismic activity would probably be along existing fault planes.

In addition, the current (flexible) design indicates that waste packages would be placed on pallets in emplacement drifts. Since the waste packages would not be placed in boreholes drilled into the tunnel wall or floor, there is no likelihood that displacement along new faults would shear waste packages. The waste emplacement areas are located in areas away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Calculations show that there would be almost no effect on repository performance from rockfall.

Hydrology models, derived from extensive studies conducted at Yucca Mountain, are based on a fault-fracture dominant flow system. The hypothetical generation of a few new faults in the future would have very minor or no effects on the current fault and fracture flow pathways. Potential new faults and fractures, therefore, would not be likely to alter repository performance (see Section 5.7.3 of the EIS).

The repository would be located above the water table in the unsaturated zone. Therefore, the most important process controlling the corrosion of waste packages is whether water would drip from seeps on the waste package. Field and laboratory testing indicate that seepage is expected to be minor and the location of the seeps would depend on fracture-matrix and drift wall interactions. Under the present design, the radioactive waste that is placed in the repository would be enclosed in a two-layer waste package and covered by a titanium drip shield. The waste package would have a chromium-nickel alloy outer layer (Alloy-22) and a stainless-steel inner layer. These materials have extremely low corrosion rates and are not expected to fail for thousands of years.

Investigations by DOE found no evidence or credible mechanism to account for a rise in groundwater to flood the waste-emplacement horizon in the vicinity of Yucca Mountain. Szymanski (DIRS 106963-1989) proposed that during the last 10,000 to 1,000,000 years, hot mineralized groundwater was driven to the surface by earthquakes and volcanic activities. This hypothesis goes on to suggest that similar forces could raise the regional groundwater in the future and inundate the repository horizon.

To investigate this hypothesis further, DOE requested the National Academy of Sciences to conduct an independent evaluation. The Academy concluded that no known mechanism could cause a future inundation of the repository horizon. Scientists working on the Yucca Mountain Site Characterization Project have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under an extremely wet climate. Based on geologic evidence, the regional aquifer is estimated to have been as much as 120 meters (390 feet) above the present elevation beneath Yucca Mountain during the past several million or more years. The occurrence of an earthquake under these extreme climatic conditions might cause an additional rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters (66 feet) or more between the water table and the waste emplacement horizon. The 1992 Little Skull Mountain earthquake (magnitude 5.6) raised water levels in monitoring wells at Yucca Mountain a maximum of less than 1 meter (3.3 feet) (DIRS 101276-O'Brien 1993). Water levels and fluid pressures in continuously monitored wells rose sharply and then receded over a period of several hours to pre-earthquake levels. The water-level rise in hourly monitored wells was on the order of centimeters and was indistinguishable after 2 hours (DIRS 101276-O'Brien 1993).

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm water upwelling hypothesis. That study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. It concluded that some crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of independent experts, including scientists from the U.S. Geological Survey, did not concur with Dublyansky's conclusions. DOE disagrees with the central conclusions in this report, but has supported continuing research by the University of Nevada, Las Vegas. Section 3.1.4.2.2 of the EIS contains more information on groundwater at Yucca Mountain.

Chapter 5 of the EIS describes the components and summarizes the results of DOE's analysis of the long-term performance of the repository (10,000-year regulatory period of 40 CFR Part 197 and for 1 million years). The performance analysis considered the inventory of long-lived radionuclides and their potential pathways to the accessible environment. The results show that the combination of natural and engineered barriers at the site would keep the radionuclides well below the regulatory limits in 40 CFR Part 197.

7.5.3 (4498)
Comment - EIS001434 / 0001
In regard to the Yucca Mountain Draft Environmental Impact Statement (EIS). I take a strong objection as a geologist with 32 years experience that the proposed Yucca Mountain area is a geological stable area.

Swarms of earthquakes are now being reported just North of Beatty. This type of seismic activity is similar to the earthquake activity that was recorded at Mt. Saint Helens before the last volcanic eruption.

The proposed Yucca Mountain Depository is made up of volcanic rocks with cinder cones that have been dated at less than 10,000 years old. It is not a question if there will be additional earthquakes and volcanic activity in the area but when will it occur and to what magnitude.

Construction of a depository that must be stable for 10,000 years or more in a volcanic area is not conceivable.

Response
Based on the results of analyses reported in Chapter 5 of the Draft EIS concerning the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely [in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197. Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region.

Section 3.1.3 of the EIS discusses the Lathrop Wells cinder cone which, at between 70,000 and 90,000 years old, is the youngest volcanic center in the region. Section 4.1.8 describes the impacts from accident scenarios associated with earthquakes during operation of the repository. Several sections in Chapter 5 of the Draft EIS consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository, have been adequately described and analyzed in the EIS.

Regarding the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the EIS explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3 (4527)
Comment - EIS001521 / 0040
Page 3-39, fourth paragraph--Define “hydrographic areas.” They are not shown on page 3-38, Figure 3-13, and not discussed as hydrologic features.

Response
DOE has changed the terminology for groundwater flow related to region, subregion, basin, and section to be consistent with the source document titled Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California (DIRS 100131-D’Agnese et al. 1997), which is the

main source for this information in Summary Section S.4.1.4 and Section 3.1.4.2.1 of the EIS. The flow in each subregion has clearly defined paths. For convenience, the subregions were divided into basins and sections. The EIS uses these boundaries, which do not define discrete independent flow systems, for descriptive purposes only (DIRS 100131-D'Agnese et al. 1997). The Jackass Flats area is part of the Fortymile Canyon section. The groundwater flow subregion, basin, and section terminology used by D'Agnese et al. (DIRS 100131-1997) is not the same as the terminology used by the State of Nevada for water appropriations (hydrographic areas based on topographic divides); Section 3.1.4.2.1 clarifies that distinction.

7.5.3 (4528)
Comment - EIS001521 / 0041
Page 3-39, fifth paragraph--The "line of springs" location should be shown on page 3-38, Figure 3-13, for clarity. Also, referring to discharge points, a potentiometric-surface map and hydrochemical data as evidence for the springs' locations, while not presenting that evidence, is insufficient. Include the map and examples of the data for clarity and justification of the statement.

Response
Figure 3-15 of the EIS shows the springs mentioned in this comment and are described as being located in Ash Meadows. DOE believes that adding a more detailed depiction of the springs' locations to this figure would be impractical. Also, the line of springs forms much of the western boundary of the Ash Meadows basin, thus a special symbol for the spring line would overlap the boundary shown. A regional potentiometric-surface map is included in this EIS.

It should be recognized that the description in the EIS of the affected environment is a broad summary of the enormous amount of information that has been compiled for the Yucca Mountain site and surrounding areas. The hydrochemical data used to support the conceptualization of groundwater flow patterns in this case is a level of information too detailed for this document. The information under consideration (that is, the general direction of flow through Amargosa Desert and its primary discharge at Alkali Flat) is reported in numerous studies and is not known to be a point of significant contention. The *Yucca Mountain Site Description* (DIRS 137917-CRWMS M&O 2000) provides more information on the Yucca Mountain site and region.

7.5.3 (4602)
Comment - EIS001452 / 0002
The Chemehuevi Tribe feels that the EIS does not sufficiently address the geological stability nor the underground water issue with regards to flow. Lack of scientific and engineering studies and data collection does not warrant this location as a prime area for high-level nuclear disposal.

The EIS does not provide data regarding the underground water flows or drainage towards the Colorado River. As stated in the EIS, "the underground water system is very complex" which indicates that no confirming data to indicate without a doubt that waters do not flow into the Colorado River.

In the event of a major earthquake at Yucca Mountain, there could be the possibility of contamination of the underground water system and the Colorado River, thus contaminating the waters of Havasu Lake and the Chemehuevi Indian Reservation.

Furthermore, attached to this statement is a copy of the Chemehuevi Tribe's Ordinance No. 97.1, PROHIBITING THE DISCHARGE OF ANY POLLUTANT INTO THE WATER OF THE CHEMEHUEVI INDIAN RESERVATION.

Response
DOE has conducted an extensive site characterization program to evaluate the proposed repository at Yucca Mountain, which is in the Death Valley Regional Groundwater Flow System. Death Valley is a closed hydrologic basin, which means that its surface water and groundwater can leave only by evaporation from the soil and transpiration from plants. This area is characterized by a very dry climate, limited surface water, and very deep aquifers. The regional slope of the water table (potentiometric surface) indicates that the groundwater flows south toward Amargosa Valley. The Central Death Valley subregion is comprised of three groundwater basins that are subdivided into smaller sections. Yucca Mountain is in the Alkali Flat-Furnace Creek groundwater basin, in which

only a small portion of the total basin recharge actually infiltrates through Yucca Mountain. The water that infiltrates the mountain and becomes groundwater recharge then flows toward Fortymile Wash and discharges with the rest of the groundwater in the Fortymile Canyon section of the groundwater basin. Flow continues south toward Amargosa Valley in the Amargosa River section (see Figure 3-15 of the EIS). The natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, more than 60 kilometers (37 miles) away, and not at the Colorado River or Lake Havasu and the Chemehuevi Indian Reservation.

Extensive studies conducted at Yucca Mountain show evidence of low infiltration and percolation rates, long groundwater residence times, and a repository horizon that has been hydrologically stable for long periods. The proposed repository emplacement areas would be in areas away from faults that could affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3 (4640)
Comment - EIS001164 / 0001
The local geology is part of a very large context. The context is the intermountain basin and range country which is a very thin part of the earth's crust. Therefore, it is stretching, bulging and subject to fairly massive earth movements, volcanism and earthquakes in the future that are simply unknowable at the present time other than they are more likely here than virtually any other place on the continent except perhaps from right along the Rim of Fire along the Pacific Ocean. But of course, it's the action over there that is driving, actually pulling the crust apart in Nevada, and it's that pulling apart of the crust that is particularly worrisome to me.

Response
DOE shares the commenter's perception that the geology of the site must be understood within the context of the surrounding region. Section 3.1.3 of the EIS discusses both regional and site geology. The *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) discusses the regional geologic setting in much greater detail than is appropriate for the EIS. While the basin and range is a product of crustal extension, it is not located along a boundary of one of the tectonic plates that comprise the Earth's crust. Therefore, the tectonic setting of the site is not comparable to locations along the "Ring of Fire" such as California in the vicinity of the San Andreas fault, the Aleutian Islands, or Japan. Section 3.1.3.3 discusses the assessment of potential seismic and volcanic hazards. These assessments are based on both regional and site data and are described in greater detail in Section 12 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000).

Section 3.1.3.1 of the EIS discusses Yucca Mountain as part of a volcanic plateau that formed between 14 million and 11.5 million years ago during explosive silicic eruptions that originated from several calderas north of the site. About 11 million years ago, this explosive activity began to wane and was replaced by less explosive and much less voluminous basaltic eruptions in the Yucca Mountain region. The most recent basaltic eruption occurred between 70,000 and 90,000 years ago at Amargosa Valley, about 10 miles south of the site. A panel of outside experts examined the data, models and related uncertainties and concluded that the probability of a volcanic dike disrupting the repository during the first 10,000 years after closure is 1 chance in 7,000 (one chance in 70 million annually). This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

DOE has been monitoring earthquakes in the Nevada Test Site region since 1978. Faults and earthquakes have been investigated as part of the site characterization program to assess seismic hazards at the site. Using the seismic hazard information, repository surface facilities would be designed to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for

Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

7.5.3 (4702)
Comment - EIS001229 / 0004
The Yucca Mountain site and surrounding area has a history of earthquakes and volcanoes. There have also been major fluctuations in the water table. However, the Department of Energy has ceased consideration of any other geologic repository sites before the Yucca Mountain has been demonstrated to be safe. The Missouri Coalition for the Environment opposes transporting high-level wastes to this unproven and yet-to-be-constructed repository.

Response
Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes potential impacts from accident scenarios associated with earthquakes during repository operations. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository.

Section 3.1.4.2.2 of the EIS discusses evidence that the elevation of the water table at Yucca Mountain has fluctuated over time, due largely to changes in the climate. Based on the evidence, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate the waste-emplacement areas at Yucca Mountain. Section 3.1.4.2.2 (Saturated Zone) discusses opposing views on fluctuations in the elevation of the water table. A small number of investigators believe that the water table has risen in the past to elevations higher than the waste-emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than 120 meters (390 feet) higher than the present level.

7.5.3 (5207)
Comment - EIS001443 / 0031
Groundwater modeling used as the basis for the DEIS does not take into account the potential for accelerated transport of radionuclides due to projected increases in regional groundwater extractions. Growth in Pahrump, the Amargosa Valley, and possible development of pending regional groundwater claims by the City of Las Vegas may lead to significant changes in the direction and volume of groundwater flow from Yucca Mountain. It is well within the ability and purview of DOE to attempt a reasonable projection of the effects of urban development on the regional groundwater system and to incorporate these expectations into the groundwater models utilized in development of the DEIS.

Specific Recommendation: Groundwater modeling conducted in support of the repository site evaluation process should be reworked to incorporate reasonable projections of future regional groundwater usage. The likely effects of regional groundwater development on contaminant plume paths, velocity, and radionuclide concentrations should be projected and mapped.

Response
Predicting trends in long-term future growth is difficult to do with confidence. This was recognized by the National Academy of Sciences, National Research Council, in its advice to the Environmental Protection Agency concerning the development of radiation-protection standards for Yucca Mountain (DIRS 100018-National Research Council 1995). It was the Council's opinion that attempts to predict future human activities and events should not be made because they would likely be more in error than using present-day conditions. In keeping with this recommendation, DOE made no attempt to predict the future course of human activity with respect to how these events could affect the long-term performance of the repository. Nevertheless, some of the uncertainties associated with groundwater flow at and near Yucca Mountain required that the Department incorporate a wide range of flow and transport parameters into the modeling effort. For example, the effective porosity (and, therefore, the resultant flow velocities modeled) for water-bearing strata was sampled from distributions typically ranging over four orders of magnitude (DIRS 101779-DOE 1998). It is reasonable to expect that any changes in aquifer behavior from drawdown due to human development would be small compared to the large variability range modeled, and thereby incorporated within the statistical range reported. In addition, with respect to the long-term performance of the repository,

simulated changes in the climate (ranging from very wet to very dry climates) easily captured the effects of any changes to the hydrologic setting caused by human activities.

7.5.3 (5491)
Comment - EIS001887 / 0159
Page 3-29 to 30; Section 3.1.3.3 - Modern Seismic Activity - Seismic Hazard

The Final EIS should include the updated results of Dr. Wernicke's research relative to tectonic deformation and make any necessary adjustments in seismic and volcanic risk estimates.

Response
DOE is continuing to fund additional investigations on the regional crustal strain rate in the Yucca Mountain region as specified in a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to the DOE that conclusions from this study would be available in 2002. This study involves 30 geodetic monument sites with continuous Global Positioning System measurements, a significant improvement over the previous study mentioned in the comment. The Final EIS incorporates the best available information.

7.5.3 (5596)
Comment - EIS001887 / 0222
Page 4-18; Section 4.1.3 - Impacts to Hydrology

The Draft EIS should give a map delineating the "region of influence." Is this region the same as the proposed 150,000 acres withdrawal area?

Response
Section 4.1.3 of the EIS describes the regions of influence for both surface water and groundwater. In neither case are the regions of influence limited to the proposed 150,000-acre withdrawal area nor can they be represented by firm boundaries on a map. Potential impacts to surface water includes not only runoff channels that could be disturbed by or receive direct runoff from proposed activities at Yucca Mountain, but downstream collection channels as well. With respect to groundwater, the region of influence encompasses those aquifers beneath Yucca Mountain and downgradient aquifers to which they contribute water.

Chapter 3 of the EIS contains descriptions and maps of the affected environment to better understand the regions of influence described in Chapter 4.

7.5.3 (5597)
Comment - EIS001887 / 0223
Page 4-19; Section 4.1.3 - Impacts to Hydrology

Define and quantify "minor changes," "minor impacts," "extremely small," and "very low."

Response
The first three phrases in the comment ("minor changes," "minor impacts," and "extremely small") are associated with summary statements that describe conclusions reached through analyses presented later in the text. Those later discussions provide an understanding of what each phrase means. Some of the conclusions reached in the discussions are based on qualitative analyses, with no attempt to associate a value or quantity with the conclusion. The use of "very low" in the second paragraph in Section 4.1.3.1 to describe the potential for groundwater contamination during preconstruction testing and performance confirmation studies is such a case. In this section and in general throughout the EIS where qualitative analyses lead to a description of impacts using terms such as "minor" or "extremely small," DOE feels that the topic is not a major issue and that the associated discussion should lead the reader to the same conclusion. DOE believes this approach is consistent with Council on Environmental Quality regulations that state [40 CFR 1502.2(b)], "Impacts shall be discussed in proportion to their significance. There shall be only brief discussion of other than significant issues. As in a finding of no significant impact, there should be only enough discussion to show why more study is not warranted."

7.5.3 (6348)

Comment - EIS001793 / 0003

Both DOE and many other scientists find many problems with this whole process. There is extensive geological data, as many people have mentioned, on Yucca Mountain. The area could not possibly keep the waste isolated. It is highly seismologically active, it contains many past volcanoes and possible magma pockets now. It has highly fractured rock and will allow flow of water and radioactive materials to occur.

Response

Based on the results of analyses on the long-term performance of the repository (Chapter 5 of the EIS), which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197). Section 3.1.3 of the Draft EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Regarding a possible magma pocket beneath Yucca Mountain, Biasi (DIRS 105358-1996) demonstrated rather conclusively that there is no low-velocity zone (a geophysical anomaly that could indicate a magma pocket) under either Crater Flat or Yucca Mountain that would suggest a major volcanic hazard. Section 4.1.8 of the EIS describes the impacts from earthquakes during operation of the proposed repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the proposed repository, have been adequately described and analyzed in the EIS.

Regarding the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the Draft EIS explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3 (6427)
Comment - EIS001632 / 0012
Second, this paragraph [p. 2-37, Section 2.1.2.3] states, "Provisions could be added for post-closure monitoring." The EIS should elaborate on when and how DOE would add post-closure monitoring.

Response
DOE would design and implement a postclosure monitoring program in compliance with the Nuclear Regulatory Commission regulations (10 CFR Part 63). Before closure, DOE would submit an application for a license amendment to the Commission for review and approval. The application would include, among other items:

1. An update of the assessment of the performance of the repository for the period after closure

2. A description of the postclosure monitoring program

3. A detailed description of measures to regulate or prevent activities that could impair the long-term isolation of the waste, and to preserve relevant information for use by future generations

The application also would describe DOE's proposal for continued oversight to prevent any activity at the site that would pose an unreasonable risk of breaching the repository's engineered barriers, or increase the exposure of individual members of the public to radiation beyond limits allowed by the Nuclear Regulatory Commission. DOE has modified Chapter 9 of the EIS to include the types of monitoring and other institutional controls that would be contemplated. The Department would develop the details of this program during the consideration of the license amendment for closure. This would allow the Department to take advantage of new technological information, as appropriate.

7.5.3 (6506)
Comment - EIS001813 / 0001
Groundwater upwelling and earthquakes are two issues not adequately addressed in the DEIS. DOE does not address the potential impact of dramatically higher water table levels than currently exist even though their own studies provide evidence that suggests this is an actual possibility. The DEIS states that "earthquakes have occurred in the Yucca Mountain geologic region of influence and are likely to occur in the future." Yet the DOE has repeatedly ignored the potential impacts of future earthquakes at the Yucca Mountain site and refuses to examine how an earthquake might affect the region's groundwater supply.

Response
Section 3.1.4.2.2 of the EIS discusses several opposing views concerning fluctuations in the elevation of the water table at Yucca Mountain. These investigators believe that the water table at Yucca Mountain has risen in the past to elevations that are higher than the subsurface waste-emplacement areas. DOE does not concur with these opposing views, nor did an expert panel that was convened by the National Academy of Sciences to specifically examine this issue (see Section 3.1.4.2.2 of the EIS for details). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level.

Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including seismicity. Section 4.1.8 of the EIS describes the impacts of earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and their effects on the performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on seismic activity, and the effects of this activity on the repository is adequately described and analyzed.

With regard to the effects of earthquakes on the region's groundwater supply, Section 3.1.4.2.2 describes the effects on well-water levels after earthquakes. In brief, water levels have fluctuated by as much as 0.9 meter (3 feet) in response to earthquake events, and confined water pressure deep in wells has fluctuated by as much as 2.2 meters (7 feet) in response to those same events. However, the water levels return to pre-earthquake levels within minutes to hours. An exception was an earthquake in the summer of 1992 that caused water levels in some wells at Yucca Mountain to fluctuate over a few months. Some investigators have speculated that earthquakes can cause very large fluctuations in water levels. Although these opposing views are described in Section 3.1.4.2.2, DOE does not concur with these views, nor did an expert panel that was convened by the National Academy of Sciences to specifically examine this issue. In summary, fluctuations in the elevation of the water table and changes in the water supply from earthquakes would be neither large nor long-lived.

7.5.3 (6648)
Comment - 010402 / 0002
Directly associated with the issue of geologic stability is the fact that radioactive water was found to be leaking into the excavated test tunnel area. The presence of radionuclides from nuclear testing found in the water are a clear indicator that this water made its way from surface origins to deep in Yucca Mountain in less than 50 years. Moisture from any source will speed the decomposition of the casks holding the irradiated fuel. The earlier that the integrity of the casks are breach [breached], will allow for higher the levels of radiation leakage into the surrounding environment. It should be noted that no matter how the casks are constructed, they would not last as long as the radioactive life of the waste inside.

All radiation leaks from this deadly waste will endanger the aquifer under Yucca Mountain. This aquifer is the major water source for the farmers, ranchers, and citizens of Amargosa Valley, Beatty and Oasis Valley. In a desert environment lacking other water sources, it is foolhardy and reckless to say the least to risk contamination of this aquifer.

Response
As described in Section 3.1.4.2.2 of the EIS, DOE has used the isotope chlorine-36 to investigate the nature of water infiltration and deep percolation at Yucca Mountain. These investigations have detected elevated amounts of "bomb-pulse" chlorine-36 from atmospheric testing of nuclear weapons during the 1950s and 1960s. The bomb-pulse chlorine-36 in the subsurface at Yucca Mountain is generally associated with faults and well-developed fracture systems close to these faults. The elevated amounts of chlorine-36 could be evidence of a connected pathway through which surface precipitation has percolated to depth within the last 50 years.

DOE believes that these findings do not indicate that the Yucca Mountain site would be unsuitable for development as a repository. Most of the water that infiltrates through Yucca Mountain moves slowly through the matrix and fracture network of the rock. Isotopic data from water extracted from the rock matrix indicate that the residence time of groundwater might be as long as 10,000 years. Furthermore, after excavating more than 11 kilometers (8.4 miles) of tunnels at Yucca Mountain, DOE found that only one fracture was moist (there was no active flow of water). This observation has been confirmed in test alcoves that are not subject to the effects of drying from active ventilation.

To ensure the correct interpretation of this chemical signal, DOE instituted additional studies to determine if independent laboratories and related isotopic studies can corroborate the detection of elevated concentrations of chlorine-36. Results of the validation studies to this point have not allowed firm conclusions and, thus, the evaluations continue. Nevertheless, the results of the Total System Performance Assessment described in Chapter 5 of the EIS incorporate the fast-flow data. The results show that the combination of natural and engineered barriers at Yucca Mountain would keep releases of contaminants during the first 10,000 years after closure well below the radiation limits established in 40 CFR Part 197.

Another important factor concerning the safety of the emplaced waste is whether percolating water would actually contact the waste packages. The process of drift excavation creates a capillary barrier that would cause the diversion of percolating water around the drift opening, further reducing the amount of water potentially capable of contacting waste packages. DOE is conducting experiments to determine the seepage threshold, which is the amount of water necessary to overcome the capillary barrier caused by excavation. Results to date suggest that the amounts of percolating water at the waste-emplacement level could be insufficient to exceed the existing capillary barrier. To increase the confidence in the safe, long-term performance of the repository, the Department would include titanium drip shields to cover the waste packages and divert any water that might infiltrate to these depths away from the waste packages. This design is described in Chapter 2 of the EIS.

7.5.3 (6957)

Comment - EIS001251 / 0001

There are physical limitations within Yucca Mountain that make it unsuitable for long-term geologic storage of radioactive waste materials.

I'm sure you are aware of the strain rates on Yucca Mountain measured by the team of Caltech and Harvard seismologists using DGPS (Wernicke et al., Science 279, 27-Mar-98, pp. 2096-2100). These measurements corroborate other triangulation records and demonstrate a strain rate "about three to four times the average Basin and Range rate." The authors believe that this strain rate will result in volcanic activity across Yucca Mountain, the Lathrop Wells cone already being the first. I see no accounting of this seismological evidence in the DEIS. I want to see this matter, the strain rate, and possible volcanic activity during the expected life of the waste site, fully explored and discussed openly.

Another matter of utmost concern is the presence of "bomb-pulse" Cl-36 and Tc-99 in rocks taken from three fracture zones (and perhaps three others) in the Exploratory Studies Facility, demonstrating fast flow in Yucca Mountain (Fabryka-Martin, et al. LA-13352-MS, UC-802, December 1997). The high strain rate (see above) will probably increase the number of fracture zones. Fast flow within the mountain requires that, once a canister corrodes, its contents will flow quickly into the environment. Surely the danger to living systems needs no further emphasis.

It is very important that the physical limitations of the Yucca Mountain site be recognized. If we are truly putting the huge quantities of radioactive wastes away for all time, and not merely responding to political expediency, then we must give grave attention to Yucca Mountain's flow patterns and instabilities. Please inform me of any action you take on these matters.

Response

As reported in Section 3.1.3.3 of the EIS, Wernicke et al. (DIRS 103485-1998) claims that the crustal strain rates in the Yucca Mountain area are at least an order of magnitude higher than the tectonic history of the area would predict. This study speculates that higher strain rates would indicate underestimation of potential volcanic and seismic hazards on the basis of the long-term geologic record. In May 1998, U.S. Geological Survey scientists reassessed seismic strain rates (DIRS 118952-Savage, Svarc, and Prescott 1999). The principal strain rates determined during the 1983-to-1998 survey confirmed previous analyses and were significantly less than those reported by Wernicke et al. (DIRS 103485-1998). The Survey scientists concluded that the residual strain rate in the Yucca Mountain area is not significant at the 95-percent confidence level after removal of effects of the 1992 Little Skull Mountain earthquake and the strain accumulation on faults in Death Valley.

DOE is continuing to fund additional investigations on the regional crustal strain rate in the Yucca Mountain region as specified in a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to DOE that conclusions from this study would be available in 2002. The Department would report conclusions as they became available. If the higher crustal strain rates were confirmed, DOE would reassess the volcanic and seismic hazard at Yucca Mountain.

The hydrologic model of Yucca Mountain is a fault-fracture flow system. The hypothetical addition of a few new faults and associated seismic events would have negligible effects on the current fault- and fracture-flow pathways. Potential new faults and fractures, therefore, would be unlikely to alter repository performance. However, if there was confirmation of higher crustal strain rates, DOE would reassess the effect on radionuclide transport and total system performance.

Yucca Mountain is part of a volcanic plateau that formed between 14 million and 11.5 million years ago during explosive silicic eruptions that originated from several calderas north of the site. About 11 million years ago, this explosive activity began to wane and was replaced by less explosive and much less voluminous basaltic eruptions in the Yucca Mountain region. The most recent basaltic eruption occurred between 70,000 and 90,000 years ago at Amargosa Valley, about 16 kilometers (10 miles) south of the site. A panel of outside experts examined the data, models and related uncertainties and concluded that the probability of a volcanic dike disrupting the repository during the first 10,000 years after closure is 1 chance in 7,000 (1 chance in 70 million annually). The estimate was recalculated in Section 3.1.3.1 of the EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

7.5.3 (7081)
Comment - EIS001847 / 0013
Why will Yucca Mountain fail to isolate nuclear waste? Why is it fractured? The answer is very simple. This area is as seismically active as the California Bay Area. There have been more than 600 earthquakes within a 50-mile radius of the site within the last 20 years. A major jolt knocked windows out of a DOE facility in the early 1990's. In 1998 and 1999 there have been a whole spate of tremblers, at greater frequencies than previously observed.

All this shaking has fractured the relatively soft rock (tuff) that forms this low snaking ridge. There are 35 active fault lines in the area, including two that traverse the repository site itself, but the entire mass of Yucca is a sieve with tiny fractures that allow water and gas to flow.

A striking feature of the Yucca landscape is a line of lava cones that extends to the west of the Mountain. The youngest cone is closest to Yucca Mountain. This is clear evidence of the possibility of a magma pocket, which the earth's crust is moving slowly across. Like the formation of the Hawaiian Islands, these lava cones are like the squirts from a subterranean pastry bag.

Further evidence supporting the presence of a magma pocket comes from research published in Science magazine under contract with the U.S. Nuclear Regulatory Commission. The use of global positioning satellites allows tracking of the movement of Earth's crust. The crust at Yucca is expanding. It is also moving westward at an accelerating rate. The authors conclude that this evidence is "consistent with" the presence of a magma pocket under Yucca Mountain.

The Western Shoshone People who have rightful claim to the land at Yucca Mountain have a different name for this site. It translates: "Serpent Swimming West." If we would listen to ancient wisdom, and pay attention to the earthquakes, we might be able to avert a major environmental catastrophe of burying nuclear waste where it will almost certainly leak.

Response
Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197). Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region.

The geodetic study reported in the March 1998 issue of *Science* (DIRS 103485-Wernicke et al. 1998) was based on baseline measurements using the Global Positioning System over the period 1991 through 1997 at five stations in the Yucca Mountain area. (This topic is discussed in Section 3.1.3.3 of the EIS.) While the authors of that study discussed the possible effects on their network from displacements associated with the June 1992 Little Skull Mountain earthquake, they did not correct the station-to-station distances for earthquake displacements.

In May 1998, scientists from the U.S. Geological Survey resurveyed a network of 14 geodetic stations that was originally installed in 1983. Two of the 14 stations were used by Wernicke et al. (DIRS 103485-1998) in their study. Based on the greater number of stations, the longer survey period (1983 through 1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake, the U.S. Geological Survey scientists concluded that the strain rate in the Yucca Mountain region is significantly less (a factor of 20 or more) than the rate reported by Wernicke et al. (DIRS 103485-1998). These results are consistent with a large body of geological and paleoseimological data that have been collected in the Yucca Mountain region during the past two decades.

Wernicke et al. (DIRS 103485-1998) speculated that the high strain accumulation across the Yucca Mountain area could be caused by magmatic inflation at depth. They pointed to an early seismic study by Oliver, Ponce, and Hunter (DIRS 106447-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study by Biasi (DIRS 105358-1996) demonstrated rather conclusively that there is no low-velocity zone (for example, magma pocket) under either Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

Section 4.1.8 of the EIS describes the impacts from earthquakes during operation of the proposed repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository, have been adequately described and analyzed in the EIS.

Regarding the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the Draft EIS explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3 (7199)

<u>Comment</u> - 010162 / 0001

Granite is porous. And as a result, and I hear our friend and welcome him from Wisconsin, talking about granite. All of these rocks are porous, and they will eventually dissolve either through microbic invasion, those are my bugs, or through natural erosion and whathaveyou.

<u>Response</u>

The rock at and below Yucca Mountain is, for the most part, composed of many thousands of feet of various types of volcanic flows that are millions of years old. Below these volcanic layers are many thousands of feet of older sedimentary rock. Sections 3.1.3 and 3.1.4 of the EIS describe the geologic and hydrologic settings of Yucca Mountain and the surrounding region in great detail. Based on the results of modeling of the long-term performance of the repository (see Chapter 5 of the EIS), which considered surface precipitation reaching the underground repository within decades and possible microbial degradation, DOE believes that the repository would operate safely; that is, it would be in compliance with the radiation-protection standards developed by the Environmental Protection Agency for the Yucca Mountain site (10 CFR Part 197).

7.5.3 (7387)

<u>Comment</u> - EIS001957 / 0014

No mention is made in the draft EIS of studies that have been conducted that have simulated the effects of potential increased infiltration at the proposed site (due to a wetter climate). One such study, for example, was published in the Journal of Ground Water of the Association of Ground Water Scientists & Engineers, July-August 1999, entitled Numerical Modeling of Perched Water Under Yucca Mountain, Nevada, by J.J. Hinds (of Lawrence Berkeley National Laboratory) and others. Significant excerpts are as follows:

“These perched water bodies are believed to have important implications for ground water travel times and flow pathways, and for radionuclide transport through the unsaturated zone. Perched water could potentially increase corrosion rates of engineered waste canisters and shorten ground water travel times, leading to more rapid and focused dispersal of radionuclides to the environment. Consequently, a thorough understanding of perched water dynamics is necessary for site evaluation.”

“To investigate the effect of a wetter climate on the unsaturated flow regime, we use the approximate steady-state results from the base-case scenario as our initial conditions and increase the infiltration rates by a factor of five ...a simulation time of 10,000 years is used, since it represents the period of time over which the waste should remain isolated.”

The article goes on to state effect of higher infiltration rates on the perched water system is substantial:

“The simulations presented in this study illustrate how contrasts in...climate...can affect moisture distribution and flow within the unsaturated zone and, particularly, the perched water system under Yucca Mountain. The persistence of perched water has important implications for waste isolation. The migration of radionuclides away from a potential repository may accumulate in perched water bodies and may become focused along structural pathways, like faults, that cut through the major hydrogeologic units and provide a direct link to the water table, allowing flow to bypass sorptive zeolites. The simulations presented here illustrate that moisture, accumulating at lithologic boundaries to form perched water, may drain to the water table along fault zones. Additional results show that the size of perched water at Yucca Mountain is sensitive to changes in climate. The introduction of more moisture into the subsurface by increasing infiltration leads to shorter ground water travel times and growth of perched water bodies...”

We contend based upon this material that the draft EIS is inadequate in assessing effects of possible climate changes over the next 10,000 years on the likelihood of transport of radionuclides from the proposed repository to the water table, and the regional ground-water flow systems, which discharge at Death Valley [NP] National Park.

Response
Section 3.1.4.2.2 of the EIS describes the occurrence of perched water below the proposed repository. The presence of perched water above the regional water table is a positive factor in relation to the potential transport of radionuclides from the repository for the following reasons:

1. The fact that water is perched between the repository horizon and the water table indicates a barrier to flow. In this case, the perching layer possesses less matrix permeability and has a smaller fracture density than the overlying rocks.

2. The age of the perched water is thousands of years. The perching layer appears to impede the downward flow of water so that the water has aged substantially (thousands of years) in its current location. This increased residence time affords greater opportunity for diffusion and sorption of radionuclides that are potentially released from a breached repository.

While the studies mentioned in the comment are not directly mentioned in the EIS, these studies were an integral part of the development of the Total System Performance Assessment. Perched water bodies, wetter climates, and related conditions (as mentioned in the comment) are incorporated directly into the calculations to estimate long-term performance of the repository. The higher infiltration rate mentioned is equivalent to the superpluvial climate included in the modeling. In the model, the faster flowpaths and the shorter travel distances occur during wetter climatic conditions.

7.5.3 (7457)
Comment - EIS001969 / 0011
Page S-36, 5.4.1.3 [S.4.1.3] Geology, second paragraph.

The correct name of the repository host rock is the Topopah Spring Tuff, not “Topopah Springs Formation” or “Topopah Springs formation.”

Response
DOE has corrected the name of the repository host rock to “Topopah Spring Tuff.”

7.5.3 (7469)
Comment - EIS001969 / 0015
Page 3-16, Site Stratigraphy and Lithology.

The sedimentary history of the region including the Tertiary sedimentary rocks (for example Pavits Springs Formation) need to be discussed in this section and included in Table 3-6 (page 3-19).

Response
Although the EIS is concerned with the sedimentary history of the region and sedimentary rock units at Yucca Mountain, the main focus is on those units important for the study of groundwater infiltration, flow, and transport. Table 3-6 is highly generalized and identifies only the Topopah Spring Tuff, the repository host rock, by name. The commenter is referred to other parts of Section 3.1.3 of the EIS that describe the history and stratigraphy of the Yucca Mountain area, and to Table 3-7, which describes the Tertiary rock units at Yucca Mountain in more detail than Table 3-6.

7.5.3 (7506)
Comment - EIS001969 / 0017
Page 3-19, first paragraph.

The “pre-Cenozoic” (see above) rocks are also exposed at Calico Hills and Striped Hills, which are as close or closer to Yucca Mountain than are the pre-Cenozoic rocks at Bare Mountain, and therefore should be included in the discussion.

For clarity, the borehole (first paragraph) should be described as 2 kilometers east of the crest of Yucca Mountain, because Yucca Mountain is physiographically defined as all the numerous ridges that surround the borehole.

Response
This comment is correct. DOE has revised Section 3.1.3.1 of the EIS to include the exposures at Calico Hills and Striped Hills.

7.5.3 (7514)
Comment - EIS001969 / 0022
Page 3-25, Section 3.1.3.2 Geologic Structure.

Discussion of the occurrence of joints and fractures in the volcanic rock at Yucca Mountain is needed in this section, including mention of the geographic and stratigraphic distribution of fractures, and whether they are fault- and/or stratigraphically-controlled.

Response
DOE has modified the discussion in Section 3.1.3.2 of the EIS. The faults described are well-defined structures; joints, along which there is no appreciable movement, also occur in the rock units mapped at the site. Within the Paintbrush Group (Tiva Canyon, Yucca Mountain, Pah Canyon, and Topopah Spring tuffs), joints have been subdivided into three groups based on how they developed and their approximate time of origin: early cooling joints, later tectonic joints, and joints due to erosional unloading (DIRS 151945-CRWMS M&O 2000). Each group of joints exhibits specific characteristics with respect to joint length, orientation, and connectivity. The cooling and tectonic joints have similar orientations (generally trending north-south), whereas cooling joints include irregularly spaced horizontal joints as well. Joints that developed from erosional unloading are variably oriented but trend predominantly east to west, perpendicular to the cooling and tectonic joints. Tectonic joints occur throughout the Paintbrush Group; cooling joints occur in each of the welded units. In general, the Tiva Canyon tuff and the Topopah Spring tuff have the highest joint frequencies and joint connectivities. The nonwelded Yucca Mountain tuff and the Pah Canyon tuff have the fewest joints. Geologic, geoengineering, and hydrologic aspects of fractures are discussed in detail in the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000). DOE has added to Section 3.1.3.2 of the EIS more information about joints and fractures in the volcanic rock at Yucca Mountain.

7.5.3 (7517)
Comment - EIS001969 / 0023
Page 3-25, Section 3.1.3.2 Geologic Structure, second paragraph.

“Major crustal compression” and “crustal extension” need to have an associated direction, such as “Major east-west crustal compression” and “east-west crustal extension.”

Crustal compression is stated to have occurred between 350 and 50 Ma [million years ago], but there is no evidence for east-west compression younger than about 100 Ma in this region.

Response
The text in Section 3.1.3.2 has been modified to indicate that major east-west crustal compression occurred periodically in the Great Basin between about 350 million years ago to about 65 million years ago. This compression moved large sheets of older rock great distances upward and eastward over younger rocks to produce mountains. References to support this discussion include Armstrong (DIRS 101583-1968), Fleck (DIRS 150625-1970), CRWMS M&O (DIRS 100127-1998), and Dunne (DIRS 102861-1986).

7.5.3 (7859)
Comment - EIS001653 / 0039
The groundwater section [3.1.4.2] also needs a thorough discussion of groundwater users in the region of influence including the type and amount of use. Future water demands estimates should be described with low, medium and high growth scenarios and not assume that the population does not grow. The DEIS concludes that Amargosa Valley area population in 10,000 years will be the same as in 1990.

Response
According to Council on Environmental Quality regulations (40 CFR 1502.15), descriptions of the environment potentially affected by a proposed action or its alternatives shall be no longer than is necessary to understand the effects of the alternatives. DOE understands that people with a particular interest in water might wish to see more detail, but believes that Section 3.1.4.2.1 of the EIS, and particularly Table 3-11, provide an adequate summary of water use in the region of influence.

Sections 4.1.3.3 and 4.1.11.2 of the EIS address projected water demands attributed to the construction and operation of the proposed repository and due to population growth as a result of the Proposed Action, respectively. Both sections evaluate impacts of the Proposed Action's water needs primarily by comparing them to current water demands. This is a conservative evaluation because the relative impact would only decrease as population grew and water demand associated with the Proposed Action became an even smaller portion on a percentage basis.

DOE assumes that the comment's reference to the use of current population numbers in 10,000 years is directed toward the long-term performance assessment discussed in Chapter 5 of the EIS. DOE did base population consequences for the 10,000-year evaluation on current population numbers. As described in Section 5.2.4.1 of the Draft EIS, DOE's use of current population numbers was in accordance with guidance provided by the National Research Council of the National Academy of Sciences. The guidance states that due to the difficulty of long-term population projection, calculations of population dose should use present population numbers.

DOE recognizes the potential for disagreement with the long-term population assumptions presented in Chapter 5, but does not have a basis on which to predict long-term population changes quantitatively and, therefore, chose to follow National Academy of Sciences guidance rather than perform such a speculative analysis. In addition, DOE notes that the evaluation does not take credit for future technologies that could improve the ability to remove radioactive materials from drinking water or the environment or for medical advances that could involve cures for cancer.

DOE has revised Chapter 5 of the EIS extensively to address the results of updated analyses. The updates cover new data collected from ongoing investigations and changes in the repository design. DOE has modified Chapter 5 analyses to conform to new standards promulgated by the Environmental Protection Agency and Nuclear Regulatory Commission as published in 40 CFR Part 197 and 10 CFR Part 63, respectively. These standards will be used to judge the performance of the repository as part of the licensing process. Chapter 5 now addresses exposure scenarios set by these standards, which define a hypothetical reasonably maximally exposed individual and a groundwater protection standard set for a hypothetical community. The hypothetical community has a defined population and location with respect to its distance along the groundwater flow path from Yucca Mountain.

7.5.3 (7956)
Comment - EIS001933 / 0001
You know that Yucca Mountain is not a mountain at all but just a ridge and that it's white band is a result of sudden shifting.

Response
DOE agrees that, as a landform, Yucca Mountain is a ridge. The Department is not clear, however, what the commenter means with regard to "a white band is a result of sudden shifting." The exposed rocks at Yucca Mountain are shades of brown and gray.

7.5.3 (8436)
Comment - 010242 / 0019
Page 2-20: Figure 2-7 - Proposed Action repository layouts for the Draft EIS high, intermediate, and low thermal load scenarios, and the S&ER flexible design operating mode.

The S&ER flexible design operating mode repository layout includes possible extensions of the repository into areas that have not been characterized with the benefit of the Exploratory Studies Facility and the cross drift. The northern extension would bring the waste emplacement area closer to the area known as the large hydrologic gradient, for which a satisfactory explanation of its origin has not been determined (and apparently is not intended to be). The southern extension area has not been investigated for the possibility of its being transected by another

NW-SE fault similar to the Sundance Fault. Also, rock characteristics, thickness of formations, and fault offset are known to vary from north to south at Yucca Mountain, all of which require detailed investigation before being included in the models used for performance assessment. Additional data, information, and analysis is needed before the S&ER flexible design repository layout is acceptable for inclusion in the Supplement.

Response
Figure 2-7 in the Supplement to the Draft EIS shows the maximum emplacement drift area that would be required for any of the various flexible-design operating modes being considered under the proposed action. Both drift areas shown in the figure for the flexible design are slightly larger than corresponding areas shown for the repository layouts described in the Draft EIS (and also shown in Figure 2-7). The only situations that would possibly require the repository to move into areas beyond the primary and lower block are associated with the Inventory Module 1 and 2 inventories described in Chapter 8 of the EIS. Section 8.1.2.1 describes the potential for the repository to accept the additional Inventory Module 1 and 2 waste as a reasonably foreseeable future action. However, these inventories could not be emplaced in Yucca Mountain without legislative action, because the repository limit is established at 70,000 MTHM. Also described in Section 8.1.2.1, should geologic blocks be needed beyond those supporting the Proposed Action, they would be characterized more fully before their use.

Potential repository areas outside the primary area have been designated (should they be needed). Although these areas have not been characterized to the extent of the primary block, they are not uncharacterized. Many of the studies and evaluations performed during site characterization have included a much broader area than what might be used for the repository. For example, faults within 100 kilometers (62 miles) of Yucca Mountain have been examined using aerial photographs. All with suspected Quaternary movement were evaluated; and the evaluations to estimate the probability of volcanic activity at Yucca Mountain looked at evidence of regional activity.

The comment is correct in noting that the flexible design layout extends farther north than the layouts described in the Draft EIS, and that this is the area of the steep hydraulic gradient, where the groundwater would be closest to the repository level. With respect to further study of this phenomenon, DOE has not said it would perform no further investigations, but that such investigations would have a lower priority than work considered to be critical. This is because DOE believes, based on expert opinions on this topic, that whatever the specific cause of this steep hydraulic gradient, there is no reason to believe that it could adversely affect the proposed repository.

With respect to depth to groundwater, the distance from the level of the repository to the water table has been adjusted slightly in the Final EIS to account for new data and the small change in repository layout. As noted in Section 3.1.4.2.2 of the EIS, the repository block would be at least 160 and as much as 400 meters (520 up to 1,300 feet) above the present water table. [The depth range described in the Draft EIS was 175 to 365 meters (570 to 1,200 feet)]. These are conservative estimates of the depth from the repository to the water table that come from the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000). A more recent document, the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001, Figure 1-13), presents a similar repository layout figure for the flexible design, but the figure is superimposed with groundwater elevation contours. In that figure, and as described in associated text, the depth from the primary block's northern most emplacement drift to the groundwater is about 210 meters (690 feet). The north main access drift loops a little further to the north where groundwater would be higher, but it would not be a location of waste emplacement. Groundwater elevation contours that cover large areas as shown in the Science and Engineering Report figure are based on a limited number of observation wells where the depth to groundwater can actually be measured. As a result, there are uncertainties associated with the exact locations of contour lines between wells. However, in this case there is an observation well located approximately 120 meters (390 feet) north of where the northern-most drift would lie. Accordingly, there is high confidence in the groundwater elevation contours in this immediate area.

7.5.3 (8887)
Comment - EIS001834 / 0028
The DEIS notes an opposing viewpoint, stating that "Several investigators have suggested that the water table in the vicinity of Yucca Mountain has risen dramatically higher than 100 meters (330 feet) above the current level, even reaching the land surface in the past (Szymanksi 1989). If such an event occurred, it would affect the performance of the proposed repository" (p. 3-49). DOE even admits, "if such an event occurred, the long term impacts would probably increase greatly" (p. 5-15). Yet, the DEIS dismisses this possibility and does not address the potential impacts of such an event.

The DEIS notes another opposing viewpoint by Davies and Archambeau which suggests that a moderate earthquake at the site could result in a water table rise of about 150 meters (490 feet) and a severe earthquake could cause a rise of about 240 meters (790 feet) in the water table, which would flood the repository. Nevada ranks third in the nation for current seismic activity. Since 1976, there have been over 600 seismic events of a magnitude greater than 2.5 within a 50-mile radius of Yucca Mountain (see attached document). The DEIS states that "earthquakes have occurred in the Yucca Mountain geologic region of influence and are likely to occur in the future" (p. 5-16). Yet, the DOE has repeatedly ignored the potential impacts of future earthquakes at the Yucca Mountain site and refuses to examine how an earthquake might affect the region's groundwater supply.

Response

Based on the results of analyses reported in Section 3.1.4.2.2 of the EIS, DOE does not believe that the waste emplacement areas would be inundated by a credible rise of the water table. Section 3.1.4.2.2 of the EIS does discuss, however, evidence that the elevation of the water table at Yucca Mountain has fluctuated over time. These fluctuations have been due largely to changes in the climate, as described in Section 3.1.4.2.2. DOE also examined the cumulative effects on the elevation of the water table from a wetter climate, earthquakes, and a volcanic eruption. Based on the evidence at hand, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate waste-emplacement areas at Yucca Mountain.

Section 3.1.4.2.2 discusses several opposing views concerning fluctuations in the elevation of the water table at Yucca Mountain. These investigators believe that the water table at Yucca Mountain has risen in the past to elevations that are higher than the waste-emplacement areas. DOE does not concur with these opposing views, nor did an expert panel that was convened by the National Academy of Sciences to specifically examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level. Although DOE disagreed with the central scientific conclusions of these investigators, DOE continues to support research in this area, as well as on other aspects of the geology and hydrology to enhance the understanding of the site.

Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with the Environmental Protection Agency's Environmental Radiation Protection Standards at 40 CFR Part 197). Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region.

It is true that Nevada ranks third, behind Alaska and California, in seismic activity. Its reputation as a highly active state comes from major historic earthquakes in western Nevada with magnitudes greater than 7 on the Richter scale. Yucca Mountain does not lie within this highly active seismic belt.

Section 4.1.8 of the EIS describes the impacts from earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository, have been adequately described and analyzed in the EIS.

With regard to the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the Draft EIS devotes almost seven pages explaining how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3 (9212)
Comment - EIS001938 / 0001
The DEIS fails to address the potentially devastating ecological impacts of the project on the natural resources of Death Valley National Park and the surrounding region.

The DEIS fails to adequately address possible impacts of the proposed action on natural resources in and around Death Valley National Park (DVNP). At 3.3 million acres, Death Valley is without question America's most spectacular desert National Park. Nearly 3.2 million acres of the Park are designated Wilderness. The mandate of the National Park Service Organic Act of 1916 is that national parks shall be protected such that they "remain unimpaired for the enjoyment of future generations." The DEIS prepared by the DOE completely and utterly fails to ensure that Death Valley National Park will indeed remain unimpaired for future generations. Similarly, the proposed project fails to ensure that the integrity of Wilderness Areas designated by the California Desert Protection Act of 1994 will be protected, or that National Wildlife Refuge (NWR) system lands will be adequately protected from degradation. The document must be revised to assess possible impacts of the proposed action on National Park System lands, Wilderness lands, and the Ash Meadows NWR, and must detail how these critical wildlands will be protected for future generations.

The DEIS does not correctly identify the current boundaries of Death Valley National Park (nor does it identify Wilderness lands that may be affected by the proposed project). The Park was created in 1994 (see P.L. 103-433), and expanded at that time from its previous smaller size as a National Monument. Wilderness areas both within the Park and on Bureau of Land Management (BLM) lands in the region surrounding the National Park were also designated at that time (see ibid.). The additional National Park Service (and Wilderness) lands that could be impacted by contamination from the repository must be disclosed in the final draft, and the potential impact of the project on *all* the lands within this unit of the National Park System – including possible radioactive leakage to groundwater and surface water resources of the Park, as well as possible impacts on resources within the expanded Parklands from accidents involving transport of high level nuclear waste -- must be analyzed. Without accurately identifying the boundaries of DVNP, or of designated Wilderness areas, it is impossible for the DEIS to contain a complete and thorough analysis of possible impacts of the project on the resources contained within DVNP and surrounding wildlands.

DVNP proper contains spectacular mountain ranges and vistas, desert bighorn sheep and other wildlife, and riparian resources including Salt Creek, Saratoga Springs, and numerous springs and seeps, all of which are the lifeblood for numerous plant, animal, bird and fish species, many of them unique to Death Valley. The Devil's Hole Detached Unit of DNVP and the Ash Meadows NWR, both in the Amargosa Valley, contain an amazing system of natural springs and seeps at Ash Meadows. This extensive above-ground aquifer harbors threatened and endangered species including the Devil's Hole pupfish and other endemic flora and fauna. The DEIS not only does not contain an adequate description of these resources, it provides little, if any, analysis of the proposed project on impacts to the natural environment.

3.2 million acres of Death Valley National Park are designated Wilderness. Additional BLM Wilderness areas surround Death Valley. Places like the Kingston Range Wilderness, Resting Spring Wilderness, the Nopah Range Wilderness and Pahrump Valley Wilderness not only contain important natural resources (e.g., springs, flora and fauna, wildlife habitat, archaeological resources), these Wilderness [areas] provide outstanding opportunities for primitive recreation including hiking, backpacking, hunting and nature study. Yet the DEIS has failed to acknowledge possible impacts of the proposed action on these wilderness lands and on wilderness-related recreation.

Response

DOE has conducted an extensive site characterization program to evaluate the proposed repository at Yucca Mountain. The general path of the water that percolates through Yucca Mountain is south toward the Amargosa Valley, into and through the area around Death Valley Junction in the lower Amargosa Valley. Groundwater from beneath Yucca Mountain would merge and mix with underflow from Fortymile Wash and then flow and mix into the very large groundwater reservoir in the Amargosa Desert, where it would move slowly due to the high effective porosity of basin deposits. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume might flow south toward Tecopa in the Southern Death Valley subregion. In addition, a small percentage of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek area of Death Valley.

Sparse potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. Such a divide would limit discharge from the shallow flow system, but would not necessarily affect the deeper carbonate flow system that could contribute discharge to the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and the deeper flow in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson, 1975). The groundwater in the northwestern part of the Amargosa Desert originates in the Amargosa River drainage in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend south from Yucca Mountain. Even if part of the flow from Yucca Mountain mixed into the carbonate pathway that supplies the Furnace Creek springs, it would be too little to significantly affect the springflow chemistry. Considering the small fraction of water that would infiltrate though the repository footprint (approximately 0.2 percent or less) compared to the total amount of water flowing through the basin and the large distances involved [more than 60 kilometers (37 miles) from the source], any component from Yucca Mountain in this very long and complicated flow path would be diluted to such an extent that it would be undetectable.

The National Park Service administers the Devils Hole Protective Withdrawal in addition to Death Valley National Park. The southward path of the groundwater that infiltrates Yucca Mountain includes flow in the Amargosa Desert near Ash Meadows and Devils Hole. In this area there is a marked decline of 64 meters (210 feet) or more in the elevation of the water table between Devils Hole and the low axis (Carson Slough) of the Amargosa Desert to the west and south. This elevation decline indicates that potential groundwater flow from the carbonate rocks of the Devils Hole Hills is westward across Ash Meadows toward the Amargosa Desert, not the other way around. Therefore, potential contamination from Yucca Mountain could not discharge to the surface or contaminate the aquifers at Ash Meadows or Devils Hole under present or likely future climates.

The assessment of long-term repository performance shows that the combination of natural and engineered barriers at the site would keep the doses resulting from releases of radionuclides well below the regulatory limits specified in 40 CFR Part 197 and would keep any release small enough to pose no significant impact on the health and safety of people or the environment. If a small fraction of the water that percolated through the repository footprint flowed into the Furnace Creek area in Death Valley, the mean peak dose would be less than the dose calculated for Franklin Lake Playa. Sections 3.1.4.2.1, 3.1.4.2.2, and 5.4 of the EIS contain additional information.

7.5.3 (9218)
Comment - 010294 / 0002
Define the Capable Faults under the NRC [Nuclear Regulatory Commission] regulations for Nuclear Generating Station Siting.

Response
A "capable fault," as defined in 10 CFR Part 100 (Reactor Site Criteria), is not applicable to Yucca Mountain. The Nuclear Regulatory Commission has developed site-specific standards for Yucca Mountain at 10 CFR Part 63, which include seismic standards.

To answer your question, however, 10 CFR Part 100 defines a capable fault as exhibiting one or more of the following characteristics: (1) Movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years; (2) Macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) A structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

7.5.3 (9800)
Comment - EIS001888 / 0386
[Clark County summary of a comment it received from a member of the public.]

A commenter indicated that the EIS should provide the technical basis to establish a groundwater-monitoring network during the pre- and post-closure phases of the repository, believing that groundwater quality, quantity, and flow in the saturated and unsaturated zones at Yucca Mountain will not be adequately known.

Response
Section 2.1.2.3 of the EIS describes, in general terms, the types of tests, experiments, and analyses DOE would conduct under the repository performance confirmation program. The types of data collected would include air temperature and humidity in the emplacement drifts; the physical condition of waste packages and drifts; groundwater flow or seepage into the drifts; saturated-zone monitoring; and others. These parameters and some of the others identified in this EIS might not be those envisioned by this commenter for monitoring radionuclide migration, but their purposes overlap those described in the comment. The purpose of the performance confirmation program is to evaluate and determine the adequacy of the information used to demonstrate compliance with performance objectives (see Chapter 5). The program would be implemented during all phases of repository construction and operation and continue until the start of closure activities. The long-term performance assessment predicts there would be no release of radiological contaminants from the repository system during the operational period (and for much longer thereafter). However, the performance confirmation program would confirm both that subsurface conditions were consistent with the assumptions used in performance analyses and that barrier systems and components operated within the expected bounds.

In addition, DOE has installed a series of test wells along the groundwater flow path between the Yucca Mountain site and the Town of Amargosa Valley as part of an alluvial testing complex. The objective of this program is to better characterize the alluvial deposits beneath Fortymile Wash along the east side of Yucca Mountain. Single- and multi-well tracer tests have begun and the results thus far have strengthened the basis of the site-scale saturated flow and transport model. Information from this program has been incorporated in the EIS.

7.5.3 (10242)

Comment - EIS001888 / 0591

We have reviewed the Environmental Impact Draft Study (EIDS) [Draft Environmental Impact Statement (Draft EIS)], and have found many areas [that] have been completely over looked.

There were no studies or surveys done in the following areas:

Faults, Possible Earthquakes, Underground Water

The builders of the Titanic believed it was unsinkable, so did those who purchased tickets, so did the press." Now, we know different. Several months ago we experienced an earthquake. It took place at an unnamed fault, unnamed because it was believed by "authorities" in the field to be inactive. Now, we know different.

Response

Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults and future seismicity. Section 4.1.8 describes the impacts from earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository, have been adequately described and analyzed.

Section 3.1.4.2 of the EIS contains a detailed discussion of groundwater at and near Yucca Mountain. Several subsections to 4.1.3 describe the impacts to groundwater during operation of the repository. Section 5.4 describes the long-term consequences to groundwater. Several subsections of 8.2 and 8.3 examine the cumulative impacts to groundwater from the repository, the Nevada Test Site, and other activities in the area that could contribute to long-term groundwater pollution. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on faults, earthquakes, and groundwater is adequately described and analyzed in the EIS.

7.5.3 (10284)

Comment - EIS002094 / 0002

Not only earthquakes, but fast flowing water, crustal expansion, escape pathways for radioactive gases and the possible presence of a magma pocket all plague the site. Most significant of all is the underground aquifer which will carry harmful doses of leaking radiation to human communities downstream for hundreds of thousands of years into the future.

Response

As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring earthquake activity at and near the Nevada Test Site since 1978. DOE has investigated faults and earthquakes during the site characterization program to provide information needed to assess seismic hazards at the site. DOE recognizes there is a seismic hazard at Yucca Mountain, but with proper design a repository can operate safely over the long term. Using seismic hazard information, surface facilities at the repository would be designed to withstand the effects of earthquakes that might occur during the lifetime of these facilities. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is equivalent of an earthquake of magnitude 6.3 within 5 kilometers (3 miles) of Yucca Mountain.

As stated in EIS Section 3.1.3.3, Wernicke et al. (DIRS 103485-1998) claim that crustal strain rates in the Yucca Mountain area are higher than would be predicted from the geologic and tectonic history. If the higher strain rates are valid, the potential seismic and volcanic hazards would be underestimated. In May 1998, scientists with the U.S. Geological Survey conducted a reassessment of crustal strain Savage, Svarc, and Prescott (DIRS 118952-1999). The principal strain rates determined over the 1983 through 1998 survey interval confirmed previous analyses and were significantly less than reported by Wernicke et al. The Survey concluded that the residual strain rate in the Yucca Mountain area is not significant at the 95 percent confidence level after removing the effects of the 1992 Little Skull Mountain earthquake and the strain accumulation on faults in Death Valley.

DOE continues to fund additional research on the regional crustal strain rate in the Yucca Mountain region through a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to the DOE that conclusions from this study would be available in 2002. If the higher crustal strain rates are confirmed, DOE will reassess the volcanic and seismic hazards at Yucca Mountain.

Faults and fractures at the site represent potential pathways for radionuclide migration from the proposed repository. Section 3.1.4.2.2 of the EIS discusses groundwater at Yucca Mountain. The chlorine-36 analyses identified locations where water has moved fairly rapidly from the surface to proposed repository depths, as well as locations where water has moved relatively slowly. Additional age-dating evidence indicates that the groundwater in the lower carbonate aquifer is at least 10,000 to 20,000 years old, which is the approximate age of the groundwater in the overlying volcanic aquifer. These apparent ages indicate that the water in these aquifers was recharged during a wetter and colder climate. The age of the groundwater and the relatively flat hydrologic gradient beneath the site (DIRS 151945-CRWMS M&O 2000) indicate that groundwater beneath the site is moving at a relatively slow rate.

Chapter 5 of the EIS discusses the long-term performance of the proposed repository, which includes predictions of impacts from radioactive and nonradioactive materials released to the environment during the first 10,000 years after repository closure. The principal means or pathways by which these materials would be released is movement through the unsaturated zone beneath the repository and then into the groundwater system. The Yucca Mountain site characterization effort has centered around learning enough about the site to make reasonable projections about how and when contaminants would enter the environment.

The long-term impacts of the repository described in the EIS are based on forecasts involving what the future environment would be like and how natural subsurface features vary over distance. There is some uncertainty associated with these types of forecasts, particularly when they must account for thousands of years and long distances. Section 5.2.4 of the EIS discusses how DOE addressed these uncertainties. Section 5.2.4 also addresses the possible effects that uncertainties could have on the impacts described in the EIS, concluding that the current performance assessment is a “snapshot in time” that would continue to be refined with additional work. DOE believes that the expected performance of the repository, as described in the EIS, is a conservative estimate, and that additional work will increase confidence in how the repository would perform over the long term.

7.5.3 (10420)

Comment - EIS001927 / 0030

Why will Yucca Mountain fail to isolate nuclear waste? The answer is very simple. Yucca Mountain is as seismically active as San Francisco Bay. Indeed, Nevada is the third most earthquake prone State in the Union after Alaska and California. Riddled with dozens of fault lines, there’s a whole lot shaking going on at Yucca Mountain. Well over 600 earthquakes with a magnitude greater than 2.5 on the Richter scale have struck within 50 miles of the proposed repository site in the past 25 years along. A 5.6 jolt, centered less than 10 short miles from Yucca Mountain, did serious damage to the DOE field office in June, 1992. In the past few years, the tremors seem to have increased in frequency. Just last fall, a quake derailed a train on a proposed repository transport route.

What does this mean for the proposed Yucca Mountain repository? Researcher Jerry Szymanski has concluded that the level of the water table has risen dramatically – perhaps over 100 meters higher than the current level – in the past. Other researchers, Davies and Archambeau, predict that a small earthquake at Yucca Mountain could raise the water table 150 meters, while a severe earthquake could raise the level nearly 250 meters – high enough to flood the repository. Such a catastrophe would lead to early breaching of waste casks and a massive release of radioactivity into the groundwater below. The DEIS admits that such a scenario is possible, but leaves it at that, not addressing the potential environmental impacts.

All this shaking has fractured the relatively soft rock (volcanic tuff) that forms this low snaking ridge. The entire mass of Yucca Mountain is a sieve with tiny fractures that allow water and gas to flow in and out, which is not exactly ideal for isolating deadly nuclear wastes.

Response

DOE recognizes that there is a seismic hazard at Yucca Mountain. However, with proper design, the combination of natural and engineered barriers at the site would keep any doses resulting from releases of radioactive materials from the repository within the regulatory limits established by the Environmental Protection Agency at 40 CFR Part 197.

DOE has conducted many studies to quantify the seismic hazard at Yucca Mountain. Based on these studies, the Department would design facilities that are important to safety to withstand appropriately large ground motions from earthquakes. Seismic effects have also been taken into account in assessing the long-term performance of a potential repository at Yucca Mountain.

While large earthquakes are possible in the vicinity of Yucca Mountain, it is not expected that any would be as large as the largest that could occur in the San Francisco Bay area. In addition, the recurrence interval for large earthquakes near Yucca Mountain is significantly longer than for large earthquakes along the San Andreas Fault in California. For example, the seismic event that occurred along the Solitario Canyon fault about 70,000 years ago (based on detailed mapping and sampling in trenches) would be equivalent to only a notable fault in the San Francisco Bay area. Moreover, the recurrence interval for a comparable earthquake along the northern San Andreas Fault is about 200 to 250 years.

As part of site characterization activities, DOE monitors the seismic activity in the Yucca Mountain region. Since 1975, more than 1,500 earthquakes with a magnitude exceeding a magnitude of 2.5 have occurred within 80 kilometers (50 miles) of the site, including the magnitude 5.6 earthquake at Little Skull Mountain in 1992. Some of the small-magnitude events (magnitude 2.5 and less) might not represent an increase in seismicity, but rather the greater sensitivity of new instrumentation.

Repository facilities that are important to safety would be designed to withstand appropriate levels of ground motion and fault displacement. To the extent practical, such facilities would be sited to avoid faults that can rupture the surface. The facilities damaged in the 1992 Little Skull Mountain earthquake were built in the 1960s and were not designed to accommodate the levels of ground motion for which the repository facilities would be designed.

Transportation casks that would be used to convey radioactive waste to Yucca Mountain would have to be certified by the Nuclear Regulatory Commission. To earn that certification, the casks must pass a drop test that simulates a transportation accident similar to the impact of a train derailment, whether caused by an earthquake or other means.

DIRS 106963-Szymanski (1989) proposed that during the last 10,000 to 1,000,000 years, hot mineralized groundwater was driven to the surface by earthquakes and volcanoes. This hypothesis goes on to suggest that similar forces could raise the regional groundwater table in the future and inundate the waste emplacement horizon.

DOE requested that the National Academy of Sciences conduct an independent evaluation. The Academy concluded (DIRS 105162-National Research Council 1992) that no known mechanism could cause a future inundation of the repository horizon. The features cited by Szymanski as proof of groundwater upwelling in and around Yucca Mountain are related to the much older (13 to 10 million years old) volcanic process that formed Yucca Mountain and the underlying volcanic rocks.

Yucca Mountain Project scientists have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under extremely wet climatic conditions. The regional aquifer has been estimated to have been a maximum of 120 meters (390 feet) above the present level beneath Yucca Mountain during the past million or more years based on mineralogic data, isotopic data, discharge deposit data, and hydrologic modeling. The occurrence of an earthquake under these extreme climatic conditions might cause an additional rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters or more between the water table and the level of the waste emplacement drifts. The 1992 Little Skull Mountain earthquake (magnitude 5.6) raised water levels in monitoring wells at Yucca Mountain a maximum of less than 1 meter (3.3 feet) (DIRS 101276-O'Brien 1993). Water level and fluid pressure in continuously monitored wells rose sharply and then receded over a period of several hours to pre-earthquake levels. The water-level rise in hourly monitored wells was on the order of centimeters and indistinguishable after 2 hours (DIRS 101276-O'Brien 1993).

Dublyansky (DIRS 104875-1998) proposed another line of evidence in support of the warm-water upwelling hypothesis. This study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. The report concludes that some of these crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of project scientists with expertise in hydrology, geology, isotope geochemistry, and climatology did not concur with Dublyansky's conclusions (DIRS 100086-Stuckless et al. 1998). Although DOE disagrees with the central scientific conclusions of Dublyansky's report, it agreed to support continuing research by Jean Cline at the University of Nevada, Las Vegas. Section 3.1.4.2.2 of the EIS contains additional information.

With regard to the rock at Yucca Mountain acting like a sieve, DOE has encountered many fractures in the course of excavating more than 11 kilometers (6.8 miles) of tunnels and test alcoves at Yucca Mountain, and only one fracture was moist. Further observations in testing alcoves that have been isolated from the effects of tunnel ventilation for several years confirm the lack of natural seepage at the waste emplacement level (DIRS 151945-CRWMS M&O 2000).

7.5.3 (10748)
Comment - EIS001886 / 0001
The EIS is premature and scientifically unsound

The presumption in the Draft EIS is that the repository will be unsaturated -- that is it will not at any relevant time have a significant probability of flooding with water. As the attached comments by Dr. Yuri Dublyansky show, the DOE's assumption is unsound. The DOE's reasoning in summarily dismissing the evidence for repository flooding in the geologic past is based on misleading and selective use of information. There is a good deal of evidence indicating flooding of the repository. There is also some evidence of relatively recent flooding (in geologic terms). The entire Yucca Mountain repository program is based on the assumption of an unsaturated repository. Given the centrality of this issue, the DOE should re-issue a draft EIS with its analysis of the environmental consequences of such flooding, so that the public can evaluate it on its merits.

Moreover, as is noted in Dr. Dublyansky's comments, the DOE has ignored the ongoing work that it has commissioned and is being performed by Dr. Jean Cline at the University of Nevada, Las Vegas [UNLV]. This DOE-funded program of research followed the publication of a report on the subject by Dr. Dublyansky that was commissioned by IEER [Institute for Energy and Environmental Research]. The results of that work were published by IEER in December 1998. The DOE project aims to confirm or negate earlier findings of hydrothermal incursions of groundwater into the repository horizon as well as to determine the date(s) in the geologic past when such incursion(s) might have occurred. The preliminary data from this work confirm the earlier work of Dr. Dublyansky. The project has not yet determined any dates for the hydrothermal events. The UNLV research will not be complete until well into 2001. Yet the DOE plans to publish its final EIS in the year 2000.

With the major exception of geologists involved with the Yucca Mountain Project, there is now widespread agreement that at some time in the geological past there were likely to have been hydrothermal incursions into the Yucca Mountain repository region. One or more such incursions in the future would utterly alter the analysis of repository impacts. This is therefore a crucial factor in projecting the performance of the proposed repository.

Were the issue being considered a marginal one, this sequence might, in some circumstances be considered acceptable. However, the questions of saturation and time of saturation are the central ones in determining repository performance. The Draft EIS is therefore premature. It should be re-issued in late 2001, at the earliest, after the UNLV findings have been published, peer-reviewed and their significance for the proposed repository has been carefully assessed.

If a Final EIS is completed without the data and analysis on hydrothermal incursions being fully taken into account in the assessment of impacts, the FEIS will be so basically deficient as to be invalid.

Besides the issue of hydrothermal incursions, the DOE needs to take fully into account the potential for the metal canisters to corrode in relatively short time periods (say, a few hundred years or less) if the repository is unsaturated but far more humid than has been assumed. Further, under such circumstances, the DOE also needs to factor in the potential for the rapid disintegration of the borosilicate glass waste form due to hydration aging.[1] Finally, the DOE needs to factor in the potential for far more rapid migration of plutonium and other actinides than has been assumed.

[1]Arjun Makhijani, Glass in the Rocks: Some Issues Concerning the Disposal of Radioactive Borosilicate Glass in a Yucca Mountain Repository, prepared for the Nevada Nuclear Waste Task Force and the Nevada Agency for Nuclear Projects, Nuclear Waste Project Office, State of Nevada. Takoma Park, Maryland: Institute for Energy and Environmental Research, January 29, 1991.

Response

Intensive investigations by DOE identified no evidence or credible mechanisms to rise the elevation of the groundwater to flood the repository horizon in the vicinity of Yucca Mountain. Opposing views by Szymanski (DIRS 106963-1989) and Dublyansky (DIRS 104875-1998) are discussed in Section 3.1.4.2.2 of the EIS.

DIRS 106963-Szymanski (1989) proposed that during the last 10,000 to 1 million years, hot mineralized groundwater was driven to the surface by earthquakes and volcanic activity. This hypothesis goes on to suggest that similar forces could raise the regional groundwater in the future and inundate the repository horizon.

DOE requested that the National Research Council render an independent evaluation of the issue. After reviewing available information, the National Research Council concluded that no mechanism was known that could cause a future inundation of the repository horizon (DIRS 105162-National Research Council 1992). The features cited by Szymanski as proof of groundwater upwelling in and around Yucca Mountain are related to the much older (13 to 10 million years old) volcanic process that formed Yucca Mountain and the underlying volcanic rocks. Significant water table excursions (exceeding tens of meters) to the design level of the repository due to earthquakes are unlikely. Section 3.1.3.1 of the EIS discusses the likelihood of volcanic activity in the area is low (1 chance in 70 million annually); if it occurred, it would probably raise the water table a few tens of meters, at most.

Scientists working on the Yucca Mountain Site Characterization Project have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under extremely wet climatic conditions. The regional aquifer has been estimated to have been as much as 120 meters (390 feet) above the present groundwater elevation beneath Yucca Mountain during the past million or more years based on mineralogic data, isotopic data, discharge deposit data, and hydrologic modeling analysis. The occurrence of an earthquake under these extreme climatic conditions might cause an additional rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters (66 feet) or more between the water table and the level of the repository emplacement drifts. The 1992 Little Skull Mountain magnitude 5.6 earthquake raised water levels in monitoring wells at Yucca Mountain less than 1 meter (DIRS 101276-O'Brien 1993). Water level and fluid pressure in continuously monitored wells rose sharply and then receded, over a period of several hours, to pre-earthquake levels. The water level rise in hourly monitored wells was on the order of centimeters and indistinguishable after 2 hours (DIRS 101276-O'Brien 1993).

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm-water upwelling hypothesis. This study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. The report concludes that some of these crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of project scientists with expertise in hydrology, geology, isotope geochemistry, and climatology did not concur with the conclusions in the report (DIRS 100086-Stuckless et al. 1998). Although DOE disagreed with the central scientific conclusions in this report, DOE agreed to support continuing research. An independent investigation by Jean Cline, University of Nevada, Las Vegas, should be completed in fiscal year 2001.

The repository would be above the water table in the unsaturated zone. Therefore the most important process controlling waste package corrosion is whether water would drip from seeps onto the waste package. Field and laboratory testing indicate that seepage would be limited and the location of the seeps would depend on fracture-matrix and drift wall interactions. Under the present design, the radioactive waste that is placed in the repository would be enclosed in a two-layer waste package and covered by a titanium drip shield. The waste package would have a chromium-nickel alloy outer layer and a stainless-steel inner layer. These materials have extremely low corrosion rates and are not expected to fail for thousands of years.

The results of studies on the degradation of borosilicate glass reported in the EIS are based on the most current models available. These models account for several alternative conceptual models (including vapor-phase degradation). They are based on the most recent data available. The models have been validated against degradation of natural basaltic glasses over very long periods in seawater. At a pH of 8 the model predicts a corrosion rate of 9×10^{-6} gram per square meter per day. The natural glass samples had been exposed to silicon-saturated seawater and had corrosion rates of 0.1 micrometers in 1000 years. This would correspond to 6×10^{-7} gram per square meter per day. Thus, the degradation models for glass in the repository performance assessment are conservative by nearly an order of magnitude.

At the Benham nuclear test site on the Nevada Test Site, rapid transport of colloid-associated plutonium was noted. The results of groundwater monitoring indicate that a small fraction of plutonium has migrated 1.3 kilometer (0.8 mile) from the blast site in 30 years. In fracture systems, colloids that are repelled from the wall rock may move even faster than nonsorbing dissolved species because they remain in the faster flowing portions of the flow paths. Plutonium colloidal transport has been included in the analysis and is the subject of continuing and additional work.

Ongoing studies suggest that water travels through the unsaturated zone at highly variable rates. Groundwater travel times for contaminants from the repository that enter the accessible environment (specified in 40 CFR Part 197) are on the order of thousands to tens of thousands of years. The natural discharge of groundwater from beneath Yucca Mountain probably occurs far to the south at Franklin Lake Playa more than 60 kilometers (37 miles) away and travel times would be even longer. The long-term performance assessment (modeling) analysis show that the combination of natural barriers of the site and engineered barriers keep the radionuclides well below the regulatory limits established at 40 CFR Part 197. See Sections 3.1.3, 3.1.4.2, and 5.4 of the EIS for additional information.

7.5.3 (10757)
Comment - EIS001886 / 0010
Draft EIS (as well as released earlier Viability Assessment) is a model illustrating how critical decisions regarding the fate of nuclear waste will be made, and on what sort of science these decisions will be based. Having spent more than 15 years and several billion dollars to characterize the Yucca Mountain site, DOE and its contractors have produced tremendous amount of highly technical information. It is contained in millions of pages of reports and publications. Final Environmental Impact Statement, as well as all other documents that will provide basis for legal decisions must be based on careful evaluation of all pertinent information contained there. It is exceedingly important not to leave any information that has bearing on the performance of the repository beyond the scope of the analysis.

Decisions regarding what is important and what is less important and may, therefore, be omitted, can only be made by highly qualified professionals. We find it incredible that among 30 members of the Draft EIS preparation team only one has a degree in geology.* We do not believe that one Bachelor of Science, however brilliant he may be, may be put in position of being responsible for evaluation and compilation of 15 year-worth work of several organizations and tens of researchers that cover substantial number of very specific and intricate fields of Earth Sciences.

*Jeffrey McCann; B.S., Geological Sciences, 1980. US DOE 1999, pp. 13-1 -- 13-7.

Response
The EIS team prepared the text of the EIS and decided on such things as the amount of information to be included in the EIS and the level of technical detail. The information and the analyses in the EIS, however, were developed by many people who were not on the EIS team, but who authored many of the references cited in the EIS (for example, geologists working for the U.S. Geological Survey). In addition, several senior geologists and hydrologists from DOE and its Management and Technical Services Contractor (Booz Allen & Hamilton) performed extensive reviews of the integrated material presented in the Final EIS. Moreover, several drafts of the EIS were reviewed by geologists not associated with the project to make sure that the information presented was accurate.

From the inception of the Yucca Mountain Project, DOE has included individuals with expertise in geology, including staff from the U.S. Geological Survey. When needed, DOE has elicited opinions from recognized experts in academia, industry, and government to address specific topics. For these reasons, the Department believes that the quantity, quality, and experience of the geological expertise applied to the EIS have been more than adequate.

7.5.3 (11037)
Comment - 010122 / 0004
The department can’t use water that it doesn’t have. The waste water from the fuel pools and from washing down the transportation casks would go through an ion exchange, supposedly trapping all the radionuclides in a filter. The water would then go to evaporation pools while the filters would be disposed of as low-level radioactive waste, on the Test Site, of course.

<u>Response</u>
The Final EIS recognizes that the Nevada State Engineer denied DOE's application for permanent water rights to support construction, operation, and maintenance of the proposed repository. The application was denied on the basis that the proposed use threatens to prove detrimental to the public interest because that use is prohibited by existing state law. DOE disagrees with this finding and, through the Department of Justice, filed an appeal of the State Engineer's decision. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear DOE's suit. The case is pending.

With respect to the management of low-level radioactive waste, the comment is correct that DOE proposes to dispose of such waste at the Nevada Test Site where adequate disposal capacity is available. The comment's description of the management of wastewater is, however, not accurate. There would be no evaporation pools for the treatment of low-level radioactive wastewater. There would be an evaporator component among the processes that would be used to clean water for recycling within the facility, but it would be a closed component with the condensate (that is, the portion evaporated and subsequently condensed back to liquid) being the material recycled. Liquid low-level radioactive waste that could not be recycled would be stabilized prior to shipment for disposal.

7.5.3 (11673)
<u>Comment</u> - EIS002295 / 0005
Yucca is a ridge not a mountain.

<u>Response</u>
DOE agrees that, as a landform, Yucca Mountain consists of a series of ridges.

7.5.3 (11924)
<u>Comment</u> - 010326 / 0002
And talking about the surface water, again I'm coming along where other people have mentioned this, but talking about the new systems that are being put in place, suggestions for the pool where they're going to be cooling down rods, spent rods, and that is also going to be affecting, or could be affecting our water.

<u>Response</u>
As indicated in Section 3.1.3 of the Supplement to the EIS and Section 4.1.3 of the EIS, surface facilities at the proposed repository would not affect the quality of surface water or groundwater. As described in Section 4.1.3.2 of the EIS, the construction of surface facilities at Yucca Mountain would be required to withstand a flood magnitude appropriate for the risk posed by the facility. That is, facilities where radioactive materials would be managed would be designed to withstand the probable maximum flood (this includes a possible spent nuclear fuel surface aging area that would be used to achieve lower-temperature operating conditions in the repository). Other facilities would be designed to withstand a 100-year flood. Appendix L of the EIS contains an assessment of the affects of flooding along major washes at Yucca Mountain. This analysis was conducted pursuant to Executive Order 11988, Floodplain Management, and in compliance with DOE's regulations that implement this Executive Order (10 CFR Part 1022, *Compliance with Floodplain/Wetlands Environmental Review Requirements*).

7.5.3 (12141)
<u>Comment</u> - EIS001933 / 0003
You know there are active fault lines and water coming up.

<u>Response</u>
Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults. Section 4.1.8 of the EIS describes the impacts of earthquakes during operation of the repository. Several sections in Chapter 5 of the EIS consider earthquakes and their effects on the performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on seismic activity and the effects of this activity on the repository is adequately described and analyzed.

Section 3.1.4.2.2 of the EIS discusses fluctuations in the elevation of the water table at Yucca Mountain caused by changes in the climate. This section also discusses several opposing views by investigators who believe that the water table at Yucca Mountain has risen in the past to elevations that are higher than the subsurface waste-emplacement areas. DOE does not concur with these opposing views, nor did an expert panel that was convened by the National Academy of Sciences to specifically examine this issue. DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level.

7.5.3 (12159)
Comment - 010327 / 0002
I'm very concerned that there's so much talk about water flow. It's very disconcerting to me that there is so much design fortification around water issues when the DOE talks about Yucca Mountain being so dry and the perfect place for waste. It's confusing to me.

Response
The environment of Yucca Mountain and surrounding areas is arid. The depth to groundwater is about 750 meters (2,500 feet) below the crest of Yucca Mountain. Under the proposed action, DOE would emplace the waste 160 to 400 meters (525 to 1,300 feet) above the water table. While the waste-emplacement area is dry, very small amounts of surface precipitation do move slowly through the rocks to the level of the proposed repository. To increase the confidence in the safe, long-term performance of the repository, the Department has included titanium drip shields that would cover the waste and divert any water that might infiltrate to these depths away from the waste casks. This design was carried forward to the Final EIS. This design is described in the Supplement to the Draft EIS, along with other new operating and design features. Even though the amount of water that could reasonably be expected to infiltrate to the depth of the emplaced waste is very small, DOE has nevertheless proposed to enhance the already substantial engineered and natural barriers to radionuclide transport.

7.5.3 (12422)
Comment - 010375 / 0008
Flooding, earthquakes that have done damage, what about larger ones?

Response
As described in Section 4.1.3.2 of the EIS, the construction of surface facilities at Yucca Mountain would be required to withstand a flood magnitude appropriate for the risk posed by the facility. That is, facilities where radioactive materials would be managed would be designed to withstand the probable maximum flood (this includes a possible spent nuclear fuel surface aging area that would be used to achieve lower-temperature operating conditions in the repository). Other facilities would be designed to withstand a 100-year flood. None of the estimated floods described in Appendix L (including the regional and probable maximum floods) would reach the height of the portals to the subsurface facilities. In summary, DOE believes that the largest floods that could reasonably be expected to occur at Yucca Mountain would not pose a threat to either surface or subsurface facilities, although flooding could temporarily interrupt vehicle traffic.

As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring seismic activity and studying the geologic structure at and near Yucca Mountain since 1978. Using these data and the results of these studies, along with input from panels of recognized experts on seismic risks and hazards, DOE would design surface facilities at the repository to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of once in 10,000 years. This is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain. The largest recorded earthquake within 50 kilometers (31 miles) of Yucca Mountain occurred in 1992 at Little Skull Mountain 20 kilometers (12 miles) southeast of Yucca Mountain.

7.5.3 (12556)
Comment - 010390 / 0002
The S&ER [Science and Engineering Report] addresses monitoring of the unsaturated and saturated zones for potential migration of radionuclides from the repository. One monitoring well located up-gradient, and four monitoring wells located down-gradient from the site are proposed. The final EIS should be amended to include a more detailed description of the proposed ground water monitoring plan and the rationale behind the monitoring system design.

Any potential radionuclide release would likely affect the perched water aquifer prior to deeper aquifers. Additionally, the perched water aquifer may be an important factor influencing the hydraulic gradient within the volcanic aquifer and subsequently any potential plume migration. Therefore, the final monitoring system design should be based on an improved hydrogeologic model, including an improved characterization of the perched water and volcanic/carbonate aquifers as well as any pertinent information obtained during the repository construction and performance confirmation program.

The proposed monitoring of the unsaturated zone, repository drifts and nuclear waste containment units is comprised of observation drifts and alcoves, equipped with monitoring instruments placed either in the emplacement drifts and/or in boreholes. The proposed monitoring appears to be adequate for this stage of the investigation. However, the final unsaturated zone monitoring plan design should be based on the thermal load operating mode and results of the ongoing thermal drift-scale and seepage tests. In addition, the final EIS should include a detailed description of the proposed monitoring device(s).

Response
Section 2.1.2.3 of the EIS briefly describes performance confirmation activities, including monitoring, that would take place during construction, operation, and through closure of the repository. DOE believes that this information is adequate for the EIS. Should the proposed action be implemented, the Department would develop detailed monitoring plans.

Monitoring during performance confirmation would involve activities similar to the current characterization activities at the Yucca Mountain. The environmental impacts of these activities would be negligible. DOE understands, however, that there are members of the public who are very interested in this element of the proposed action. Accordingly, the Department will continue to make monitoring information available in documents, such as the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001) and a Performance Confirmation Plan, that focus more on the technical detail of the Proposed Action.

DOE agrees that possible effects of the repository on perched water bodies could be important to the overall performance of the system. The Science and Engineering Report states that "Key geologic, hydrogeologic, geomechanical, and other physical processes or factors (and related parameters) will be monitored and tested throughout construction, emplacement, and operation to detect any significant changes from baseline conditions" (DIRS 153849-DOE 2001). Continued definition of the performance confirmation is ongoing and would be described in the license application in more detail, including the rational of design.

7.5.3 (12689)
Comment - 010480 / 0001
On page 2-25 under Design Evaluation. Water dripping on waste packages would increase the likely hood of corrosion. What kind of water? Already contained from underground testing? And the mixing of radionuclides which at this point no one know really what lies in the water below Yucca Mountain. Tritium was found but filtered out.

Other brush under the rug. This could bring a problem if you don't know the contents of the water that is going to drip on the shield. What about the perched water? Could it drip on the shield or maybe you found all the perched water. You could drill holes all over that mountain and never find, all the perched water or where all the water may be found.

Underground testing and the buried waste don't mix. Not only don't the water mix but we can't find out if the underground testing has got into the water or the Tuff and could seep down on the shields or perk up from below with a sudden movement form the Mother Earth. And lets don't forget about the content of the water dripping and radionuclides and the mixing of [divergent] isotopes.

Response
DOE recognizes that corrosion of the waste packages would be more rapid if liquid water dripped directly on the packages. This is one of the reasons the design described in the Supplement to the Draft EIS included titanium drip shields that would cover the waste packages. These shields would be made of different material than the waste packages; thus, their degradation would be driven by different processes. While intact, the drip shields would

protect the waste packages from falling rocks as the drifts degrade, as well as protect the waste packages from any possible dripping water (the waste packages would still be the primary engineered barrier to radionuclide transport). DOE added this second line of defense primarily as an additional layer of conservatism for the licensing safety case and to compensate for large uncertainties in the corrosion rates of the waste package materials.

As described in Section 3.1.4.2.2 of the EIS, DOE has discovered elevated concentrations of “bomb-pulse” chlorine-36 and tritium at depth in Yucca Mountain. Anomalous concentrations of these isotopes are believed to be from atmospheric testing of nuclear weapons during the 1950s and 1960s. At Yucca Mountain, these isotopes are generally associated with faults and well-developed fracture systems close to these faults; their presence is evidence of connected pathways through which surface precipitation has percolated to depth within the last 50 years.

DOE believes that these findings do not indicate that the Yucca Mountain site would be unsuitable for development as a repository. Most of the water that infiltrates through Yucca Mountain moves very slowly through the matrix and fracture network of the rock. Isotopic data from water extracted from the rock matrix indicate that the residence time of groundwater might be as long as 10,000 years. Furthermore, after excavating more than 11 kilometers (8.4 miles) of tunnels at Yucca Mountain, DOE found that only one fracture was moist (there was no active flow of water). This observation has been confirmed in test alcoves that are not subject to the effects of drying from active ventilation.

To ensure the correct interpretation of this chemical signal, DOE instituted additional studies to determine if independent laboratories and related isotopic studies can corroborate the detection of elevated concentrations of these isotopes. Results of the validation studies to this point have not allowed firm conclusions and, thus, the evaluations continue. Nevertheless, the results of the Total System Performance Assessment described in Chapter 5 of the EIS incorporate the fast-flow data. The results show that the combination of natural and engineered barriers at Yucca Mountain would keep releases of contaminants during the first 10,000 years after closure well below the radiation limits established in 40 CFR Part 197.

Section 3.1.4.2.2 of the EIS describes the occurrence of perched water below the area of the proposed repository. The presence of perched water above the regional water table is a positive feature of the site for two reasons. First, the existence of perched water between the repository horizon and the water table indicates a barrier to flow. The perching layer possesses less matrix permeability and has a smaller fracture density than the overlying rocks. Second, the age of the perched water is thousands of years despite exhibiting a geochemical and isotopic signature that supports an interpretation of relatively rapid surface-to-depth recharge (tens to hundreds of years). In other words, the perching layer is so effective in impeding the downward flow of water that the water has aged substantially (thousands of years) in its current location. This increased residence time affords greater opportunity for diffusion and sorption of radionuclides that could be released from a breached repository.

Section 8.3 of the EIS describes the cumulative long-term impacts to groundwater from the repository and from past, present, and reasonably foreseeable future activities at the Nevada Test Site. As noted in Section 8.3.2.1.1, the estimated total potential cumulative impact (Yucca Mountain Repository plus Nevada Test Site underground testing) would be 0.17 millirem per year to the maximally exposed individual. For analytical purposes, DOE made the very conservative assumption that the radionuclide contaminants in the groundwater at the Test Site would be transported in an identical manner to those from the repository and that peak concentrations from both sources would occur at precisely the same time. The Department believes that the contribution to cumulative impacts from underground testing represents a reasonable upper bound of the actual cumulative impacts.

7.5.3 (13098)
Comment - 010227 / 0016
The lower temperature design, which is mentioned as a possibility in the SDEIS, assumes the use of an area that hasn’t been studied yet. This is seen on page 2-20. Since this area has not been studied yet, there is the possibility of many fast-pathways of water movement, earthquake faults and possibly evidence of igneous activity that may not have been seen in the studies done to date.

Response
Figure 2-7 of the Supplement to the Draft EIS shows the maximum emplacement drift area that would be required for any of the various flexible-design operating modes being considered under the proposed action. Both drift areas

shown in the figure for the flexible design are slightly larger than corresponding areas shown for the repository layouts described in the Draft EIS (also shown in Figure 2-7). The only situations that would possibly require the repository to move into areas beyond the primary and lower block are those associated with the Inventory Module 1 and 2 inventories as described under cumulative impacts in Chapter 8 of the EIS. Section 8.1.2.1 describes the potential for the repository to accept the additional Inventory Module 1 and 2 waste as a reasonably foreseeable future action. However, legislative action would be required to emplace at Yucca Mountain more than the 70,000-MTHM limit specified in the NWPA. As described in the same section, should geologic blocks be needed beyond those supporting proposed action, they would be more fully characterized before their use.

Potential repository areas have been designated (should they be needed) that are outside the primary block area. Although these outside areas have not been characterized to the extent of the primary block, they are not uncharacterized. Many of the studies and evaluations performed under the Yucca Mountain characterization project have included a much broader area than what might be used for the subsurface repository. For example, faults within 100 kilometers (62 miles) of Yucca Mountain have been examined using aerial photographs and all with suspected Quaternary movement were evaluated; and the evaluations to estimate the probability of volcanic activity at Yucca Mountain looked at evidence of regional activity.

7.5.3 (13451)
Comment - 010296 / 0036
As stated by Nye County in its earlier comments on the DEIS, the impacts on water resources in Nye County were not adequately defined or assessed. The DSEIS at Section 3.1.3.1 Water Use, Evaluation of Impacts, does nothing to address these deficiencies, rather it simply restates that potential impacts would be minor and changes for impacts under the S&ER flexible design parameters would be unlikely. Buqo (1999) conducted a thorough evaluation of the impacts of the proposed repository on the water resources of the region and found that there were already significant resource injuries, constraints on water development, and a reduction in long-term productivity, loss of habitat and species, and reduced water availability. The DEIS included a brief statement recognizing that Nye County recognized these impacts and did not refute that these impacts are to be expected. However, the DEIS did not carry these impacts forward in their evaluation of direct, indirect, cumulative direct, and cumulative indirect impacts of the proposed action on the water resources of the region of influence. Rather the DEIS chose an approach that is inconsistent with both the intent and the letter of NEPA [National Environmental Policy Act]. The DSEIS perpetuates the same erroneous evaluation of impacts on water resources as that presented in the DEIS and is thus considered deficient. The DSEIS must be revised to address the impacts on the water resources of Nye County and must present evaluation of the impacts that have been identified by the County.

Response
DOE believes that the analysis of impacts to water availability presented in the EIS is adequate. Section 4.1.3.3 of the EIS estimates the amount of water the Department would need to support the repository. Sections 6.3.2.2 and 6.3.3.2 estimate water needs for each rail corridor and heavy-haul truck route, respectively. With respect to the amount of groundwater available in the areas discussed in the EIS, DOE identifies estimates of perennial yield used by the State of Nevada. Because most of the water demand associated with the Proposed Action would occur at the repository, the EIS presents a range of water availability (or perennial yield) estimates for the groundwater basin in that area.

As described in Section 4.1.3.3 of the EIS, DOE expects that the impacts to groundwater during the construction, operation and monitoring, and closure of the repository would be minor. Groundwater pumping for use at the repository would decrease groundwater availability to some extent in downgradient areas. Section 4.1.3.3 points out, however, that the quantity of groundwater that would be needed for the repository would be small compared to the quantities currently being withdrawn in downgradient areas. Therefore, the Proposed Action would have very little effect on the availability of groundwater in these downgradient areas.

7.5.3 (13470)
Comment - 010021 / 0001
Due to the volume of requests that we receive, we have not performed a detailed review of the project. However, we offer the following comments.

The community affected by this project participates in the National Flood Insurance Program (NFIP). Under this program, the Federal government makes affordable flood insurance available within participating communities. In exchange, the communities adopt certain floodplain management regulations to reduce the risk of flood damage. In support of the NFIP, FEMA has undertaken a nationwide effort to identify and map flood hazards. These flood hazards are shown on Flood Insurance Rate Maps (FIRMS), which FEMA produces for each community participating in the program. The FIRMS show identified Special Flood Hazard Areas (SFHAs). The SFHA is an area that is subject to inundation during a flood having a 1-percent chance of occurrence in a given year (also known as the base flood or 100-year flood).

Flood insurance is required for structures within SFHAs in order to protect Federal financial investments and to reduce the cost of disaster assistance. Further, the floodplain management regulations adopted by participating communities affect the construction and improvement of structures located in SFHAs. Accordingly, FEMA's concerns with the project are associated with its location in relation to identified SFHAs.

Floodplain Management Criteria for Construction in SFHAs

Our first area of concern relates to structures that may be part of the project. For new or substantially improved structures (including manufactured housing) located within SFHAs, the NFIP regulations require a community to:

- Issue permits for construction.

- Ensure that the lowest floor (including basement) is elevated to or above the base flood elevation shown on the community's FIRM.

- Ensure that any enclosed areas below the base flood elevation are used solely for access, temporary storage, or parking; are constructed of flood-resistant materials; and are properly vented to allow equalization of hydrostatic pressure in the event of a flood.

- Maintain records of permits and lowest floor elevations.

For purposes of floodplain management, a "structure" is defined as any walled and roofed building that is located principally above ground. A structure is defined as being "substantially improved" if the cost of the improvements is greater than 50 percent of the market value of the structure.

These requirements are the minimum floodplain management criteria that must be adopted by a community for participation in the NFIP. Each community that participates in the NFIP has a floodplain management ordinance that reflects these requirements. If the community's ordinance contains more restrictive criteria, the requirements of that ordinance take precedence over the minimum requirements of the NFIP.

Effects of the Project on Flood Hazards

Our second area of concern relates to the potential effects of the project on flood hazards. If the project will physically affect flood hazards shown on the FIRM, it is subject to the following:

- The project should not worsen flood hazards to adjacent properties, particularly if those properties contain insurable structures.

- FEMA has designated floodways along certain flooding sources. The floodway, which is the area that must remain free of development to ensure the safe passage of floodwaters, is shown on the FIRM. The NFIP regulations prohibit construction in the floodway unless it can be demonstrated that the construction will not cause any increase in base flood elevations.

The FIRM should accurately reflect changes to flood hazard information, such as shifts in floodplain boundaries or changes in base flood elevations, once construction is completed. If construction results in any change to the flood hazard data shown on the FIRM, the community must request a revision to the FIRM within 6 months of completion of the work. FEMA has developed an application/certification package that the community must use to request a revision. This package is available electronically on FEMA's website at www.fema.gov/mit/tsd/FRM_form.htm.

You can contact the community to obtain a copy of the current FIRM. Additional copies may be obtained for a fee from our Map Services Center; information about ordering maps is available on our website at www.fema.gov/msc.

We encourage you to work closely with the floodplain administrator for the affected community to ensure that the proposed project complies with the community's floodplain management ordinance and to ensure that the goals of the NFIP are met.

Response
DOE examined the concerns expressed in this comment in a Floodplain/Wetlands Assessment for the proposed repository at Yucca Mountain (Appendix L of the EIS). This analysis was conducted pursuant to Executive Order 11988, *Floodplain Management*, and in compliance with DOE regulations that implement this Executive Order (10 CFR Part 1022, *Compliance with Floodplain/Wetlands Environmental Review Requirements*).

7.5.3.1 Surface Hydrology/Geology

7.5.3.1 (234)
Comment - 14 comments summarized
Commenters said that neither the Draft EIS nor the Supplement to the Draft EIS considered storm runoff in Fortymile or Topopah Wash. Flooding of the Amargosa River could disrupt above-ground repository operations, transport fuel spills, oil leaks, and other toxic contaminants to Death Valley, close highways, and halt the transport of nuclear waste to Yucca Mountain. Radioactive materials transported in these floods would adversely affect Death Valley National Park, Amargosa Valley, Death Valley Junction, Tecopa, Shoshone, and all others areas downstream of Yucca Mountain and the Nevada Test Site near the Amargosa River. Some said that the Supplement should have included a stormwater flooding analysis of the proposed 0.81-square-kilometer (200-acre) storage pad near the North Portal. Commenters said that DOE ignored a recent report by scientists of the U.S. Geological Survey that showed that large storms in the 1990s had the potential to transport dissolved and particulate matter far beyond the boundary of the Nevada Test Site and the Yucca Mountain area. Some said the flooding would also affect the Timbisha Shoshone community and the land they have just been given to build their residential homes in Death Valley.

Response
Appendix L of the EIS contains a floodplain/wetlands assessment of the major washes at Yucca Mountain, including Fortymile and Topopah Washes. This analysis was conducted pursuant to Executive Order 11988, *Floodplain Management*, and in compliance with DOE's regulations that implement this Executive Order (10 CFR Part 1022, *Compliance with Floodplain/Wetlands Environmental Review Requirements*).

Section 3.1.4.1.2 of the EIS describes the flood potential at Yucca Mountain based largely on studies by the U.S. Geological Survey reported in 1984 and 1992. The new study mentioned by commenters was prepared by Glancy and Beck (DIRS 155679-1998). Glancy and Beck noted that the largest volume flood recorded along Fortymile Wash occurred in February 1969 with a peak flow of about 570 cubic meters (20,000 cubic) feet per second. Based on an eyewitness account, the entire wash (wall to wall) was filled with water about 1.2 meters (4 feet) deep (DIRS 155679-Glancy and Beck 1998). The floodplain assessment in the EIS (Appendix L) relied largely on a floodplain analysis prepared in 1984 by the U.S. Geological Survey (DIRS 102783-Squires and Young 1984). In that study, and as reported in Appendix L, peak discharge estimated along Fortymile Wash during a 100-year flood is 340 cubic meters (12,000 cubic feet) per second. During a 500-year flood, peak discharge along Fortymile Wash is estimated to be 1,600 cubic meters (58,000 cubic feet) per second. Hence, the actual flow in Fortymile Wash in 1969 as reported by Glancy and Beck was about 230 cubic meters (8,000 cubic feet) per second larger than the estimated 100-year flood, but 1,100 cubic meters (38,000 cubic feet) per second smaller than the estimated 500-year flood.

As described in Section 4.1.3.2 of the EIS, surface facilities at Yucca Mountain would be required to withstand a flood magnitude appropriate for the risk posed by the facility. That is, facilities where radioactive materials are to be managed would be sited and designed so that flooding from a 100-year, 500-year, regional maximum, or even a probable maximum flood would not adversely affect these facilities (this includes a possible spent nuclear fuel aging area that would be used to achieve lower-temperature operating conditions in the repository). Other facilities would be designed to withstand a 100-year flood. In summary, DOE believes that the largest floods that could reasonably be expected to occur at Yucca Mountain would not pose a threat to the repository, although flooding could temporarily interrupt vehicle traffic. Therefore, the probability that hazardous materials stored at the surface would be transported to the Amargosa River and eventually to Death Valley is considered very unlikely.

DOE recognizes that accidents cannot be eliminated and that there is the possibility for leaks or spills of contaminants during the construction and operation of the repository. However, the Department believes that implementing proper planning, training, and engineered controls, and adhering to the standards set by environmental regulations, can effectively reduce the probability of accidents occurring. Such actions can also reduce the severity and improve response (cleanup) should accidents occur.

7.5.3.1 (1485)
Comment - EIS001521 / 0028
Page 3-33, 3.1.4.2 [3.1.4.1.2] Yucca Mountain Surface Drainage, first paragraph--(Occurrence) Is Fortymile Wash the same as Fortymile Canyon on page 3-34, Figure 3-12 (and other figures in this volume)? Use consistent terminology.

Response
Fortymile Wash exits Fortymile Canyon just to the northeast of the Yucca Mountain site. Both are appropriate designations depending on the feature being described (wash or canyon). Although the “Fortymile Canyon” label in Figure 3-12 is in the area where the canyon begins, the corresponding text deals with drainage features (the washes). Therefore, for consistency, DOE has changed the label in Figure 3-12 to “Fortymile Wash.”

7.5.3.1 (1489)
Comment - EIS001521 / 0030
Page 3-35, Table 3-9--No reference is given for regional maximum flood numbers, and why show these numbers anyway? Repository design is for a pmf [probable maximum flood] event.

Response
The source of the data in Table 3-9 is identified in footnote “a” at the bottom of the table. The Draft EIS identified a secondary reference for the information presented (that is a summary of geologic and hydrologic information developed by DOE for the EIS). The EIS now identifies the primary reference for estimates of the 100-year, 500-year, and regional maximum floods, which is Squires and Young (DIRS 102783-1984), as indicated in Figure 3-12.

Both regional and probable maximum flood levels are presented in the EIS primarily for comparison. For those reviewers more familiar with the regional maximum flood designation and how it is developed, the comparison clearly shows that the probable maximum flood value is a more conservative basis for facility design. Also, probable maximum flood values were generated only for specific areas where there would be facilities constructed under the proposed action. There has been no attempt to extrapolate these flood levels to a more drainage-wide basis. Accordingly, leaving the regional maximum flood estimates in the text and in Figure 3-12 provides the reader a better indication of a maximum, or worst-case, flood estimate over a much larger area.

7.5.3.1 (1490)
Comment - EIS001521 / 0029
Page 3-33, 3.1.4.2 [3.1.4.1.2] Yucca Mountain Surface Drainage, second paragraph (Flood Potential). Why is a “regional maximum flood” important when repository facilities are designed for a “probable maximum flood” (pmf)? Also, the definition of a regional maximum flood in the “PREDICTED FLOODS” blockout presents no relationship to time, or recurrence intervals, or flow volumes. Why include this term or does it have an analytical use?

Response
The areal extent of the “regional maximum flood,” 500-year flood, and 100-year flood in Fortymile Wash and principal tributaries in the vicinity of the repository were mapped in the early 1980s by personnel with the U.S.

Geological Survey (DIRS 102783-Squires and Young 1984). The "probable maximum flood" was subsequently delineated in several areas at Yucca Mountain by Blanton (DIRS 100530-1992) using a methodology developed by the U.S. Bureau of Reclamation. Nuclear Regulatory Commission rules require mapping areas of "probable maximum flood" for sensitive facilities. Thus, the earlier work by the U.S. Geological Survey continues to be useful because it gives a broad overview of flood hazards over an extensive area. The definition of "regional maximum flood" follows usage by the U.S. Geological Survey (see EIS Section 3.1.4.1.2).

Both regional and probable maximum flood levels are presented in the EIS primarily as a means of comparison. For those reviewers more familiar with the regional maximum flood designation and how it is developed, the comparison clearly shows that the probable maximum flood is a more conservative basis for facility design. Also, probable maximum flood values were generated only for specific areas where facilities would be constructed under the Proposed Action. There was no attempt to extrapolate these flood levels to a more drainage-wide basis. Accordingly, leaving the regional maximum flood estimates in the text and in Figure 3-14 provides the reader with a better indication of a maximum, or worst-case, flood estimate over a much larger area.

7.5.3.1 (1492)
Comment - EIS001521 / 0031
Page 3-35, second paragraph--"In no case" is a rather strong statement when the estimated area of inundation for a pmf [probable maximum flood] event may come within about 300 feet of the north portal (see page 3-34, Figure 3-12). The ranges for error of estimation of volumetric estimates for a pmf event need to be very small in order to support this statement. Are they? These ranges should be included with the data.

Response
DOE has revised the EIS to include the following statement: "None of the identified flood estimates predicts water levels high enough to reach either the North or South Portal openings to the subsurface facilities, which would be at either end of the Exploratory Studies Facility tunnel shown in the figure." This change better reflects the original intent of the sentence.

The primary flood estimate studies referenced in the EIS (DIRS 100530-Blanton 1992, DIRS 108883-Bullard 1992, and DIRS 102783-Squires and Young 1984) do not include ranges of error for either the regional or probable maximum floods. However, it should be noted that DOE has developed a large map (designated YMP-98-218.3) of the flood level data presented in Figure 3-12 of the EIS. This larger map contains contour lines with a finer resolution than Figure 3-12 and shows the roughly 300 feet between the North Portal and the probable maximum flood inundation level to cover a vertical drop of 30 to 40 feet. Once outside the primary drainage channels, it would take huge volumes of water to make up this difference in elevation.

7.5.3.1 (4268)
Comment - EIS001521 / 0026
Page 3-31, 3.1.4.1 Surface Water, 3.1.4.1.1 Regional Surface Drainage, first paragraph--the term "permanent streams" should be changed to "perennial streams" for consistency with other DEIS sections. Also, the referred locations, Tecopa, Peterson Reservoir, Lower Crystal Marsh, Horseshoe Reservoir, and Ash Meadows, are not shown on page 3-32, Figure 3-11, as they should be.

Response
DOE has changed "permanent stream" to "perennial stream" in Section 3.1.4.1.1, and added Tecopa, Peterson Reservoir, Lower Crystal Marsh, Horseshoe Reservoir, and Ash Meadows to Figure 3-11.

7.5.3.1 (4269)
Comment - EIS001521 / 0027
Page 3-32, Figure 3-11--The surface drainage areas shown on the figure are not discussed in the text. Why are they important? How do they relate to each other and what is their significance to this DEIS? Were they separated by hydrologic unit characteristics? In other words, why is this figure presented?

Response
Figure 3-11 of the EIS shows the general surface-water drainage areas, or divides, in the region of Yucca Mountain. It supports the surface drainage discussion in Section 3.1.4.1.1. The cited source (DIRS 101062-Waddell 1982)

describes the subdivisions, which correspond to hydrographic areas defined by the Nevada State Engineer. The simplified figure provides an overview of the regional drainage so the text does not have to present more detail than is necessary.

7.5.3.1 (4561)
Comment - EIS001521 / 0074
Page 3-126, 3.2.2.2.3.2 Ground Water, first paragraph--Ground-water sub-basins and hydrographic areas do "not" equate (see page 3-38, Figure 3-13).

Response
DOE agrees that use of the terms subregion, basin, and section is not clear, and has changed the text to be consistent with the source document titled *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California* (DIRS 100131-D'Agnese et al. 1997), which is the main source for this information in Summary Section S.4.1.4 and Section 3.1.4.2.1 of the EIS. The flow in each subregion has clearly defined paths. For convenience the subregions were divided into basins and sections. The EIS uses these boundaries, which do not define discrete independent flow systems, for descriptive purposes only (DIRS 100131-D'Agnese et al. 1997). The groundwater flow subregion, basin, and section terminology used by D'Agnese et al. (DIRS 100131-1997) is not the same as that used by the State of Nevada for water appropriations (hydrographic areas based on topographic divides); Section 3.1.4.2.1 clarifies that distinction. DOE has added an illustration to show the relationship between the Death Valley region and subregions.

7.5.3.1 (4562)
Comment - EIS001521 / 0075
Page 3-128, Table 3-43--Hydrographic areas and ground-water basins do "not" equate.

Response
DOE agrees that the subregion, basin, and section usage is not clear, and has changed the region, subregion, basin and section terminology for groundwater flow in the text to be consistent with the source document titled *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California* (DIRS 100131-D'Agnese et al. 1997), which is the main source for this information in Summary Section S.4.1.4 and Section 3.1.4.2.1 of the EIS. The flow in each subregion has clearly defined paths. For convenience the subregions were divided into basins and sections. The EIS uses these boundaries, which do not define discrete independent flow systems, for descriptive purposes only (DIRS 100131-D'Agnese et al. 1997). The groundwater flow subregion, basin, and section terminology used by D'Agnese et al. (DIRS 100131-1997) as not the same as that used by the State of Nevada for water appropriations (hydrographic areas based on topographic divides); Section 3.1.4.2.1 clarifies that distinction. DOE has added an illustration to show the relationship between the Death Valley region and subregions.

7.5.3.1 (5494)
Comment - EIS001887 / 0162
Page 3-31; Section 3.1.4.1.1 - Regional Surface Drainage

The Draft EIS does not contain any information regarding potential discharge of contaminated groundwater that would not meet either the Nevada Water Quality Standards or the California Water Quality Standards. The Draft EIS should be reissued to include a discussion on the potential for migration of contaminants in the groundwater and possible discharge at points in Nevada and California. The question of whether this discharge would meet both Nevada's and California's Water Quality Standards should also be addressed.

Response
Chapter 3 of the EIS describes the environment that might be impacted by the proposed action; Chapters 4 and 5 describe the consequences of the proposed action. Chapter 4 addresses the consequences of constructing, operating and monitoring, and closing the repository. Chapter 5 addresses the consequences of long-term performance. As indicated in Section 4.1.3 of the EIS, the DOE believes that there is little potential for groundwater contamination during the construction, operation and monitoring, and closure phases of the proposed action. The potential for groundwater contamination is associated with the repository's long-term performance, which has been analyzed in great detail in the EIS. Estimated impacts to groundwater--and to people using that water--from the slow release of

contaminants from the repository over thousands of years are described in Chapter 5 (and in Chapter 8 with respect to cumulative impacts). The Energy Policy Act of 1992 (Public Law 102-486) directed the Environmental Protection Agency to promulgate public health and safety standards for the protection of the public from releases from radioactive materials stored or disposed of at the Yucca Mountain site. These standards have been developed and published as 40 CFR Part 197, *Environmental Radiation Protection Standards for Yucca Mountain, Nevada*. The same Act also required the Nuclear Regulatory Commission to modify its technical requirements for approving or disapproving the repository to be consistent with the Environmental Protection Agency requirements. These standards have also been established at 10 CFR Part 63, *Disposal of High-Level Radioactive Wastes in a Proposed Geological Repository at Yucca Mountain, Nevada*. These standards, mandated by law, will be used to judge the adequacy of the performance of the repository as part of the licensing process. The EIS does not in fact "analyze for" a particular standard. The EIS describes possible environmental impacts using the best available data and analysis techniques at the time of its development. In Section 5.4, the EIS does, however, compare projected groundwater contamination and corresponding exposure levels to current standards set by the Environmental Protection Agency for community drinking-water systems. These comparisons are made only as a reference point for readers of the EIS.

7.5.3.1 (5590)
<u>Comment</u> - EIS001887 / 0215
Page L-3; Figure L-1 -- Yucca Mountain site topography, floodplains, and potential rail corridors

This map should include the entire proposed withdrawal area, indicating the 100 and 500 year flood zones as well as rail and road corridors. Since the withdrawal area would be considered part of the Yucca Mountain repository site, the entire site and any proposed construction or improvements must be considered in the floodplain assessment.

<u>Response</u>
Figure L-1 of the EIS identifies potential flooding areas associated with proposed DOE actions at the Yucca Mountain site. This is consistent with requirements in 40 CFR Part 1022 to identify and assess all actions that could affect floodplains and wetlands. There are other drainage features (washes, gullies, etc.) in other portions of the withdrawal area, but repository construction and operation would not affect them. Showing the entire withdrawal area would show the location of other drainage features, but if included on the same map, it would be at the expense of showing less detail in the area where construction would take place. Also, the referenced flood studies (the results of which are shown as the flood inundation zones in Figure L-1) only included Fortymile Wash and its tributaries. That is, the same level of detail is not available for all drainage features in the withdrawal area.

With respect to rail and road corridors, the assessment in Appendix L of the EIS includes the listing of surface-water resources (including springs and riparian areas) along the various routes or corridors. In addition, the appendix now includes a listing of 100-year flood zones that would be crossed by the rail corridors based on available flood maps published by the Federal Emergency Management Agency. It does not, however, present the level of detail to include 100- or 500-year floodplain maps. DOE recognizes in the assessment (Section L.1) that a more detailed floodplain/wetlands assessment of the selected rail corridor or heavy-haul truck route would be necessary if DOE selected either transportation option.

As suggested in the Foreword to the EIS, Chapter 6, and Section 11.2.2, more detailed field surveys, government consultation, analyses, and National Environmental Policy Act reviews would be prepared if a decision was made to select a specific rail alignment within a corridor or a specific location of an intermodal transfer station or the need to upgrade the associated heavy-haul routes. These would include consultations with state wildlife management agencies, the Bureau of Land Management, the Army Corps of Engineers, and other applicable government agencies. They also would include field surveys (as applicable) and more detailed assessments and analyses of wetlands and other waters; floodplains; sensitive species; and other related issues.

7.5.3.1 (5591)
Comment - EIS001887 / 0216
Page L-9; Section L.3.1.1 - Flooding

The nearest man-made structure within Fortymile Wash is the NTS road leading to Yucca Mountain. It should also be noted that, within the last decade, flooding has crossed and caused closure of U.S. Highway 95 at Fortymile Wash.

Response
The comment correctly points out that the nearest manmade structure in Fortymile Wash is the Nevada Test Site road leading to Yucca Mountain. A few roads and foundation supports for bridges that cross washes would be the only features present within the 100-year floodplain, and these would be designed to withstand the effects of potential floods. DOE has completed a flood-hazard assessment and is conducting additional analysis. Future documents will report the results of these additional studies.

7.5.3.1 (6467)
Comment - EIS001632 / 0028
Page 3-63, Section 3.1.5.1.4: This section states that "Fortymile Wash and some of its tributaries might be classified as Waters of the U.S..." It is likely that Fortymile Wash is a Water of the U.S., as well as the Amargosa River and its tributaries: Yucca Wash, Drill Hole Wash, Midway Valley Wash, Busted Butte Wash, Solitario Canyon Wash, and Crater Flat. Also, tributaries to the washes stated above may meet the Waters of the U.S. criteria, per U.S. Army Corps of Midway Valley assessment.

Response
The washes listed in the comment are tributaries to Fortymile Wash, and Fortymile Wash is a tributary to the Amargosa River. Because they are tributaries, the EIS text acknowledges that these washes might be classified as "waters of the United States." At present, there has been no formal designation of these drainage channels. Without such a designation, DOE believes that it is appropriate in the EIS to continue to indicate that these washes might be classified as waters of the United States. The Department will continue to coordinate with the Army Corps of Engineers regarding any possible future designation of these or other affected washes.

7.5.3.1 (6478)
Comment - EIS001632 / 0034
Page 4-24: Activity in drainages and washes may require a Section 404 permit if it takes place in Waters of the U.S.

Response
DOE agrees with this comment and recognizes the potential need for Section 404 permitting. Section 11.2.2 of the EIS discusses this potentially applicable requirement. As indicated in Section 11.2.2, DOE may need to obtain a permit from the U.S. Army Corps of Engineers if the repository or the transportation facilities requires the discharge of dredge or fill materials into waters of the United States.

7.5.3.1 (7377)
Comment - EIS001957 / 0017
Section 3.1.4.1, Hydrology, Surface Water, Regional Surface Drainage -- The draft EIS acknowledges that the Amargosa River system drains Yucca Mountain and the surrounding areas, and flows into the Badwater Basin in Death Valley. Nonetheless, potential environmental consequences (within Death Valley NP [National Park]) due to possible leakage of harmful radioactive constituents from the proposed repository or from transportation into this surface drainage are not considered in the draft EIS.

Response
Section 4.1.3 of the EIS addresses potential impacts to surface water and groundwater during construction, operation and monitoring, and closure of the repository. Sections 6.3.2 and 6.3.3 address potential impacts from the transport of spent nuclear fuel and high-level radioactive waste on branch rail lines and heavy-haul routes in Nevada, respectively. These sections discuss potential impacts to both surface water and groundwater along the various transportation routes evaluated. DOE believes that due to the manner in which the wastes would be managed and packaged, little potential exists for release of radioactive materials during normal operations. Sections 4.1.8 and

6.2.4 address potential impacts at the repository and during transportation, respectively, from accidents. Impacts addressed in these sections are in the form of exposures to people because that is the primary concern before cleanup actions could be completed. Consistent with this position, the transportation accidents are assumed to take place in an urban area where impacts would be greatest. Specific impacts to Death Valley National Park from accidents were not evaluated because none of the possible waste-transport routes go through the Park.

Some groundwater contamination is expected during the long-term performance of the repository as discussed in Chapter 5 of the EIS. Over the thousands of years after the repository is closed, waste containers would slowly degrade allowing a slow release of contaminants to be carried by percolating water to the groundwater. Section 3.1.4.2.1 of the EIS indicates that the primary discharge point for groundwater flowing beneath Yucca Mountain is Franklin Lake Playa in Alkali Flat. Some of the groundwater reaching this far may also by-pass the playa and continue to Death Valley. It is also recognized in the EIS that a fraction of the groundwater beneath the Amargosa Desert may flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in Furnace Creek Wash in Death Valley. Chapter 5 of the EIS does not specifically address risks to people in Death Valley National Park from groundwater use and consumption. However, it can be clearly seen in the evaluation presented in Chapter 5 that risks would decrease with increased distance from the repository. Accordingly, impacts to Death Valley National Park would be less than the impacts predicted at the farthest locations evaluated in the EIS.

7.5.3.1 (7513)
Comment - EIS001969 / 0021
Page 3-24, first paragraph, and Page 3-33, Flood Potential.

Boulders as large as 2 meters in diameter, as well as sand, silt, and clay, are part of the alluvial deposits on these fans and stream beds. This boulder-size material has the potential for significant destructive force during the flash floods.

Response
Section 3.1.3 of the EIS has been changed to indicate that the alluvial deposits on fans and in stream beds includes boulders, cobbles, pebbles, sand, silt and clay; Section 3.1.4.1.2 has been modified to indicate that mud flows may include boulder-size material.

7.5.3.1 (8038)
Comment - EIS000391 / 0004
Mineral County believes that a number of issues are not addressed properly, not addressed adequately, or not addressed at all in the Draft EIS. These issues include but are not limited to:

Uncertainty in models and data used for site characterization and repository performance. Mineral County's flood plain map is incorrect. If this is so, how reliable is the information gathered for Yucca Mountain and other areas? The flood plain report in the DEIS is too generalized. Mineral County would like to have a detailed flood plain analysis done of Yucca Mountain and each affected county.

Response
DOE has conducted an extensive site characterization program to evaluate the proposed repository site at Yucca Mountain and has gained valuable knowledge on how the system would perform over the long-term. DOE recognizes that additional data would further define and reduce uncertainty about some aspects of the long-term performance of the repository, but also recognizes that some areas of uncertainty are inherent to the process. That is, the analysis of future periods, such as 10,000 years into the future, must deal with uncertainties that are both technical and societal. The approach DOE took in the evaluation of the long-term performance of the repository (summarized in Chapter 5 of the EIS) was to recognize the uncertainties that are important to the evaluation and to identify those it might improve with additional data. Regarding uncertainties that are the result of a data gap, the approach was to make conservative assumptions where necessary, realizing that information gained from ongoing studies might eventually support less conservative assumptions and estimates of impacts. Section 5.2.4 of the EIS discusses uncertainties associated with the long-term assessment of repository performance and the philosophy for dealing with them.

The approach and the data DOE used are scrutinized by the Nuclear Regulatory Commission and the Environmental Protection Agency, which set the standards for repository performance and the approach to predicting performance. These agencies, in turn, look to input from the international nuclear energy community and guidance from the National Academy of Sciences in prescribing methods and standards. Thus, the projections of impacts for 10,000 years represent, in the opinion of DOE, the best possible synthesis of knowledge and understanding that the Department can bring to the solution of disposing of spent nuclear fuel and high-level radioactive waste.

Regarding the Mineral County floodplain map being incorrect, the EIS does not discuss Mineral County floodplain issues because neither the proposed repository nor any of the candidate transportation routes would be in Mineral County. However, DOE can address the general concern expressed by the comment. The floodplain/wetlands assessment in Appendix L of the EIS examines and compares the effects of the potential construction of a branch rail line or an intermodal transfer station with its associated route for heavy-haul trucks on floodplains and wetlands in the vicinity of Yucca Mountain and along the candidate routes. DOE did not evaluate potential effects along existing routes because the design of those roads should meet the 100-year floodplain design specifications. Section L.1 recognizes, however, that a more detailed floodplain/wetlands assessment of the selected rail corridor would be necessary after any decision on a specific corridor.

In addition, and as suggested in the Foreword to the EIS, Chapter 6, and Section 11.2.2 (subsection on Compliance with Floodplain/Wetlands Environmental Review Requirements) DOE would perform detailed field surveys, additional government consultation, analyses, and National Environmental Policy Act reviews if a decision was made to select a specific rail alignment within a corridor or a specific location of an intermodal transfer station or the need to upgrade the associated heavy-haul routes. These would include consultations with state wildlife management agencies, the Bureau of Land Management, the U.S. Army Corps of Engineers, and other applicable government agencies. They also would include field surveys (as applicable) and more detailed assessments and analyses of wetlands and other waters; floodplains; sensitive species; and other related issues.

7.5.3.1 (8155)
Comment - EIS000817 / 0083
P. 3-35 & 36. The U.S. Geological Survey 1997 has a new methodology that could result in larger 100-year flood limits. And there are differences of opinion on the complex groundwater systems. So it comes down to -- which experts do you choose to believe? And at which point in time do you say -- "No further studies -- we know what we know is right?" I think "never" is the answer. You just don't really know for sure any of this. It's all prediction, assumption, uncertainty, especially with global warming and climate change very evident already. Floods and droughts will change water routes -- droughts could actually open up fissures and fractures to wider openings I would expect. You can't predict the weather long term any more than our local weather man I suspect -- you don't know for sure.

Response
This comment refers to statements in Section 3.1.4.1.2 of the EIS on a revised U.S. Geological Survey method for calculating peak flood discharges in the southwestern United States. This method applies only to 2-, 5-, 10-, 25-, 50-, and 100-year floods and not to the 500-year flood or the larger regional maximum flood or probable maximum flood. Moreover, DOE has not applied the revised method in the Yucca Mountain area because of inadequate records at gauging stations (DIRS 151945-CRWMS M&O 2000). Flood potential studies do not attempt to predict flood events. Rather, they use past stream discharge records to estimate statistically the probable recurrence frequency of peak discharges and areas of inundation. This is a standard engineering technique to enable the safe design of facilities in flood-prone areas, and is not unique to the Yucca Mountain Site Characterization Project. The Nuclear Regulatory Commission requires the calculation of probable maximum flood for sensitive nuclear facilities.

7.5.3.1 (8888)
Comment - EIS001834 / 0029
The DEIS also notes that the DOE will use controls to limit surface water contamination, but the DEIS does not outline the impacts that could occur if DOE's controls fail. It is unacceptable to state categorically that there will be no impacts because controls are in place. If that were true, the word "accident" would not be in our vocabulary.

Response
DOE agrees that there is a potential for accidents. However, the Department feels that proper planning and training, in addition to engineered controls and adherence to standards set by environmental regulations, can effectively reduce the probability of their occurring. Such actions can also reduce the severity and improve response actions (cleanup) should accidents occur, thereby minimizing environmental impacts.

DOE also agrees that it would be improper to state categorically that there would be no impacts to surface water. Section 4.1.3.2 of the EIS discusses potential impacts to surface water from the Proposed Action. The discussion identifies activities that could involve discharges of water to the surface and the types of materials that could cause surface-water contamination if released. In addition, the discussion describes features of the site and proposed activities that would tend to minimize the potential for releases or the impacts from releases if they occurred. In addition to the planning, training, controls, and regulatory compliance actions described above, the following features would tend to minimize the potential for impacts to surface waters:

1. Natural surface water is seldom present at the site to receive and spread contamination.

2. The types and nature of hazardous materials that would be present at the site to support the Proposed Action would be limited in variety and quantity, with handling and storage in accordance with regulatory requirements.

3. The spent nuclear fuel and high-level radioactive waste at the site would be in sealed, high-integrity containers unless they were inside facilities.

4. DOE would build facilities in the Restricted Area (where it would manage radioactive materials) to withstand the probable maximum flood.

7.5.3.1 (10923)
Comment - EIS000244 / 0008
The surface water is almost nonexistent except during some of the storms there because of what little surface water there is. There is sometimes six inches of rain, sometimes ten inches of rain. And I don't know the evapotranspiration there, but I know miles to the south of Ward Valley was 105 inches a year. So the potential of evaporation is ten times more than the rainfall or more.

Response
The commenter apparently is referring to Sections 3.1.2.2 and 3.1.4 of the Draft EIS regarding rainfall amounts and potential evaporation rates. Winter rainfall can exceed 5 centimeters (2 inches) daily in the Yucca Mountain region, and summer thunderstorms can exceed 2.5 centimeters (1 inch) in a matter of hours. These statements are consistent with the commenter's observation. Section 3.1.4 describes that the, potential evaporation is about 170 centimeters (66.9 inches) per year, which far exceeds the annual precipitation of 10-25 centimeters (3.9-9.8 inches) per year in the region and is in general agreement with the commenter's observation.

7.5.3.1 (11001)
Comment - EIS000623 / 0002
On [page] 6-62, it mentions that there's only one spring. Well, I found that not to be true. Looking on any of the maps that we have here, and there is an additional one that is below this, just so that it is on record for the water and maybe not just a spring but because wherever water comes from the ground there is one flowing well, there are six additional springs, there are six borderline springs. And I'd also like to mention of this if there ever was a problem, the old pluvial lakes that existed out here, a lot of them drained into Crescent Valley. Grass Valley and Carico Lake Valley have drainages that come into here. All this water flows from there to here. So if anything in between here and there is happening, it is unretrievable, there would be problems. Also there are three creeks that run year round that would be near this or through the proposed rail route, Steiner, Skull, Callahan, and also I might add a fourth one, Indian Creek as well, which is just right up over here. That is one of my main concerns, as well as our hot spring system that we have. Now, there are two private residences with thermal springs, and at the Hot Springs Point, the spring is undeveloped, and a lot of animal life in this valley go there for watering and for food, as well as, I might add, the Loudens, on their developed spring, and I have seen this personally, many types of migratory fowl and animals come through there as well.

Response
The EIS identifies one spring as being inside the 0.4-kilometer (0.25-mile) corridor in which the Carlin branch line would be located. However, Table 6-25 of the EIS also identifies 10 additional springs that are outside the corridor, but within 1 kilometer (0.62 mile). The table also shows five streams or riparian areas within the corridor and two others within 1 kilometer. Names and locations of specific surface-water resources summarized in Table 6-25 are shown in Table 3-37. Without knowing what areas on the map the commenter pointed to, DOE cannot determine whether or not the commenter is aware of additional surface-water resources that should be identified in the EIS. Table 3-37 lists Skull Creek as being in the corridor and the reference to this information (DIRS 104593-CRWMS M&O 1999) shows Steiner Creek being in the corridor of a Carlin line variation (see Figure 3-23). Callaghan and Indian Creeks were not found in the reference, but other creeks in the area with different names were identified.

Section 6.3.2.2.2 of the EIS discusses impacts to wildlife from the construction and operation of a branch rail line in the Carlin Corridor. DOE believes the potential for contaminants to be released to water resources during construction or operation of a branch rail line would be minor, as discussed in Section 6.3.2.1.

7.5.3.1 (12175)
Comment - EIS001622 / 0037
Page 3-35, Table 3-10. The total dissolved solids values listed in the table only range from 45 to 122 mg/L. However, the bicarbonate values alone are listed as ranging from 32 to 340 mg/L. Given the data presented in the table, TDS values should range from 51.5 to 516 mg/L. This discrepancy in the data table needs correction.

Response
The comment is correct. The values listed in Table 3-10 for total dissolved solids are not appropriate considering the other values listed in the table. An investigation of the problem found that the sampling sites represented by the values for total dissolved solids are a subset of the sampling sites represented by the other numbers in the table. DOE has corrected Table 3-10, and each data-range is from the same set of sampling locations. For example, the values for total dissolved solids remain the same, but the bicarbonate values range between 32 and 109 milligrams per liter.

7.5.3.1 (12668)
Comment - EIS000206 / 0009
Question that is not answered by DOE: the geology underground has proven difficult to model; recent data at the adjoining NTS have demonstrated far faster migration of plutonium underground than DOE scientists have predicted.

The important of question of water seepage through the site remains open; higher than expected levels of Chlorine 36 at the repository level can only be explained by water penetration from the surface in the last few decades.

Response
Section 3.1.4.2.2 of the EIS describes recent findings on the Nevada Test Site concerning the migration of plutonium. The small amount of plutonium detected in groundwater farther than expected from its source (a 1968 underground nuclear test) was apparently associated with the movement of colloids (very small particles). These findings suggest that radionuclides that are attached to colloids move faster than dissolved radionuclides because the colloids can travel in the faster parts of the flow paths, and sorb less onto host rocks than do dissolved radionuclides. Thus, the potential for faster movement of colloids becomes particularly important for radionuclides with high sorption, such as plutonium. Analysis of the long-term performance of the proposed repository incorporates the potential for plutonium to move with colloids (see Chapter 5 and Appendix I of the EIS). As described in Section I.3.1, DOE left plutonium species (specifically plutonium-239 and -242) in the model in spite of high sorption rates because of the large inventory that would be in the repository and the potential for colloidal transport. Consistent with this, the summary of modeling results in Section 5.4.2 attributes projected impacts from plutonium migration to colloidal transport, not transport as a dissolved element. The modeling of plutonium transport on colloids began with parameters derived from data obtained on the Nevada Test Site. The modeling, however, included input parameters that were above and below those derived from the Test Site data because the specifics of colloid properties and transport are not adequately known.

Section 3.1.4.2.2 of the EIS discusses the results of chlorine-36 studies. Water in limited parts of the Exploratory Studies Facility has apparently infiltrated from the surface to the waste-emplacement horizon in about 50 years. Water movement through rock fractures at the site is a key component of infiltration. This infiltration occurs much quicker along fractures than through the rock matrix. Chapter 5 and Appendix I of the EIS describe the models DOE used to analyze the long-term performance of the repository, including a model of flow through the unsaturated zone that simulates the movement of water through Yucca Mountain. As described in Section I.2.2 of the EIS, this model incorporates several different rock types to simulate different rates of water movement. It uses annual infiltration rates based on three different climates that could occur over thousands and hundreds of thousands of years (the current climate is the driest of the three). The quantity and location of water moving through the underground repository is a critical factor in analyzing long-term performance, and DOE would like to reduce the amount of uncertainty associated with the data being used in the model simulations.

7.5.3.2 Subsurface Hydrology/Geology

7.5.3.2 (2)
Comment - 13 comments summarized
Commenters were concerned that the repository would adversely affect Death Valley National Park. Some said that the repository would release radioactive contaminants into the groundwater which would threaten springs, surface water, and threatened and endangered species in Death Valley National Park and the Devils Hole Protective Withdrawal. Some noted that the springs in Furnace Creek Wash supply domestic and commercial water to Furnace Creek and maintain sensitive wildlife habitat. Others wanted to know how much of the spring flow in Death Valley was from the volcanic aquifer beneath Yucca Mountain.

Response
As described in Chapter 5 of the EIS, analyses of long-term performance of the repository have shown that releases of contaminants from the repository during the 10,000-year compliance period would be very small and well below the standards contained in 40 CFR Part 197. Measurable adverse impacts to humans and the environment would not be expected in any areas south of the repository, including Death Valley.

As described in Section 3.1.4 of the EIS, DOE has conducted an extensive program to characterize the direction and nature of groundwater flow and transport from the Yucca Mountain site. The general path of water that percolates through Yucca Mountain is southward toward the town of Amargosa Valley, then beneath the area around Death Valley Junction in the southern Amargosa Desert. The groundwater beneath Yucca Mountain merges and mixes with groundwater beneath Fortymile Wash. This groundwater then flows toward, and mixes with, the large groundwater reservoir in the Amargosa Desert. The natural discharge point of this groundwater occurs farther south in Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume may flow south toward Tecopa into the southern Death Valley area. A fraction of the groundwater may flow through fractures in the relatively impermeable Precambrian rocks at the southeastern end of the Funeral Mountains toward springs in the Furnace Creek area of Death Valley. Potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. This divide would limit discharge from the shallow flow system, but would not necessarily affect the flow from the deeper carbonate aquifer that may contribute discharge to springs in the Furnace Creek area (DIRS 100465-Luckey et al. 1996).

Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and from deeper flow in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson 1975). Groundwater in the northwestern Amargosa Desert originates in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend southward from Yucca Mountain. Even if part of the flow from Yucca Mountain mixes with the carbonate pathway that supplies the springs in Furnace Creek, it would be too little to noticeably affect the water quality of these springs. Considering the small amount of water that would infiltrate though the repository footprint compared to total amount of water flowing through the basin (approximately 0.2 percent or less), and the large distances involved [more than 60 kilometers (37 miles) from the source], any component of flow from Yucca Mountain that traveled this long and complicated flow path would be diluted to such an extent that it would be undetectable.

Groundwater that infiltrates through Yucca Mountain does not discharge at either the Devils Hole Protective Withdrawal or in Ash Meadows. The elevation of the water table in the Devils Hole/Ash Meadows area is about 64 meters (210 feet) higher than the water table in the Amargosa Desert to the west and south. This elevation decline indicates that groundwater from the carbonate rocks beneath the Devils Hole Hills flows westward across Ash Meadows toward the Amargosa Desert, not the other way around. Therefore, potential contaminants from Yucca Mountain could not discharge at springs in Devils Hole and Ash Meadows nor contaminate the aquifer.

Based on the foregoing discussion, and on analyses reported in the EIS, the ecosystem of Death Valley National Park would not be effected by the construction, operation, or closure of a repository at Yucca Mountain.

7.5.3.2 (8)
Comment - 16 comments summarized
Commenters said that the EIS inadequately described the relationships among the lower carbonate aquifer, the overlying volcanic units, and the alluvial units in valley areas. Because of data uncertainties, commenters said that DOE should acquire more data, develop better models, and describe a groundwater monitoring program. Commenters said that most groundwater studies were done on a regional scale and that apparent hydraulic-conductivity measurements are not very reliable at this scale. These commenters said that DOE should conduct additional hydraulic analysis of units near the repository and in downgradient areas based on multiwell draw-down tests, and provide additional description of the hydrologic data that have been gathered at Yucca Mountain. Commenters noted that only one well penetrates the deep carbonate aquifer. This was not considered to be adequate for determining the direction of groundwater flow and hydraulic conductivity, or to support the conclusion in the EIS that the entire carbonate aquifer has an upward gradient. Some said additional studies should be conducted on the fracture pathways leading to the carbonate aquifer. Given the many uncertainties about the hydrology of the region, commenters said that DOE needs much more information to conclude that the repository would operate as planned. Others noted that the cause of the large hydrologic gradient immediately north of Yucca Mountain has not been determined and that uncertainties exist about the pattern of groundwater flow beneath Pahute Mesa and Fortymile Wash, and the relationship of this flow to groundwater movement beneath Yucca Mountain. Because DOE acknowledges that data uncertainties exist, DOE should also acknowledge uncertainty regarding the direction of groundwater flow.

Response
DOE believes that it has sufficient information and understanding of the hydrologic setting to make an adequate determination of the potential environmental impacts from the Proposed Action. DOE, the U.S. Geological Survey, and others have been evaluating and assessing the hydrologic setting and associated characteristics at the Yucca Mountain site and nearby region for more than two decades. During this time DOE has modified its program to reflect new information and assessments and to accommodate reviews by independent parties, both internal and external to the Department. Nevertheless, DOE recognizes that additional information would refine its understanding of the regional groundwater flow system, and would reduce uncertainties associated with flow and transport in the alluvial, volcanic, and carbonate aquifers.

To obtain additional information, DOE has supported Nye County, with it's program (called the *Early Warning Drilling Program*) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the ongoing site characterization program (and possible performance confirmation program (which is described below) could be used in conjunction with that of the Early Warning Drilling Program to refine the DOE understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information, which is described in Section 3.1.4.2.1 of the EIS.

In addition, DOE has installed a series of test wells along the groundwater flow path between the Yucca Mountain site and the Town of Amargosa Valley as part of an alluvial testing complex. The objective of this program is to better characterize the alluvial deposits beneath Fortymile Wash along the east side of Yucca Mountain. Single- and multi-well tracer tests have begun and the results thus far have strengthened the basis of the site-scale saturated flow and transport model. This program is described in Section 3.1.4.2.1 of the EIS.

If the site were approved, DOE would continue to implement a "performance confirmation program," elements of which could address the hydrologic system. The purpose of this program is to evaluate the adequacy of the information used to demonstrate compliance with performance objectives. The performance confirmation program would continue through closure of the repository (possibly as long as 300 or more years after the end of emplacement). Data from this monitoring could offer a means to further understanding of the hydrologic system and reduce uncertainties.

Section 3.1.4.2.2 of the EIS refers to the large hydraulic gradient north of the site. An expert elicitation panel (DIRS 100353-CRWMS M&O 1998) addressed this feature and narrowed its likely cause to two theories: (1) flow through the upper volcanic confining unit or (2) semiperched water. The consensus of the panel favored the perched-water theory. Whatever the cause, the experts were in agreement that the probability of any large transient change in the configuration of this gradient is extremely low (DIRS 100353-CRWMS M&O 1998).

The understanding of the flow system and hydraulic relationships of the lower carbonate aquifer are based not only on data from well UE 25p #1 at Yucca Mountain, but on a large body of regional hydrologic and chemical evidence collected over the past 40 years. In addition to the one well (UE 25p #1) that penetrated the carbonate aquifer at Yucca Mountain, another well (NC-EWDP-2DB) along the potential flow path in Fortymile Wash has penetrated the carbonate aquifer and an upward hydraulic gradient was present. Well NC-EWDP-2DB, along with six additional planned wells, will help characterize the carbonate aquifer system near Yucca Mountain as part of the Nye County Early Warning Drilling Program. Four other wells at Yucca Mountain, as reported by Luckey et al. (DIRS 100465-1996), are believed to indicate the potentiometric level in the carbonate aquifer. Elsewhere in the general area, particularly at the southern end of the Nevada Test Site and eastward from the springs in Ash Meadows, the hydraulic relationship between the lower carbonate aquifer and overlying units is well understood (DIRS 101167-Winograd and Thordarson 1975). The very presence of the springs in Ash Meadows demonstrates the fact of an upward hydraulic gradient in the lower carbonate aquifer. Because the lower carbonate aquifer is buried by some 6,000 feet of unconsolidated deposits in the Amargosa Desert west of the springs in Ash Meadows, no wells have been drilled to this aquifer at this location. Claassen (DIRS 101125, 1985) presents hydraulic and hydrochemical evidence of subsurface discharge from the lower carbonate aquifer to the alluvial fill of the Amargosa Desert to the west of Rock Valley Wash. In addition, several investigators have concluded from hydrologic, chemical, and isotopic evidence that the lower carbonate aquifer is the source of the large springs in Furnace Creek Wash (Death Valley). DOE believes that there is sufficient information to make an informed determination about potential impacts from a repository at Yucca Mountain.

DOE would design and implement a postclosure monitoring program in compliance with the Nuclear Regulatory Commission regulations (10 CFR Part 63). Before closure, DOE would submit an application for a license amendment to the Nuclear Regulatory Commission for review and approval. The application would include, among other items:

1. An update of the assessment of the performance of the repository for the period after closure;

2. A description of the postclosure monitoring program;

3. A detailed description of measures to regulate or prevent activities that could impair the long-term isolation of the waste, and to preserve relevant information for use by future generations.

The application also would describe DOE's proposal for continued oversight to prevent any activity at the site that would pose an unreasonable risk of breaching the repository's engineered barriers, or increase the exposure of individual members of the public to radiation beyond limits allowed by the Nuclear Regulatory Commission. DOE has modified Chapter 9 of the EIS to include the types of monitoring and other institutional controls that would be contemplated. The Department would develop the details of this program during the consideration of the license amendment for closure. This would allow the Department to take advantage of new technological information, as appropriate.

7.5.3.2 (111)
Comment - 23 comments summarized
Commenters said that many studies have demonstrated that fractures at Yucca Mountain provide fast paths for surface water to penetrate to the waste-emplacement horizon and then to the saturated zone. Some noted that water samples collected along fractures and from the exploratory studies facility contain elevated amounts of chlorine-36 and tritium. The source of the chlorine-36 and tritium is atmospheric testing of nuclear weapons during the past 50 years in the Pacific and on the Nevada Test Site. This discovery contradicts earlier models of the unsaturated zone that depict water moving very slowly through pores in the rock. Some commenters said that contaminated groundwater could reach humans through water wells in less than 1,000 years, thereby disqualifying the site because it meets the conditions of 10 CFR 960.4-2-1. Others said that based on these findings, it is clear that the expected performance of the repository would result in significant radionuclide contamination of groundwater and, ultimately, surface waters downgradient from the site.

Response
As part of its site characterization activities, DOE has conducted a variety of investigations into the nature of water falling as precipitation on Yucca Mountain and passing through the unsaturated zone to the groundwater beneath. One such study has been to quantify the concentrations of certain radioisotopes in the Exploratory Studies Facility. Isotopes, such as chlorine-36 and tritium, which occur naturally and as a byproduct of atmospheric nuclear weapons testing, respectively, serve as indicators of the rate of flow through the unsaturated zone.

Results from preliminary studies have identified these isotopes in concentrations that tend to suggest that there are connected pathways through which surface precipitation has percolated to the repository horizon within the last 50 years. However, these isotopes have been found at locations that are generally associated with known, through-going faults and well-developed fracture systems close to the faults at the proposed repository horizon.

To ensure the correct interpretation of this chemical signal, DOE instituted additional studies to determine if independent laboratories and related isotopic studies can corroborate the detection of elevated concentrations of these radioisotopes. Results of the validation studies to this point have not allowed firm conclusions and, thus, the evaluations continue.

DOE believes that these findings do not indicate that the Yucca Mountain site should be declared unsuitable for development as a repository. Most of the water that infiltrates Yucca Mountain moves slowly through the matrix and fracture network of the rock, and isotopic data from water extracted from the rock matrix indicates that residence times are generally several thousand to as long as 10,000 years. Furthermore, after excavating more than 11 kilometers (8.4 miles) of tunnels at Yucca Mountain, DOE determined that only one fracture was moist (there was no active flow of water). This observation has been confirmed in test alcoves that are not subject to the effects of drying from active ventilation.

Nevertheless, the total system performance assessment incorporates the more conservative water movement data as well as information from other water infiltration and associated hydrogeological studies. As a result of this evaluation, DOE would not expect the repository (combination of natural and engineered barriers) to exceed the prescribed radiation exposure limits during the first 10,000 years after closure.

With regard to the expected long-term performance of the repository, modeling described in Chapter 5 shows that the combination of natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials from the repository to very small amounts during the first 10,000 years after permanent closure. This would comply with the limits specified by the Environmental Protection Agency in 40 CFR Part 197, *Environmental Radiation Protection Standards for Yucca Mountain, Nevada*.

With respect to disqualifying conditions at Yucca Mountain, explicit disqualifiers were included in DOE’s 1984 site suitability guidelines (10 CFR Part 960) in order to guide the agency’s assessment of multiple sites under consideration for repository development. At that time, failure to meet the qualifying condition of any guideline was a basis for disqualifying a site. Under the Nuclear Waste Policy Act, as amended in 1987, Congress directed DOE to focus only on Yucca Mountain and directed the Environmental Protection Agency and the Nuclear Regulatory Commission to promulgate standards to protect public health and safety (40 CFR Part 197 and 10 CFR Part 63).

Failure to meet the Environmental Protection Agency standards or the Nuclear Regulatory Commission criteria for licensing would disqualify the Yucca Mountain site.

In 1996, DOE published proposed amendments to its guidelines (10 CFR Part 960) to reflect the prevailing scientific view on how to evaluate the suitability of the Yucca Mountain site for the development of a nuclear waste repository (61 *FR* 66158). Because Congress had by this time required DOE to focus only on Yucca Mountain, DOE's proposed amendments dealt with provisions of the guidelines that were applicable to the site recommendation stage. In November 1999, DOE revised its 1996 proposal (64 *FR* 67054) to focus on the criteria and methodology to be used for evaluating geological and other related aspects of the Yucca Mountain site.

In 1987, amendments to the Nuclear Waste Policy Act specified Yucca Mountain as the only site DOE was to characterize. For this reason, and given advancements in site characterization, DOE proposed in 1996 to clarify and focus its 1984 guidelines to apply only to the Yucca Mountain site, but never made the revised guidelines final. In 1999, DOE proposed to further revise the terms of the guidelines (draft 10 CFR Part 963), based on three primary reasons:

1. To address comments that criticized the omission of essential details of the criteria and methodology for evaluating the suitability of the Yucca Mountain site.

2. To update the criteria and methodology for assessing site suitability based on the most current technical and scientific understanding of the performance of a repository at the Yucca Mountain site, as reflected in the DOE report, *Viability Assessment of a Repository at Yucca Mountain* (DOE 1998a).

3. To be consistent with the then-proposed site-specific licensing criteria for the Yucca Mountain site issued by the Nuclear Regulatory Commission (the Commission has since finalized these criteria at 10 CFR Part 63), and the then-proposed site-specific radiation protection standards issued by the Environmental Protection Agency (finalized at 40 CFR Part 197).

In 2001, DOE finalized its guidelines to evaluate the suitability of the Yucca Mountain site for development as a geologic repository (10 CFR Part 963).

7.5.3.2 (228)
Comment - 91 comments summarized
Commenters said that Yucca Mountain is not a stable or safe place for a geologic repository because the region is prone to faulting, earthquakes, and volcanic activity. Commenters pointed out that Nevada is the third-most seismically active state in the nation and that the 1992 earthquake at Little Skull Mountain severely damaged DOE buildings near Yucca Mountain. Others cited recent studies in Science Magazine that the earth's crust at the site is moving faster than previously estimated. This suggests that DOE underestimated the volcanic and seismic hazards at Yucca Mountain, including evidence for a shallow magma chamber beneath Yucca Mountain which increases the likelihood for a volcanic eruption.

Many commenters said that DOE did not examine these subjects in the EIS, or examined them inadequately, or disagreed with DOE's assessment of the impacts that these geologic hazards pose on the short- and long-term performance of the repository. Many others questioned how DOE could be sure of the estimated impacts from these hazards considering the 10,000-plus years that the repository is required to operate safely.

Response
Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future earthquakes and volcanic activity, DOE believes that a repository at Yucca Mountain would result in small short- and long-term environmental impacts. Concerning the adequacy of the descriptions and analyses in the EIS, Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes the likely impacts from accidents caused by earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Some factual changes and clarifications that have been included in the Final EIS, and DOE believes

that the EIS adequately describes and analyzes on the geology, geologic hazards, and the effects of these hazards on the repository.

As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring seismic activity and studying the geologic structure at and near Yucca Mountain since 1978. Using the results of these and other studies conducted in the Region, along with input from panels of recognized experts on seismic risks and hazards, surface facilities at the repository would be designed to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of once in 10,000 years. This is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

The 1992 earthquake at Little Skull Mountain 20 kilometers (12 miles) southeast of Yucca Mountain was the largest recorded earthquake within 50 kilometers (31 miles) of the proposed site of the repository. This earthquake, with a Richter magnitude of 5.6, did not damage facilities or structures at Yucca Mountain. It did, however, cause about $100,000 damage to buildings at the Field Operations Center in Jackass Flats about 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility). These old buildings were not constructed to the seismic design specifications that would be used for surface facilities at Yucca Mountain.

The State of Nevada ranks third, behind Alaska and California, in seismic activity. Nevada's reputation as a seismically active state comes from major historic earthquakes in western and central Nevada with magnitudes of 7 or more on the Richter scale. This seismic belt may be an extension into Nevada of the Death Valley-Furnace Creek fault system in southeastern California. The average frequency of earthquakes of magnitude 6.0 to 6.9 in western Nevada has been about one every 10 years; earthquakes of magnitude 7 and greater average about one every 27 years. Yucca Mountain does not lie within this highly active seismic belt. Nevertheless, DOE estimated the impacts from extremely large and unlikely seismic events ("beyond design-basis") that could cause the waste-handling building to collapse and damage the pressurized-water reactor fuel assemblies. DOE concluded that the impacts from such an extreme event would be small because of the physical form of the fuel assemblies, protection by the building rubble, and the long distance to the nearest population.

The study reported in *Science* was prepared by Wernicke et al. (DIRS 103485-1998) and is discussed in Section 3.1.3.3 of the EIS. This study was based on measurements using a Global Positioning System over the period from 1991 to 1997 at five stations in the Yucca Mountain area. The authors claim that the crustal strain rates in the Yucca Mountain region are at least an order of magnitude higher than would be predicted from the Quaternary volcanic and tectonic history of the area. If higher strain rates exist, the authors suggest that the volcanic and seismic hazards at Yucca Mountain could be underestimated on the basis of the long-term geologic record.

In May 1998, scientists from the U.S. Geological Survey resurveyed the area using a network of 14 geodetic stations that was originally installed in 1983 (DIRS 103458-Savage, Svarc, and Prescott 1998). Two of the 14 stations were used by Wernicke et al. (DIRS 103458-1998) in their study. Based on the greater number of stations, the longer survey period (1983 to 1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake, the U.S. Geological Survey concluded that the strain rate in the Yucca Mountain region is about an order of magnitude lower than that reported by Wernicke et al. (DIRS 103485-1998). The results of the U.S. Geological Survey study are consistent with a large body of geological data that has been collected in the Yucca Mountain region during the past two decades.

Wernicke et al. (DIRS 103485-1998) also speculated that the high strain accumulation across the Yucca Mountain area could be driven by magmatic inflation at depth. They pointed to an early seismic study that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma (DIRS 106447-Oliver, Ponce, and Hunter 1995). A subsequent study demonstrated rather conclusively that there is no low-velocity zone under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard (DIRS 105358-Biasi 1996).

Based on the subsequent investigations by the U.S. Geological Survey described above, DOE does not concur with the results reported by Wernicke et al. (DIRS 103485-1998). DOE is nevertheless continuing to monitor crustal strain in the Yucca Mountain region through a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of this study, recently estimated in a quarterly report to the Yucca Mountain Project that conclusions should be available in 2002.

DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. Section 5.2.4 of the EIS describes how DOE dealt with these uncertainties. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Nuclear Regulatory Commission indicates that absolute proof is not to be had in the ordinary sense of the word (see 10 CFR Part 63), and the Environmental Protection Agency finds that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance (see 40 CFR Part 197).

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to assessing the long-term performance of the repository addresses and compensates for important uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

The proposed waste emplacement horizon at Yucca Mountain would be excavated in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have much less affect on subsurface facilities than surface facilities. Inspection of tunnels in the Yucca Mountain area after earthquakes has revealed little evidence of disturbance. Furthermore, the proposed waste emplacement horizon is not near faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide releases. Postemplacement seismic activity at Yucca Mountain would probably be along existing fault planes.

As described in Section 3.1.3 of the EIS, the most recent volcanic eruption in the area occurred between 70,000 and 90,000 years ago about 10 miles south of the Yucca Mountain site. The next-youngest eruptions were in Crater Flat west of Yucca Mountain where four northeast-trending cinder cones developed about 1 million years ago. A panel of experts examined the data, models, and related uncertainties, and concluded that the probability of a volcanic dike disrupting the repository during the first 10,000 years after closure is 1 in 7,000 (one chance in 70 million per year). This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRMS M&O 2000). Although extremely unlikely, a volcanic eruption through the repository could spread ash and entrained waste into the atmosphere and magma into the waste-emplacement drifts. DOE estimated the potential impacts to the nearest population, conservatively assuming the direction and speed of wind transport of an ash plume, and determined that the impacts to public health and safety would be very small. DOE also determined that magma flowing into the waste-emplacement drifts would have minimal impacts on the long-term performance of the repository.

As described in Chapter 5, during the first 10,000 years after closure of the repository, earthquake-induced shaking could dislodge rocks from the roof of the emplacement drifts. The likelihood of falling rocks splitting open a waste package is essentially zero because waste packages would be protected by titanium drip shields. Even if a drip shield were ruptured by falling rocks, the force and impact would be absorbed by the drip shield and not transferred completely to the waste package. Furthermore, the metal walls of the waste package itself would be designed to withstand the impact from falling rocks.

7.5.3.2 (229)

Comment - 24 comments summarized

Commenters said that groundwater could rise sufficiently high to flood the underground repository. Some pointed to reports that theorized that groundwater had risen to elevations in the past that could inundate the proposed waste-emplacement horizon. Others said that DOE did not consider these studies adequately. Some pointed out that DOE is funding additional work on this topic through the University of Nevada, Las Vegas, and that the EIS should not be completed until this work is done. Still others said that DOE should have examined the impacts to the long-term performance of the repository if an extreme climatic change caused groundwater to enter the underground repository. Reasons cited for rises of the water table included, in addition to climatic changes, earthquakes and volcanic eruptions.

Response

Section 3.1.4.2.2 of the EIS discusses the views of several investigators concerning fluctuations in the elevation of the water table that are in opposition to DOE's views regarding that subject. These investigators have stated that the water table at Yucca Mountain has risen in the past to elevations that are higher than the proposed waste-emplacement horizon beneath Yucca Mountain. Based on the results of these and other analyses reported in Section 3.1.4.2.2, DOE has concluded that no credible combination of future climate change, earthquakes, and volcanic eruptions could raise the water table sufficiently high to inundate the waste emplacement horizon.

The water table is about 750 meters (2,500 feet) below the crest of Yucca Mountain. Under the Proposed Action, DOE would emplace the waste 160 to 400 meters (525 to 1,300 feet) above the water table. Section 3.1.4.2.2 of the EIS describes evidence that the elevation of the water table has fluctuated over the past million years. Scientists working on the Yucca Mountain Project have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under extremely wet climatic conditions. The regional aquifer beneath Yucca Mountain is estimated to have been at most 120 meters (390 feet) above its present elevation during Quaternary time based on mineralogic data, isotopic data, and discharge-deposit data. An earthquake occurring under these extreme climatic conditions might cause an additional temporary rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters (66 feet) or more between the water table and the level of the waste emplacement drifts. The Little Skull Mountain earthquake (magnitude 5.6) raised water levels in monitoring wells at Yucca Mountain less than one meter (DIRS 101276-O'Brien 1993). Water level and fluid pressure in continuously monitored wells rose sharply and then receded to pre-earthquake levels over a period of several hours. The rise of water levels in wells monitored at hourly intervals was on the order of centimeters and indistinguishable after two hours (DIRS 101276-O'Brien 1993).

Szymanski (DIRS 106963-1989) hypothesized that during the last 10,000 to 1 million years, earthquakes and volcanic activity drove hot mineralized groundwater to the surface. This hypothesis goes on to suggest that similar forces could raise the regional water table in the future and inundate the proposed waste emplacement horizon. DOE requested the National Academy of Sciences to conduct an independent evaluation of this issue. The Academy examined the model upon which this theory is based and rejected its most important aspects. The Academy concluded that the evidence cited by Szymanski as proof of groundwater upwelling--exposed vein-like deposits of calcium carbonate and opaline silica--could not reasonably be attributed to that process. Furthermore, the Academy found that the combination of earthquakes and volcanic activity would not raise the water table more than a few tens of meters. Finally, the Academy concluded that the carbonate-opaline veins originated from surface precipitation and surface processes, not from upwelling groundwater.

Dublyansky (DIRS 104875-1998) proposed an alternative interpretation of past groundwater levels at Yucca Mountain. This study examined tiny pockets of water (called "fluid inclusions") trapped in the carbonate-opaline veins at Yucca Mountain. According to Dublyansky, the fluid inclusions indicate that the veins were caused by rising hydrothermal water and not by downward percolation of surface water. A group of project scientists specializing in hydrology, geology, isotope geochemistry, and climatology did not concur with Dublyansky's conclusions (DIRS 100086-Stuckless et al. 1998). DOE has nevertheless agreed to continue funding research on this topic through the University of Nevada-Las Vegas. DOE views this additional research as a supplement to previous efforts. In November 2001, preliminary results were made public that support the earlier conclusions of DOE and the National Academy of Sciences. See Section 3.1.4.2.2 for additional information.

In another opposing view, Davies and Archambeau (DIRS 103180-1997) suggest that an earthquake of moderate magnitude could displace southward the large hydraulic gradient that now exists north of the site. The authors speculate that if this were to occur, the water table at Yucca Mountain could rise 150 meters (490 feet). A severe earthquake, as suggested by the authors, could raise the water table 240 meters (790 feet) and flood the waste emplacement horizon. DOE convened a panel of five recognized groundwater experts to review the issues raised by Davies and Archambeau. The consensus was that a rise in the elevation of the water table due to earthquakes would be neither large nor long-lived (DIRS 100353-CRWMS M&O 1998).

DOE does not believe that the scenarios presented by Szymanski, Dublyansky, and Davies and Archambeau are credible; therefore, they are not reasonably foreseeable. Furthermore, there is no credible evidence to support a rise of the water table to a level that could inundate the waste emplacement horizon. In fact, DOE believes that geologic evidence strongly indicates that water levels have not risen to levels that could affect the performance of the repository. Therefore, DOE did not evaluate the impacts to the long-term performance of the repository from inundation by groundwater because such impacts are not reasonably foreseeable. This approach is consistent with regulations of the Council on Environmental Quality at 40 CFR 1501.1, which directs agencies to focus on significant environmental issues and reduce the accumulation of extraneous background data.

7.5.3.2 (230)

Comment - 42 comments summarized

Commenters said that the repository would contaminate groundwater with radioactive materials and other pollutants that would adversely affect the health of people and wildlife. Some said that DOE did not examine the issue of groundwater contamination in the EIS, or examined it inadequately, or disagreed with the results reported in the Draft EIS. Others said that DOE cannot guarantee that the repository would not contaminate the groundwater and that any contamination is unacceptable. Some feared the repository would contaminate groundwater in a broader area, including Las Vegas, the Colorado River, and other parts of Nevada and California. Others questioned how DOE can reliably predict the release of radioactive materials from the repository over thousands and millions of years considering that the data and models used to make these predictions are not reliable.

Response

Based on the results of analyses reported in Chapter 5 of the EIS, DOE believes that a repository at Yucca Mountain would have negligible short and long-term environmental impacts. DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, which considered faults, earthquakes, volcanism, and fast-flow movement of water through the mountain, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

Sections 3.1.3 and 3.1.4 of the EIS describe the geologic and hydrologic settings of Yucca Mountain and the surrounding region in great detail. Subsections of 8.2 and 8.3 consider the cumulative impacts to groundwater from the repository, the Nevada Test Site, and other activities in the area that could contribute to long-term groundwater pollution. DOE believes that the information in the EIS on the amount and type of contaminants released over time from the repository and from other sources in the region have been adequately described and analyzed in the EIS. Estimated releases to the accessible environment during and after the 10,000-year regulatory period would be limited geographically to the groundwater flow system described in Section 3.1.4.2 of the EIS; contaminants from the repository could not reach the Las Vegas Valley, the Colorado River, or any other parts of Nevada and California.

DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. Section 5.2.4 of the EIS describes how DOE dealt with these uncertainties. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Nuclear Regulatory Commission indicates that absolute proof is not to be had in the ordinary sense of the word (see 10 CFR Part 63), and the Environmental Protection Agency finds that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance (see 40 CFR Part 197).

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to assessing the long-term performance of the repository addresses and compensates for important uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Meanwhile, DOE recognizes that the acquisition of additional data would further reduce uncertainties. Studies are planned to gather some of this information. Section 2.1.2.3 of the EIS describes the types of tests, experiments, and analyses the Department would conduct during the “performance-confirmation” phase of the program. This program would continue for perhaps as long as 300 years after emplacement ends (through closure of the repository as described in Section 2.1.2). The purpose of the performance-confirmation program is to evaluate the accuracy and adequacy of the information used to demonstrate compliance with performance objectives.

7.5.3.2 (315)
Comment - EIS000002 / 0002
Nevada has a Great Basin, that is, it is a land of interior drainage. Nevada had a violent geologic metamorphosis, millions of years ago, undergoing continual erosion for a long period. It experienced earth movements which have been continual and vigorous to this day in the interiors of its volcanic mountains. As a result, most of the mountain ranges in the Great Basin are bounded by faults on either one side or on both sides of the mountains. During the period of the geologic metamorphosis drainage to the prehistoric seas was disrupted, causing diversion of the streams into the interior basins and setting the basic structure of water to drain into the interior of the faults and crevices of the volcanic mountains. To place canisters or tanks that store nuclear waste into such volcanic

mountains, that could cause these containers to break or leak, is placing the entire interior water supply to the state at great risk for nuclear contamination. The DOE has not addressed this issue sufficiently.

Response
DOE has conducted an extensive site characterization program to evaluate the suitability of Yucca Mountain for a repository. Yucca Mountain is in the Death Valley Regional Groundwater Flow System, which is part of the larger Great Basin physiographic subprovince. This area is characterized by a very dry climate, limited surface water, and very deep aquifers. The region is a closed hydrologic system, which means its surface water and groundwater can leave only by evaporation from the soil and transpiration from plants. The central Death Valley hydrologic subregion is comprised of three groundwater basins that are subdivided into smaller sections. Yucca Mountain is in the Alkali Flat-Furnace Creek groundwater basin. Some of the water that infiltrates through Yucca Mountain joins groundwater in the Fortymile Canyon section and flows toward the Amargosa River section (see Figure 3-13 of the EIS). Thus, the small fraction of the total water in the basin that might move though a repository would be likely to flow toward the south toward Amargosa Valley, and therefore does not pose any risk of contamination to the entire water supply of the state.

The areas proposed for waste emplacement at Yucca Mountain are located in areas away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Additional fault movements or displacements from postemplacement seismic activity would probably be along existing fault planes.

Hydrology models, derived from extensive studies conducted at Yucca Mountain, are based on a fault-fracture flow system. Inception of a few new faults and associated seismic events would have very minor or no effect on the current fault- and fracture-flow pathways, and would therefore be unlikely to alter repository performance. Modeling of long-term performance shows that the combination of natural and engineered barriers at the site would keep releases of radionuclides well below the regulatory limits established at 40 CFR Part 197.

DOE considered volcanic disturbances and conducted extensive assessments. The rocks at Yucca Mountain were formed 11.5 to 14 million years ago by large silicic ash flows that were erupted during a period of intense tectonic activity. The volcanism that produced these ash flows stopped millions of years ago and, based on the geology of similar volcanic systems in the Great Basin, no additional large volume silicic volcanism is likely. Less explosive and much smaller volume basaltic volcanism in the Yucca Mountain region began about 11 million years ago as silicic eruptions waned and continued as recently as 70,000 to 90,000 years ago. Disruption of a repository at Yucca Mountain by volcanoes would be highly unlikely. For more information, see EIS Sections 3.1.3, 3.1.4.2, and 5.4. The chance of a volcanic disruption at or near a repository at Yucca Mountain is one chance in 7,000 during the first 10,000 years after closure (one chance in 70 million annually).

This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout (one chance in 63 million annually), considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

7.5.3.2 (501)
Comment - EIS000125 / 0001
My concern is the perched water and if we had had underground nuclear testing out at the Test Site which has polluted the water out there, and now we have perched water which they have found which has a certain amount of chemicals in it, how are these chemicals in this perched water going to react with the other chemicals that are in these spent fuel rods?

In other words, one radionuclide does not mix with another radionuclide, and what about the isotopes in there? There’s a big question here with perched water.

And we’re just willing to go out there and just tear everything up we want to tear up to put this spent fuel rod in the ground where we got a possibility of one nuclide mixing with another radionuclide that we have had underground nuclear testing out there and it just is not going to mix.

If we ever had any underground nuclear testing out there, it might be a different story because in that first part, you have different chemicals, but because we have found the chemicals that were in the underground nuclear testing in those perched water -- you're going to put that canister. You don't even know all where the perched water is. You haven't even done that much studying. You have found some. You have admitted to that.

So I think the study of perched water and one radionuclide mixing with the other could cause some major melt down, and then we're just going to be in a big mess.

Response
Section 3.1.4.2.2 of the EIS describes the occurrence of perched water below the area of the proposed repository. Later in the same section, results of water chemistry analysis of the perched water are presented in a table. The constituents identified occur naturally as a result of the water's interaction with the rock through which it passes. This comment appears to express concern over the potential of a nuclear criticality as a result of the mixing of radionuclides outside the disposal containers and as a result of the presence of the perched water. DOE has studied the potential for such a reaction to occur (including effects from the presence of water) as a result of the proposed action. The results of those studies, which characterize the potential for criticality events to range from highly unlikely to not credible, are summarized in Section 5.8 of the EIS.

7.5.3.2 (589)
Comment - EIS000127 / 0006
They found fifteen to thirty fractures per meter in the tunnel that they've drilled. They found crystals that were made by either water going up or water going down and they don't know which, and they found chambers in the mountain, big ones that they tried to fill up with gravel before their own scientists got to look at it.

Response
As part of its site characterization activities, DOE built the Exploratory Studies Facility for scientific and engineering studies, testing, and experiments (see Section 1.4.3.1 of the EIS). The objective of these subsurface investigations is to obtain an understanding of conditions in the potential repository horizon and in the overlying rock units. The Exploratory Studies Facility intersects a zone that contains a relatively high concentration of fractures (DIRS 101367-Albin et al. 1997). This zone consists of more than five fractures per linear meter of tunnel. Most of this intense fracturing occurred adjacent to faults. The Main Drift in the area of the fracture zone is parallel to the Ghost Dance Fault approximately 100 meters (330 feet) to the east. In general, the intense zone of fracturing appears to occur only in the middle nonlithophysal zone of the Paintbrush Group (DIRS 101367-Albin et al. 1997). Fracture frequency is lower in other parts of the Main Drift (DIRS 101367-Albin et al. 1997).

Because borehole samples drilled before the excavation of the Exploratory Studies Facility contained mineral crystals, DOE anticipated the presence of fractures in the subsurface and planned to study their characteristics. As the comment indicates, scientific activities in the Exploratory Studies Facility mapped, sampled, and analyzed additional mineral crystals. The information obtained by scientists working on the Yucca Mountain Project agrees with the results of earlier studies reviewed by the National Academy of Sciences that concluded that the downward percolation of groundwater caused the formations of the crystals. Section 3.1.4.2.2 of the EIS discusses this issue and alternative interpretations.

During excavation of the Exploratory Studies Facility, DOE inspected conditions to determine if the Bow Ridge fault zone had been intersected and found a "chamber" or void (DIRS 152214-Elkins 1995). At the time of the inspection, there was an opening at the top of the cutter head of the tunnel-boring machine that was 2 to 3 meters (7 to 10 feet) wider than the tunnel. The opening extended about 6 meters (20 feet) above the shield of the tunnel-boring machine, tapering to less than 0.5 meter (1.6 feet) near the top of the opening. The opening was at most about 2 to 3 meters thick (normal to the tunnel). The upper 3 to 4 meters (10 to 13 feet) of the opening was smooth, indicating that it probably existed before the excavation. It was photographed, the material was sampled, and the opening was stabilized before excavations proceeded. Analyses indicated that fibercreting the void face and filling the void with lean cement would not interfere with planned test activities at the Bow Ridge fault zone.

7.5.3.2 (725)

Comment - EIS000210 / 0003

Ground water migration in the area is also well documented and should add to the scientific basis for rejecting this as the final selected site as a high level nuclear repository. Please take some time to review the literature to evaluate the impacts of 'what if' scenarios if these waste chambers become flooded and radionuclides are leached into the groundwater. What have past radioecology studies at Nevada Test Site, Chernobyl, Rocky Flats, Project Rio Blanco, Hanford and other hot sites where tritium, etc. have been known to migrate off site taught us? Cannot correlations be drawn for Yucca and its surrounds? Should not the EIS ask these extremely difficult, worst case questions? That way everyone goes into this Waste Priesthood, a clearly defined group of elite individuals who will need to be trained and cultivated to watch over and safeguard this waste for the material's life some tens of thousands of years, with a full understanding and at least a plan for eventual catastrophic seismic failure.

Response

The possibility of groundwater rising sufficiently in the future to inundate the waste packages is remote. There are no credible mechanisms that can account for such a rise. Szymanski (DIRS 106963-1989) proposed that during the last 10,000 to 1,000,000 years, earthquakes and volcanic activities drove hot mineralized groundwater to the surface, and deposited calcite and opal at Yucca Mountain. This hypothesis goes on to suggest that similar forces could raise the regional groundwater in the future and inundate the repository.

To investigate this hypothesis further, DOE requested the National Academy of Sciences to conduct an independent evaluation. The Academy concluded in its 1992 report (DIRS 105162-National Research Council 1992) that no known mechanism could cause a future inundation of the repository horizon. The geologic evidence indicates that groundwater never reached the repository horizon; in fact, the largest rise seems to have been about 120 meters (390 feet) during the last several million or more years. Based on simulations of earthquake effects, the predicted water table rise could be about 20 meters (66 feet) at most. The 1992 Little Skull Mountain earthquake raised water levels in some monitoring wells by a maximum of less than 1 meter.

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm water upwelling hypothesis. That study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. It concluded that some crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of independent experts, including scientists from the U.S. Geological Survey, did not concur with Dublyansky's conclusions. DOE disagrees with the central conclusions in this report, but has supported continuing research by the University of Nevada, Las Vegas. EIS Section 3.1.4.2.2 contains more information on groundwater at Yucca Mountain.

The comment refers to several other places that might offer insights to processes at Yucca Mountain. DOE recognizes the value of such comparisons, but realizes the need for care in the selection of an appropriate site for comparison to process of interest at Yucca Mountain. An ideal comparison site to long-term radionuclide transport at Yucca Mountain would have to satisfy the following conditions: (1) a known source term, (2) a similar set of radionuclides, (3) well characterized site data, (4) similar geologic conditions, (5) observable long-term conditions, (6) identifiable boundaries of the system, and (7) a clear-cut process that can be separated from other processes.

An example of a comparison site mentioned by the comment is the April 1986 accident at the Chernobyl nuclear power plant. After studying this accident, DOE determined that the conditions at Chernobyl and Yucca Mountain are different in several major aspects, such as climate, geologic and tectonic setting, and depth to the water table. The Chernobyl catastrophe was an above-ground explosion accompanied by an atmospheric release of radionuclides, with subsequent contamination of the land surface. Radionuclides that descended from the atmosphere to the land were distributed through surface-water reservoirs, and then entered the unsaturated zone and percolated down through zones of preferential flow toward the water table. In contrast, atmospheric transport at Yucca Mountain would not be a factor, and surface-water transport of radionuclides would be negligible. Furthermore, the suite of radionuclides at Yucca Mountain would be somewhat different from the radionuclides at Chernobyl.

Background conditions and expected modes of contamination for Chernobyl and Yucca Mountain are not directly analogous. What DOE learned from reviewing the more than 13 years of investigations of infiltration and contaminant transport at Chernobyl can provide insight to some of the flow and transport processes at Yucca Mountain. The most important conclusions of this study are as follows:

1. Spatial and temporal variations of infiltration rates and fast preferential flow in the near-surface zone depend on topography. Near-surface fast infiltration and migration of radionuclides in the unsaturated zone occur in surface depressions. Despite the low level of contamination detected in groundwater, the appearance of Chernobyl radionuclides confirms the presence of localized, preferential, radionuclide transport though the unsaturated zone.

2. Rapid groundwater contamination around Chernobyl might not be associated directly with the near-surface zones of preferential flow.

3. Section 13 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) contains a more complete discussion of DOE's natural analog study.

7.5.3.2 (870)
Comment - EIS000252 / 0004
Sometimes I refer to the Yucca Mountain facility as just the parking lot for this high level waste is that the mountain has been -- in more recent research the mountain is not going to be the primary thing that is going to contain the waste. It is going to be the canister and the containers.

Response
As described in Section 2.1 of the EIS, DOE is relying on both the inherent geologic features of the mountain and manmade barriers to ensure the long-term isolation of the spent nuclear fuel and high-level radioactive waste from the human environment. The packaging or container holding the materials when they are emplaced in the repository is a major component of the engineered barriers.

7.5.3.2 (914)
Comment - EIS000089 / 0003
We get a lot of rain one year and then a couple years we don't get no rain at all, so they average things out. They come up with these working models that don't work.

We know that for sure right now because, you know, back in the '90s when we were setting off the bombs in the ground, we said, "Hey, that's going to contaminate the groundwater."

They said, "Oh, no. It's not going to contaminate the groundwater. It's going to be contained." These bombs are going off, they create these lasts pops underneath and that bomb is so hot, it just melts everything around it. There's no problems here.

Even if it does get into the groundwater, that groundwater will never move.
Now they're talking about plumes underwater, underground. I was so disgusted the other way. I know this DOE is putting this information out. You guys are liable to us. You're going to have to live with yourselves.

So what are we going to do? We're sitting out here. First they said, "Don't worry about it, folks. It's never going to move, the groundwater even if it does get contaminated."

"Well, it's moved a mile away from the site. We've detected the radiation in the groundwater. May be our models weren't right, so we're figuring 10,000 years before it reaches Death Valley."

Response
Many of the studies conducted at Yucca Mountain are designed to help DOE make reasonable projections of how and when contaminants in the groundwater might travel from the repository. The explanations in the EIS present the consensus understanding of experts working for DOE, its contractors, other government agencies, academia, and the public sector. The projections consider not only average and worst-case environmental parameters (such as precipitation and infiltration) from measured values in current and historical records, but also geologic-scale evidence to determine what occurred in the past and, therefore, what might occur in the future.

As suggested by the commenter, the amount of water moving through the mountain is one of the key parameters incorporated in the projection of contaminant movement. As described in Sections 5.2.4.1 and I.2.2 of the EIS, the performance assessment includes a large range of water fluxes reflecting wide rainfall variations that could occur over thousands and hundreds of thousands of years, and assumes that the current climate is the driest it will ever be at Yucca Mountain.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials. Section 5.6 of the EIS contains additional information.

7.5.3.2 (949)
<u>Comment</u> - EIS000259 / 0001
Inyo County is very concerned about the long-term threat the repository poses to regional groundwater supplies and to communities east of the Owens Valley. Hydrologic studies conducted by Inyo, Nye and Esmeralda Counties point to the existence of a continuous aquifer running from beneath Yucca Mountain southwards to Tecopa, Shoshone and Death Valley Junction. These studies also support the contention that water flowing beneath Yucca Mountain flows southeast to become surface water flowing into Death Valley. Some of this water is used in Death Valley for commercial and domestic purposes, and of course supports natural habitat under Federal protection.

The two studies I'm referring to are a 1996 publication titled "An Evaluation of the Hydrology at Yucca Mountain: The Lower Carbonate Aquifer and Amargosa River" and the 1998 "Death Valley Springs Geochemical Investigation." These studies were conducted with Federal funding in accordance with USGS quality assurance and quality control measures, and will be submitted to DOE in conjunction with our written comments in January.

Nowhere in the Environmental Impact Statement does DOE address our findings, either to acknowledge or deny the implications of these studies with regard to potential pathways for contaminants to reach human populations or a National Park. These studies have been available to DOE for some time and are absent from the 50,000 pages of technical background material which went into development of the EIS.

This is a critical oversight on the part of DOE, which needs to be corrected by serious consideration of the scientific work sponsored by the County and the placement of our findings in the proper context.

<u>Response</u>
DOE acknowledges in the EIS that the groundwater flowpath from Yucca Mountain includes the locations identified by the commenter, with the exception of the Owens Valley area. Section 3.1.4.2.1 describes groundwater beneath Yucca Mountain as flowing to Jackass Flats, the Amargosa Desert, and then south to the primary point of discharge at Franklin Lake Playa in Alkali Flat, which is southeast of Death Valley Junction. The EIS states that some groundwater reaching this far might bypass the playa and continue into the Death Valley basin, which would require flow through the Tecopa and Shoshone areas. The EIS recognizes that a small amount of the groundwater beneath the Amargosa Desert might flow through the southeastern end of the Funeral Mountains toward springs in the Furnace Creek Wash area of Death Valley.

Chapter 5 of the EIS does not specifically address risks to people and natural resources in Tecopa, Shoshone, or Death Valley National Park as a result of groundwater use and consumption. However, the evaluation in Chapter 5 clearly shows that risks would decrease with increased distance from the repository. Accordingly, impacts to these other areas, because they are farther away along the groundwater flowpath, would be less than those for the farthest distance evaluated in the EIS. Section 5.9 addresses impacts to biological resources as a result of long-term repository performance. As indicated in that section, DOE does not quantify impacts to biological resources as a result of exposures to contaminated groundwater, but relates them to the minimal impacts expected for humans through the use and consumption of the groundwater.

As described in Section 3.1.4 of the EIS, the Death Valley regional groundwater flow system is a terminal hydrologic basin. That is, there is no natural pathway for groundwater or surface water to leave the basin other than by evaporation or transpiration through plants; Death Valley is the lowest part of the basin. With this in mind, impacts to groundwater east of Owens Valley, but outside the Death Valley flow system, would not occur. For areas within the Death Valley flow system, but west of Death Valley, any contaminants reaching Death Valley over thousands of years would have to flow up the hydrologic gradient on the west side of Death Valley to reach areas east of Owens Valley which would not occur.

DOE received the two reports identified in the comment. It did not reference them in the EIS (similar to many other reference sources), because the conclusions they present are not contradictory or inconsistent with the information in the EIS. For example, the primary conclusion of the "Geochemistry" report is as follows: "The water can come from recharge in 1) the area of NTS [Nevada Test Site] and Yucca Mountain; or 2) the Amargosa Basin fill deposits, or 3) the area to the east that includes the Ash Meadows springs, or some combination of all three" (DIRS 147808-King and Bredehoeft 1999). The EIS identifies the apparent link of groundwater from beneath Amargosa Desert to the Furnace Creek springs and suggests that the link could involve groundwater from beneath Yucca Mountain by identifying it in the flowpath. The earlier "Lower Carbonate Aquifer" report concludes that (1) groundwater movement beneath Yucca Mountain is upward out of the carbonates into the tuff; (2) if contaminants reach the carbonates, travel times could be relatively short; (3) discharges to springs on the east side of Death Valley appear to be linked to the carbonates; (4) Esmeralda County is not in the groundwater flow path from Yucca Mountain; and (5) there are geohydrologic data gaps for the carbonate aquifer (DIRS 147808-Bredehoeft, King, and Tangborn 1996). These conclusions are consistent with data and analyses in the EIS.

7.5.3.2 (1146)
Comment - EIS000087 / 0003
Furthermore, you heard about volcanism. Well, that translates to volcanic activity nearby. Well, the water comes out of my wells is 70 degrees. That's warm for subterranean water.

It says there's current volcanic activity, and my well is not the only well in the valley. In fact, it's very typical of the temperature of the water comes out of the ground.

And right next to Yucca Mountain, which no one seems to talk about, where the cinder cone mining is, well, the cinder cone where they're mining, where they're taking cinders out a recent volcanic upheaval of lava which formed the cinder cone.

You can look at Yucca Mountain and you look slightly to the right or the east and there's very volcano sitting there.

It's not something that the average geologist should be able to miss.

Response
The volcanic history of Yucca Mountain and surrounding areas is described in Section 3.1.3 of the EIS. This section describes the location and nature of volcanic eruptions in the Yucca Mountain area (the most recent of which occurred about between 70,000 and 90,000 years ago), as well as the possibility of their recurrence (unlikely). The EIS makes specific mention of the cinder cones that can be seen in the area. In describing current land use at Yucca Mountain, Section 3.1.1.2 mentions the mining of volcanic cinders (at the cone just north of U.S. 95).

Section 5.7.2 of the EIS provides further discussion on evaluations that have been performed on the probability of volcanic activity recurring in the area of Yucca Mountain. This section discusses the affect that such an unlikely event might have were it to occur, including the intrusion of liquid magma or hot gases into the repository.

With regard to the temperature of groundwater, groundwater temperature tends to approach the mean annual temperature of the air. In the Amargosa Desert – Las Vegas area, the mean annual air temperature is about 18º to 19º C (64º to 66º F) (DIRS 151945-CRWMS M&O 2000). A slight elevation in water temperature above the annual average air temperature is probably due to contributions from deeper aquifers where the water is warmer. Some researchers (DIRS 103415-Dudley and Larson 1976) concluded that flow in the lower carbonate aquifer intercepts crustal heat flow and transports it laterally toward discharge areas. As an alternative, it might be the result of deeper warm water rising along the fault line.

7.5.3.2 (1177)
Comment - EIS000111 / 0001
While, when I was out in Ash Meadows, I was reading some literature from the Park Service there and apparently -- oh, quite sometime ago, I can't remember what. I couldn't find the article.

Anyway, some divers went down in Devil's Hole or one of those springs there and disappeared.

Well, a few months later, they found one of the diver's tanks in it -- what is it Sea of Cortez or the Gulf of California, you know, down in Mexico, and then I'm not sure what government agency did it, but they added some dye to the spring, and within a short time -- and I can't remember whether it was days or a couple weeks -- it showed up in -- again in the Sea of Cortez or whatever you call that Gulf of California.

Well, this brings an international aspect into contamination of groundwater, and I think this very definitely needs to be addressed, and with our research techniques in looking for oil and so forth, ground penetrating radar and whatever, I'm sure that this deep aquifer, wherever it is, or river or whatever it is, can be found and located and tested.

The surface flow definitely goes down a few hundred feet, goes along the Amargosa River and then on into Death Valley, but the deeper flow apparently goes into Mexico.

Response
There is no connection between Devils Hole or Ash Meadows and the Sea of Cortez. Yucca Mountain is in the Death Valley hydrologic basin, which is part of the larger Great Basin physiographic subprovince. This area is characterized by a very dry climate, limited surface water, and very deep aquifers. The Death Valley basin is a closed hydrologic basin, which means that its surface water and groundwater can leave only by evaporation from the soil and transpiration from plants.

The general path of the groundwater that infiltrates through Yucca Mountain is southward and includes flow in Amargosa Desert near Ash Meadows and Devils Hole. In this area there is a marked decline of about 64 meters (210 feet) in the water table elevation between Ash Meadows and the low axis (Carson Slough) of the Amargosa Desert area to the west and south. This elevation decline indicates that the groundwater flow is from Ash Meadows toward the Amargosa Desert, not the other way around. Therefore, potential contamination from Yucca Mountain could not discharge to the surface at Ash Meadows or Devils Hole. Sections 3.14.2.1 and 5.3 contain more information.

7.5.3.2 (1477)
Comment - EIS001521 / 0011
Page S-41, fifth paragraph--The term "perennial yield" is confusing. Perennial usually refers to surface water (stream) conditions and indicates that water is flowing along the stream course on a continuing basis, but it has no connotation in terms of base-flow quantities and/or volumetric measurements. Ground-water hydrologists usually use the term "safe yield" (which no one really likes or has adequately defined) or the term "optimal yield" (defined by a set of socio-economic objectives associated with ultimate water use). In either case, the concern is to prevent overdraft of an aquifer (water being discharged from an aquifer is greater than recharge water coming into it), but to use a term that supposedly relates to overdraft concerns, and that heretofore has not been used in the hydrological sciences causes confusion (an element of the DEIS that should be eradicated, or at least, limited).

Response
The term "perennial yield," which is equivalent to the term "safe yield," is commonly used by the Nevada State Engineer's Office in relation to water appropriations. The definition used in the EIS (Summary Section S.4.1.4 and in Section 3.1.4.2.1) was established by Walker and Eakin (DIRS 103022-1963) as "the maximum amount of water that can be withdrawn from the groundwater system for an indefinite period of time without causing a permanent depletion of the stored water or causing a deterioration of the water." This definition is also used by the Nevada State Engineer's Office. The term "safe yield" has been added to the EIS in parentheses where appropriate.

7.5.3.2 (1482)
Comment - EIS001521 / 0021
Page 3-22, Figure 3-7--There are many more than the three or four “major” faults shown on this figure (see page 3-23, Figure 3-8, and page 3-27, Figure 3-10), and as such, the figure presents a very unrealistic presentation of the faulting in the repository area.

Response
This figure has been updated and includes additional faults in the repository block area.

7.5.3.2 (1483)
Comment - EIS001521 / 0022
Page 3-23, Figure 3-8--The geology and faulting presented on this cross-section does not correlate well with the B-B’ trace on page 3-22, Figure 3-7. The cross-section should be simplified to accurately represent the trace as shown on the generalized bedrock geology map.

Response
DOE has updated this figure in Section 3.1.3 of the Final EIS. The faults shown on the cross-section now correspond to the faults shown on the updated geologic map.

7.5.3.2 (1491)
Comment - EIS001521 / 0020
Page 3-17, Figure 3-5--(Legend) No ages for the “Caldera volcanic center” and “Other bedrock” units are given, while the others show approximate ranges. Consistency is needed. Also, Qby, Qbo, Typ, and Tyb are not defined here or in the text. Do these units relate to page 3-19, Table 3-6, or page 3-20, Table 3-7?

Response
DOE has added a range of ages for the caldera and bedrock designations to the legend of Figure 3-5 of the EIS, and an explanation to clarify rock designations to the footnote in the figure (such as Qby, Typ, and Tyb). The figure shows the locations of calderas and generalized age groupings of volcanic rocks and does not correspond directly to all the units listed in Tables 3-6 and 3-7 in Section 3.1.3.1.

7.5.3.2 (1493)
Comment - EIS001521 / 0032
Page 3-36, 3.1.4.2.1 Regional Ground Water, first paragraph--Concerning the “confining unit” statement, see Summary, comment number 7 in this review.

Response
DOE agrees that, technically, a confining unit does not allow movement of considerable quantities of water between aquifers. In some areas of the Death Valley region, the confining units do allow considerable water movement and should more properly be called *aquitards*. However, these units are sufficiently confining to support artesian conditions over much of their distribution in the regional basin.

7.5.3.2 (1494)
Comment - EIS001521 / 0033
Page 3-37, second paragraph--(Basins) In discussing regional geographic features, a reference to page 3-38, Figure 3-13 should be made (or to another figure that shows the entire Death Valley region). Also, recharge and discharge points would be much easier to visualize with a figure. According to page 3-38, Figure 3-13, ground-water flow is primarily to the south; the only western flow-direction arrow shown is questioned.

Response
DOE agrees that a reference to a figure would be helpful. This section of the Final EIS now includes a reference to a new figure that shows the entire Death Valley regional flow system. The figure that was Figure 3-13 in the Draft EIS continues to be referenced later in the discussion. In addition, in Figure 3-13 the Spector Range section and the Indian Springs Valley section show a groundwater flow to the west, so not just the Funeral Mountain section has a western flow-direction arrow.

7.5.3.2 (1495)
Comment - EIS001521 / 0034
Page 3-37, third paragraph--All of the comments listed in the Summary items numbered 8, 9, and 10 in this review are pertinent to this paragraph and page 3-38, Figure 3-13. Also, were ground-water levels measured in wells that were completed in the same aquifer? If not, this would make the potentiometric-surface map useless (a figure showing this surface would also help). Statement about "other data" should be referenced. Mention in the discussion that flow in the aquifer(s) below Yucca Mountain is addressing primarily the water-table aquifer. Likewise, discharge areas relevant to the aquifer(s) underlying Yucca Mountain are also in reference to the water-table aquifer, or are they? Clarification is needed.

Response
The responses to the referenced comments on the Summary (numbered 8, 9, and 10) identified changes to the Final EIS that have been applied to subsections of Chapter 3.

With respect to the comment about the comparability of wells completed in different aquifers, the *Yucca Mountain Site Description*, provides interpretations of report data to define regional potentiometric levels and hydraulic gradients (DIRS 151945-CRWMS M&O 2000). Among these interpretations are the following:

1. Although the consolidated rock commonly has very low permeability, and very low rates of groundwater flow, the entire groundwater system, valley-fill and bedrock, should be treated as one integral system.

2. Though vertical gradients exist between the valley-fill aquifers and consolidated bedrock aquifers, on a regional scale, the potentiometric levels are similar enough that all water level data, regardless of well construction, can be used to define regional potentiometric levels.

Regarding the validity of the water-level monitoring program and resulting potentiometric maps, the commenter is referred to D'Agnese et al. (DIRS 100131-1997) with respect to the Death Valley region, and to Luckey et al. (DIRS 100465-1996) with respect to the Yucca Mountain vicinity. A figure, showing the potentiometric surface of the Death Valley basin from D'Agnese et al. (DIRS 100131-1997), has been added to the EIS in Section 3.1.4.1.2.

The statement concerning "other data" is intended to be a simple concession that more than "water levels in wells" has gone into the generation of regional potentiometric surface maps. More detail on the other types of information and interpretations used can be found in the Site Description (DIRS 151945-CRWMS M&O 2000).

The groundwater flow path described in Section 3.1.4.2.2 is from the volcanic aquifers beneath Yucca Mountain to the alluvial aquifers beneath Amargosa Desert. These are the aquifers in which the water table occurs in these areas, but the DOE is hesitant to introduce additional aquifer terminology to this already complicated discussion. DOE believes that the current description presents an adequate picture of groundwater flow to the average reader. The referenced documents provide additional information.

7.5.3.2 (1496)
Comment - EIS001521 / 0036
Page 3-37, fifth paragraph--Pahute Mesa-Oasis Valley ground-water sub-basin includes "all" of Gold Flat and Oasis Valley; southern part of Cactus Flat; and southern part of Kawich Valley (designated a ground-water section, so it must be important). See page 3-38, Figure 3-13, for name locations.

Response
DOE has modified the text to better describe the area included in the Pahute Mesa-Oasis Valley groundwater basin.

7.5.3.2 (1497)
Comment - EIS001521 / 0035
Page 3-37, fourth paragraph--Is outflow from the Ash Meadows ground-water sub-basin, in part, to a lower portion of the Alkali Flat-Furnace Creek Ranch ground-water sub-basin? Is the latter basin composed of upper and lower aquifer units, or is this merely referring to an entry point and the incoming ground water becomes homogenized volumetrically in the Alkali Flats-Furnace Creek Ranch water-table aquifer? Again, a potentiometric-surface map would greatly facilitate the visualization of these concepts. Also, Ash Meadows is the primary discharge point for

which sub-basin? Are the springs at Ash Meadows a discharge point for the water-table aquifer (for which the sub-basin designations have been defined), or for a deeper confined aquifer (the lower carbonate aquifer on page 3-45, Figure 3-15)? A reference is needed for the statement "...springs occur in a line along a major fault."

Response
As described in the Basins discussion in Section 3.1.4.2.1, groundwater in the Ash Meadows basin that does not discharge at the springs travels to the alluvial aquifers at the south end of the Amargosa Desert (which is in the Alkali Flat-Furnace Creek basin), as suggested by most investigators (DIRS 101167-Winograd and Thordarson 1975; DIRS 101125-Claassen 1985; DIRS 103010-Kilroy 1991; DIRS 100131-D'Agnese et al. 1997; DIRS 148866-Laczniak et al. 1999). In addition, most investigators suggest that the alluvial fill of the Alkali Flat-Furnace Creek groundwater basin is underlain by the lower carbonate aquifer. However, deep drilling has not verified this, and the lateral continuity and hydrologic properties of the lower carbonate aquifer beneath the Alkali Flat-Furnace Creek groundwater basin are unknown. In the alluvial aquifers of the Amargosa Desert, mixing probably occurs as the flow continues toward the south. The Final EIS now contains a regional potentiometric surface map.

Ash Meadows is the primary discharge point for the Ash Meadows Groundwater Basin (as shown in Figure 3-13). The Final EIS applies "basin" and "section" terminology uniformly. As indicated in the last paragraph of the introduction to Section 3.1.4.2.1, at least part of the water discharged at the springs in the Ash Meadows area is from the carbonate aquifer.

The reference for the sentence containing "…springs occur in a line along a major fault…," as well as the next sentence, is D'Agnese et al. (DIRS 100131-1997) as well as the Site Description (DIRS 151945-CRWMS M&O 2000).

7.5.3.2 (1498)
Comment - EIS001521 / 0037
Page 3-38, Figure 3-13--The Amargosa Desert is not shown on this figure. Again, is it Alkali Flats-Furnace Creek ground-water sub-basin or Alkali Flats-Furnace Creek "Ranch" ground-water sub-basin?

Response
DOE has added "Amargosa Desert" to the groundwater basin figure in Section 3.1.4.2.1. The correct name is the "Alkali Flat -- Furnace Creek groundwater basin"; "Ranch" has been deleted from the name.

7.5.3.2 (1772)
Comment - EIS000572 / 0004
The ground water, there are no water rights left in Nevada. Las Vegas, everything, they are fighting over the water rights for the Truckee River. Some don't have irrigation or anything else.

If we lose more water because of radiation leaks, then what are we going to do? I mean, if we have no water because we have messed up, we have put radioactivity into it, just because we decided that there is no other suitable site for it.

Response
DOE recognizes the importance of water to the inhabitation and development of land in southern Nevada. The EIS points out that groundwater availability is a concern in many of the areas that the repository or associated transportation actions could affect. Chapter 3 notes (see Table 3-11) that current water appropriations for the Amargosa Desert are higher than some estimates of perennial yield for that area (though actual withdrawals are much less).

In discussing potential Nevada routes for transporting spent nuclear fuel and high-level radioactive waste to the proposed repository, the EIS identifies hydrographic areas crossed by routes that are "Designated Groundwater Basins" (see Tables 3-39, 3-40, and 3-57). The State of Nevada places this designation on hydrographic areas where permitted water rights approach or exceed the estimated perennial yield, and the water resources are being depleted or require additional administration, including State declaration of preferred uses (municipal and industrial, domestic supply, agriculture, etc.). Tables 3-39 and 3-57 indicate that the Las Vegas and Amargosa Desert areas are Designated Groundwater Basins, and that the Jackass Flats area (hydrographic area 227A), from which DOE would withdraw water for the proposed repository, is not. However, Section 4.1.3.3 recognizes that groundwater withdrawn at Jackass Flats would to some extent reduce the amount of underflow that would reach downgradient areas. In addition, it indicates that the Amargosa Desert would be the first area to experience such an impact, and that the amount of water required by the repository would be very small in comparison to the amount already being withdrawn in that area. In summary, water is a critical factor in the region, but the amount of water needed to support the Proposed Action would be minor.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (2228)
Comment - EIS000622 / 0012
There's also a concern about what water will be used in that area. The water in that area that is being discussed for use in making cement and that kind of thing, spraying down the grounds, is already potentially contaminated from testing. Testing took place above, below and actually within the water table at the Nevada Nuclear Test Site.

Response
Section 3.1.4.2.2 of the EIS addresses groundwater quality. As part of DOE's effort to characterize Yucca Mountain, DOE has monitored water quality in wells and springs throughout the area. There is no indication that DOE activities at the Nevada Test Site have contaminated the groundwater beneath Yucca Mountain or the water in wells J-12 and J-13, which is used for site characterization activities at Yucca Mountain. The nuclear tests referred to in this comment occurred 30 to 40 kilometers (19 to 25 miles) northeast of the Yucca Mountain site. There is evidence from monitoring at the Nevada Test Site that plutonium has migrated about 1.3 kilometers (0.8 mile) from one underground test (DIRS 101811-DOE 1996). For analytical purposes, Section 8.3.2.1.1 of the EIS assumed that radioactivity from weapons testing on the Nevada Test Site would eventually be transported by groundwater to the same sites analyzed in the EIS for releases from the repository. The cumulative dose from the repository and the Nevada Test Site 18 kilometers (11 miles) south of the repository after 10,000 years is estimated in the EIS to be 0.42 millirem per year [0.22 millirem from the repository (the mean dose) and 0.2 millirem from weapons testing].

7.5.3.2 (2267)
Comment - EIS000540 / 0001
DOE studies show the surface water infiltration and the rate of ground water contamination will take place in the Yucca Mountain area much more rapidly than previously thought. As a result of those studies, we believe that there is a potential for radionuclide exposure to residents living nearby in the Amargosa Valley.
Nevada's largest dairy which serves the Los Angeles commercial market is located in that valley. And I believe the Draft Environmental Impact Statement fails to address this issue.

Response
Ongoing studies suggest that water travels through the unsaturated zone at highly variable rates. Groundwater travel times for contaminants from the repository that enter the accessible environment (specified in 40 CFR Part 197) are on the order of thousands to tens of thousands of years. The natural discharge of groundwater from beneath Yucca Mountain probably occurs far to the south at Franklin Lake Playa more than 60 kilometers (37 miles) away and travel times would be even longer. Modeling of long-term performance of the repository shows that the combination of natural and engineered barriers at the site would keep the radionuclides well below regulatory limits established at 40 CFR Part 197.

In evaluating the potential human health impacts of the repository, DOE considered all exposure pathways, including agricultural and animal products such as milk, for residents of Amargosa Valley. These pathways are included in the dose factors described in Section G.2.4.1 for operations and Section I.4.4.6 for long-term performance. From these analyses, DOE concluded that no latent cancer fatalities would occur in the surrounding populations from exposure to ionizing radiation from the Yucca Mountain Repository during operations and during the 10,000-year postclosure period. The potential exposure to ionizing radiation for anyone outside Amargosa Valley would be negligible.

7.5.3.2 (2301)

Comment - EIS000568 / 0003

I particularly am in disagreement with the ground water situation. First of all, it is really vague in the EIS. You try to look it up, you can't even find it. It's in other portions of the text. It's really scattered. But basically what I understood from it is your solution to the pollution is dilution. That's so bogus.

So I would like to see that if nothing else corrected.

Response

Groundwater is discussed in many separate sections of the EIS because DOE followed the standard format recommended for EISs by the Council on Environmental Quality (40 CFR Part 1502.10). Each of these groundwater sections is listed in the Table of Contents to the EIS.

As described in the EIS, contaminants that may eventually escape from the repository would most likely move in thin vertical plumes through flow tubes beneath the repository. This flow model would tend to reduce the amount of contaminant dispersion and dilution compared to a model in which these contaminants would mix on a large scale with groundwater flow in the saturated zone. Dilution of contaminants is a process that would occur in the natural environment at Yucca Mountain. DOE has incorporated this process into the models of the long-term performance of the repository based on the best understanding of the site.

7.5.3.2 (2386)

Comment - EIS000111 / 0002

We have access throughout through springs in the Amargosa area.

So whether it was USGS or whoever who did the testing felt the water was so deep in the ground that it wouldn't be economical to pump, and there's plenty of other groundwater, so they didn't pursue it any further, but I think this needs to be addressed, because it would be a great resource for southern Nevada, but also it's something that apparently in some areas is close enough to the surface to be seen, as the springs in Ash Meadows are, and so it would be contaminated, and the general groundwater flow seems to come down that way.

Response

DOE assumes that this comment refers to discussions in Chapter 5 of the EIS on the selection of locations to be evaluated for impacts related to the long-term performance of the proposed repository. In describing impacts from the slow release of contaminants over thousands of years from the repository, Chapter 5 explains that because groundwater would be the primary transport mechanism, the locations of highest impact would be along the groundwater flowpath downgradient of the repository site. It also explains that the highest possible exposure scenario would be to individuals living along the flowpath who would be using and consuming the groundwater and consuming their own crops and livestock watered from the same source.

Section 5.3 of the EIS indicates that the place closest to the repository site where people currently live is about 20 kilometers (12 miles) to the south in the direction of groundwater flow (southeast to south) where groundwater is about 100 meters (330 feet) below the ground surface. (The Draft EIS inappropriately linked the depth to groundwater to the 5-kilometer distance. DOE has corrected this in the Final EIS.) Closer to the repository, the depth increases to more than 200 meters (660 feet), while it decreases farther south (into the Amargosa Desert). As stated in the EIS, groundwater depths much more than 100 meters would impose economic constraints on agricultural uses of the land. Therefore, the hypothetical exposed individuals might never be closer than 18 kilometers (11 miles) from the site, and there are no people in the area now.

The comment is correct that there is groundwater available and that it is currently used in areas such as Amargosa Desert, but the depths to groundwater in these areas are shallower than they are closer to the proposed repository site. The comment is also correct that there are springs in the area, but none has been identified on the specific groundwater flowpath between Yucca Mountain and Alkali Flat. The many springs of the Ash Meadows area are close to this flowpath, but they contribute water to the flow rather than receive water from it (see Section 3.1.4.2.1 of the EIS).

7.5.3.2 (2498)
<u>Comment</u> - EIS001912 / 0044
Groundwater section needs a map showing different aquifer systems in the region of influence. Groundwater section needs a figure showing all springs in the area and discussion of the relationship of the springs to the various aquifers, if any. There is also a need to describe baseline information on water chemistry in the region of influence.

<u>Response</u>
DOE agrees that an additional figure would help readers understand the relationship of the different aquifer systems in the region and has, therefore, has added a figure to Section 3.1.4 of the EIS showing a generalized hydrogeologic cross-section from Yucca Mountain to the northern portion of the Amargosa Desert. The figure is a simplified representation of groundwater levels, aquifers, and confining units in this area.

DOE believes that Section 3.1.4 of the EIS adequately describes the general location of major springs in the region of influence and that a figure showing these locations is not required. The area of primary interest is the pathway that groundwater travels from beneath Yucca Mountain. As described in Section 3.1.4.2.1, this pathway is to Jackass Flats, to Amargosa Desert, and then to Death Valley. Section 3.1.4.2.2 describes the aquifers involved in this flowpath. The primary point of discharge along this path is Franklin Lake Playa in Alkali Flat, although some of the flow from the Amargosa Desert might travel to the Furnace Creek area of Death Valley. Figures 3-15 and 3-20 both show Alkali Flat and Furnace Creek. There are no other major springs or seeps along the pathway from Yucca Mountain.

A fraction of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring-discharge points in the Furnace Creek area of Death Valley. Several large springs (Texas, Travertine, and Nevares) in the Furnace Creek Wash area of Death Valley discharge about 4 million cubic meters (3,250 acre-feet) per year near Furnace Creek Ranch on the east side of Death Valley.

The EIS mentions other well-known springs in the region, even though they are not in the groundwater pathway from Yucca Mountain. The best known are near Beatty, and in Ash Meadows. Section 3.1.4.2.1 of the EIS discusses the springs in Ash Meadows and Figures 3-15 and 3-20 show the location of Ash Meadows. In addition, Section 3.1.4.2.2 identifies Saturated Zone Groundwater Quality in two of the sampling points as springs in the Ash Meadows area. These springs are listed in Table 3-19 and shown in Figure 3-20.

The EIS contains several discussions of groundwater chemistry and quality. Section 3.1.4.2.1 contains a Groundwater Quality discussion that compares regional groundwater sampling and analysis results to national drinking-water standards. Section 3.1.4.2.2 includes a discussion of Saturated Zone Groundwater Quality that summarizes water chemistry for the volcanic and carbonate aquifers (Table 3-18) and the results of groundwater sampling and analysis for radioactivity (Table 3-19). This information establishes a baseline for the quality and characteristics of area groundwater.

7.5.3.2 (2760)
<u>Comment</u> - EIS000897 / 0001
What scenarios will be used for future groundwater use in the area, and why were they selected?

<u>Response</u>
DOE assumed that this comment is asking about the groundwater-use scenario used to assess impacts related to the long-term performance of the proposed repository, as discussed in Chapter 5 of the EIS. Section 5.4 describes the exposure scenario for an individual having a diet and lifestyle representative of the current residents of Amargosa Valley, at 18 kilometers (11 miles) from the repository. The scenario assumed that this individual would "…grow half of the foods that the individual would consume on the property, irrigate crops and water livestock using groundwater, and would also use groundwater as a drinking water source and to bathe and wash clothes." DOE developed this scenario because it represents the highest exposure that could reasonably be expected for a resident of the Amargosa Desert area.

The analyses described in the Final EIS are based on the individual exposure scenario specified by the Environmental Protection Agency in their regulations at 40 CFR Part 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*. In this case, the regulation calls the hypothetical individual the "reasonably maximally exposed individual" and describes this individual as a person who would live at a point of maximum contaminant concentration about 18 kilometers (11 miles) from the repository site. This person would have a diet and living style representative of people now living in Amargosa Valley and would drink 2 liters (0.5 gallon) of water per day from wells tapping the groundwater at the person's residence. The EIS also addresses the scenario for a groundwater protection standard, which is another requirement established in 40 CFR Part 197. In this case though, specific water standards would be met by a segment of groundwater that the regulation identifies by volume (that would be used annually by a hypothetical community) and location (with respect to the groundwater flow path from Yucca Mountain).

7.5.3.2 (3281)
Comment - EIS001107 / 0002
The Draft EIS is deficient in its analysis of the potential impact of a release of radioactive materials into the groundwater. The Draft EIS states "[t]he groundwater flow system of the Death Valley region is very complex, involving many aquifers and confining units. Over distance, these layers vary in their characteristics or even their presence. In some areas confining units allow considerable movement between aquifers..." Draft EIS, 3.1.4.2.1. The Draft EIS continues to discuss scientific disagreements over the groundwater flow around Yucca Mountain, and to state that "additional research is needed to resolve the issues." Draft EIS, 3.1.4.2.2. The Draft EIS concludes that "[n]atural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, and spring discharge in Death Valley is a possibility." Draft EIS, 5.3 (emphasis added). The geologic repository proposed will contain the majority of the United States' radioactive waste, basic questions regarding where groundwater from the site will travel should not be couched in uncertainties.

Response
DOE believes there is little uncertainty about the southerly flow of groundwater from Yucca Mountain to the Amargosa Desert, then to the primary discharge point at Alkali Flat (Franklin Lake Playa). The EIS description of this flowpath often includes words such as "general," "most," and "primary" because not all of the flow discharges at Alkali Flat. For example, a small amount of the groundwater from Yucca Mountain that mixes with the large groundwater reservoir in the Amargosa Desert might move to the southwest through fractures in relatively impermeable Precambrian rocks at the southeastern end of the Funeral Mountains. In addition, a small amount of the flow reaching Alkali Flat remains as groundwater and provides underflow to southern Death Valley. The component of flow to the southwest would either discharge in springs near Furnace Creek Ranch or continue to move as groundwater toward the Death Valley saltpan. With regard to the main flow to the south, groundwater moving past Alkali Flat moves toward discharge and evapotranspiration locations in the Shoshone-Tecopa area. Chapter 5 summarizes the proposed repository's long-term performance, which includes projected effects at several distances from the Yucca Mountain site along the primary groundwater flowpath (Yucca Mountain to Amargosa Desert to Alkali Flat). There is no reason to suspect that any of the possible branches to this flowpath could experience greater impacts.

7.5.3.2 (3499)
Comment - EIS001521 / 0010
Page S-41, second paragraph--Again, the three ground-water sub-basins are not part of the Death Valley ground-water basin but are divisions of a subset of that basin, the Central Death Valley ground-water subregion.

Response
DOE agrees that the subregion, basin, and section labels are not clear, and has changed them to be consistent with *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California* (DIRS 100131-D'Agnese et al. 1997), which is the main source for this information in Section S.4.1.4 and Section 3.1.4.2.1 in the EIS.

7.5.3.2 (3502)
Comment - EIS001521 / 0009
Page S-40, Figure S-19--(Legend) "Subregion boundary" should be labeled as the "Central Death Valley Subregion boundary" and the subregion should be defined in the text; "Ground-water basins and sections" should be labeled

"Ground-water sub-basins and sections" and defined hydrogeologically in the text; Pahute Mesa-Oasis Valley Ground-Water Basin should be designated as a sub-basin (as well as the other two sub-basins); and Jackass Flats appears to be part of the Specter Range section and not part of the Fortymile Canyon section. What is a ground-water section? The term is not defined in the Summary text, or anywhere else in the DEIS for that matter. Do sections equate to the State of Nevada's hydrographic areas? According to the referral to the Jackass Flats area (page S-41, fifth paragraph), they do not equate.

Response
DOE agrees that the subregion, basin, and section labels are not clear, and has changed them to be consistent with *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California* (DIRS 100131-D'Agnese et al. 1997), which is the main source for this information in Sections S.4.1.4 and 3.1.4.2.1 in the EIS. The flow in each subregion has clearly defined paths; for convenience, the subregions were subdivided into basins and sections. These boundaries are for descriptive purposes only and do not define discrete independent flow systems (DIRS 100131-D'Agnese et al. 1997). The groundwater flow subregion, basin, and section terminology used in D'Agnese et al. (DIRS 100131-1997) is not the same as that used in State of Nevada water appropriations, which is based on topographic divides. DOE has clarified that distinction in Section 3.1.4.2.1. A new figure shows the relationship between the Death Valley region and subregions.

7.5.3.2 (3522)
Comment - EIS001150 / 0002
Possible ground water contamination in the event of an earthquake, corrosion of casks, etc.

Response
DOE has conducted an extensive site characterization program at Yucca Mountain to evaluate the effects of existing faults and additional faulting on the groundwater flow and transport system. In addition, DOE has performed extensive analyses on the design of the waste packages.

The waste-emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide releases. Additional fault displacements from post-emplacement seismic activity probably would be on existing fault planes. Calculations show that there would be almost no effect on repository performance from rockfalls.

A fault-fracture flow system is the basis for the hydrology models. This model is derived from extensive studies conducted at Yucca Mountain. The addition of new faults and associated seismic events would have very minor or no effect on the current fault- and fracture-flow pathways and, therefore, would be unlikely to alter repository performance. Analysis of long-term repository performance shows that the combination of the site's natural and engineered barriers would keep radionuclides well below the regulatory limits established at 40 CFR Part 197. EIS Sections 3.1.3 and 3.1.4.2.2 contain more information.

Because the repository would be above the water table in the unsaturated zone, the most important process controlling waste package corrosion would be whether water would drip from seeps onto the waste packages. Field and laboratory testing indicate that seepage would be limited and the locations of the seeps would depend on fracture-matrix and drift-wall interactions. Under the present design, radioactive waste in the repository would be enclosed in a two-layer waste package and covered by a titanium drip shield. The waste package would have a chromium-nickel-alloy (Alloy-22) outer layer and a stainless-steel inner layer. These materials have extremely low corrosion rates and would be unlikely to fail for thousands of years. Section I.2.4 contains more information.

7.5.3.2 (4038)
Comment - EIS001513 / 0001
There is a lot of uncertainty surrounding the future of Yucca Mountain. So many questions remain about its geology. There is known seismic activity in the area. Recent studies reveal that groundwater may move faster than previously thought. There may also be more volcanic activity than previously thought. Many questions remain about Yucca Mountain. Before we store 70,000 tons of nuclear waste, we must give all of these issues more attention.

Response

Regarding the inherent uncertainty associated with geologic and hydrologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the Draft EIS explains how DOE dealt with these issues.

Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 of the Draft EIS describes the impacts from accident scenarios associated with earthquakes during operation of the repository. Several sections in Chapter 5 of the Draft EIS consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository, have been adequately described and analyzed in the EIS.

As part of its site characterization program, DOE has used a variety of naturally occurring isotopic indicators, one of which is chlorine-36, to investigate the nature of infiltration and deep percolation of water at the site. Results from this program indicate elevated amounts (values above normal background measurements) of “bomb-pulse” chlorine-36 from nuclear testing during the 1950s and 1960s. Detection of this “bomb-pulse” chlorine-36 in the subsurface at Yucca Mountain generally associated with faults and well-developed fracture systems close to these faults.

Detection of elevated levels of chlorine-36 could be evidence of a connected pathway through which surface precipitation has percolated to depth within the last 50 years.

These results, however, must be viewed in their proper context regarding the question of whether waste can be stored safely at Yucca Mountain. Overall, most of the water that infiltrates into Yucca Mountain moves much more slowly through the matrix and fracture network of the rock. Only a small fraction has moved through the connected portion of the fracture network with relatively fast travel times. Carbon isotope data from water extracted from the matrix correspond to residence times as long as 10,000 years.

The elevated values of bomb-pulse chlorine-36 detected in the subsurface correspond to increases of between about two to eight times the amount of naturally occurring background chlorine-36. This background signal is the amount observed in the regional aquifers and the matrix waters of rocks in the unsaturated zone. Furthermore, even elevated bomb-pulse values represent exceedingly minute increases in the amount of chlorine-36. Naturally occurring ratios of radioactive chlorine-36 to the other isotopes of chlorine (chlorine-35 and -37) are on the order of one chlorine-36 atom to approximately 2 trillion other chlorine atoms. Their detection is more a tribute to the precision of the analytical methods used in this study (accelerator mass-spectrometry) than it is an indication of an unsuitable environment for the emplacement of high-level radioactive waste. To ensure the correct interpretation of this subtle chemical signal, studies are under way to determine if independent laboratories and related isotopic studies can corroborate this detection of elevated amounts of chlorine-36.

Another important factor regarding the safety of emplaced waste concerns whether percolating water would actually come in contact with waste packages. The process of drift excavation creates a capillary barrier that would cause the diversion of percolating water around the drift opening, further reducing the amount of water potentially capable of contacting waste packages. DOE is conducting a series of experiments to determine the seepage threshold, which is the amount of water necessary to overcome the capillary barrier caused by excavation. Results to date suggest that the amounts of percolating water at the waste-emplacement level could be insufficient to exceed the existing capillary barrier.

Additional evidence to the overall lack of observable fluid flow in the subsurface is the fact that throughout the excavation of more than 11 kilometers (6.8 miles) of tunnels (Exploratory Studies Facility and cross drifts) and testing alcoves, only one fracture was moist. No active flow of water was observed. Further observations from testing alcoves that are isolated from the effects of tunnel ventilation for several years confirm the lack of observable natural seepage at the repository level. In summary, despite encountering millions of fractures in the course of excavation activities, there is scant evidence that even modest quantities of water penetrate to the depth of the waste-emplacement horizon.

7.5.3.2 (4044)

Comment - EIS001524 / 0004

The DEIS is inconsistent when it states that water flows at highly variable rates through the saturated zone of Yucca Mountain because it states earlier that the amount of water affected would be minimal due to low rate of flow (Section 5.2.3.1). By assuming a low flow rate (despite mentioning later that rates were variable), the DEIS underestimated the potential amount of seepage that could occur into the repository (DEIS, p. 5-10).

Response

DOE agrees that the discussion in the Draft EIS may be confusing and warrants clarification. The first part of the paragraph is intended to describe how the number of seeps that flow into drifts, and the amount of water that they would carry, are limited by the small amount of water moving through the mountain. That is, the only source of the seepage is infiltration from surface precipitation and Yucca Mountain is in a warm, semiarid climate. The statement at the end of the paragraph describes how the time it takes for percolating water to move through the unsaturated zone is highly variable ("...less than 100 years to thousands of years…"). Use of the terminology "rate at which water flows" in the first statement did not provide a clear enough description of a quantity rate (amount per time) as intended. Accordingly, it has been changed to indicate the "small quantity of water flowing through". DOE believes that the amount of water included in modeling efforts as moving through the unsaturated zone at Yucca Mountain is consistent with results of numerous field measurements and studies and the portion of that water predicted to actually seep into the drifts is conservatively high. The commenter is referred to the *Total System Performance*

Assessment – Viability Assessment (DIRS 101779-DOE 1998, Vol. 3) for a more detailed discussion on infiltration and seepage into drifts.

7.5.3.2 (4145)
Comment - EIS001199 / 0003
As evidenced in the experimental boreholes made for possible use in deep in ground storage, radioactive material from the above ground nuclear testing was found. The highly radioactive nuclear materials do not have to be water soluble, for even very, small radioactive particles can be transported in the flow of water in the underground water table.

What may be worse is that an earthquake at Yucca Mountain could cause groundwater to surge into the storage area, forcing dangerous amounts of plutonium into the atmosphere and contaminating the water supply. This is not an unlikely scenario, given that the area is a seismic minefield. Over the last 20 years, more than 621 earthquakes have been recorded in the area, at a magnitude of 2.5 or higher.

According to an article in a recent Chemical & Engineering News, where it was previously believed that plutonium in the stable oxide is exclusively Pu(IV), the present work shows that Pu02 can exist in a much higher oxidative state. It is suggested that more than 25% of plutonium atoms are actually in the Pu(VI) state.

A key factor in favor of burying plutonium waste was supposedly the highly insoluble nature of Pu(IV) compounds. In light of the fact that the Pu(VI) species does exist, and is more soluble in water, it will therefore be more mobile in geological environments. Thus, the safety of this storage plan needs to be reconsidered.

Response
DOE agrees with this comment that nuclear-bomb era (post-1952) radionuclides appear to have reached the waste emplacement horizon at Yucca Mountain, as described in Section 3.1.4.2.2 of the EIS. With respect to the transport of insoluble contaminants in groundwater as colloidal particles, this phenomenon is described in Section 3.1.4.2.2 for the colloidal transport of plutonium from an underground detonation site on Pahute Mesa at the Nevada Test Site.

Additional research is addressing the relative magnitude of radionuclide migration by colloidal versus dissolved transport (particularly for plutonium) and definition of the effect of variation in the geochemical environment on colloid stability and transport. In addition, the reversibility of colloid sorption (the conditions in which colloids can bind or release radionuclides) is being analyzed.

7.5.3.2 (4264)
Comment - EIS001521 / 0013
Page S-66, Table S-1--Water demand values listed under Hydrology (ground water and surface water), of 250 to 480 acre-feet per year, are not the same as those listed for the Jackass Flats hydrographic area on page 3-40, Table 3-11, footnote f, of Volume 1 (300 acre-feet for the eastern third of the area and 580 acre-feet for the western two-thirds). Where did the 250 to 480 acre-feet values come from? Revise for consistency.

Response
The information in Table S-1 of the Draft EIS is misleading. DOE has revised the short-term impact entry for Hydrology. Tables 2-7 and 8-5 reflect this change.

The “250 to 480 acre-feet values” from the Draft EIS represent the range of expected water demand for the repository during the operational period, and not the perennial yield values. Section 4.1.3.3 of the EIS discusses the projected water demand.

7.5.3.2 (4344)
Comment - EIS001191 / 0007
DOE's own data shows that Yucca Mountain will fail to contain the waste.

- The presence of water within the proposed repository that is of recent origin (less than 50 years) indicates that ground water is percolating through the mountain at a rate that violates the DOE's own standard for an acceptable repository site.

- At least 33 seismic faults lie close to, or within, the site. 621 earthquakes of magnitude 2.5 or greater have occurred within 50 miles of the site over the last 20 years, including a 5.6 level quake centered just 12 miles from the site in 1992. A magnitude 5 or 6 earthquake at the site could dramatically raise the water table beneath the repository, flooding the chamber and leading to a corrosive breakdown of the disposal canisters and a possible steam explosion, thereby releasing plutonium and other waste products into the air and ground water.

Response
DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, changes in the climate, and fast-path fractures extending from the surface to the water table, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

DOE agrees that evidence of nuclear-age water reaching the level of the proposed repository, along with other data collected at the site, has shown that water movement through rock fractures and faults is an important component of the site's long-term performance. Modeling of the long-term performance of the repository shows that the rate of radionuclide travel from the repository would be in compliance with the radiation protection standards in 40 CFR Part 197. Accordingly, DOE believes that the predicted releases of radionuclide from the repository would not be considered significant.

DOE recognizes there is a significant seismic hazard at Yucca Mountain, but with proper design, a repository can operate safely over the long term. The possibility of groundwater rise and repository inundation is remote because no credible mechanism is known that can account for such a rise in groundwater to the elevation of the emplaced waste. Szymanski (DIRS 106963-1989) proposed that during the last 10,000 to 1 million years, hot mineralized groundwater was driven to the surface by earthquakes and volcanic activities and deposited calcite and opal at Yucca Mountain. This hypothesis goes on to suggest that similar forces could raise the regional groundwater in the future and inundate the emplacement horizon.

To investigate this hypothesis further, DOE requested that the National Academy of Sciences conduct an independent evaluation. The Academy concluded in National Research Council (DIRS 105162-1992) that no known mechanism could cause a future inundation of the repository horizon. The geologic evidence indicates that groundwater never reached the repository horizon; in fact, the largest rise seems to have been about 120 meters (390 feet) during the last several million or more years. Based on simulations of earthquake effects, the predicted water table rise could be about 20 meters (66 feet) at most. The 1992 Little Skull Mountain earthquake raised water levels in some monitoring wells by a maximum of less than 1 meter.

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm water upwelling hypothesis. That study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. It concluded that some crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of independent experts, including scientists from the U.S. Geological Survey, did not concur with Dublyansky's conclusions. DOE disagrees with the central conclusions in Dublyansky's report, but has supported continuing research by the University of Nevada, Las Vegas. See Section 3.1.4.2.2 of the EIS for more information.

7.5.3.2 (4503)
Comment - EIS001455 / 0004
By now, everyone knows that under the site at Ward Valley, where the government wanted to dump “low level” radioactive waste, is the largest groundwater aquifer in the state, containing an estimated thirty million acre feet of water. But how did that water get there? The Native Americans, who have been there for thousands of years, say the Amargosa River, which the E.I.S. sloughs off as if it is meaningless because it is mostly a dry river bed, used to be above ground. It went underground during a massive earthquake, which made a big crevasse, and caused the river to sink, and water to be trapped in the rock formations beneath the ground. And the report is correct—the groundwater flow system is very complex, and there is scientific uncertainty about the groundwater flow boundaries. To put it correctly, they don’t have a clue where that water runs underground, and how the emissions from the buried nuclear waste is going to migrate underground.

Forked-tongued talk, like “the depth to groundwater and the arid environment would combine to reduce the potential for meaningful contaminant migration” (at P. S-41) is meaningless and deceitful. What is a meaningful contaminant migration?

Response
The geology/hydrology of Ward Valley is outside the scope of the Yucca Mountain EIS. However, the commenter should compare information on Ward Valley to available information on the Central Valley of California.

The Native American oral history cited by the commenter might reflect an ancient seismic event that affected the Amargosa River. However, the groundwater that occurs in the aquifers beneath the Yucca Mountain site originated as precipitation, recharge, and infiltration in areas (see Section 3.1.4.2 of the EIS). The groundwater modeling technique utilizes probabilistic methods to account for the complexities of the groundwater system and uncertainties in both data and processes.

The EIS does not say there would be no groundwater contamination under the proposed repository at Yucca Mountain. Chapter 5 of the EIS describes the long-term performance of the proposed repository, and predictions of impacts from radioactive and nonradioactive materials released to the environment during the first 10,000 years after repository closure. The primary means, or pathways, by which these materials would become available, over time, to humans and the environment include gradual container failure and leaching of contaminants through the unsaturated zone beneath the repository, then to the groundwater. DOE believes it has learned about contaminant migration as a result of its experience at other waste-management facilities. In addition, the Yucca Mountain characterization effort has centered (and continues to center) around learning enough about the site to make reasonable projections about how and when contaminants would move should the proposed repository action take place.

Section 5.7 of the EIS presents results of analyses performed for “what-if” scenarios. These evaluations include looking at potential impacts from disruptive events such as human intrusion (by drilling) and volcanic and seismic disturbances. The long-term performance analysis includes looking at much wetter climates than exist today at Yucca Mountain and the potential effects on radionuclide transport.

DOE uses the term “meaningful contaminant migration” to indicate a level of radionuclide release and transport that would result in adverse health effects to the individual receptor (see Chapter 5 of the EIS).

7.5.3.2 (4523)
Comment - EIS001521 / 0007
Page S-39, sixth paragraph--(Ground Water) By definition, confining units “do not” allow considerable (ground-water) movement between aquifers. If they do, they are not confining units. The term “aquitards” should be used when and where ground water moves through lowly-permeable units.

Response
DOE agrees that, technically, a confining unit does not allow “considerable movement” between aquifers. In some areas in the Death Valley region these units allow considerable water movement, and normally would be called aquitards. However, these units are sufficiently confining to support artesian conditions over much of their distribution in the regional basin.

7.5.3.2 (4524)
Comment - EIS001521 / 0008
Page S-39, seventh paragraph, and page S-41, first paragraph--The Amargosa Desert is not shown on page S-40, Figure S-19. Also, the relationship between the Death Valley ground-water basin, the Central Death Valley Subregion, and the three sub-basins should be clarified. Is it the Alkali Flat-Furnace Creek "Ranch" ground-water sub-basin or the Alkali Flat-Furnace Creek ground-water sub-basin (page S-40, Figure S-19)?

Response
In Summary Section S.4.1.4 and in Section 3.1.4.2.1 of the EIS, DOE has added "Amargosa Desert" to the groundwater basin figure and has added a new figure to show the Death Valley Regional Groundwater System and the three subregion boundaries. The correct title is "Alkali Flat - Furnace Creek groundwater sub-basin"; "Ranch" has been deleted.

7.5.3.2 (4525)
Comment - EIS001521 / 0038
Page 3-39, second paragraph--According to page 3-38, Figure 3-13, Fortymile Canyon lies within the Alkali Flats-Furnace Creek Ranch ground-water sub-basin, yet it is not mentioned here. This is a very important hydrogeologic feature and should be emphasized.

Response
The comment is correct. DOE has added the Fortymile Canyon Section to the text in Section 3.1.4.2.1.

7.5.3.2 (4526)
Comment - EIS001521 / 0039
Page 3-39, third paragraph--Reference the "one numerical model for infiltration" statement and justify the use of an average rate versus analyzing end members of a range of values. Also, the "in comparison" sentence should provide referenced values, or there is nothing to compare.

Response
The statement was attributed to one of the two references listed at the beginning of Section 3.1.4 of the Draft EIS. Since publication of the Draft EIS, DOE has updated the reference materials for this discussion. The reference for the statement identified in the comment is the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000, Table 8.2-9). In response to this and other comments, DOE has added specific citations to Section 3.1.4.

The paragraph in question states that recharge in the local Yucca Mountain area is small in relation to other areas contributing to the same groundwater flow, and provides a simple basis for that statement. That is, other areas in the vicinity have both higher precipitation and higher infiltration rates. DOE believes more detail (such as ranges of infiltration estimates and precipitation for Yucca Mountain and for other areas in the vicinity, as well as comparative surface areas) is not necessary to justify the statement. Such detail would, in fact, make the explanation more complicated than necessary. In addition, Section 3.1.4.2.2 contains a more detailed discussion of infiltration rates at Yucca Mountain.

7.5.3.2 (4529)
Comment - EIS001521 / 0042
Page 3-39, sixth paragraph--Again, the "Central Death Valley" designation is for a ground-water sub-region, not a ground-water basin.

Response
DOE agrees that the subregion, basin, and section labels are not clear, and has changed them to be consistent with *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California* (DIRS 100131-D'Agnese et al. 1997), which is the main source for this information in Sections S.4.1.4 and 3.1.4.2.1 in the EIS. The flow in each subregion has clearly defined paths; for convenience, the subregions were subdivided into basins and sections. These boundaries are for descriptive purposes only and do not define discrete independent flow systems (DIRS 100131-D'Agnese et al. 1997). The groundwater flow subregion, basin, and section terminology used in D'Agnese et al. (DIRS 100131-1997) is not the same as that used in State of

Nevada water appropriations, which are based on topographic divides. DOE has clarified that distinction in Section 3.1.4.2.1. A new figure shows the relationship between the Death Valley region and subregions.

7.5.3.2 (4530)
Comment - EIS001521 / 0043
Page 3-40, first paragraph--If hydrographic areas are finer divisions of basins and/or sub-basins, define them hydrologically. Also, the hydrographic areas are not consistent with locations shown on page 3-38, Figure 3-13, because they are not even shown on the figure. Reference water-use withdrawal amounts listed throughout the paragraph. Define Devil's Hole and why it is important.

Response
DOE agrees that the subregion, basin, and section labels are not clear, and has changed them to be consistent with Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California (DIRS 100131-D'Agnese et al. 1997), which is the main source for this information in Summary Section S.4.1.4 and Section 3.1.4.2.1 in the EIS. The flow in each subregion has clearly defined paths; for convenience, the subregions were subdivided into basins and sections. These boundaries are for descriptive purposes only and do not define discrete independent flow systems (DIRS 100131-D'Agnese et al. 1997). The groundwater flow subregion, basin, and section terminology used in D'Agnese et al. (DIRS 100131-1997) is not the same as that used in State of Nevada water appropriations, which are based on topographic divides. DOE has clarified that distinction in Section 3.1.4.2.1. A new figure shows the relationship between the Death Valley region and subregions.

DOE has added the Devils Hole Protective Withdrawal to the EIS text. Section 3.1.5.1.3 describes the special status species in the Ash Meadows/Devils Hole Protective Withdrawal.

7.5.3.2 (4531)
Comment - EIS001521 / 0044
Page 3-49, Table 3-11--The low end of the Jackass Flats hydrographic area "perennial" yield estimate is 880 acre-feet per year; yet on page S-41, Section S.4.1.4 Hydrology, of the Summary, fifth paragraph, that number is given as 890 acre-feet--which is correct?

Response
The correct Jackass Flats hydrographic area perennial yield estimate is 880 acre-feet (1,085,000 cubic meters) per year. DOE has changed the number in Summary Section S.4.1.4.

7.5.3.2 (4532)
Comment - EIS001521 / 0045
Page 3-41, first paragraph--The comment about the usage of acre-feet should have come earlier in the chapter as it has already been used several times (on page 3-37, for example).

Response
It is standard practice in DOE EISs to present numerical values in metric units with corresponding English unit conversions in parentheses. The paragraph in question, which is immediately after Table 3-11, describes the use of acre-feet in that table because it is the first instance in that section to present water quantities in English units only (because it is the commonly understood term to describe such quantities). DOE believes that this deviation from the standard practice warranted an explanation. "Acre-feet" is defined in the Glossary and in standard dictionaries, so there should be little confusion.

7.5.3.2 (4533)
Comment - EIS001521 / 0046
Page 3-41, second paragraph--(Ground-Water Quality) Programs that sample ground water for water-quality purposes are mentioned but no generalized information about the results are listed. Even though more detailed results concerning the subject are given in subsequent sections of Chapter 3 for the Yucca Mountain area, because this discussion is about regional hydrological aspects, generalized water-quality descriptions of the ground-water sub-basins should be listed, if available.

<u>Response</u>
The second paragraph of the Groundwater Quality discussion in Section 3.1.4.2.1 of the EIS (which follows the paragraph identified in the comment) presents generalized water quality descriptions for the Yucca Mountain region. It focuses on the water quality of the area downgradient from Yucca Mountain (that is, the Amargosa Desert area). Because this is the regional groundwater that the repository could eventually affect, the EIS describes the baseline water quality by comparing the analytical results of sampling groundwater and springs in this region to the most widely recognized standards for water quality: the Environmental Protection Agency's drinking-water standards. To be brief, the discussion states that the sampled locations "...met primary drinking water standards, but that a few sources exceeded secondary and proposed standards." Then it identifies the specific parameters exceeded. The source of the information (DIRS 104828-Covay 1997) contains additional detail. In addition, Section 3.1.4.2.2 of the EIS discusses radiological parameters in groundwater samples.

7.5.3.2 (4534)
<u>Comment</u> - EIS001521 / 0047
Page 3-41, 3.1.4.2.2 Ground Water at Yucca Mountain; Unsaturated Zone, first paragraph--(Water Occurrence) Given that the perched-water bodies contain young water, as compared to pore-space water, and the attitude of the geologic units is dipping downward into a fault plane, could it be that the perched water exists merely by the fact that faulting off-set of a somewhat incompetent unit (like the Calico Hills nonwelded unit) creates a lowly-permeable fault "gouge" (or fill) that prevents further movement of water down that fault plane? In time, the Calico Hills nonwelded unit underlying the perched-water body will become saturated and drain off the perched water down-dip toward the fault plane (unless there is substantial and constant source of recharge to sustain the perched-water body). Therefore, the presence of the perched water indicates that there may be significant amount of lowly-permeable fault gouge associated with this faulted system. Perhaps too much importance is being placed on the perching unit (layer).

<u>Response</u>
The scenario for the origin of the perched water described in the comment is reasonable and consistent with the general scenario identified under the Yucca Mountain project. The description is also very similar to the scenario described in the last paragraph of the Water Source and Movement discussion under Section 3.1.4.2.2 of the EIS. See Striffler et al. (DIRS 104951-1996) for additional information on the several different scenarios that could result in the accumulation of perched water in the subsurface formations at Yucca Mountain.

The discussion of perched water in the EIS reflects the emphasis placed on this phenomenon in the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) from which the description in the EIS was abstracted. The Site Description places considerable importance on perched water in conceptual models of flow in the unsaturated zone.

Section 3.1.4.2.2 of the EIS does not judge the importance of the perched water that has been found at Yucca Mountain. But DOE does believe that it is important from the standpoint of full disclosure to describe these water bodies. Also, as identified in the EIS, dating of perched water has aided DOE's understanding of water movement along faults and fractures in the subsurface.

7.5.3.2 (4536)
<u>Comment</u> - EIS001521 / 0049
Page 3-44, Table 3-12--Provide permeability information for all described hydrogeologic units to coincide with hydrologic discussion on previous pages. Also, only effective-porosity values are meaningful in determining water movement through sub-surface units--are these effective-porosity estimates? If not, they should be replaced with the appropriate estimates. The description of the Calico Hills nonwelded unit should include the basal vitrophyre and nonwelded tuffs of the Topopah Spring Tuff (as shown on page 3-45, Figure 3-15). This is important because later discussions (page 3-47, third paragraph) suggest that the basal vitrophyre and nonwelded tuffs of the Topopah Spring Tuff may or may not be the perching layer.

<u>Response</u>
Table 3-12 pertains to the unsaturated zone, in which water flow is vertical and mainly through fractures. Permeability data on the unsaturated zone consist mainly of tests of saturated permeability measurements for cores, which would provide little information on water flow in the unsaturated zone. The more significant data with

respect to movement of water in the unsaturated zone includes matrix saturation and hydraulic potential for which a large database exists, and is used in modeling unsaturated flow. Matrix saturation is included in Table 3-12 of the Draft EIS (Table 3-13 in the Final EIS), but hydraulic potential does not lend itself to simple tabulation. Effective porosity was not measured in the U.S. Geological Survey testing of some 4,900 core samples from the unsaturated zone (see DIRS 100033-Flint 1998).

The last part of this comment suggests that the “basal vitrophyre and nonwelded tuffs” of the Topopah Spring Tuff be specifically identified as part of the Calico Hills nonwelded unit in Table 3-12 of the Draft EIS. The primary sources of information for this table are Flint (DIRS 100033-1998) and Montazer and Wilson (DIRS 100161-1984). The description of the Calico Hills nonwelded unit in Table 3-12 of the Draft EIS identifies four subunits and notes that zeolites occur in the lower three subunits. Tracing the information back to the primary sources, the top subunit of the four is the basal portion of the Topopah Spring Tuff. To simplify the presentation, this level of detail is not included in the table. Moreover, Figure 3-15 of the Draft EIS (Figure 3-17 in the Final EIS) shows the vitrophyre and nonwelded tuffs at the base of the Topopah Spring Tuff as included in the upper volcanic confining unit. Flint (DIRS 100033-1998) and Montazer and Wilson (DIRS 100161-1984) provide more detail on the hydrogeologic units at Yucca Mountain.

7.5.3.2 (4537)
Comment - EIS001521 / 0050
Page 3-44, second paragraph--(Water Source and Movement) Range values should be used as well as the average. Using the high-end of the infiltration range of 3 inches per year would have an order of magnitude difference (when considering the resultant consequences on the stability of waste in the repository) as compared to an average of 0.3 inch. Water volumes would be much greater, and the amount of time to reach a relevant sub-surface horizon much less.

Response
DOE used numerical data from the reference cited in the subsection (DIRS 100147-Flint, Hevesi, and Flint 1996) to illustrate the temporal and spatial variability of net infiltration in the vicinity of Yucca Mountain. Flint, Hevesi, and Flint (DIRS 100147-1996) developed conceptual and numerical models of net infiltration on the basis of analyses of field-moisture profile measurements at 99 neutron boreholes over an 11-year period (1984 to 1995). Thus, the infiltration models, which serve as inputs to models of recharge to the saturated zone, are based on qualitative and detailed quantitative measurements in different topographic/geologic terrains. The ranges and average values of net infiltration cited in the EIS summarize the results of this numerical modeling.

DOE believes that Flint, Hevesi, and Flint (DIRS 100147-1996) and the Site Description (DIRS 151945-CRWMS M&O 2000), which is now also referenced in this discussion, explain the data in sufficient detail and that the EIS does not require additional explanation.

7.5.3.2 (4538)
Comment - EIS001521 / 0051
Page 3-45, Figure 3-15--There is no mention of the areal extent of the hydrogeological unit QTc, valley-fill confining unit. Does it underlie QTa, valley-fill aquifer, in many, most, or all places? Also, “uva, Upper volcanic” should have “aquifer” added to the name.

Response
The subsurface extent of the QTc unit is not well established, and DOE has modified the “Comments” column in Figure 3-15 of the EIS accordingly. In addition, DOE has changed the heading for the “uva” unit in Figure 3-15 to “Upper volcanic aquifer.”

7.5.3.2 (4539)
Comment - EIS001521 / 0052
Page 3-46, first and second paragraphs--The discussion of water movement through the unsaturated zone via fault-plane pathways is the over-riding reason for including the high-end range value for infiltration, and the possible movement of water to and through a proposed repository block (see Volume I, comments number 36 in this review). Yucca Mountain is resident to many prominent faults (especially for the expanded area of the l-t-l build-out blocks),

and an assessment of the Mountain's appropriateness for use as a viable site for radioactive-waste disposal must include a probable high-end analysis.

Response
Chapter 3 of the EIS describes the nature of the environment that would be affected by the Proposed Action. Using average values in Chapter 3 to describe characteristics such as infiltration does not exclude using a range of values to describe impacts in other parts of the EIS. Chapter 5 of the EIS discusses the specific manner in which modeling was conducted and the parameters that were used. Section 5.2.3 is of particular relevance to this comment as it describes the analyses performed to model infiltrating water through the unsaturated and saturated zones. This section also describes how wetter climates were considered in modeling long-term performance of the repository.

7.5.3.2 (4540)
Comment - EIS001521 / 0053
Page 3-47, second paragraph, third bullet--Explain why the 10-foot soil depth over a fracture is important. If the soil horizon is already saturated prior to a precipitation event, the residence time of infiltrating water in that soil horizon may be minimal before a fault plane is encountered. In addition, a 10-foot thick soil in this environment would be somewhat unusual; or are we discussing alluvial, colluvial, or other surficial deposits here?

Response
Where soil thickness exceeds 3 meters (10 feet), infiltration of surface water and nuclear-age chlorine-36 at Yucca Mountain is negligible. This is because soil zones thicker than 3 meters (10 feet) retain infiltrating moisture sufficiently long so that evapotranspiration recycles it to the atmosphere. In this context, DOE used the term "soil" to include alluvial, colluvial, and eolian deposits (DIRS 100147-Flint, Hevesi, and Flint 1996).

The source of the 3-meter (10-foot) soil-depth criterion is CRWMS M&O (DIRS 104878-1998). That report cites an earlier report (DIRS 100144-Fabryka-Martin et al. 1997) as the basis for the three criteria, including soil depth.

DOE does not believe that the EIS requires more information.

7.5.3.2 (4541)
Comment - EIS001521 / 0054
Page 3-47, third paragraph--The statement, "...low-permeability zeolite zones impede the vertical flow of water near (the base of) the Topopah Spring welded unit and its contact with the underlying Calico Hills nonwelded unit, forming perched-water bodies," suggests that the perching-zeolitic zone is within the basal part of the Topopah Spring welded unit, and not the basal vitrophyre and nonwelded tuffs of the Topopah Spring Tuff (which is the upper part of the Calico Hills nonwelded hydrogeologic unit, see page 3-45, Figure 3-15). Please clarify the sub-surface location of the perching unit. Also, after clarification, this statement should come earlier in Chapter 3 where perched-water bodies are first mentioned (see the Unsaturated Zone, Water Occurrence discussion on pages 3-41 and 3-42).

Response
The comment refers to a statement in the subsection on Water Source and Movement in Section 3.1.4.2.2 regarding the occurrence of perched, saturated water bodies within the unsaturated zone at Yucca Mountain.

As explained in the Yucca Mountain Site Description (see reference in Section 8.5.2), the majority of perched water bodies were found in formations overlying relatively impermeable matrix material, such as the Topopah Spring basal vitrophyre. Although the vitrophyre is extensively fractured, in many locations the fractures have been filled with clays and zeolitic materials that impede vertical flow. At borehole SD-7, and possibly elsewhere, portions of the Calico Hills unit have been extensively altered to zeolites to create perched water bodies. Thus, either the basal vitrophyre of the Topopah Springs Tuff or the underlying Calico Hills Formation can cause perching depending upon the local degree of alteration. As both stratigraphic units may be of very low permeability, it is not always clear which forms the perching horizon, and the issue may not be of great importance.

In order to avoid confusion, the cited statement in the EIS has been revised.

Regarding the suggestion to move text on p. 3-47 forward to p. 3-42, DOE does not believe this would be appropriate.

7.5.3.2 (4542)
Comment - EIS001521 / 0055
Page 3-48, Table 3-13--From which hydrogeologic unit was the analyzed pore water collected? This water-quality comparison is meaningful for only those units near and connected with the perched-water bodies. Was pore water collected from the Calico Hills nonwelded unit, beneath a perched-water body (if doable)? This would help determine if the perched water is moving down through the unit and "down dip" towards the fault plane where a higher degree of remobilization may occur.

Response
According to the source of Table 3-13 (DIRS 104951-Striffler et al. 1996), the perched water samples came from boreholes NRG-7A, SD-9, UZ-14, SD-7, and UZ-1; the pore water samples came from four zones of UZ-14 between depths of 383.7 and 464.7 meters (1258.8 and 1,524.6 feet). Striffler et al. (DIRS 104951-1996) reports that perched water was found at a depth of 381 meters (1,250 feet) in UZ-14 and limited flow was observed to about 465 meters (1,526 feet). Thus, the top three pore-water samples (from cores) in Table 3-13 of the Draft EIS were from the same depth zone as the perched water and the fourth was from near its base. Striffler et al. (1996) also includes analysis of saturated zone waters from boreholes G-2 and H-1. However, Table 3-13 of the Draft EIS does not include these results. Yang, Rattray, and Yu (DIRS 100194-1996) present several chemical analyses of pore waters from below the perched zone in UZ-14. However, there is little variability among common ions (see DIRS 100194-Yang, Rattray, and Yu 1996).

7.5.3.2 (4543)
Comment - EIS001521 / 0056
Page 3-48, Saturated Zone, first paragraph--(Water Occurrence) Again, the upper confining unit description does not include the basal vitrophyre and nonwelded tuffs of the Topopah Spring Tuff (see page 3-45, Figure 3-15). Also, why change the names of the hydrologic units as they are listed for the Yucca Mountain vicinity on page 3-45, Figure 3-15, when discussing the hydrogeologic sequence immediately below the Mountain (middle volcanic aquifer on the figure is referred to as the lower volcanic aquifer in the text)? This causes confusion and is incorrect nomenclature when looking at the hydrogeology of the Yucca Mountain vicinity/area.

Response
DOE agrees with the first portion of this comment and, to be consistent, "the vitrophyre and nonwelded tuffs at the base of the Topopah Spring Tuff" has been added to the description of the upper volcanic confining unit.

With respect to the second part of the comment, a problem faced by the EIS in presenting a simplified picture of the groundwater hydrology at Yucca Mountain is that the multiple studies involved and referenced have not been totally consistent in their nomenclature. As a result, the text in the referenced paragraph of the EIS attempts to use a simple terminology that is frequently used and recognizes that the terminology is slightly different in some studies.

The confusion regarding nomenclature of hydrogeologic units in the saturated zone noted by the reviewer is regrettable and the result of changes triggered by varying U.S. Geological Survey reports. Luckey et al. (DIRS 100465-1996) presented a table correlating geologic thermomechanical and hydrogeologic units for the Yucca Mountain area (in which, incidentally, the lowermost part of the Topopah Spring Tuff is included in the Upper Volcanic Confining unit). D'Agnese et al. (DIRS 100131-1997) used different hydrogeologic units in describing the groundwater flow system of the Death Valley region. Then, in the *Yucca Mountain Site Description* (DIRS 137917-CRWMS M&O 2000), the U.S. Geological Survey introduced the nomenclature shown in Figure 3-15 of the Draft EIS, which used the new terms Middle Volcanic Aquifer and Middle Volcanic Confining Unit, and redesignated the Lower Volcanic Aquifer and Lower Volcanic Confining Unit to apply to older materials.

7.5.3.2 (4544)
Comment - EIS001521 / 0057
Page 3-48, Saturated Zone, second paragraph--"Downstream" is a surface-water term, and is not used for discussing ground-water movement. Down gradient is appropriate. Also, there are many flowpaths beneath Yucca Mountain,

not one, as the discussion seems to indicate. Relate the first sentence of this paragraph to page 3-38, Figure 3-13, for clarity.

Response
DOE agrees that downgradient is more accurate, and the Final EIS now uses it, rather than downstream. In addition, DOE agrees that the description of the flowpath in this paragraph is a simplification. However, the attempt here is to describe how the transition is made from the volcanic aquifers being the primary source of groundwater at Yucca Mountain to the valley-fill aquifer being the primary source of groundwater in Amargosa Desert. DOE believes that the paragraph accomplishes this without being overly complex for the average reader. The wording regarding the groundwater flow path is consistent with the *Total System Performance Assessment – Viability Assessment* (DIRS 101779-DOE 1998). DOE has added a figure to Section 3.1.4.2.2 that depicts a generalized hydrogeologic cross section of the area that helps clarify this discussion.

7.5.3.2 (4545)
Comment - EIS001521 / 0058
Page 3-48, Saturated Zone, third paragraph--"Evidence" for water ages should be given, or at least an example, with statements and values referenced. In fact, nearly every sentence in this paragraph (continued at the top of page 3-49) requires a reference. "Limited data" do not show anything unless they are shown. And referenced.

Response
Evidence for the age of the water is contained in Sections 5.3 and 9.2 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000, Table 8.2-9). In response to this and other comments, DOE has added specific citations to Section 3.1.4.

7.5.3.2 (4546)
Comment - EIS001521 / 0059
Page 3-49, first paragraph--(top of page) The statement, "This indicates that, in the vicinity of Yucca Mountain, water from the lower carbonate aquifer is pushing up against a confining layer with more force than the water in the upper aquifers is pushing down" which defines the relationship of confining pressure, hydrostatic pressure, and related overburden "weight" is totally misleading. Recharge areas were not mentioned (altitude relationships), and many confined aquifers are not overlain by other aquifers but by very thick sequences of confining materials that contain little or no extractable ground water. I suggest using a referenced definition from a book on hydrogeology to define the pressure relationships between confined versus non-confined aquifers.

Response
DOE does not believe that the EIS is misleading. The intent of the cited description is to present in simple terms the conditions observed in the vicinity of Yucca Mountain. DOE did not attempt to describe the reasons (higher recharge areas, overburden weight, etc.) behind the artesian condition, only that the condition was present. The comment is correct that many confined aquifers are not overlain by other aquifers, but at Yucca Mountain the volcanic aquifers do overlie the confined lower carbonate aquifer. DOE believes the EIS description appropriately states that water in the lower carbonate aquifer is at higher pressure than water at the bottom of the volcanic aquifer, and that the direction of leakage through the confining unit, if any, would be upward. Luckey et al. (DIRS 100465-1996) contains a more detailed discussion of this topic.

7.5.3.2 (4547)
Comment - EIS001521 / 0060
Page 3-49, second paragraph--During wetter periods, I doubt that the "saturated zone" was as much as 100 meters higher than it is today because the climatic conditions have nothing to do with tectonism; perhaps a clarification, that the water-table altitude (or another referenced aquifer water level) may be 100 meters higher today than during wetter periods, is needed.

Response
DOE has revised the subject paragraph to provide the clarification.

7.5.3.2 (4548)
<u>Comment</u> - EIS001521 / 0061
Page 3-50, second paragraph--(Hydrologic Properties of Rock) Define hydraulic conductivity, as other parameters are defined.

<u>Response</u>
DOE agrees with this comment and has defined "hydraulic conductivity."

7.5.3.2 (4549)
<u>Comment</u> - EIS001521 / 0062
Page 3-51, Table 3-14--Transmissivity (T) and hydraulic conductivity (K) numbers are not comparable, and of little use, since T values are given in units per day and K values are in units per year. Why make it so difficult to spot check the calculated T values by constantly requiring chronological versions of the K values? Also, more detail is needed about the calculated T values as shown in the table. On quick inspection, using the given unit thickness (or thickness range) and the given K-value range, the T-value range for the upper volcanic aquifer is 38.6 to 5,671 square meters per day (not 120 to 1,600); for the upper volcanic confining unit the range is 1.8 to 85.9 (not 2.0 to 26); for the lower volcanic aquifer it is <1.4 to 9,014 (not 1.1 to 3,200); and the T-value range for the lower volcanic confining unit is 0.002 to >82.6 square feet per day (not 0.003 to 23). Of course, these values need to be "rounded" using significant-figure protocol. The higher end members of the estimated T-value ranges would have a significant impact on the potential movement of contaminants through this hydrogeologic system, so the T values in Table 3-14 need to be substantiated.

<u>Response</u>
The apparent hydraulic conductivity values have been changed to values in meters per day from values in meters per year for ease of comparison with transmissivity values presented for those units in Table 3-14 of the Draft EIS. The transmissivity (T) and "apparent" hydraulic conductivity (K) values are all from Luckey et al. (DIRS 100465-1996). As explained in that reference, the hydraulic conductivity values were calculated by dividing the reported transmissivity of the tested interval by the thickness of that interval in the borehole, which Luckey et al. (DIRS 100465-1996) recognized might be misleading and therefore used the term "apparent hydraulic conductivity" in the table. Because Table 3-14 of the Draft EIS lists "typical thickness" of the hydrogeologic units (also derived from DIRS 100465-Luckey et al. 1996), it is not surprising that the back calculation of T values from "apparent" hydraulic conductivity and "typical" thickness as described in the comment does not agree with tabulated T values. The text introducing Table 3-14 points out some of the problems in applying single borehole test data to hydrogeologic units, but the more detailed discussions in Luckey et al. (DIRS 100465-1996) are especially pertinent to this comment.

7.5.3.2 (4550)
<u>Comment</u> - EIS001521 / 0064
Page 3-53, first paragraph--Reference age-date values and climatic discussion.

<u>Response</u>
Section 3.1.4 of the Final EIS now references the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000), and specific citations have been added to the text. Age-dating information and discussion of climates is from CRWMS M&O (DIRS 151945-2000).

7.5.3.2 (4551)
<u>Comment</u> - EIS001521 / 0065
Page 3-53, second paragraph--Again, Fortymile Canyon or Wash? Also, define "substantial" recharge. The connotation is that 3,400 acre-feet of recharge along the course of Fortymile Canyon are "not" substantial, true or not? To most hydrogeologists this amount of recharge, in an arid environment, is indeed substantial.

<u>Response</u>
"Fortymile Wash" is the intended terminology in this case. The Fortymile Wash recharge discussion in the EIS has been revised to reflect the results of a more recent study. As described in the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000), the more recent study (DIRS 102213-Savard 1998) incorporated a loss factor not considered in the previously cited study (DIRS 100602-Osterkamp, Lane, and Savard 1994) and, accordingly, is

believed to result in a more appropriate estimate of infiltration actually reaching groundwater. The newer estimates of recharge through Fortymile Wash are notably decreased from those presented in the Draft EIS. The EIS now presents a recharge estimate for only a 42-kilometer (26-mile) section of the wash that is in the area of Yucca Mountain as compared to the entire 150-kilometer (93-mile) length described in the Draft EIS. This further reduces the average annual recharge value now identified in the EIS as 110,000 cubic meters (88 acre-feet).

7.5.3.2 (4552)
Comment - EIS001521 / 0066
Page 3-53, sixth paragraph--(Outflow from Volcanic Aquifers at and Near Yucca Mountain) Again, a potentiometric-surface map would greatly clarify the discussion of the configuration of the ground-water surface. A lot is left to "faith" in these discussions (are descriptions accurate?). Also, again, page 3-38, Figure 3-13, does not show ground-water movement to and discharge occurring in Death Valley; it is questioned.

Response
DOE has added a figure to Chapter 3 of the Final EIS to show the estimated potentiometric surface of the Death Valley region. As noted in the legend to Figure 3-15 in the Draft EIS, the question mark on the figure indicated uncertainty concerning a component of the groundwater flow path from the Amargosa Desert to the Furnace Creek area. To avoid confusion, DOE has removed the question mark and the legend note from the figure.

The natural discharge point for groundwater from beneath Yucca Mountain is Franklin Lake Playa. A small amount of groundwater might flow through fractures in the relatively impermeable rocks in the Funeral Mountains toward discharge points in Death Valley.

7.5.3.2 (4553)
Comment - EIS001521 / 0067
Page 3-55, Figure 3-17--Are the legend designations rock types or aquifers (for example, carbonate rock)? If they are rock types, hydrologic and water-quality information collected from relevant wells are not correlative, and thus useless.

Response
The legend indicates the aquifer from which DOE has drawn water samples. DOE has changed the legend from "contributing unit" to "contributing unit (aquifer)."

7.5.3.2 (4554)
Comment - EIS001521 / 0068
Page 3-56, Table 3-16--This is a very difficult table to analyze. What is a median water level? Water levels are usually established as an annual average or more often, measurements are made on given dates and are compared on a year-to-year basis. What was the period of measurement for the study? Was it 1992 through 1997? Is "Average deviation about the median" an annual average fluctuation or a fluctuation from year-to-year on a given date? Also, for "Difference (from the) baseline," are median and baseline equal terms? Water levels measured in production wells (J-12 and J-13) are meaningless.

Response
Table 3-17 summarizes water-level changes in seven wells in Jackass Flats that have been monitored for several years. Results of the monitoring have been published by the USGS in annual reports, the latest of which, is cited as the source of Table 3-17. Explanations of the monitoring program and the data presentation given in the cited source answer the questions raised by the commenter.

Regarding median water levels, "median" is used in the usual statistical sense of the mid-point value of a ranking of several values, such as an annual median water level. As explained in La Camera, Locke, and Munson (DIRS 103283-1999), the median water level is used because the calculated median is less affected by a few high or low values than the arithmetic mean.

Regarding the period of record, as shown in hydrographs for all seven wells, the period of record ranges from 1983 to the present for most wells, although the record for well J-11 began in 1990, and for well JF-3 in 1992.

"Average deviation about the median" is explained in the text and graphically in La Camera, Locke, and Munson (DIRS 103283-1999). For each well, an average median water level was calculated for a baseline period, depending upon the available records. This baseline period was 1985-91 for JF-1, JF-2, and JF-2a; 1989-91 for J-13; 1990-91 for J-11 and J-12; and 1992-93 for JF-3. This baseline median (column 2 in Table 3-17) then serves as a standard for comparison for each well. For each well, a median water level is calculated and the yearly difference of this value from the baseline median is shown in columns 4 through 9 of Table 3-17. Thus, a consistent downward water-level trend is represented by a series of negative values in columns 4-9, as in the case of wells J-12, J-13, and JF-3. Conversely, a rising trend is indicated by a series of positive values, as in the case of J-11 and JF-2a. The U.S. Geological Survey has used this particular style of data presentation for many years in annual reports on groundwater data for the Yucca Mountain Region.

With regard to the observation that water level in production wells J-12 and J-13 are meaningless, DOE assumed that the comment indicates a belief that these represent pumping levels. This is not the case. As explained in La Camera, Locke and Munson (DIRS 103283-1999), water levels in wells J-12, J-13, and nearby JF-3 that might have been affected by pumping or recent pumping of the wells are not in the database.

DOE does not believe that further explanation is needed for Table 3-17 in the EIS because most of the questions relate to standard data presentation by the U.S. Geological Survey, which is explained in the reference cited as the source of the data.

7.5.3.2 (4556)
Comment - EIS001521 / 0069
Page 3-57, first paragraph --The nearness to or distance from Fortymile Canyon (or Wash) has little, if anything, to do with water levels measured in the wells. The key is, in which aquifer is each well completed? According to page 3-56, Table 3-16, the two wells with largest positive variations in water level were JF-2a and J-11. Well JF-2a is completed in carbonate-rock (aquifer) and well J-11 is completed in volcanic-rock (aquifer)(see page 3-55, Figure 3-17), the latter being located some six miles east of the other five wells completed in a north-south line near Fortymile Canyon (which are also completed in volcanic rock). Well JF-2a water levels are obviously not connected to like measurements made in the Fortymile Canyon well array. Well J-11 is located down-dip geologically (see page 3-43, Figure 3-14, for the general geological attitude of units) from the north-south Fortymile Canyon well array, and is probably completed in a differing volcanic aquifer than wells JF-1, JF-2, JF-13, JF-12, and JF-3. Well-completion data, constructed hydrogeologic cross-sections, and water-quality data would help resolve this issue and more clearly define the hydrogeologic system.

Response
The comment is correct that distance from Fortymile Wash has little bearing on water level changes in wells JF-2a (UE 25 p#1) or J-11. DOE has revised the paragraph referred to in the comment, noting that well JF-2a taps the lower carbonate aquifer and, therefore, pumping from the volcanic aquifers would be unlikely to affect that well, and that well J-11 is a long distance from and up the hydraulic gradient from active production wells J-12 and J-13.

7.5.3.2 (4557)
Comment - EIS001521 / 0070
Page 3-57, Table 3-17--Composite water-quality data are presented for 12 volcanic-aquifer wells (footnote b), but page 3-55, Figure 3-17, shows only eight (by my count) wells completed in volcanic rock. Why the discrepancy? Also, are all 12 of these volcanic-aquifer wells completed in the same aquifer? Is there a water-quality variation from the upper-volcanic aquifer to the lower-volcanic aquifer? Correlate tabular water-quality data with well-completion data and show an appropriate location map.

Response
Figure 3-17 is not related to Table 3-18. The figure is a map of sites in the Yucca Mountain region where water-level measurements are made, whereas Table 3-18 presents data on water chemistry from aquifers at Yucca Mountain. Table 3-18 now cites Benson and McKinley (DIRS 101036-1985) as the source of the analyses and the wells sampled that are identified in that table.

Fourteen wells were sampled to generate the volcanic-aquifer data presented in Table 3-18. Footnote b has been changed accordingly. (The original count considered the C-well complex as one well rather than three separate wells.)

The intent of Table 3-18 of the Draft EIS is to show a general difference between water from the volcanic aquifers and water from the carbonate aquifer. The DOE believes this is achieved in the table without providing more complicated detail. Although lateral differences in chemical quality of water in the volcanic aquifers at Yucca Mountain are observed, other than the pronounced difference from water in the carbonate aquifer noted in the EIS, little difference in chemical or isotopic character has been noted relating to stratigraphy of the volcanic rocks.

7.5.3.2 (4558)
Comment - EIS001521 / 0071
Page 3-58, Table 3-18--Separate the two volcanic aquifers (upper and lower) in the "Contributing aquifer" column, if possible. Also, footnote b reference to Figure 3-18 should be to Figure 3-17.

Response
The source document for the data listed in Table 3-18 of the Draft EIS does not distinguish or identify the aquifer that the "volcanic" wells tap, only that they are intended to be representative of water from the volcanic sequence. Separating the volcanic aquifers in the table would not be practicable, because well J-13 taps the upper volcanic aquifer, the upper volcanic confining unit, the lower volcanic aquifer, and the lower volcanic confining unit, whereas the C wells tap the upper volcanic confining unit and the lower volcanic aquifer (see DIRS 100465-Luckey et al. 1996).

DOE has changed footnote b to refer to what was Figure 3-17 in the Draft EIS.

7.5.3.2 (4559)
Comment - EIS001521 / 0072
Page 3-58, first paragraph--(sentence immediately following Table 3-18). Will monitoring for comparisons between the differing contributing aquifers continue throughout the operation of the proposed repository and well into the post-closure period? It would be reassuring, if true.

Response
DOE has supported Nye County with it's program (called the *Early Warning Drilling Program*) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the performance confirmation program (if Yucca Mountain is approved for a repository), could be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information was available from the Early Warning Drilling Program. Since then this program has gathered more information (see Section 3.1.4.2.1 of the EIS).

Monitoring requirements directly associated with proposed repository operations could be specified in a Nuclear Regulatory Commission license. DOE would develop this monitoring program based on data collected from the performance confirmation program, the Early Warning Drilling Program, and future regulatory requirements. The purpose of the performance confirmation program would be to determine if the repository was performing as predicted.

DOE would design and implement a postclosure monitoring program in compliance with the Nuclear Regulatory Commission regulations (10 CFR Part 63). Before closure, DOE would submit an application for a license amendment to the Commission for review and approval. The application would include, among other items:

1. An update of the assessment of the performance of the repository for the period after closure

2. A description of the postclosure monitoring program

3. A detailed description of measures to regulate or prevent activities that could impair the long-term isolation of the waste, and to preserve relevant information for use by future generations

The application also would describe the DOE proposal for continued oversight to prevent any activity at the site that would pose an unreasonable risk of breaching the repository's engineered barriers, or increase the exposure of individual members of the public to radiation beyond limits allowed by the Nuclear Regulatory Commission. DOE has modified Chapter 9 of the EIS to include the types of monitoring and other institutional controls that would be contemplated. The Department would develop the details of this program during the consideration of the license amendment for closure. This would allow DOE to take advantage of new technological information, as appropriate.

7.5.3.2 (4566)
Comment - EIS001521 / 0080
Page 5-24, Figure 5-3--The flow-direction arrow in the lower southeast corner of the figure (near and pointing towards the California-Nevada border) is not within the Central Death Valley (hydrologic) Subregion, as shown on page 3-38, Figure 3-13. Why is it shown and is it important? Also, again, the community of Lathrop Wells is now known as Amargosa Valley.

Response
This comment is correct. Figure 5-3 no longer shows the flow arrow. In addition, DOE has changed "Lathrop Wells" to "Amargosa Valley" in the figure and text in Section 5.3.

7.5.3.2 (4583)
Comment - EIS001521 / 0095
Also during the discussion of geology, hydrogeology, and hydrology in Chapter 3 there is great confusion from one section to another when trying to determine the differences between (or similarities among) designations for, physical and chemical characteristics of, structural controls on, and areal and sub-surface extents of discussed units.

Response
The subject comment is not sufficiently specific for a direct response. However, it should be noted that all comments received are considered in revisions to the EIS, and insofar as feasible, confusion between sections will be eliminated.

7.5.3.2 (4763)
Comment - 010447 / 0002
Scientists from Lawrence Livermore and Los Alamos National Laboratories have reported that plutonium from an underground nuclear weapons test at Pahute Mesa on the Nevada Test Site had migrated almost a mile from the where the test had occurred. This finding contradicts DOE predictions about how fast plutonium moves through groundwater pathways. Until now, DOE had contended that plutonium movement is slow, several inches or feet over hundreds of years. This major discovery that plutonium has moved almost a mile in less than 30 years has great implications for DOE's plans to isolate spent nuclear fuel and high-level radioactive waste at Yucca Mountain.

Response
Section 3.1.4.2.2 of the EIS describes recent findings on the Nevada Test Site concerning the migration of plutonium. The small amount of plutonium detected in groundwater farther than expected from its source (a 1968 underground nuclear test) was apparently associated with the movement of colloids (very small particles). These findings suggest that radionuclides that are attached to colloids move faster than dissolved radionuclides because the colloids can travel in the faster parts of the flow paths, and sorb less onto host rocks than do dissolved radionuclides. Thus, the potential for faster movement of colloids becomes particularly important for radionuclides with high sorbtion, such as plutonium. Analysis of the long-term performance of the proposed repository incorporates the potential for plutonium to move with colloids (see Chapter 5 and Appendix I of the EIS). As described in Section I.3.1, DOE left plutonium species (specifically plutonium-239 and -242) in the model in spite of high sorbtion rates because of the large inventory that would be in the repository and the potential for colloidal transport. Consistent with this, the summary of modeling results in Section 5.4.2 attributes projected impacts from plutonium migration to colloidal transport, not transport as a dissolved element. The modeling of plutonium transport on colloids began with parameters derived from data obtained on the Nevada Test Site. The modeling, however, included input

parameters that were above and below those derived from the Test Site data because the specifics of colloid properties and transport are not well known.

7.5.3.2 (4778)
Comment - EIS001519 / 0004
Statements about the unlikelihood of nuclear waste contaminating groundwater because of the dry, dusty climate in the Yucca Mountain are incorrect when the effects of a climate change are taken into consideration. Since the 1970s the global temperature has continued to increase, and the 1990s has been the hottest decade ever. Should this increase continue, the possibility of polar ice melting also increases, which would raise the water level, possibly into the level of the repository where contamination would occur. In addition, a sudden, rapid climate change even within the next ten years could raise the water table within dangerous proximity of the repository.

Response
Several phenomena affect the energy budget of the atmosphere on short time scales, ranging from decades to centuries. These events include perturbations such as solar variability, volcanism, variation in carbon-dioxide content, and the El Niño southern oscillation. Human-caused increases in carbon dioxide have generated much scientific and public concern, because higher levels of atmospheric carbon dioxide trap outbound long-wave radiation, thus warming the Earth.

The consequences of a warmer Earth would almost certainly result in greater amounts of water vapor entering the atmosphere, which would increase precipitation in some areas. However, it is not known if climate changes affect carbon dioxide levels or vice versa. The *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) describes the timing, magnitude, and character of past climate changes in the Yucca Mountain area and establishes the rationale for projecting such changes into the future. Based on this information, a model of climate change has been developed in which the modern-day climate at Yucca Mountain would persist for another 400 to 600 years, followed by a warmer and much wetter monsoon climate for 900 to 1,400 years, followed by a cooler and wetter glacial-transition climate for 8,000 to 8,700 years.

Inundation of the repository by rising groundwater during any of these climate changes would be highly improbable because no credible mechanism can account for such a rise. Szymanski (DIRS 106963-1989) proposed that during the last 10,000 to 1 million years, earthquakes and volcanic activities drove hot mineralized groundwater to the surface at Yucca Mountain and deposited calcite and opal. This hypothesis goes on to suggest that similar forces could raise regional groundwater in the future and inundate the repository horizon.

DOE requested the National Academy of Sciences to conduct an independent evaluation. The Academy concluded in its 1992 report (DIRS 105162-National Research Council 1992) that no known mechanism could cause a future inundation of the repository horizon. The geologic evidence indicates that groundwater never reached the repository horizon; in fact, the largest rise might have been about 115 to 120 meters (380 to 390 feet) during the last several million years. Earthquakes could raise the water table by at most 20 meters (66 feet). The 1992 Little Skull Mountain earthquake raised water levels in some monitoring wells by a maximum of less than 1 meter (3 feet).

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm water upwelling hypothesis. That study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. It concluded that some crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of independent experts, including scientists from the U.S. Geological Survey, did not concur with Dublyansky's conclusions. DOE disagrees with the central conclusions in this report, but has supported continuing research by the University of Nevada, Las Vegas. See Section 3.1.4.2.2 of the EIS for information on groundwater at Yucca Mountain.

7.5.3.2 (5161)
Comment - EIS001444 / 0014
Water Resources
There is no specific reference to any model that was used, other than modeling was done for the unsaturated zone or a 3-D model was developed for the saturated zone. What are the names of the models used?

Response
Appendix I of the Draft EIS contains details on the models used. In particular, Figure I-1 shows the interrelations of models used in the total system performance assessment. The regional model was developed by the U.S. Geological Survey and was built using the MODFLOWP computer program.

7.5.3.2 (5199)
Comment - EIS001443 / 0024
The DEIS recognizes uncertainties about groundwater flow boundaries among sub-basins within the Death Valley groundwater basin. Contamination of the deep regional aquifer which appears to underlie both Yucca Mountain and the Tecopa-Shoshone-Death Valley Junction area, poses the most significant long-term threat to the citizens and economy of Inyo County. Inyo County, in conjunction with Nye and Esmeralda Counties (Nevada) and the USGS, have engaged in groundwater research which points to a direct connection between water in the deep 'Lower Carbonate Aquifer' beneath Yucca Mountain and surface discharges (springs) in Death Valley National Park ("An Evaluation of the Hydrology at Yucca Mountain: The Lower Carbonate Aquifer and Amargosa River," Inyo & Esmeralda Counties, 1996, and "Death Valley Springs Geochemical Investigation," Inyo County, 1998, provided as Attachments A & B). These studies were funded with DOE grant money and done to a high standard of scientific accuracy, being subject to Federal (USGS) quality assurance and quality control measures.

The 1996 study of the Lower Carbonate Aquifer suggests a significant degree of hydrologic connectivity between the Lower Carbonate Aquifer lying beneath the proposed repository and surface manifestations of the same formation within Death Valley National Park. The study also indicated that populations in Amargosa Valley (including the California towns of Death Valley Junction, Shoshone, and Tecopa) utilize groundwater that may be hydrologically contiguous to a southward extension of the Lower Carbonate Aquifer.

The 1998 investigation of the geochemistry of spring waters in the mountains east of Death Valley (some of which are developed to serve domestic and commercial uses in Death Valley) gave indications that these spring waters may be dominated by input from the Lower Carbonate Aquifer, perhaps via relatively fast pathways through fractures in the formation. It should be noted that these same springs also sustain populations of a number of threatened and endangered species.

The Draft Environmental Impact Statement does not address our findings, either to acknowledge or deny the implications of these studies with regard to potential pathways for contaminants to reach human populations or a National Park. Our studies, which have been available to DOE for some time, are absent from the estimated 50,000 pages of technical background material which went into development of the DEIS. We are formally including, by reference, these studies into our comments on the DEIS.

The County considers this a critical oversight on the part of DOE, which should be rectified by serious consideration of our scientific work and placement of our findings in the proper context.

The entire range of available scientific studies on groundwater flow in the Amargosa Valley, including applicable groundwater dating methodologies and flow velocity measurements, should be discussed. Competing models and methods and their results should be compared by the DEIS to provide a clear view of the current state of knowledge on the region's hydrology. The discussion of subsurface transport mechanisms of radionuclides needs further development, comparing the potential roles of colloidal, suspended particulate, and solution transport of contaminants under a range of assumptions about climate and subsurface conditions.

Specific Recommendation: DOE should review the above-cited research products for merit, incorporating the information into the hydrology database compiled for purposes of evaluating potential impacts to regional aquifers. If our reports have been submitted using a format or methodology not acceptable to DOE, Inyo County should be informed immediately to allow the County to redirect our research and reporting efforts. The DEIS should utilize the entire range of available hydrologic models and methods to bound projections of groundwater flow, contaminant transport concentrations, and velocity in the region potentially impacted by release of radioactive contaminants from the repository.

Response

Section 3.1.4.2.1 of the EIS acknowledges that the groundwater flow path from Yucca Mountain extends to Jackass Flats, the Amargosa Desert, and then southward to the primary point of discharge at Franklin Lake Playa in Alkali Flat southeast of Death Valley Junction. Some of the groundwater that reaches Franklin Lake Playa might bypass the playa and continue on to Death Valley via Tecopa and Shoshone. The EIS also acknowledges that a fraction of the groundwater beneath the Amargosa Desert might flow through the southeastern end of the Funeral Mountains toward springs in the Furnace Creek Wash area of Death Valley.

Chapter 5 of the EIS does not specifically address risks to people and natural resources in the areas of Tecopa, Shoshone, or Death Valley National Park from groundwater use and consumption. However, it can be clearly seen in the evaluations in Chapter 5 that risks would decrease with increasing distance from the repository. Accordingly, impacts to these other areas, because they are farther away on the groundwater flow path, would be less than those for the furthest distance evaluated in the EIS. Section 5.9 of the EIS addresses impacts to biological resources as a result of the long-term performance of the repository. As indicated in this section, DOE does not quantify impacts to biological resources from exposures to contaminated groundwater. Rather, DOE equates impacts to biological resources to the negligible impacts expected to humans from the use and consumption of this groundwater.

Regarding the comment's discussion of the referenced geochemistry report, the conclusion stated in the comment is not consistent with the conclusion of the report. The comment states that the investigation documented in the report "… gave indications that these spring waters may be dominated by input from the Lower Carbonate Aquifer." However, in describing the source of the Death Valley springs, the report's conclusion states that it remains unanswered. The report further concludes, "The water can come from recharge in 1) the area of the NTS [Nevada Test Site] and Yucca Mountain; or 2) the Amargosa Basin fill deposits, or 3) the area to the east that includes the Ash Meadows springs, or some combination of all three" (DIRS 147808-King and Bredehoeft 1999).

DOE acknowledges receipt of the two reports identified by the comment. These reports are not specifically referenced in the EIS (similar to numerous other source materials that are not specifically referenced), because their conclusions are not contradictory or inconsistent with the information already in the EIS. With respect to the conclusion discussed in the preceding paragraph, for example, the EIS identifies the possible link between groundwater beneath the Amargosa Desert and the springs in the Furnace Creek area, and suggested that some of this spring discharge could involve groundwater from beneath Yucca Mountain. The second report cited by the comment ("Lower Carbonate Aquifer") concludes that: (1) groundwater movement beneath Yucca Mountain is upward out of the carbonates into the tuff; (2) if contaminants reach the carbonates, travel times could be relatively short; (3) discharges to springs on the east side of Death Valley appear to be linked to the carbonates; (4) Esmeralda County is not in the groundwater flow path from Yucca Mountain; and (5) there are geohydrologic data gaps with respect to the carbonate aquifer (DIRS 147808-Bredehoeft, King, and Tangborn 1996). DOE believes that these conclusions are consistent with information in the EIS.

Chapter 5 of the EIS describes how the movement of contaminants, released from the slow degradation of the waste packages within the repository, has been modeled. The model factored in the slow movement of water through the rock matrix and the relatively fast movement of water along rock fractures and faults. Although the rate at which groundwater moves is very important to the model, it is not the only factor that controls the movement of contaminants. Section I.2.4 of the EIS describes how the waste package degradation has been modeled and how the cladding and waste form degradation models come into play before the contaminants would become available for transport through the unsaturated and saturated zones. Section I.2.4 also describes the various mechanisms that would affect how these materials move through these zones, including movement with colloids and the sorption and desorption that would take place as individual radionuclide or chemical species interacted with the rock through which they were moving. These and other parameters have been integrated into the performance assessment model to present a defendable and conservative estimate of impacts to groundwater and downgradient users of that groundwater.

The site characterization program at Yucca Mountain has gained valuable knowledge about the groundwater flow system, but it is recognized that collecting additional data would reduce several uncertainties regarding the long-term performance of the repository. It is recognized, however, that some uncertainty is inherent to the process. The approach taken in the long-term performance assessment was to recognize the uncertainties that are important to the evaluation, and then identify which uncertainties could be reduced by additional data and which ones would not.

With respect to uncertainties due to data gaps, the approach is to use conservative assumptions where necessary, with the understanding that the information gained from ongoing studies may eventually support less conservative assumptions and less conservative estimates of impact. These and other types of uncertainties are discussed further in Section 5.2.4 of the EIS. Section 5.2.4 also addresses issues of variability (as opposed to uncertainties) associated with the natural features of the system being modeled. It then goes on to describe the various techniques, such as sensitivity analysis, used in the modeling effort to analyze uncertainties and variabilities and to gauge their affects on the modeling results.

In summary, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3.2 (5270)
<u>Comment</u> - EIS001887 / 0024
The Draft Environmental Impact Statement (Draft EIS) for the Yucca Mountain high-level waste project includes an evaluation of environmental consequences (in terms of dose) of alternative repository design concepts and alternatives. The conclusion drawn from the results of these evaluations is that compliance is achieved.

There is, however, strong evidence that casts doubt on the validity of the conclusions and these compliance assessments in light of NWPA and NEPA [National Environmental Policy Act] requirements. This evidence is related to the choice of groundwater pathways selected for the analyses.

At Yucca Mountain, the primary human exposure pathway is through ingestion of groundwater. In conducting a performance assessment for Yucca Mountain, an accurate view of the groundwater flow field is essential. The velocity of the groundwater is one of the most sensitive parameters in the transport equation and, therefore, strongly influences dose calculations. The direction of the groundwater pathway is important as it dictates the hydrologic and geochemical character of the rock encountered along the pathway. Direction, along with velocity, strongly influences sorption and other important variables such as dilution and effective porosity in the saturated zone.

There has been considerable debate over the actual flow paths that would be followed by radionuclides released from the repository. Modeling results performed by the State of Nevada (Lehman and Brown, 1994, Lehman and Brown, 1995) indicate major differences may exist in flow path direction, velocity, and sorptive capability compared to that used in the latest assessments by DOE, including the Draft EIS, if all available data sets are utilized.

By failing to evaluate credible alternative models or opposing views of the saturated zone, DOE is not in compliance with NEPA. Being out of compliance with NEPA means automatic noncompliance with the NWPA. DOE is specifically out of compliance with NEPA Section 1502 for not summarizing, discussing or using important data sets; failure to evaluate credible opposing viewpoints; and not proposing testing to reduce uncertainty in the choice between alternative conceptual flow paths.

Response

DOE believes that the evaluation of potential environmental consequences documented in the EIS does present a sound case for compliance. This comment mentions that the choice of groundwater pathways selected for the analysis of compliance in the EIS is flawed due to the omission of unspecified data sets. Without identification of these data sets it is not possible to address this issue specifically. Therefore, the following discussion addresses pathway selection from the standpoint of an overall assessment of the present state of knowledge of saturated zone flow in the vicinity of Yucca Mountain.

The comment makes several references to the modeling performed by Lehman and Brown, particularly the evaluation of alternative saturated zone flowpaths that their work suggests. DOE scientists performed an assessment of their modeling efforts and concluded that, due to weaknesses in the model and the results of more recent hydrologic and chemical investigations, there is insufficient support for the suggested alternative flowpaths. Specific model deficiencies include model documentation, lack of data supporting wide, permeable northwest-oriented fault zones, poor agreement to observed temperatures (Solitario Canyon and Paintbrush faults), permeabilities much larger than documented in some areas, and over-constrained boundary conditions (DIRS 151948-CRWMS M&O 2000).

Key features of the saturated zone conceptual model suggested by Lehman and Brown (DIRS 149173-1996) require water movement across the repository block from west to east via discrete northwest-trending fracture zones. The proposed model suggests that another fault zone exists just to the south of the repository footprint. The following paragraphs contain specific examples of field data and hydrochemical investigations that contrast with the conclusions of the State's investigators.

Immediately to the west of Yucca Mountain the elevation of the water table increases abruptly approximately 45 meters (148 feet) as you cross the Solitario Canyon Fault going from east to west. This change in water table elevation is presumably due to a strong permeability contrast caused by juxtaposition of lithologic units and gouge along this fault. The net effect is to produce a geologic barrier that inhibits hydrologic communication across the fault. Evidence of this barrier is seen in the different chemical and isotopic signature of water collected from the east and west sides of the fault. A similar barrier to north-south flow may exist along Yucca Wash to the north of Yucca Mountain.

Additional evidence of the isolation of the flow regime near Yucca Mountain comes from analyses of uranium-234:uranium-238 ratios. Anomalously high ratio values initially established in the unsaturated zone are preserved in the upper saturated zone beneath Yucca Mountain, a condition which would not be expected if sufficient throughflow of water (moving either north to south, or west to east) was passing beneath Yucca Mountain. Reducing chemical conditions have been observed in the upper saturated zone near the site east of the fault (borehole WT-17), indicating a lack of dissolved oxygen and restricted circulation. This is in sharp contrast to values recorded in the channel of Fortymile Wash at the latitude of Yucca Mountain where moderate uranium-

234:uranium-238 ratios, oxidizing conditions, and younger water is observed. Simply put, the water that underlies Yucca Mountain appears to lie within a backwater that experiences limited throughflow and sluggish circulation. All of these findings argue against the high-permeability flow paths suggested by the Lehman and Brown (DIRS 149173-1996) model.

The comment states correctly that groundwater velocity is one of the most sensitive parameters in the transport equation. The preceding paragraph offers several lines of evidence that argue against rapid flow in the saturated zone beneath Yucca Mountain.

In addition, mapping recently conducted to refine the geologic model of Yucca Mountain did not find any evidence to support the State's contention regarding the existence of an undiscovered high-permeability fault zone south of the site. In conclusion, consideration of the available data from field studies and analytical laboratory determinations do not support the alternative model proposed by Lehman and Brown (DIRS 149173-1996).

7.5.3.2 (5496)
Comment - EIS001887 / 0164
Page 3-38; Section 3.1.4.2.1 - Regional Groundwater

Figure 3-13 should depict the entire Death Valley Regional Groundwater Flow System, not just a portion of the system, and include the associated groundwater flow paths. The Draft EIS states that the Death Valley Regional Groundwater Flow System is a closed system with groundwater not leaving the system except by evapotranspiration. Figure 3-13 should graphically show this.

Response
A figure has been added to show the entire Death Valley regional groundwater system and the subregion divisions.

7.5.3.2 (5498)
Comment - EIS001887 / 0166
Page 3-39; Section 3.1.4.2.1 - Regional Groundwater

Only the water quantity for the low thermal load is given here. What is the quantity for the intermediate and high thermal loads, and why were the data not given?

Response
In the Draft EIS, DOE used the water quantity for the low thermal-load because it represented the repository layout with the largest area, potentially intercepting the largest amount of infiltration from the surface, and therefore representing the most conservative estimate. Therefore, the water quantities for the intermediate and high thermal-loads were not provided. In Section 3.1.4.2.1 of the Final EIS, it is stated that the quantity of water that might move through a repository area of 10 square kilometers (2,500 acres) under one of the operating modes, assuming 4.7 millimeters (0.2 inch) of infiltration per year, would be about 0.2 percent of the estimated 23.4 million cubic meters (19,000 acre-feet) that moves from the Amargosa Desert to Death Valley on an annual basis.

7.5.3.2 (5503)
Comment - EIS001887 / 0167
Page 3-41; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

What would be "sufficient quantities of water" for DOE to collect? There are more than a few places in the ESF that dripped water.

Response
DOE has clarified this statement in Section 3.1.4.2.2 of the EIS. Researchers working in the Exploratory Studies Facility have encountered a few moist areas in the rock, but there no dripping water or water has accumulated or collected in the drift.

7.5.3.2 (5504)
Comment - EIS001887 / 0168
Page 3-42; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Is perched water found only below the proposed repository horizon?

Why wasn't Chlorine 36 also used here, along with tritium?

Response
Within the proposed repository boundary, perched water bodies have been detected only below the waste-emplacement level. Hydrochemical analyses of samples from these perched water bodies show no detectable amounts of tritium and yield values of chlorine-36 only slightly above background levels. There is no evidence of recharge from recent infiltration of waters containing "bomb-pulse" isotopic indicators in any of the sampled perched water bodies.

The presence of perched water beneath the waste-emplacement level (above the regional water table) is a positive factor in relation to the potential transport of radionuclides for the following reasons:

1. The fact that the water is perched between the repository horizon and the water table indicates a barrier to flow. In this case, the perching layer possesses less matrix permeability and has a smaller fracture density than the overlying rocks

2. The age of the perched water is thousands of years. The perching layer appears to impede the downward flow of water so that the water has aged substantially (thousands of years) in its current location. This increased residence time provides greater potential for diffusion and sorption of radionuclides released from a breached repository.

7.5.3.2 (5506)
Comment - EIS001887 / 0170
Page 3-46; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Define and quantify "relatively rapid water movement."

Response
Section 3.1.4.2.2 of the EIS indicates that water infiltration in the rock above the waste emplacement horizon slows substantially once it reaches the high porosity and low-density fracture zone of the Paintbrush nonwelded unit. Studies have shown residence times on the order of 10,000 years in the matrix of this unit (DIRS 104983-CRWMS M&O 1999). Also described in this section is the finding of "bomb-pulse" or "nuclear age" water at the waste-emplacement level. This finding indicates that some water has moved from the surface along isolated fracture pathways in the Paintbrush unit to the waste emplacement level within 50 years.

7.5.3.2 (5508)
Comment - EIS001887 / 0171
Page 3-46; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Define and quantify "very small amounts" of fallout. What is the basis for the assumption of "very small amounts" of fallout?

Response
As indicated in the "Chlorine-36 Studies" text box in Section 3.1.4.2.2 of the EIS, chlorine-36 occurs naturally in the atmosphere. That is, it is part of the nonradioactive chlorine in the atmosphere that settles on the Earth's surface. Without a nuclear fallout contribution, the natural or background ratio of chlorine-36 to chlorine is about 500×10^{-15} (DIRS 151945-CRWMS M&O 2000). That is 1 part per 2 trillion (one chlorine-36 atom in 2 trillion chlorine atoms).

Global fallout from thermonuclear testing, primarily from tests in the Pacific Proving Ground, resulted in maximum meteoric chlorine-36-to-chlorine ratios of about 400 times background or $200{,}000 \times 10^{-15}$. Present day chlorine-36-to-chlorine ratios in surface soils at Yucca Mountain are generally in the range of $1{,}500 \times 10^{-15}$ to $3{,}000 \times 10^{-15}$ (DIRS 151945-CRWMS M&O 2000).

This is a simplification of the variables DOE considered in the chlorine-36 studies. However, it indicates the very small quantities of chlorine-36, with or without contributions from fallout that DOE is investigating. The Department did not intend the EIS text in question to be a statement on the importance of the fallout; but to indicate that the numbers are extremely small. The *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) and *Evaluation of Flow and Transport Models of Yucca Mountain, Based on Chlorine-36 and Chloride Studies for FY98* (DIRS 104878-CRWMS M&O 1998) contain more information.

7.5.3.2 (5509)
<u>Comment</u> - EIS001887 / 0172
Page 3-47; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Give the best estimate of groundwater travel time, not just less than 10,000 years.

<u>Response</u>
The analyses of groundwater travel times, which were reported in the Draft EIS, were originally prepared for the *Total System Performance Assessment -- Viability Assessment* (DIRS 101779-DOE 1998, Volume 3). These analyses used a conservative approach with respect to some aspects of the natural system; that is, the analyses incorporated parameter values that were meant to ensure that Total System Performance Assessment results would have little chance of being criticized as optimistic.

In general, the value of a conservative description of the natural system is to provide a more easily defensible Total System Performance Assessment for consideration by regulatory bodies. However, due to the compounding effects of such conservatisms, the model results presented in the Draft EIS are not suitable for evaluating groundwater travel time or examining the anticipated performance of the natural system because they present a somewhat unrealistic “worst case” scenario. Efforts are underway to produce a more realistic assessment of the performance of the natural system that is more suited to evaluation of anticipated transport and groundwater flow issues.

As part of its site characterization activities, DOE has undertaken various studies to identify and consider characteristics of the unsaturated (above water table) and saturated (water table) zones, such as the flow of water and transport of radionuclides, that are relevant to analyzing groundwater travel times. DOE also has considered physical evidence such as the chemistries and ages of water samples from these zones. Because of the inherent uncertainties in understanding such natural processes as groundwater flow, DOE has developed numerical models to represent an approximation of these processes and to bound the associated uncertainties.

Based on these models, which incorporate the results of these studies and available corroborating physical evidence, DOE estimates that the median groundwater travel times would be about 8,000 years (from the repository down through the unsaturated zone into the saturated zone and out to the accessible environment), and average groundwater travel times would be longer. These models indicate that small amounts of water potentially moving in “fast paths” from the repository to the accessible environment could do so in fewer than 1,000 years. However, the models and corroborating physical evidence indicate that most water would take much more than 1,000 years to reach the accessible environment. The long-term performance of the repository shows that the combination of natural and engineered barriers at the site would keep radionuclides well below the regulatory limits established at 40 CFR Part 197. See Sections 3.1.3, Section 3.1.4.2, and Section 5.4 of the EIS for additional information.

7.5.3.2 (5512)
<u>Comment</u> - EIS001887 / 0173
Page 3-49; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

The Draft EIS should discuss more fully the fluid inclusion work on the calcite and opal veins and coatings underway at UNLV. The Draft EIS contains a brief discussion of the controversy over evidence that hydrothermal activity may have occurred at Yucca Mountain in the past and could reoccur during the lifetime of the repository.

The text gives the misleading impression that this matter has been resolved in DOE's favor as a result of a NAS review of the issue. In fact, the issue is the subject of an ongoing joint study being implemented by the University of Nevada Las Vegas, DOE, and the State of Nevada. Preliminary indications from data and analysis emerging from this study indicate that fluid inclusions found in calcite-silica deposits at depth within the exploratory tunnel at Yucca Mountain are of hydrothermal origin. Work is ongoing to confirm this finding and to discover the age of the fluid inclusions. The outcome of this study has significant implications for the suitability of Yucca Mountain as a repository site and for the viability of the Proposed Action as described in the Draft EIS.

Response
Based on the results of the analyses in Section 3.1.4.2.2 of the EIS, DOE does not believe that a credible rise of the water table would inundate the waste emplacement areas. However, that section does discuss evidence that the elevation of the water table at Yucca Mountain has fluctuated over time, due largely to changes in the climate. In addition, DOE examined the cumulative effects on the elevation of the water table from a wetter climate, earthquakes, and a volcanic eruption. Based on the evidence at hand, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate the waste emplacement areas at Yucca Mountain.

Section 3.1.4.2.2 of the EIS discusses several opposing views on fluctuations in the elevation of the water table at Yucca Mountain. These investigators believe that the water table has risen in the past to elevations that are higher than the proposed waste emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue (as described further in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than 120 meters (390 feet) higher than the present level. Although DOE has disagreed with the central scientific conclusions in this report (DIRS 104875-Dublyansky 1998), it continues to support independent research in this area, as well as on other aspects of the geology and hydrology that enhances an understanding of the site. The Department considers the fluid inclusion study being conducted at the University of Nevada, Las Vegas, as a supplemental confirmatory research effort. The EIS includes an update on the status of the University's study.

7.5.3.2 (5514)
Comment - EIS001887 / 0175
Page 3-52; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Provide the actual feet/mile or meters/kilometer for the slope of the water table east of the Solitario Canyon fault.

Response
DOE has added text to Section 3.1.4.2.2 of the EIS to quantify the gentle slope of the water table in this area.

7.5.3.2 (5515)
Comment - EIS001887 / 0176
Page 3-53; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

The use of the word "probably" in the third paragraph on this page does nothing but cause one to doubt the veracity of the statement.

Why is the average net infiltration rate on this page given as 4.5 millimeters over 220 square kilometers but on page 3-44, it is given as 4.5 millimeters over 230 square kilometers? Also, why wasn't the infiltration rate for the repository area used instead of the rate from the larger study area?

The statement that the groundwater pathway beneath Yucca Mountain is southerly conflicts with Figure 3-13 and other figures used in various DOE presentations that show an initial eastward flow of the groundwater, then down Fortymile Wash.

Response
DOE has deleted the word "probably" from the paragraph cited by the commenter. In the Draft EIS, the correct area is 220 square kilometers (89 square miles). It should be noted that estimates of net infiltration now presented in the

EIS are from a more recent infiltration study and differ slightly from those presented in the Draft EIS. Also, the analysis in question now uses the net infiltration rate estimated for the 4.7 square kilometer (1.8 square mile) repository area. The overall direction of groundwater flow in the basin is to the south and the initial eastward flow of the groundwater at Yucca Mountain is a local phenomenon, so DOE does not find a conflict between the statement and Figure 3-13 of the Draft EIS.

7.5.3.2 (5517)
Comment - EIS001887 / 0177
Page 3-54; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Define and quantify the term "small" as used in the sentence regarding the volume of water pumped from USW VH-1.

Response
According to records supplied by the Yucca Mountain Project to the Nevada State Engineer, DOE has pumped less than 800 cubic meters (0.65 acre-foot) of water from borehole USW VH-1 since 1992. The Department considers this to be a comparatively small amount of water.

7.5.3.2 (5602)
Comment - EIS001887 / 0228
Page 4-25; Section 4.1.3.3 - Impacts to Groundwater from Construction, Operation and Monitoring, and Closure.

This section discusses the potential for contaminant migration to the groundwater and does not state whether any impacts to groundwater quality are predicted. It appears that DOE did not analyze potential water quality impacts of the repository project, especially consequences of long-term repository performance. The Draft EIS should indicate what analysis was used to determine impacts to water quality, if any, and show any impacts to water quality that might occur.

Response
As stated in Section 4.1.3.3 of the EIS, the depth to groundwater, the thickness of alluvium in the area, and the arid environment at Yucca Mountain would combine to reduce the potential for surface contaminants to reach groundwater during the preclosure period. Hence, DOE does not predict that contaminants from materials inadvertently released at the surface (or in the waste emplacement areas) would reach groundwater during the preclosure period. If such a release were to occur, however, DOE would remediate the site of the release according to procedures in applicable plans, such as a Spill Prevention Control and Countermeasure Plan.

Based on the results of extensive analyses reported in Chapter 5 of the EIS, DOE believes that a repository at Yucca Mountain would operate safely during the postclosure period. DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (5603)
Comment - EIS001887 / 0229
Page 4-29; Section 4.1.3.3 - Impacts to Groundwater from Construction, Operation and Monitoring, and Closure

What type of general groundwater flow patterns changes would be expected from pumping more than 0.72 million cubic meters from the western portion of Jackass Flats? Although the Draft EIS states that the changes would be "small," the changes expected and any impacts from these changes should be discussed here.

Response
Since issuance of the Draft EIS, two efforts have been completed to model groundwater flow and estimate impacts associated with water use for the repository and are described in Section 4.1.3.3 of the Final EIS. The results of one

effort, which assumed a conservatively high water demand for the repository over a period of 100 years, indicated a small [about 0.3 meter (1 foot)] drawdown from project pumping as far away as the community of Amargosa Valley after 100 years. It also indicated that the additional drawdown would be minor compared to drawdown from ongoing groundwater withdrawals in the region. The other effort compared two steady-state simulations (baseline and predictive future) and estimated a drawdown of less than 1.2 meters (4 feet) at Amargosa Valley as a result of the proposed action's water demand.

7.5.3.2 (5651)
Comment - EIS001887 / 0271
Page 5-11; Section 5.2.3.1 - Limited Water Contacting Waste Package

The last sentence of this section should state that the rate of water movement through the unsaturated zone can be from 50 years to thousands of year, not less than 100 years to thousands of years, as stated in this section.

Response
The commenter's suggested change would not alter the meaning of the sentence. DOE has therefore retained the original sentence in the Final EIS.

7.5.3.2 (5767)
Comment - 010027 / 0012
On Page 2-20 a number of repository layouts are illustrated. The "Flexible Design" and "Low Thermal Load" layout options extend further north than the proposed design. These, therefore, appear to extend closer to a location where, in previous analyses, the groundwater level would be closer to the repository horizon. This is not discussed or described, however, in the SEIS.

Response
Figure 2-7, on page 2-20 of the Supplement to the Draft EIS shows three repository layouts from the Draft EIS, with the fourth layout for the flexible design which is the current proposed design. This comment is correct in noting that the flexible design layout extends farther north than the layouts described in the Draft EIS. The comment is also correct that this is the area where the groundwater would be closest to the repository level. The Supplement does not go into detail on this change because it would be unlikely to make a notable change in the impacts of the Proposed Action.

The reported depth of groundwater from the level of the repository has been revised slightly in the Final EIS to account for new data and the small change in repository layout. As noted in Section 3.1.4.2.2, the repository block would be at least 160 meters (520 feet) and as much as 400 meters (1,300 feet) above the present water table. [The depth range described in the Draft EIS was 175 to 365 meters (570 to 1,200 feet).] These are conservative estimates of the depth from the repository to the water table taken from the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000). A more recent document, the *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001), presents a similar repository layout figure for the flexible design, but it is superimposed with groundwater elevation contours. In Figure 1-13 of that report, and as described in the associated text, the depth from the primary block's northern most emplacement drift to the groundwater table would be about 210 meters (690 feet). The north main access drift loops a little farther to the north where groundwater would be higher, but it would not be a location of waste emplacement. Groundwater elevation contours that cover large areas, as shown in the figure in the Science and Engineering Report, must be based on a limited number of observation wells at which the depth to groundwater can be measured. As a result, there are uncertainties associated with the exact locations of contour lines between wells. However, in this case there is an observation well approximately 120 meters (390 feet) north of where the northernmost drift would lie. Accordingly, there is high confidence in the groundwater elevation contours in this immediate area.

7.5.3.2 (5809)

Comment - EIS001887 / 0441

The Nuclear Waste Policy Act requires that an EIS, consistent with the National Environmental Policy Act, be prepared and accompany a recommendation for site approval. The amended NWPA (1987) still requires consistency with NEPA, but does not require the DOE to consider:

1. The need for the repository
2. Alternative sites to Yucca Mountain, or
3. Non-geological alternatives

NWPA Section 114(f) specifically states that all other provisions of NEPA apply. NEPA Section 1502.22 relates to incomplete or unavailable information. NEPA regulations require that, if information is available that would aid in evaluating uncertain effects, it must be obtained and analyzed unless it is too expensive to do so. If costs are prohibitive, then it must be disclosed as incomplete or unavailable information. Specifically, regulations require that if information cannot be obtained, the EIS must include:

1. A statement that such information is incomplete or unavailable.

2. A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment.

3. A summary of existing credible scientific evidence that is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment.

4. The agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.

The Yucca Mountain Draft EIS is not in compliance with numbers 2, 3, or 4 above. While DOE has stated that information used in determining the groundwater flow model is incomplete or unavailable, the existing credible scientific evidence relevant to evaluating reasonably foreseeable significant adverse impacts has not been summarized nor has it all been utilized in developing flowpaths.

To be in compliance with NEPA, DOE is required to consider effects of credible alternative models in the Draft EIS. While the Draft EIS recognizes differing viewpoints regarding groundwater flow and references the State of Nevada-funded studies of Lehman and Brown, 1995, there has been no evaluation of the impacts. (See Attachment U to these comments for an expanded discussion of this topic.)

Response

DOE believes that the EIS is consistent with the National Environmental Policy Act, as amended (42 U.S.C. 4321 *et seq.*), and with the Nuclear Waste Policy Act, as amended (42 U.S.C. 10101 *et seq.*). DOE acknowledges in several places in the EIS that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, including incomplete or unavailable information, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Sections 3.1.4.2.1 and 3.1.4.2.2 discuss opposing views on groundwater conditions and groundwater boundaries. Although DOE disagrees with the central scientific conclusions of these opposing views, it continues to support research in several areas and on other aspects of the geology and hydrology of the region to enhance the Department's understanding of the site.

7.5.3.2 (5858)
<u>Comment</u> - 010422 / 0002
[Have full disclosure of] what the specific geology of the proposed storage area as well as expert opinion on the suitability of the property for storage.

<u>Response</u>
Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. This description includes the opinions of many experts who have reviewed and provided input to the site characterization process. Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, DOE believes that a repository at Yucca Mountain would operate safely; that is, in compliance with the Environmental Protection Agency's *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*, at 40 CFR Part 197. Under the Nuclear Waste Policy Act, it is the Secretary of Energy's responsibility to either recommend or not recommend the Yucca Mountain site to the President for construction of a repository. The Secretary will base the decision on the vast amount of information collected by DOE and other agencies during the past several decades.

7.5.3.2 (5874)
<u>Comment</u> - EIS001622 / 0018
Need for More Thorough Evaluation of Potential Groundwater Impacts in California

Inyo County, California testified before DOE on the long-term threat that the Yucca Mountain repository poses to regional groundwater supplies and to communities east of Owens Valley. Studies conducted by Inyo County and Nye and Esmeralda Counties in Nevada point to the existence of a continuous aquifer running from beneath Yucca Mountain south to Tecopa, Shoshone and Death Valley Junction. These studies indicate that water flowing beneath Yucca Mountain flows generally south to become surface water and groundwater flowing into Death Valley that is used for commercial and domestic purposes and supports natural habitats. Some of these springs also support populations of a number of threatened or endangered species.

In addition to determining potential pathways for radionuclides, the DEIS should evaluate the effect of DOE's proposed groundwater extraction in Jackass Flats on the flux or rate of flow of groundwater to discharge areas of the regional aquifer in California. The groundwater extraction proposed at Jackass Flats will eventually exceed the perennial yield that has been defined in the DEIS. All extraction, even that which does not exceed perennial yield, will decrease the amount of water that flows through the aquifer and is discharged at down-gradient springs and wetlands. This decrease would almost certainly affect such habitat deleteriously.

The source of water at Jackass Flats will be supplied by (1) more water entering the groundwater system (increased recharge), (2) less water leaving the system (decreased discharge, and/or (3) removal of water that was stored in the system, or some combination of these three. It is unlikely that recharge will increase. Since recharge will probably not increase, we are left with the conclusion that less water will be discharged from the aquifer, and the amount of groundwater in storage will be decreased. Both of these results will decrease the down-gradient groundwater supply from the regional aquifer to springs and wetlands.

Recommendation: The DEIS should more fully evaluate potential pathways for radionuclides reaching regional groundwater supplies in eastern California, such as in the Death Valley region. The DEIS should evaluate the above-referenced studies and include them in their analyses of the potential migration of radionuclide contaminants to regional groundwater supplies. The DEIS should also include a discussion of proposed methods, including monitoring wells and water resource studies, to determine the amount of change in flux that can be expected, the potential effects of that change on aquatic and riparian habitat and water supply, and proposed mitigation procedures.

Response

The EIS recognizes that the region's groundwater flowpath includes the locations identified in this comment, with the exception of the Owens Valley area. Section 3.1.4.2.1 describes the flowpath for groundwater beneath Yucca Mountain to be to Jackass Flats to the Amargosa Desert, and then south to the primary point of discharge at Alkali Flat (Franklin Lake Playa) southeast of Death Valley Junction. The EIS also recognizes that some groundwater reaching this far might bypass this playa area and continue into the Death Valley basin, which would require moving through the Tecopa and Shoshone areas. The EIS recognizes that a small fraction of the groundwater flow beneath the Amargosa Desert might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek Wash area of Death Valley.

Chapter 5 of the EIS does not specifically address risks to people and natural resources that might be experienced in the Tecopa, Shoshone, or Death Valley National Park areas as a result of groundwater use and consumption. However, the evaluation presented in Chapter 5 shows that risks would decrease with increased distance from the repository site. Accordingly, impacts to these other areas, because they are farther away on the groundwater flowpath, would be less than those for the furthest distance evaluated in the EIS. Section 5.9 addresses impacts to biological resources as a result of the long-term performance of the repository. As indicated in this section, DOE did not quantify impacts to biological resources as a result of exposures to contaminated groundwater, but did relate them to the minimal impacts expected for humans through the use and consumption of the groundwater.

As described in Section 3.1.4 of the EIS, the Death Valley regional groundwater flow system is a terminal hydrologic basin. That is, there is no natural pathway for water (groundwater or surface water) to leave the basin other than by evaporation or transpiration through plants, and Death Valley is the low area for the basin. With this in mind, impacts to groundwater of the area east of Owens Valley would be unlikely as a result of the Proposed Action. Depending on the specific location of concern, it would be outside the Death Valley regional groundwater flow system (DIRS 100131-D'Agnese et al. 1997) or its groundwater flows toward the same basin in Death Valley National Park. (That is, groundwater from Yucca Mountain would have to flow down to the Death Valley basin and back up-gradient to reach areas east of Owens Valley that are outside of the Park.)

Section 4.1.3 of the EIS addresses the relatively short-term impacts associated with the extraction of groundwater to support the operational phases (that is, construction, operations and monitoring, closure) of the proposed repository. (These are considered short-term in comparison to those dealing with the long-term performance of the proposed repository that are discussed in Chapter 5.) As identified in Section 4.1.3.3, the peak projected annual water demand for the repository action [360,000 cubic meters (290 acre-feet)], when combined with projected demand from the

Nevada Test Site [350,000 cubic meters (280 acre-feet)], would approach, but would not exceed, the lowest estimate of perennial yield for the western two-thirds of the Jackass Flats hydrographic area [720,000 cubic meters (580 acre-feet)]. This combined withdrawal rate would be well below the highest estimates of the perennial yield of this area. Section 4.1.3.3 recognizes that groundwater withdrawal at Jackass Flats would, to some extent, reduce the amount of underflow that would reach down-gradient areas. However, it also discusses that the first area to experience an impact would be the area of the Amargosa Desert, and that the amount of water required by the repository action is very small in comparison to the amount of groundwater already being withdrawn in that area.

Since the publication of the Draft EIS, additional efforts have taken place to model the impacts of the proposed repository's groundwater withdrawals on the regional groundwater. Results of these efforts, which predict relatively minor changes in both water elevation outside of the Yucca Mountain area and in the amount groundwater flux into Amargosa Desert, are now described in Section 4.1.3.3 of the EIS.

7.5.3.2 (5887)
Comment - EIS001622 / 0020
Need for Hydrogeologic Cross-Section and Water Level Maps

The DEIS does not contain a hydrogeologic cross-section--a basic tool for evaluating the potential impact of contaminates on groundwater--to help evaluate potential groundwater migration from the proposed repository into the Amargosa and Death Valleys. The EIS should include the cross-section as well as maps showing water level isocontours. Without this information, potential environmental impacts to groundwater in California cannot be reasonably assessed. In addition, the DEIS' characterization of the carbonate aquifer in the vicinity of Yucca Mountain is insufficient. It appears that only a single well completed in this aquifer was tested. This method does not provide reliable data on groundwater flow direction or aquifer hydraulic conductivity. More field data are needed to enhance the computer-modeling effort. Without the actual parameters of the aquifer, it is difficult to judge the model's reliability for predicting the fate and transport of radionuclides 10,000 years into the future.

Recommendation: The DEIS should include a hydrogeologic cross-section and maps showing water-level isocontours to help evaluate potential groundwater migration from the proposed repository into the Amargosa and Death Valley regions. More field data on groundwater flow direction or aquifer hydraulic conductivity are needed to enhance the computer modeling effort.

Response
DOE agrees with this comment on the importance of developing hydrogeologic cross sections and water-level isocontour (or potentiometric surface) maps. The Department did not include more of this type of information in the Draft EIS to keep the discussion as simple and brief as possible. However, as a result of this comment and others, Section 3.1.4 of the Final EIS contains a potentiometric surface map of the region and a hydrogeologic cross section simplified from the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000). DOE believes that the EIS text provides a simplified description consistent with those in the hydrogeologic cross sections.

With respect to the second part of the comment, DOE plans to acquire additional characterization data for the carbonate aquifer. The Nye County Nuclear Waste Repository Project Office has embarked on an independent verification, testing, and oversight drilling program that includes the Early Warning Drilling Program. Information from the ongoing site characterization program and from the performance confirmation program (if Yucca Mountain is approved for a repository), would be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

7.5.3.2 (5932)
Comment - EIS001622 / 0036
Section 3.1.4.1.2 DOE correctly notes that precipitation is not uniform either spatially or temporarily at the site; e.g., most recharge occurs during the winter months. However, DOE never provides an estimate of the volume of water flux through the mountain, nor, is enough data available to determine what part of the mountain will be

affected by the so-called “fast paths” through the mountain. DOE needs to provide information on the water flux through Yucca Mountain and the most probable areas affected by the “fast paths” in the unsaturated zone.

Response
Section 3.1.4.2.2 discusses volume of water flux through Yucca Mountain. With regard to possible “fast-flow” pathways through the mountain, DOE has used a variety of naturally occurring isotopes (for example, chlorine-36) to investigate this process. Results to date have detected elevated amounts (values above normal background measurements) of “bomb-pulse” chlorine-36 in several places in the Exploratory Studies Facility from nuclear testing conducted during the 1950s and 1960s, principally in the Pacific. The locations where this bomb-pulse chlorine-36 has been detected in the Exploratory Studies Facility are associated generally with known through-going faults and well-developed fracture systems close to those faults. This suggests that connected pathways exist through which surface precipitation has percolated to the repository horizon within the last 50 years.

DOE based the selection of the proposed repository block in large part on the lack of mapped surface faults in this part of Yucca Mountain. In light of the close association of the detection of chlorine-36 with mapped surface faults, DOE does not anticipate the presence of many undiscovered fast paths. Continued chlorine-36 sampling in the cross drift that would extend above the repository has not identified additional fast paths. The fast paths identified to date have been factored into the Total System Performance Assessment for the repository.

7.5.3.2 (5935)
Comment - EIS001622 / 0039
Section 3.1.4.2.2. It is significant that the character of the pore water from the rock matrix is chemically distinct from water found in fractures. It is also significant that water in the perched zones does not appear to receive a large contribution from the rock matrix; indicating all significant flow, both in terms of volume and velocity, is via fracture flow through the mountain. DOE should estimate at what level of precipitation (infiltration) fracture flow becomes the dominant flow path.

Response
The characteristics of the pore water and perched water have been very helpful in determining how water moves through the unsaturated zone at Yucca Mountain. However, DOE believes that the comment that “all significant flow, both in terms of volume and velocity, is via fracture flow through the mountain” is an over simplification. Water movement in the unsaturated zone at Yucca Mountain is controlled by the structure and characteristics of each geological formation, or layer, it encounters. In some layers, fracture flow is the predominant mechanism; in at least one layer, however, matrix flow is much more important, even dominant.

Infiltration and percolation have been studied extensively at Yucca Mountain. The *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) discusses field investigations and model development in this area. These studies are difficult to conduct at Yucca Mountain because the low precipitation and high evapotranspiration rates are not conducive to direct measurements of infiltration, but they have shown that infiltration at the surface is highly variable, both temporally and spatially. They have enabled DOE to develop a conceptual model of how water moves through the unsaturated zone if it gets deep enough to avoid surface, or near-surface, evapotranspiration. The conceptual model, supported by field data as well as numerical models, indicates that water moves through the Tiva Canyon welded unit and Topopah Springs welded unit (where the underground repository would be located) is predominantly through fractures and faults. Lying in between these two units is the Paintbrush nonwelded unit. Matrix flow is the dominant flow mechanism through the Paintbrush nonwelded unit because of its relatively high matrix permeability and porosity and low fracture density (DIRS 151945-CRWMS M&O 2000). Matrix flow through this unit substantially attenuates the downward movement of percolating water. The chlorine-36 studies, discussed in Section 3.1.4.2.2 of the EIS, suggest that quick pathways (less than 50 years) extending to the underground repository are associated with fractures or faults cutting through the Paintbrush nonwelded unit. Data collected also indicate that the lateral movement of water at the top of this unit is minor and, accordingly, the amount of water moving down through faults and fractures is small compared to that moving through the matrix.

This conceptual model of water percolation is supported by data gathered during efforts to determine the age of the perched water that lies below the level of the proposed repository. The age of this water is estimated to be thousands of years; too young for water moving solely through the matrix and too old for water moving predominantly via fractures and faults. The conceptual model for water percolation at Yucca Mountain would indicate that the perched water is a mixture of water of different ages. Some of the water has had its travel time attenuated as a result of matrix flow, whereas some water has traveled relatively fast through faults and fractures.

7.5.3.2 (5937)
Comment - EIS001622 / 0040
Table 3-14. Calling the basal vitrophyre and the Tram Tuff confining units seems to be little more than wishful thinking. Apparent hydraulic conductivities up to 40 m/yr. in the Tram Tuff are not that much different than the underlying carbonate aquifer ("described as a "a regionally extensive aquifer system through which large amounts of groundwater flow") displaying a permeability of 69 m/yr. Water percolating through the mountain will take the path of least resistance; therefore, the higher permeability value for the Tram Tuff is probably more indicative of its "typical" permeability.

Response
The apparent hydraulic conductivity of up to 40 meters per year cited by the commenter refers to those bedded tuffs, lava flows, and flow breccias beneath the Tram Tuff, not to the Tram Tuff itself (EIS Table 3-14). Evidence supporting the view that these hydrogeologic units act as a confining layer comes from pressure and temperature measurements conducted in borehole UE-25 p#1. This 1,800-meter (6,000-foot)-deep borehole penetrates the deep Paleozoic carbonate aquifer, exhibits excess pressure head [approximately 17 meters (56 feet)] and elevated temperature compared to measurements of these parameters in virtually all other boreholes in the vicinity of Yucca Mountain. In addition, the chemistry of water from this borehole unambiguously identifies the water as coming from the regional carbonate aquifer. All other water samples taken from boreholes that bottom in the lower volcanic aquifer and lower volcanic confining unit exhibit a chemical signature distinctly volcanic. Isolation of these two chemical systems is strong evidence for the bedded tuffs, lava flows, and flow breccias acting as an effective confining unit.

Similarly, aquifer pumping tests conducted in that part of the lithologic section that includes the basal vitrophyre of the Topopah Spring Tuff and the Calico Hills-Prow Pass nonwelded tuffs (collectively, the upper volcanic confining unit) produce only modest amounts of water compared to the overlying and underlying hydrogeologic units (considered to be aquifers). Additional evidence of the resistance to flow that these units possess is in the unsaturated zone, where the basal vitrophyre and portions of the Calico Hills serve as layers upon which perched water has accumulated.

7.5.3.2 (5938)
Comment - EIS001622 / 0041
Section 3.1.4.2.2, Page 3-52. DOE states that "the actual and relative amounts of inflow [into the volcanic aquifers below Yucca Mountain] from each (of the four potential) sources are not known." This is an essential piece of information necessary for any effective modeling of groundwater flow from beneath the mountain and toward Franklin Playa. Any model lacking this information would not provide a meaningful or reliable characterization of groundwater flow.

Response
DOE has conducted an extensive site characterization program to evaluate the proposed repository at Yucca Mountain. During site characterization the Department has performed tests to develop a defensible site-scale saturated-zone flow and transport model. The *Saturated Zone Flow and Transport Process Model Report* (DIRS 145738-CRWMS M&O 2000) and subsequent updates summarize this model. Chapter 2 of that report discusses the evolution of the saturated-zone process model. In particular, Section 2.5 summarizes the current saturated-zone flow and transport model. Chapter 3 of the report describes model development and Section 3.2.2 presents boundary conditions. The site-scale flow and transport model is compatible with the regional-scale model described by D'Agnese et al. (DIRS 100131-1997), the Hydrogeologic Framework Model, and available data on recharge within the site-scale model area. Most of the inflows and outflows from the site-scale saturated-zone model occur as flow across the lateral boundaries. The best available estimates of flow rates are cell-by-cell fluxes calculated by the regional-scale model for the site-scale model, then calibrated against known data points in the model domain. The text in question has been revised to better reflect new data from individual locations have been integrated into models to development estimates of the saturated zone water balance.

7.5.3.2 (5939)
Comment - EIS001622 / 0042
Section 3.1.4.2.2, Page 3-56. The data from Well JF-2a are troublesome. Why would this well exhibit a 27cm increase in elevation when all the other wells in the area exhibit 3- to 9-cm decreases? This apparent contradiction is glossed over in the text and not discussed except to relate the well locations to the proximity of Fortymile Wash. If wells JF-12, JF-13, and JF-3 were not pumped would their static levels also increase? By not providing an explanation of these static water levels, DOE indicates that the hydrogeology below and directly downgradient of Yucca Mountain is poorly understood. More data is necessary to both understand the down gradient hydrogeology and as input to more meaningful groundwater modeling.

Response
The comment is correct that the Draft EIS did not highlight a potentially key piece of information about well JF-2a. As shown in Figure 3-17, this well is in the carbonate aquifer. There is a possibility that the water elevation in the well has not yet reached an equilibrium condition. DOE has added a sentence to the text to describe this possibility. The primary intent of Section 3.1.4.2.2, however, is to state the findings to date from the applicable reference, which is a recommendation for additional monitoring to determine if the water levels are correlated to a causative action or condition.

The reference material that DOE used did not correlate water level fluctuations with proximity to Fortymile Wash. The Draft EIS mentioned Fortymile Wash in this context only because it had been identified as an area of periodic recharge (see the Inflow to Volcanic Aquifers at Yucca Mountain discussion in Section 3.1.4.2.2). The reference to the wells' proximity to Fortymile Wash has been removed.

7.5.3.2 (5940)
Comment - EIS001622 / 0043
Section 4.1.3.2 There is some discussion here that water percolating into the repository drifts [if any] would be pumped to the surface. What is the maximum volume of water expected to percolate into the drifts?

Response
The average percolation flux under present conditions is about 5 millimeters (0.2 inch) per year and the capillary-barrier effect of the excavation of the drifts should cause a diversion of this percolating water around the excavated drifts. Therefore, it is uncertain if any water would seep into the drifts that would require pumping to the surface. Additional evidence of the overall lack of fluid flow in the subsurface is that throughout the excavation of more than 11 kilometers (6.8 miles) of tunnels for the Exploratory Studies Facility, only one fracture was moist. Further observations in testing alcoves that have been isolated from the effects of tunnel ventilation for several years confirm the lack of natural seepage at the waste-emplacement level. In summary, despite finding millions of fractures in the course of excavation at Yucca Mountain, there is scant evidence that even modest quantities of water penetrate to waste-emplacement depths.

7.5.3.2 (5943)
Comment - EIS001622 / 0047
In summary, the hydrogeologic and geochemical characterization of Yucca Mountain and vicinity is not complete. Major uncertainties remain about the "fast paths" through the mountain and the flow paths from the underlying volcanic and carbonate aquifers to the alluvial aquifer in Amargosa Valley and possibly on to Death Valley. It is also unclear what effect the Ghost Dance fault (and other faults) east of the proposed facility could have on ground water flow. Currently, the ground water modeling performed on these flow paths, based on little or no information, is little more than conjecture.

Response
DOE continues to evaluate the "fast paths" through the mountain by experimentation and verification of chlorine-36 sampling, as described in Section 3.1.4.2.2 of the EIS. Results of the verification sampling and continued experimentation, if available, are presented in the Final EIS and supporting documents.

The Draft EIS was developed using the best available information for hydrochemical and geochemical characterization. Many experiments are ongoing and some of the resulting data are included in the EIS. DOE recognized that the saturated zone requires additional characterization in order to fully evaluate the effects of faults on flowpaths and the relationships between the alluvial/valley fill aquifer, volcanic aquifer, and carbonate aquifer systems. DOE initiated a Cooperative Agreement with Nye County to address a number of the characterization uncertainties mentioned in this comment and has included the available data into the Final EIS. The Nye County program is described below.

DOE has supported Nye County with it's program (called the *Early Warning Drilling Progra*m) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the performance confirmation program (if Yucca Mountain was recommended and approved for a repository) could be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

In addition, DOE has installed a series of test wells along the groundwater flow path between the Yucca Mountain site and the Town of Amargosa Valley as part of an alluvial testing complex. The objective of this program is to better characterize the alluvial deposits beneath Fortymile Wash along the east side of Yucca Mountain. Single- and multiwell tracer tests have begun and the results thus far have strengthened the basis of the site-scale saturated flow and transport model. Information from this program has been incorporated in the EIS.

DOE realizes that the data obtained from the Nye County Cooperative Agreement Early Warning Drilling Program are critical to understanding the saturated zone system and performance assessment calculations south of Yucca Mountain. All data obtained from the Nye County Early Warning Drilling Program would be utilized to the extent possible for the enhancement of the saturated zone models. DOE scientists would perform sorption studies on lithologic material extracted from Nye County boreholes for incorporation into the saturated zone transport model and abstraction into the performance assessment calculations. DOE would use chemical data to enhance current studies on the understanding of saturated flow systems and various hydrochemical facies. Groundwater elevation data would continue to be determined from all wells and would be used to define flow and transport paths, calibration of models, and support the geologic framework model.

7.5.3.2 (5944)
Comment - EIS001622 / 0046
It is amazing that, in a project that is to completely characterize the subsurface in and around Yucca Mountain, there has been no high-resolution geophysical surveys conducted to further delineate the geologic structures below Yucca Mountain that may enhance (of hinder) ground water flow. We recommend that such surveys be conducted as a very cost-effective way of gathering useful subsurface geologic information.

Response
DOE used several geophysical methods, including seismic reflection, gravity, and magnetic surveys, to characterize the subsurface geologic structure of Yucca Mountain at and near the repository. A single magnetotelluric line and several vertical seismic profiles provided supplementary information.

In the Yucca Mountain area, DOE conducted a 32-kilometer- (20-mile)-long seismic reflection survey across Bare Mountain, Crater Flat, Yucca Mountain, Midway Valley, and Fortymile Wash. Where this regional profile crosses the repository site, the reflection data show a series of west-dipping normal faults that displace volcanic rocks and the Tertiary/pre-Tertiary contact at depth. DOE collected gravity data from geophysical surveys and used these data to interpret regional structure and to aid in the interpretation of shallow structures at Yucca Mountain, such as the location of and displacement along faults. The Department conducted ground magnetic surveys at Yucca Mountain to estimate the location of faults and the displacement along these faults. Because buried faults and geologic heterogeneities at Yucca Mountain could affect the long-term performance of the repository, DOE used magnetotelluric methods to detect and characterize these features.

DOE combined the information from these geophysical studies with the results of other field studies, including detailed geologic mapping of the surface and in the Exploratory Studies Facility. In addition, boreholes drilled at the site supplied information on the vertical and lateral distribution of hydrogeologic units, hydrologic properties of the rocks, thermal and other geophysical conditions and properties, chemistry of the contained fluids, pneumatic pressure, and water content and potential. Additional data for some of these parameters came from excavations for the Exploratory Studies Facility and from boreholes drilled in drifts and alcoves of the Exploratory Studies Facility.

Using this combined data set, DOE derived detailed geologic and hydrologic models that describe the spatial models of rock layers, faults, rock properties, and mineral distributions in the subsurface and to simulate three-dimensional fluid flow and support site-performance models of Yucca Mountain. For a more complete discussion of site scale geophysical studies, see Section 4.6.5 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000).

7.5.3.2 (5955)
Comment - EIS001622 / 0056
The DEIS is not consistent in its evaluation of environmental consequences over long time intervals. It takes current predictions and projects them into the future to be used in the long-term analysis. For example, in the last paragraph p. 5-23 the DEIS concludes that no contamination of the carbonate aquifer is possible because there is currently an apparent hydraulic head of 120 feet in this aquifer forcing water up into the volcanic aquifers, therefore no contamination of surface springs in California would occur. This does not consider the potential for a future change in hydraulic gradients due to climate change, seismicity, etc., over very long periods of time. The potential of surface water contamination from groundwater should be more rigorously evaluated and potential impacts described.

Response
A discussion was added to Section 5.3 to address your concerns. In particular, the “Saturated Zone Process Model Report” dedicates a chapter to changes in the saturated zone flow system (DIRS 145738-CRWMS M&O 2000). In that chapter the changes in climate, tectonics, water table elevation, groundwater flux, recharge, and discharge are addressed. These changes are considered for a time period of 10,000 years. Under these scenarios, the conclusion remains the same; no contamination would occur in the discharge areas of the carbonate aquifer system.

7.5.3.2 (5956)
Comment - EIS001622 / 0063
The risk assessment indicates that Amargosa and Death Valleys are the points of discharge of volcanic and carbonate aquifers into the alluvial aquifer used as a water source by the local population. However, according to some publications (e.g., USGS OFR 83-542) most of the water recharged into Amargosa Valley alluvial aquifer is from snow melt and rainfall from the surrounding mountains. The EIS should provide support for either of these two cases: that the majority of recharge is from surface recharge or that it is from underflow from the volcanic and/or carbonate aquifers.

Response
DOE recognizes that precipitation falling at higher elevations in the surrounding mountains is often cited as the primary source of the water in the Amargosa Desert alluvial aquifer. In addition, surface waters in the area are described as ephemeral, with flowing water only in response to heavy precipitation or in localized areas supplied by springs. Some might consider this a contradiction, but the primary source of the water in the alluvial aquifer is from water recharged at higher locations. Groundwater recharged at higher elevations reaches the Amargosa Desert as underflow by the pathways, or aquifers, described in Section 3.1.4 of the EIS.

The report *Water for Nevada* (DIRS 103016-State of Nevada 1971) identifies and quantifies estimates of surface water and groundwater resources for each hydrographic area in the state. For the Amargosa Desert (Hydrographic Area Number 230), the report identifies sources of surface water as being less than 50 acre-feet (about 61,700 cubic meters) per year as runoff from mountains and “some” (unquantified) surface-water inflow from other hydrographic areas. The report identifies sources of groundwater for this area as 600 acre-feet (about 740,000 cubic meters) per year from direct precipitation and 44,000 acre-feet (about 54.3 million cubic meters) per year as groundwater inflow from other hydrographic areas, particularly Mercury Valley, Rock Valley, Jackass Flats, and Crater Flat. These areas are at relatively high elevations and are groundwater conduits for recharge at even higher elevations farther away. All the studies and reports of which DOE is aware indicate that groundwater that originates in adjacent hydrographic areas is the primary source for the groundwater of the Amargosa Desert.

7.5.3.2 (5961)
Comment - EIS001622 / 0060
The draft EIS's risk assessment related to groundwater consumption is based on groundwater migration from the proposed Yucca Mountain repository into the Amargosa and Death Valleys. The draft EIS does contain some information on the regional geology of the Yucca Mountain area. However, the draft EIS does not contain a hydrogeologic cross-section, a basic tool for evaluation of potential impact of contaminants on groundwater. It appears that there is enough information about the area to prepare such a cross-section. Therefore, the EIS should be modified to include: a single, regional, hydrogeological cross section showing the piezometric surface along the potential pathway of groundwater flow; geological formations; the relationships among the volcanic, alluvial and carbonate aquifers; and the outflow locations of carbonate aquifer springs down-gradient from the site. The EIS should also include maps showing water level isocontours. Together, these maps and the cross-section would convey a conceptual model of the site hydrogeologic conditions. Without such maps and cross-sections potential environmental impacts cannot be reasonably assessed.

Response
DOE agrees with the commenter. Section 3.1.4 of the Final EIS includes a potentiometric surface map of the region and a simplified hydrogeologic cross-section.

7.5.3.2 (5962)
Comment - EIS001622 / 0061
The draft EIS appears to contain contradictions regarding which aquifer is present at the actual repository site. For example on page 3-48, the draft EIS states that the saturated zone at Yucca Mountain has three aquifers: upper volcanic, lower volcanic, and lower carbonate aquifer. However, the last two sentences of this paragraph indicate that only two aquifers are present as follow: "The lower volcanic aquifer discussed here corresponds to the middle volcanic aquifer shown in Figure 3-15. The lower volcanic aquifer shown in Figure 3-15 has not been identified in the area of the proposed repository."

The upper volcanic aquifer shown in Figure 3-15 does not occur at the site (Topopah Spring Welded Unit - host rock for the repository). However, because the upper volcanic aquifer occurs down-gradient of the site, the EIS should address the potential pathway of contaminated plume across different hydrogeologic units, including aquicludes and faults.

Response
DOE faced a problem in presenting a simplified picture of the groundwater hydrology at Yucca Mountain because previous studies have not been consistent in their nomenclature. The Department nevertheless believes that the EIS description of aquifers at Yucca Mountain is not contradictory, although it does try to explain one inconsistency in aquifer designations. The paragraph referred to in the comment describes three aquifers, two in the volcanic sequences and one in the carbonate formation. It then indicates that at the repository site the rock unit making up the upper volcanic aquifer is above the saturated zone due to its tilt. Two sentences at the end of the paragraph explain that the sequence forming the lower volcanic aquifer in Figure 3-15 of the Draft EIS has not been found at Yucca Mountain (that is, the middle volcanic aquifer in Figure 3-15 is the lower volcanic aquifer described in the text, and the lower volcanic aquifer described in Figure 3-15 is not present at Yucca Mountain).

Chapter 5 of the EIS summarizes long-term repository performance including contaminant modeling efforts. In addition, the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) contains more detail on the contaminant pathways included in the model. With respect to the specific comment, Section 3.7.1.4 of the Viability Assessment indicates that DOE believes the flow in the saturated zone is primarily through the fractured tuffs of the middle volcanic aquifer (the lower volcanic aquifer described in the EIS) and the valley fill alluvium.

7.5.3.2 (6063)
Comment - EIS001898 / 0009
DOE should correct areas of discrepancy in water use data and provide clarifying information regarding the potential for and impacts from overdrafts of groundwater in the FEIS.

Basis:

Table 3-11 notes that the figures for current water appropriations do not include Federal reserved water rights (FRRs) for the NTS and Nellis AFR. These FRRs should be added to the total appropriations for a more accurate measure of committed resources.

Table 3-11 and DEIS Section 3.1.4.2.1 (Affected Environment - Regional Groundwater) suggest that ample water is available for new appropriations to support the Proposed Action because average annual withdrawals (actual use) are well below the appropriation limits. Although the use of average withdrawals may be appropriate, it is possible that this could be misleading because users are entitled to withdraw or sell their full appropriations.

When discussing the water demands expected during performance confirmation in Section 4.1.3.1 (Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure -- Impacts to Hydrology from Performance Confirmation) the DEIS omits mention of NTS and Nellis AFR wells in the area. The pumpage from those wells should be added to that from J-11 and J-12 and the C-well complex in the proposed land withdrawal area for an improved estimate of the water demand. The wide range in the perennial yield figures (880 to 4000 acre-feet for Area 227a) should be explained. The perennial yield and committed resources figures for Area 227a in Nevada Division of Water Planning (1992) do not agree with Table 3-11. DOE should provide additional justification for the perennial yield figures, considering the variance from information in other sources, to support its assessment of potential overdraft in the region.

The discussion of water demand during construction, operation and monitoring, and closure in Section 4.1.3.3 (Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure -- Impacts to Groundwater from Construction, Operation and Monitoring, and Closure) of the DEIS also should be clarified. This discussion should make clear where the water will be obtained to meet the combined water demand for the repository, the NTS, and Nellis AFR. Under one scenario, the perennial yield of Area 227a would be exceeded. The text should be clarified to explain the impacts of any possible overdraft.

The discussion in DEIS Section 4.1.3.3 (Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure -- Impacts to Groundwater from Construction, Operation and Monitoring, and Closure) includes at least one scenario where the Jackass Flats basin would be in overdraft status. In addition, Table 3-11 presents the Amargosa Desert Area 230 in a potential overdraft situation. DOE (1996) confirms that historic data show that DOE withdrawals at Yucca Flats have annually exceeded the perennial yield. The potential impacts of these overdrafts should be discussed.

DOE should correct discrepancies in water-use discussions and data in the FEIS. The evaluation of groundwater use during construction, operation, and monitoring should include a discussion of the potential for overdrafts.

References:

Nevada Division of Water Planning. *Nevada Water Facts, 1992*. 241353. Carson City, NV: Nevada Division of Water Planning. 1992.

U.S. Department of Energy, *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Location sin the State of Nevada*. DOE/EIS-0243-F,239895. Las Vegas, NV: U.S. Department of Energy. 1996.

Response

Federal Reserve Water Rights are noted in the footnote to Table 3-11, but are not quantified because they are not directly comparable to water appropriations authorized by the State of Nevada. As stated in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996), the Federal Reserve Water Rights position is that the Nevada Test Site is "…entitled to withdraw the quantity of water necessary to support the NTS missions." The Nevada Test Site EIS does not quantify or limit these rights, except for their purpose, and the repository EIS concurs with this view. With respect to identifying committed water resources, the repository EIS is obligated to identify cumulative impacts of other Federal and non-Federal actions. Chapter 8 discusses the past, present, and foreseeable future actions and associated water demands. In this manner, the EIS does indirectly identify quantities of water expected to be associated with reserved water rights (that is, if their impacts would be cumulative with those of the Proposed Action).

The purpose of Table 3-11 of the Draft EIS and its associated text is not to suggest that ample water is available. The intent is only to describe existing groundwater resources and use in the region of Yucca Mountain. DOE agrees that average withdrawals do not tell the entire story when looking at groundwater resources and their availability. This is the reason that both water appropriations and estimates of perennial yield are also shown in the table. In addition, DOE understands, though not expressed in the EIS, that the State Engineer must consider factors in addition to those shown in the table when considering requests for water appropriations.

Chapter 8 of the EIS describes the cumulative impacts of groundwater use by the Nevada Test Site, Nellis Air Force Range, and the proposed repository. Additional text has been added to Section 8.2.3.2 to better address other uses of groundwater in the area. As identified in Section 4.1.3.3, the peak projected annual water demand for the proposed action [360,000 cubic meters (290 acre-feet)], when combined with projected demand from the Nevada Test Site [350,000 cubic meters (280 acre-feet)], would approach, but would not exceed, the lowest estimate of perennial yield for the western two-thirds of the Jackass Flats hydrographic area [720,000 cubic meters (580 acre-feet)]. The corresponding discussion in Section 4.1.3.1 of the EIS (impacts from performance confirmation) is intentionally brief because of the relatively small annual water demand projected for that phase of the project. The evaluation in this section compares projected water demand to the perennial yield estimates and shows them to be minor. The addition of the Nevada Test Site demand would still put projected water withdrawals well below the lowest estimates of perennial yield, which were not mentioned.

With respect to the wide range of perennial yield figures identified for hydrographic area 227a, an explanation of the origin and basis for each of these numbers is beyond the scope of the EIS. A partial answer is that estimates of recharge are difficult and vary widely in this area where evapotranspiration is high and quantities of surface water are low. An order of magnitude difference between recharge estimates for the same study area is not unusual in the literature. The source of the perennial yield information presented in Table 3-11 of the Draft EIS is in a footnote to the table. The cited source identifies the studies from which the perennial yield values are taken and discusses those studies. The EIS recognizes that the Nevada Division of Water Planning uses an estimate of perennial yield that is not totally consistent with those listed in Table 3-11. Tables 3-35 and 3-43 of the Draft EIS both include a footnote indicating that the Nevada Division of Water Planning uses a combined perennial yield of 30 million cubic meters (24,000 acre-feet) for hydrographic areas 225 through 230. This estimate was not used in the tables because it has not been divided into the individual areas. DOE thought it important to give estimates and discuss perennial yield based on these smaller areas, so it used the best available data (on an individual hydrographic area basis). DOE believes that the EIS considers a wide range of perennial yield values, particularly for hydrographic area 227a (Jackass Flats), and that this is appropriate and conservative. The fact that the Nevada Division of Water Planing uses different values for some of the committed resources is due to the use of a more recent reference in the EIS (DIRS 103406-NDWP 1992).

As indicated above, Chapter 8 of the EIS discusses other (nonrepository) water demands in the Yucca Mountain region. However, Section 4.1.3.3 does clearly indicate that there would be an ongoing Nevada Test Site water demand from the same hydrographic area from which the Yucca Mountain Site Characterization Project would be withdrawing water. This section does not mention water demands for the Nellis Air Force Range because there are no demands in this hydrographic area. It does discuss the potential for overdraft of this hydrographic area. This hydrographic area (227a – Jackass Flats) is not an isolated basin. It receives water both from the surface (recharge from precipitation) and as underflow from upgradient areas. It also loses water as underflow to downgradient areas. As described in the EIS, withdrawing only slightly more water than the low estimate of perennial yield (which is based solely on recharge from local precipitation) would be unlikely to cause a depletion of the reservoir because of the higher quantities estimated to be moving through as underflow. However, it would probably result in a minor shifting of the general groundwater flow patterns to compensate. Since the publication of the Draft EIS, two groundwater modeling efforts have been completed to simulate the effects of the projected water demands by the repository on the groundwater flow system. The Final EIS has been modified to discuss the results of these efforts, which are consistent with the general impacts discussed above.

As indicated above, effects of overdrafting within Jackass Flats are discussed in this EIS and modifications have been added to the Final EIS to address the results of applicable modeling efforts. With respect to the Amargosa

Desert, Section 4.1.3.3 of the EIS states that water demand associated with the proposed repository would have only a small impact on water availability in Amargosa Desert. That is, actual or potential overdrafting of groundwater in the Amargosa Desert would be attributed predominantly to pumping in that area and would not be substantially affected by the amount of water needed to support the repository. Accordingly, possible impacts from overdrafting in Amargosa Desert are not discussed in the EIS. Overdrafting at Yucca Flat is not described in the EIS because it does not have a direct connection to the Proposed Action. Figure 3-13 of the Draft EIS shows that Yucca Flat is within the Ash Meadows Groundwater Basin and the direction of groundwater flow from there is toward Frenchman Flat and eventually to the Ash Meadows area and, if remaining as underflow, to the Amargosa Desert. This is consistent with the State of Nevada report *Water for Nevada* (DIRS 103016-State of Nevada 1971), which shows no groundwater inflow to this hydrographic area (area 159 – Yucca Flat), but does show its groundwater outflow going to Frenchman Flat, which also receives underflow from adjacent areas. The Nevada Test Site withdraws water from Frenchman Flat (hydrographic area 160), but at quantities far below its perennial yield (DIRS 101811-DOE 1996). Based on this picture of groundwater flow conditions, overdrafting at Yucca Flat would be expected to result in very localized conditions, probably not even extending far into Frenchman Flat because the combined water use for these two areas (Yucca and Frenchman Flats) is only a small fraction of their combined perennial yield [1.8 million cubic meters (1,400 acre-feet) of peak annual water demand versus 16,350 acre-feet of perennial yield (DIRS 101811-DOE 1996)]. Any affects on the groundwater flow from Yucca Flat overdrafting would surely be lost by the time groundwater flow reaches the southern end of the Amargosa Desert where impacts could be cumulative with those of the Proposed Action. Accordingly, Chapter 8 discusses impacts of the total water demand and cumulative impacts from the Nevada Test Site and the Proposed Action and does not address noncumulative issues that are internal to the Test Site.

7.5.3.2 (6135)
Comment - EIS001654 / 0020
Page S-39. What is the Groundwater Risk?

The discussion about groundwater admits to uncertainties about the groundwater flow system in the region of the repository. The text does not address the on-going work being conducted by Nye County that will presumably reduce some of that uncertainty.

The wording of section S.4.1.4 is a little too opaque, it seems to us. In describing what would pose a threat to groundwater, the text says a "contaminant" would have to be spilled or released and then carried down by its own weight or by infiltrating water. Then it says the arid climate and depth to groundwater combine to reduce the potential contaminant migration. This section should be expanded and linked to discussions elsewhere about the specific (and only?) "contaminant" that is the dominant long-term concern for this repository: the contaminants of concern are radionuclides.

We have heard testimony at the various public hearings about risks to groundwater contamination due to theorized release projections of radionuclides. We have seen opinions expressed but we are unable to judge what factual basis there is for what seems like a branch of science in which uncertainty continues even as more data becomes available. Maybe better answers won't be available until the testing program results are analyzed or during the licensing application review process. Until then, it would seem that the section on groundwater could be improved to better educate the public than the current wording does.

Response
The commenter is correct about the work that Nye County will conduct. DOE has supported Nye County with it's program (called the *Early Warning Drilling Program*) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the performance confirmation program (if Yucca Mountain is approved for a repository), could be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

DOE agrees that additional clarification is appropriate for the contaminant migration. Section S.4.1.4 is intended to summarize discussions in Section 4.1.3 of the EIS that cover potential impacts associated with the active phases of the proposed repository action (that is, construction, operation and monitoring, and closure). Chapter 5 of the EIS discusses long-term, postclosure impacts, including the potential for radionuclide migration. DOE has modified the text in the Summary.

7.5.3.2 (6182)

Comment - EIS000929 / 0004

The Draft EIS states, "There is scientific uncertainty about the exact locations of the groundwater flow boundaries." In the next paragraph, it states, "The depth to groundwater and the arid environment [of the Yucca Mountain site] would combine to reduce the potential for meaningful contaminant migration." I'm not following this logic: "We really don't know where the groundwater is going, but we're sure it won't be contaminated...much." In addition, the Nye County Department of Natural Resources indicates that radioactivity from the US Ecology commercial low-level waste disposal facility has been detected off-site. If this is happening at a low-level waste facility, how can we be assured it will not happen at the Yucca Mountain site?

Response

DOE has conducted an extensive site characterization program to evaluate the suitability of Yucca Mountain for a repository. During site characterization, the Department has performed numerous tests to develop a reasonable model of site-scale saturated-zone flow and transport. The latest version of the model is summarized in the *Saturated Zone Flow and Transport Process Model Report* (DIRS 151948-CRWMS M&O 2000) and subsequent technical updates. Chapter 2 of that report discusses the evolution of the saturated zone process model. In particular, Section 2.5 summarizes the current saturated zone flow and transport model. Section 3 of the report presents the details of the model development in which the boundary conditions are presented in Section 3.2.3. The site-scale flow and transport model is designed to be compatible with the regional-scale model described by D'Agnese et al. (DIRS 100131-1997), to use the Hydrogeologic Framework Model, and to use available data on recharge within the site-scale model area. Most of the inflows to and outflows from the site-scale saturated zone flow model occur as flow across its lateral boundaries. The best available estimates of flow rates are cell-by-cell fluxes calculated by the regional-scale model for the site-scale model, then calibrated against known data points in the model domain.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information). The EIS based its analysis of impacts on a state-of-the-art modeling technique that is internationally recognized as an adequate and proper approach. The results of this analysis, described in Chapter 5 of the EIS, indicate that impacts would be low. Appendix I of the EIS and supporting documents contain details of the analysis methodology. See Sections 3.1.4.2.1 and 5.4 of the EIS for additional information.

7.5.3.2 (6282)

Comment - EIS001639 / 0007

The EIS makes use of "bulk permeabilities" in their analysis of groundwater flow and contaminant transport. The use "bulk" or average transport times tends to reduce the real effects of groundwater contamination. The study ignores the fact that groundwater flow will predominate through preferential pathways that exhibit the fastest not the "bulk" permeabilities. Thus the report tends to elucidate the average rather than the worst case scenario.

Response

The EIS does not describe the use of bulk permeabilities in its analysis of groundwater flow and contaminant transport. The only use of this terminology that could be found was in Section 3.1.3.1, Geology, where it is stated that the joints and fractures common in welded tuffs result in "greater bulk permeabilities than those of the nonwelded and bedded tuffs." That is, the rate of water movement in the welded tuffs is increased by the presence of joints and fractures.

The EIS does, however, describe the importance of groundwater flow through fractures (the fast pathway described in the comment) in developing models of flow and contaminant transport. These discussions are in Chapter 5 of the EIS. Specifically, Section I.2.2 describes how modeling of the long-term performance of the repository had to account for water movement in the unsaturated zone being through both the rock matrix and rock fractures, with the latter flow being much more rapid. Section I.2.2 of the EIS contains additional information on how these two flow mechanisms were accommodated by use of a dual-permeability model. Refer to Volume 3, Section 3.1.1, of the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for a more detailed description of the dual-permeability model and its flexibility to represent a wide range of matrix-versus-fracture flow behavior. In addition, the Viability Assessment contains a detailed description of how flow in the saturated zone was modeled. Again, the discussion describes how the saturated zone model had to account for movement through fractured media where flow and contaminant movement would occur primarily through fractures.

7.5.3.2 (6456)
Comment - EIS001632 / 0020
Section 3 of the draft EIS provides information about the hydrogeologic conditions in the vicinity of Yucca Mountain. The certainty of this information varies considerably, and it is difficult for the reader to understand how uncertainties will be resolved and how the data still being gathered will affect the design of the repository and the projections for ground water contamination. EPA [Environmental Protection Agency]suggests that the final EIS summarize ongoing studies and their expected impact on design and on ground water quality projections.

Response
DOE believes that it has sufficient information and understanding of the hydrologic setting to adequately determine the potential environmental impacts from the Proposed Action. DOE and others have been evaluating and assessing the hydrologic setting and associated characteristics at the Yucca Mountain site and nearby region for many years. DOE's site characterization program has been redirected from time-to-time to reflect and accommodate reviews by independent parties, both internal and external to the Department. Nevertheless, it is clear that the regional and site-specific hydrologic setting is complex and uncertainties remain. Additional information would refine DOE's understanding of, for instance, the regional groundwater flow system, and would further reduce uncertainties associated with flow and transport in the alluvial, volcanic and carbonate aquifers.

In recognition of these uncertainties, DOE has supported Nye County with its program (called the *Early Warning Drilling Program*) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the performance confirmation program (if Yucca Mountain is approved for a repository) could be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

In addition, DOE has installed a series of test wells along the groundwater flow path between the Yucca Mountain site and the Town of Amargosa Valley as part of an alluvial testing complex. The objective of this program is to better characterize the alluvial deposits beneath Fortymile Wash along the east side of Yucca Mountain. Single- and multi-well tracer tests have begun and the results thus far have strengthened the basis of the site-scale saturated flow and transport model. This program is described in Section 3.1.4.2.1 of the EIS.

Although DOE has improved its understanding of the hydrologic system, uncertainties would remain given the time frame of concern (waste isolation for thousands of years). If the site was approved, DOE would institute a *performance confirmation and testing program*, elements of which would address the hydrologic system. The purpose of this program would be to evaluate the accuracy and adequacy of the information used to determine whether the repository would be expected to meet long-term performance objectives. The performance confirmation program, which would continue through closure of the repository (possibly as long as 300 years), would offer a means to further understanding of the hydrologic system and reduce uncertainties.

7.5.3.2 (6457)

Comment - EIS001632 / 0021

Most of the ground water studies described in Section 3 were done on a regional scale and may not provide accurate site-specific data for the saturated zone beneath the proposed repository. Section 3 provides general statements about ground water data, but fails to inform the reader about aquifer-specific data, such as the length of time data have been collected on the carbonate aquifer and the number of wells sampled over various periods of time. This information is particularly important for modeling the transport of radionuclides in the saturated zone.

Response

DOE has initiated a program to evaluate the hydrologic processes in the saturated zone, particularly the hydrogeologic relationship between the volcanic aquifer, alluvial aquifer, and carbonate aquifer. This is currently being addressed through a cooperative agreement between Nye County and DOE, referred to as the Early Warning Drilling Program. Recent results from this program have been incorporated into this Section 3.1.4.2.1 of the EIS.

Section 3.1.4.2.2 of the EIS refers to large hydraulic gradient north of the site. Specific information related to the saturated zone and carbonate aquifer can be found in the cited references in Section 12 of the EIS. With regard to the saturated zone and the carbonate aquifer, one well (UE 25p #1) penetrated the carbonate aquifer at Yucca Mountain, another well (NC-EWDP-2DB), along the potential flow path in Fortymile Wash, has penetrated the carbonate aquifer and an upward hydraulic gradient was present. Well NC-EWDP-2DP, along with six additional planned wells, will help characterize the carbonate aquifer system near Yucca Mountain as part of the Nye County Early Warning Drilling Program. Four other wells at Yucca Mountain, as reported by Luckey et al (DIRS 100465-1996), are believed to indicate the potentiometric level in the carbonate aquifer. Elsewhere in the general area, particularly at the southern end of the Nevada Test Site and eastward from the springs in Ash Meadows, the hydraulic relationship between the lower carbonate aquifer and overlying units is well understood (DIRS 101167-Winograd and Thordarson 1975). The very presence of the springs in Ash Meadows demonstrates the fact of an upward hydraulic gradient in the lower carbonate aquifer. Because the lower carbonate aquifer is buried by some 6,000 feet of unconsolidated deposits in the Amargosa Desert west of the springs in Ash Meadows, no wells have been drilled into this aquifer. Claassen (DIRS 101125-1985) presents the hydraulic and hydrochemical evidence of subsurface discharge from the lower carbonate aquifer to the alluvial fill of the Amargosa Desert to the west of Rock Valley Wash. In addition, several investigations have concluded from hydrologic, chemical, and isotopic evidence that the lower carbonate aquifer is the source of the large springs in Furnace Creek Wash (Death Valley). Thus, the understanding of the flow system and hydraulic relationships of the lower carbonate aquifer are based not only on data from well UE 25p #1 at Yucca Mountain, but on a large body of regional hydrologic and chemical evidence collected over the past 40 years.

7.5.3.2 (6459)

Comment - EIS001632 / 0023

Page 3-41, Section 3.1.4.2.2: This section describes the Topopah Spring tuff unit, in which repository will be built, as fractured, very permeable, and extensively interconnected; and, perched water forms at its contact with the underlying Calico Hills non-welded unit. Page 3-48 states that water chemistry analysis has found that “perched water reached its current depth with little interaction with rock. This, in turn, provides strong evidence that flow through faults and fractures is the primary source of perched water.” The final EIS should address this concern: if seismic activity occurred at these fault zones, water could move faster (or slower) through the faults and fractures, possibly increasing the mounding of perched water. This is different than the “upwelling” referred to on page 3-49.

Response

Section 3.1.4.2.2 of the EIS indicates that perched water is formed when water percolating down through the subsurface encounters a zone of lower permeability and, as a result, accumulates. Vertical movement of water probably stills occurs, but at a slower rate below the perched water than above. In the tilted strata at Yucca Mountain, the accumulation of perched water must be accompanied by a feature such as a fault to restrict the lateral movement of water. The surface of the perched water then remains at a fairly stable elevation once the inflow and outflow rates are balanced. At Yucca Mountain this is attributed to less infiltration (a drier climate than when most of the perched water accumulated) and/or the elevation of the perched water reaching a point where the lateral restriction changes and the water “spills” out, or it could just reflect a long-term, steady-state condition.

The commenter is correct that seismic activity could change the rate at which water moves in the unsaturated zone, but it would be much less likely to change the quantity of water moving through the unsaturated zone because quantity is related chiefly to climate. That is, the rate at which water would reach the perched zone might increase for a short period of time as water above it "drained" from the system as a result of increased permeability. But eventually the amount of water reaching the perched water would again be controlled by the amount of water entering the system (that is, infiltration). For either the short-term increase in flux or the long-term climate-driven flux to cause significant "mounding" of the perched water, the seismic activity would have to result in a decreased permeability below the perched zone and/or an extension (lengthening) of the lateral restriction to flow. A scenario of increased perched water elevation is not addressed in the EIS because neither of these conditions would be expected to occur to any significant extent as a result of seismic activity. Compared to the overlying Topopah Spring welded unit, seismic activity might cause less fracturing in the Calico Hills nonwelded unit (the unit causing the perching condition), but it would not be expected to decrease the latter's permeability. The barrier to lateral flow at faults is believed to be the result of the juxtaposition of a more permeable layer against a less permeable layer caused by the fault displacement. Therefore, to lengthen the barrier, the offset would have to be lengthened. This is an obvious result of displacement, but the greatest displacement in the Yucca Mountain area [32-centimeter (13-inch); Section 3.1.3.3 of the EIS] would be exceeded less than once in 100,000 years. Correspondingly, fault displacement would not be expected to significantly increase the depth of perched water.

DOE has considered hundreds of "what if" scenarios involving features, events, and processes (FEPs) and how they might affect the long-term performance of the repository. Those scenarios not excluded because of low probability or low consequences or for other reasons were subjected to more detailed analysis and included in long-term performance modeling. This process is documented in DOE's FEP database and associated documentation. The FEP process does not specifically address "mounding" of the perched water, but it does cover what is believed to be a more realistic scenario; the relatively rapid draining of the perched water due to seismic activity. In this case, were such an event to take place after containers in the repository had begun to degrade, it could result in a fast pulse of contamination reaching the saturated zone. This scenario was excluded from analysis in the long-term performance modeling because it was reasoned that the volume of water associated with the perched system is not great enough to cause a significant "pulse" to the saturated zone.

7.5.3.2 (6461)
Comment - EIS001632 / 0024
Page 3-46: The final EIS should provide an up-to-date analysis of the chlorine-36 transport data.

Response
As part of its site characterization activities, DOE has conducted a variety of investigations into the nature of water falling as precipitation on Yucca Mountain and passing through the unsaturated zone to the groundwater beneath. One such study has been to quantify the concentrations of certain radioisotopes in the Exploratory Studies Facility. Isotopes, such as chlorine-36 and tritium, which occur naturally and as a byproduct of atmospheric nuclear weapons testing, serve as indicators of the rate of flow through the unsaturated zone (see Section 3.1.4.2.2 of the EIS for details).

Results from preliminary studies have identified these isotopes in concentrations that tend to suggest that there are connected pathways through which surface precipitation has percolated to the repository horizon within the last 50 years. However, these isotopes have been found at locations that are generally associated with known, through-going faults and well-developed fracture systems close to the faults at the proposed repository horizon.

To ensure the correct interpretation of this chemical signal, DOE instituted additional studies to determine if independent laboratories and related isotopic studies can corroborate the detection of elevated concentrations of these radioisotopes. Results of the validation studies to this point have not allowed firm conclusions and, thus, the evaluations continue.

DOE believes that these findings do not indicate that the Yucca Mountain site should be declared unsuitable for development as a repository. Most of the water that infiltrates Yucca Mountain moves slowly through the matrix and fracture network of the rock, and isotopic data from water extracted from the rock matrix indicates that residence times might be as long as 10,000 years. Furthermore, after excavating more than 11 kilometers (8.4 miles) of tunnels at Yucca Mountain for the Exploratory Studies Facility, DOE determined that only one fracture was moist (there was no active flow of water). This observation has been confirmed in test alcoves that are not subject to the effects of drying from active ventilation.

Nevertheless, the total system performance assessment incorporates the more conservative water movement data as well as information from other water infiltration and associated hydrogeological studies. As a result of this evaluation, DOE would not expect the repository (combination of natural and engineered barriers) to exceed the prescribed radiation exposure limits during the first 10,000 years after closure.

7.5.3.2 (6462)
Comment - EIS001632 / 0025
Page 3-49: Lower carbonate aquifer. Since data are limited, the EIS should not conclude that the lower carbonate aquifer has an upward gradient. Page 3-51 states that there is only one transmissivity value based on tests from a single well. Also, on page 3-52, it seems preliminary to count this aquifer as a possible source of inflow to the volcanic aquifers. The final EIS should acknowledge the limited confidence that can be placed on the gradient interpretation with the data currently available.

Response
DOE has started a program to evaluate the hydrologic processes in the saturated zone, particularly the hydrogeologic relationship between the volcanic aquifer, alluvial aquifer, and carbonate aquifer. This is currently being addressed through a cooperative agreement between Nye County and DOE, referred to as the Early Warning Drilling Program. Recent results from this program have been incorporated into this Section 3.1.4.2.1 of the EIS.

With regard to the saturated zone and the carbonate aquifer, one well (UE 25p #1) penetrated the carbonate aquifer at Yucca Mountain, another well (NC-EWDP-2DB) along the potential flow path in Fortymile Wash penetrated the carbonate aquifer and an upward hydraulic gradient was present. Well NC-EWDP-2DP, along with six additional planned wells, will help characterize the carbonate aquifer system near Yucca Mountain as part of the Nye County Early Warning Drilling Program. Four other wells at Yucca Mountain, as reported by Luckey et al (DIRS 100465-1996), are believed to indicate the potentiometric level in the carbonate aquifer. Elsewhere in the general area, particularly at the southern end of the Nevada Test Site and eastward from the springs in Ash Meadows, the hydraulic relationship between the lower carbonate aquifer and overlying units is well understood (DIRS 101167-Winograd and Thordarson 1975). The very presence of the springs in Ash Meadows demonstrates the fact of an upward hydraulic gradient in the lower carbonate aquifer. Because the lower carbonate aquifer is buried by some 6,000 feet of unconsolidated deposits in the Amargosa Desert west of the springs in Ash Meadows, no wells have been drilled into this aquifer. Claassen (DIRS 101125-1985) presents the hydraulic and hydrochemical evidence of subsurface discharge from the lower carbonate aquifer to the alluvial fill of the Amargosa Desert to the west of Rock Valley Wash. In addition, several investigations have concluded from hydrologic, chemical, and isotopic evidence that the lower carbonate aquifer is the source of the large springs in Furnace Creek Wash (Death Valley). Thus, the understanding of the flow system and hydraulic relationships of the lower carbonate aquifer are based not only on data from well UE 25p #1 at Yucca Mountain, but on a large body of regional hydrologic and chemical evidence collected over the past 40 years.

7.5.3.2 (6463)
Comment - EIS001916 / 0003
[Section] (S.4.1.4) Hydrology. The groundwater travel time is too rapid to isolate radioactive particles leading to groundwater contamination due to the fractured nature of Yucca Mountain.

Response
As part of its site characterization program, DOE has used a variety of naturally occurring isotopic indicators, one of which is chlorine-36, to investigate the nature of infiltration and deep percolation of water at the site. Results from this program detected elevated amounts (values above normal background measurements) of “bomb-pulse” chlorine-36 in several places in the Exploratory Studies Facility from nuclear testing conducted during the 1950s and 1960s. The locations where this bomb-pulse chlorine-36 has been detected in the Exploratory Studies Facility are associated generally with known through-going faults and well-developed fracture systems close to those faults. This suggests that there are connected pathways through which surface precipitation has percolated to the repository horizon within the last 50 years. These findings, however, must be viewed in the context of whether waste can be stored safely at Yucca Mountain. Overall, most of the water that infiltrates into Yucca Mountain moves much more

slowly through the matrix and fracture network of the rock. Only a small fraction has moved quickly through the connected portion of the fracture network. Carbon isotope data from water extracted from the matrix correspond to residence times as long as 10,000 years.

The elevated values of bomb-pulse chlorine-36 detected in the subsurface correspond to increases of between about two to eight times the amount of naturally occurring "background" chlorine-36. This background signal is the amount measured in the regional aquifers and in the matrix water of rocks in the unsaturated zone. Furthermore, even elevated bomb-pulse values represent exceedingly minute increases in the amount of chlorine-36. Naturally occurring ratios of radioactive chlorine-36 to the other isotopes of chlorine (chlorine-35 and -37) are about one chlorine-36 atom to approximately 2 trillion other chlorine atoms. Their detection is more a mark of the incredible precision of the analytical methods employed in this study (accelerator mass spectrometry) than it is an indication of an unsuitable environment for the emplacement of high-level radioactive waste. To ensure the correct interpretation of this subtle chemical signal, studies are under way to determine if independent laboratories and related isotopic studies can corroborate this detection of elevated amounts of chlorine.

Another important factor regarding the safety of the emplaced waste is whether percolating water would come in contact with waste packages. The process of drift excavation creates a capillary barrier that could cause percolating water to be diverted around the drift opening, further reducing the amount of water potentially capable of contacting the packages. DOE has been conducting a series of experiments to determine the seepage threshold, which is the amount of water needed to overcome the capillary barrier created due to excavation. Results obtained to date suggest that the expected amounts of percolating water in the repository horizon under the present climate would be too small to exceed the existing capillary barrier.

Additional evidence that attests to the overall lack of observable fluid flow in the subsurface is the fact that throughout the excavation of more than 11 kilometers (8.4 miles) of tunnels and testing alcoves, only one fracture was moist (there was no active flow of water). After collecting and analyzing the moisture from this fracture, DOE detected no bomb-pulse chlorine-36. Only background levels of chlorine-36 were evident, indicating old water. Further observations from test alcoves that have been isolated from the effects of tunnel ventilation for several years, confirm the lack of observable water seepage in the repository horizon. In summary, despite encountering millions of fractures in the course of excavations, there is scant evidence that even modest quantities of water penetrate to repository depths.

DOE's original 1984 site suitability guidelines (10 CFR Part 960) have been superseded by Yucca Mountain-specific guidelines (10 CFR Part 963) promulgated by DOE in 2001. Even though 10 CFR Part 960 no longer applies to Yucca Mountain, DOE believes that information and analyses do not support a finding that the site would have been disqualified under the groundwater travel time disqualifying condition at 10 CFR 960.4-2-1(d). Under that condition, a site would be disqualified if the expected groundwater travel time from the disturbed zone (the area in which properties would change from construction or heat) to the accessible environment would be less than 1,000 years along any pathway of likely and significant radionuclide travel. The definition of groundwater travel time in 10 CFR 960.2 specifies that the calculation of travel time is to be based on the average groundwater flux (rate of groundwater flow) as a summation of travel times for groundwater flow in discrete segments of the system. (In this case, the geologic and hydrologic subunits comprising the unsaturated and saturated zones.) As a practical matter, this definition provides for the consideration of the rate at which most of the water moves through the natural system to the accessible environment.

As part of its site characterization activities, DOE has undertaken various studies to identify and consider characteristics of the unsaturated (above water table) and saturated (water table) zones, such as the flow of water and transport of radionuclides, that are relevant to analyzing groundwater travel times. DOE also has considered physical evidence such as the chemistries and ages of water samples from these zones. Because of the inherent uncertainties in understanding such natural processes as groundwater flow, DOE has developed numerical models to represent an approximation of these processes and to bound the associated uncertainties.

Based on these models, which incorporate the results of these studies and available corroborating physical evidence, DOE estimates that the median groundwater travel times would be about 8,000 years, and average groundwater travel times would be longer. These models indicate that small amounts of water potentially moving in "fast paths" from the repository to the accessible environment could do so in fewer than 1,000 years. However, the models and corroborating physical evidence indicate that most water would take more than 1,000 years to reach the accessible environment. Given this, DOE believes that the site would not have been disqualified under the groundwater travel condition at 10 CFR 960.4-2-1.

The natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa more than 60 kilometers (37 miles) away and travel times to this point would be even longer. Modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at Yucca Mountain would keep doses resulting from any releases within the regulatory limits established at 40 CFR Part 197.

7.5.3.2 (6464)
Comment - EIS001632 / 0026
Page 3-52: The final EIS should provide data from the ongoing investigations on the cause of the potentiometric difference north and south of the site, and it should describe what these data suggest about the potential for water from the north to flood the repository.

Response
Section 3.1.4.2.2 of the EIS refers to the large hydraulic gradient north of the Site. An expert elicitation panel addressed this feature and narrowed its likely cause to two theories: (1) flow through the upper volcanic confining unit or (2) semi-perched water. The consensus of the panel favored the perched-water theory. Whatever the cause, the experts were in agreement that the probability of any large transient change in the configuration of this gradient is extremely low (DIRS 100353-CRWMS M&O 1998). DOE has initiated a program to evaluate the hydrologic processes in the saturated zone, particularly the hydrogeologic relationship between the volcanic aquifer, alluvial aquifer, and carbonate aquifer. This is currently being addressed through a cooperative agreement between Nye County and DOE, referred to as the Early Warning Drilling Program. Recent results from this program have been incorporated into Section 3.1.4.2.1 of the Final EIS.

7.5.3.2 (6465)
Comment - EIS001632 / 0027
Page 3-57: In the discussion about water levels in the 7 wells, the significance of their proximity or distance to Fortymile Wash is unclear.

Response
The reference from which DOE extracted this information does not correlate water-level fluctuations with proximity to Fortymile Wash. The Draft EIS mentioned this only because Fortymile Wash is an area of periodic recharge, which could have a local, temporary affect on the elevation of groundwater (see Section 3.1.4.2.2 of the EIS). The reference to the wells' proximity to Fortymile Wash has been removed.

7.5.3.2 (6468)
Comment - EIS001632 / 0029
Page 3-31: We are confused about the discussion of the Amargosa River system and the statement that there is a ground water discharge near Beatty, NV. The final EIS should clarify the direction of the ground water flow which, according to Figure 3-13 (page 3-38), does not appear to be in the direction of Beatty.

Response
Section 3.1.4.1.1 of the EIS discusses surface water in the region of Yucca Mountain and indicates that groundwater discharges to the channel of the Amargosa River near the community of Beatty, Nevada. The purpose of this discussion is only to identify areas along the river channel where surface water exists on a regular basis. It is not to identify the source of the groundwater that supplies the flow; this information is included in the discussion of regional groundwater in Section 3.1.4.2.1 of the EIS (which includes Figure 3-13). In the discussion of Basins in Section 3.1.4.2.1, the description of the Pahute Mesa-Oasis Valley groundwater basin indicates groundwater outflow is southward to the Amargosa Desert. The flow arrow shown in Figure 3-13 of the Draft EIS at the south end of the Pahute Mesa-Oasis Valley basin points southward toward Amargosa Desert and shows the groundwater pathway to be beneath the community of Beatty. Accordingly, groundwater discharged in the area of Beatty comes from the Pahute Mesa-Oasis Valley basin.

7.5.3.2 (6479)
Comment - EIS001774 / 0002
The Yucca Mountain site which is supposed to be isolated from the water aquifer theoretically for thousands of years has been found with rainwater that contains contaminants that are man-made and date from the last 40 years. The movement of rain water through the Yucca Mountain site should, according to federal officials, disqualify it as a site. The 1992 earthquake destroyed the Yucca Mountain press center. This should give you a clue that the site is much more than a public relations disaster, it is an environmental disaster waiting to happen.

Response
As part of its site characterization activities, DOE has conducted a variety of investigations into the nature of water falling as precipitation on Yucca Mountain and passing through the unsaturated zone to the groundwater beneath. One such study has been to quantify the concentrations of certain radioisotopes in the Exploratory Studies Facility. Isotopes, such as chlorine-36 and tritium, which occur naturally and as a byproduct of atmospheric nuclear weapons testing, serve as indicators of the rate of flow through the unsaturated zone (see Section 3.1.4.2.2 of the EIS for details).

Results from preliminary studies have identified these isotopes in concentrations that tend to suggest that there are connected pathways through which surface precipitation has percolated to the repository horizon within the last 50 years. However, these isotopes have been found at locations that are generally associated with known, through-going faults and well-developed fracture systems close to the faults at the proposed repository horizon.

To ensure the correct interpretation of this chemical signal, DOE instituted additional studies to determine if independent laboratories and related isotopic studies can corroborate the detection of elevated concentrations of these radioisotopes. Results of the validation studies to this point have not allowed firm conclusions and, thus, the evaluations continue.

DOE’s original 1984 site suitability guidelines (10 CFR Part 960) have been superseded by Yucca Mountain-specific guidelines (10 CFR Part 963) promulgated by DOE in 2001. Even though 10 CFR Part 960 no longer applies to Yucca Mountain, DOE believes that information and analyses do not support a finding that the site would have been disqualified under the groundwater travel time disqualifying condition at 10 CFR 960.4-2-1(d). Under that condition, a site would be disqualified if the expected groundwater travel time from the disturbed zone (the area in which properties would change from construction or heat) to the accessible environment would be less than 1,000 years along any pathway of likely and significant radionuclide travel. The definition of groundwater travel time in 10 CFR 960.2 specifies that the calculation of travel time is to be based on the average groundwater flux (rate of groundwater flow) as a summation of travel times for groundwater flow in discrete segments of the system. (In this case, the geologic and hydrologic subunits comprising the unsaturated and saturated zones.) As a practical matter, this definition provides for the consideration of the rate at which most of the water moves through the natural system to the accessible environment.

As part of its site characterization activities, DOE has undertaken various studies to identify and consider characteristics of the unsaturated (above water table) and saturated (water table) zones, such as the flow of water and transport of radionuclides, that are relevant to analyzing groundwater travel times. DOE also has considered physical evidence such as the chemistries and ages of water samples from these zones. Because of the inherent uncertainties in understanding such natural processes as groundwater flow, DOE has developed numerical models to represent an approximation of these processes and to bound the associated uncertainties.

Based on these models, which incorporate the results of these studies and available corroborating physical evidence, DOE estimates that the median groundwater travel times would be about 8,000 years, and average groundwater travel times would be longer. These models indicate that small amounts of water potentially moving in “fast paths” from the repository to the accessible environment could do so in fewer than 1,000 years. However, the models and corroborating physical evidence indicate that most water would take more than 1,000 years to reach the accessible environment. Given this, DOE believes that the site would not have been disqualified under the groundwater travel condition at 10 CFR 960.4-2-1.

Furthermore, after excavating more than 11 kilometers (6.8 miles) of tunnels at Yucca Mountain, DOE determined that only one fracture was moist (there was no active flow of water). Further observations from testing alcoves isolated from effects of tunnel ventilation for several years confirm the lack of observable natural seepage at the repository level.

Nevertheless, the total system performance assessment incorporates the more conservative water movement data as well as information from other water infiltration and associated hydrogeological studies. As a result of this evaluation, DOE would not expect the repository (combination of natural and engineered barriers) to exceed the prescribed radiation exposure limits during the first 10,000 years after closure.

Another important factor regarding the safety of emplaced waste is whether percolating water would actually come in contact with waste packages. The process of drift excavation creates a capillary barrier that causes a diversion of percolating water around the drift opening, further reducing the amount of water potentially capable of contacting waste packages. DOE has been conducting a series of experiments to determine the seepage threshold, the amount of water necessary to overcome the capillary barrier created due to excavation. Results to date suggest that the expected amounts of percolating water at the repository level might be insufficient to exceed the existing capillary barrier.

The Little Skull Mountain earthquake of 1992, which is the largest recorded earthquake within 50 kilometers (31 miles) of Yucca Mountain (Richter magnitude 5.6), caused no damage at Yucca Mountain. It did damage the Yucca Mountain Field Operations Center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic-design specifications planned for the facilities at Yucca Mountain. DOE is designing surface facilities associated with the proposed repository with extremely conservative margins of safety to ensure safe operation regardless of the potential for strong seismic occurrences.

7.5.3.2 (6484)
Comment - EIS001632 / 0035
Page 4-25, Section 4.1.3.3: The assessment of impacts to ground water should reference the discussion on radionuclide transport in ground water in Section 5.2. Readers may be confused by the page 4-25 discussion which focuses on the impact from spills and the potential for a contaminant to infiltrate and percolate through the unsaturated zone, rather than on the full range of ground water contamination.

Response
DOE concurs with this suggestion. Cross-references to Chapter 5 have been added to Section 4.1.3.3 to avoid confusion between short-term preclosure effects and long-term performance after closure.

7.5.3.2 (6521)
Comment - EIS001813 / 0004
The DOE has failed to take into consideration the potential for severe health related consequences related to possible groundwater contamination. Simply denying that the groundwater will not become contaminated and that the population will not grow is not acceptable and renders the current DEIS unacceptable. Therefore, the DOE must not recommend the development of a geologic repository at Yucca Mountain.

Response
Appendix F describes the health effects from radiation. DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (6553)
Comment - EIS001632 / 0047
Page 5-13: Section 5.2.3.4 discusses the different paths radionuclides can take, but should discuss pathways through the alluvial, volcanic and carbonate aquifers.

<u>Response</u>
The intent of Section 5.2.3.4 of the Draft EIS (Sections I.2.2 and I.2.8 of the Final EIS) is to describe the process models and radionuclide movement tendencies. Section 3.1.4.2.1 provides aquifer and pathway information.

7.5.3.2 (6555)
<u>Comment</u> - EIS001632 / 0048
Page 5-23: This section states "Because of this pressure difference, water from the volcanic aquifer does not flow into the carbonate aquifer; rather the reverse occurs." This statement relies on just one data point in the carbonate aquifer. In Chapter 3, this uncertainty was noted. One data point does not provide certainty, and the EIS should not assume that the entire carbonate aquifer has an upward gradient, given the amount of fracturing and faulting involved. Nor should the EIS state that no contamination will occur at Ash Meadows, since Chapter 3 noted that it was a discharge point.

<u>Response</u>
DOE recognizes that additional data would further define the flow system and reduce uncertainties about the interactions among the alluvial, volcanic, and carbonate aquifers in the saturated zone. DOE has initiated a program to evaluate the hydrologic processes in the saturated zone, particularly the hydrologic relationships between the volcanic aquifer, alluvial aquifer, and carbonate aquifer. This is currently being addressed through a cooperative agreement between Nye County and DOE, referred to as the Early Warning Drilling Program. Recent results from this program have been incorporated into Section 3.1.4.2.1 of the Final EIS.

It is correct that only one well penetrates the lower carbonate aquifer at Yucca Mountain. Four other wells at Yucca Mountain, as reported by Luckey et al (DIRS 100465-1996), are believed to indicate the potentiometric level in the carbonate aquifer. Additional wells are being drilled to characterize the carbonate aquifer system near Yucca Mountain as part of the Early Warning Drilling Program. One of the wells drilled under this program, which is about 19 kilometers (12 miles) south of the repository site, also penetrated the carbonate aquifer and shows an upward gradient at that location.

With regard to the comment on Ash Meadows, groundwater that infiltrates through Yucca Mountain does not discharge at the Devils Hole Protective Withdrawal or in Ash Meadows. The elevation of the water table in the Devils Hole/Ash Meadows area is about 64 meters (210 feet) higher than the water table in the Amargosa Desert to the west and south. This east-to-west decline in the elevation of the water table indicates that groundwater from the carbonate rocks beneath the Devils Hole Hills flows westward across Ash Meadows toward Amargosa Desert--not the other way around. Therefore, contaminants from Yucca Mountain could not discharge at springs in Devils Hole and Ash Meadows nor contaminate the aquifer.

7.5.3.2 (6557)
<u>Comment</u> - EIS001632 / 0049
Page 5-27, second paragraph and Page 5-31, bottom paragraph: Page 5-27 states that 22 acre-feet of water per year infiltrate through the repository, while page 5-31 cites 25 acre-feet. Which value is correct?

<u>Response</u>
This comment identifies the infiltration rates for the high and intermediate thermal loads. The amount of infiltration, or flux, that would go through the proposed repository would vary based on the thermal loads being considered. Sections 5.4.1, 5.4.2, and 5.4.3 of the Draft EIS address the high, intermediate, and low thermal load scenarios, respectively. For each scenario, the footprint of the repository (that is, the size of the repository perpendicular to downward moving infiltration) expands to a larger size to support the lower waste loading. With the high thermal load scenario, the waste would be tightly packed and an estimated 27,000 cubic meters (22 acre-feet) of water would infiltrate through the repository. An estimated 31,000 cubic meters (25 acre-feet) of water would go through the repository under the intermediate thermal load scenario. With a low thermal load repository, the waste would be spread out and an estimated 57,000 cubic meters (46 acre-feet) of water would infiltrate through the repository. The same concept is applicable to the higher-and lower-temperature operating modes, which influence the size of the underground emplacement and, therefore, the estimated quantity of water that would infiltrate.

7.5.3.2 (6725)
Comment - EIS001522 / 0003
Another reason that it is problematic for the DOE to assert that the environmental impacts of a permanent, high-level nuclear waste repository will be small is that the DOE admits that repository flooding would be catastrophic, and yet that Yucca Mountain experienced a wetter and cooler period 10,000 to 50,000 years ago (DEIS, 1999, 3-49); if the repository area was flooded 10,000 years ago, then it is reasonable to believe it could be flooded again, in the future, especially because the climate changes appear to be cyclic. Even the DOE admits that climate change at Yucca Mountain is uncertain, and that “the record shows continual variation, often with very rapid jumps, between cold glacial … and warm interglacial climates” (DEIS, 1999, 5-17).

DOE’s alleging that the impacts of Yucca Mountain will be small also is inconsistent with its own statements when it reported the findings of Dublyansky (1998) that warm upwelling water has infiltrated the Yucca repository site (DEIS, 1999, 3-49). In response to these findings, the DOE notes that “both parties [the DOE, which supports the repository, and the state of Nevada, which opposes it] have agreed that additional research is needed to resolve the issues [surrounding this upwelling finding] (DEIS, 1999, 3-50). If the DOE thus admits that the upwelling data need to be resolved, and if such repository flooding would be catastrophic, then the DOE cannot consistently claim that effects of Yucca Mountain will be minor. In addition, the DOE admits that the data on Yucca Mountain are sparse and contradictory; for example, the DOE says that “there are a number of published estimates of perennial yield for many of the hydrographic areas in Nevada, and they often differ from one another by large amounts” (DEIS, 1999, 3-127). Given such discrepancies, it is inconsistent, controversial, and therefore premature to say that building a repository in such an area will cause few environmental impacts.

On the issue of repository flooding, it is interesting to note that the DOE itself claims that “The potential for flooding at the repository site is extremely small” (DEIS, 1999, 4-19), even though its own claims in the preceding paragraph cast doubt on this issue. In particular, if the claims are correct, then it is impossible to know whether the potential for flooding is small or great until the upwelling data are resolved.

Response
This comment deals with two widely different phenomena under the single term “flooding,” namely (1) surface flooding by streams and (2) inundation of the proposed repository due to a rise of the water table. To avoid confusion, this response uses “flooding” to represent that due to stream flow, and “inundation” to represent the effect of a rising water table.

DOE agrees that the Yucca Mountain area has experienced several wetter periods over the past 500,000 years. However, it does not agree with the assertion that the proposed waste-emplacement areas were inundated 10,000 years ago. To investigate this hypothesis further, DOE requested the National Academy of Sciences conduct an independent evaluation. The Academy concluded in its 1992 report (DIRS 105162-National Research Council 1992) that no known mechanism could cause a future inundation of the waste-emplacement areas.

DIRS 106963-Szymanski (1989) proposed that during the last 10,000 to 1,000,000 years, hot mineralized groundwater was driven to the surface by earthquakes and volcanic activities. This hypothesis goes on to suggest that similar forces could raise the regional groundwater in the future and inundate the waste-emplacement areas. The features cited by Szymanski as proof of groundwater upwelling in and around Yucca Mountain are related to the much older (13-10 million years old) volcanic process that formed Yucca Mountain and the underlying volcanic rocks.

Significant water-table excursions (exceeding tens of meters) to the waste emplacement areas from earthquakes would be unlikely. As discussed in EIS Section 3.1.3.1, the likelihood of volcanic activity in the area is low (one chance in 70 million annually), and would raise the water table a few tens of meters, at most.

DOE scientists have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under extremely wet climatic conditions. The regional aquifer has been estimated to have been a maximum of 120 meters (390 feet) above the present level beneath Yucca Mountain during the past million or more years based on mineralogic data, isotopic data, discharge deposit data, and hydrologic modeling. An earthquake under these extreme climatic conditions could cause an additional rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters (66 feet) or more between the water table and the level of the waste emplacement areas. The

1992 Little Skull Mountain earthquake (magnitude 5.6), raised water levels in monitoring wells at Yucca Mountain a maximum of less than 1 meter (3.3 feet) (DIRS 101276-O'Brien 1993). Water level and fluid pressure in continuously monitored wells rose sharply and then receded over several hours to pre-earthquake levels. The water level rise in hourly monitored wells was on the order of centimeters and indistinguishable after 2 hours (DIRS 101276-O'Brien 1993).

Regarding Dr. Dublyansky's alternative interpretation (DIRS 104875-Dublyansky 1998), the fact that the EIS cites his report is not a DOE endorsement of his theory. As explained in Section 3.1.4.2.1, DOE arranged a review of Dr. Dublyansky's work by a group of experts, who disagreed with his theory. However, DOE is not opposed to further research on the topic of fluid inclusions, and is providing financial support to independent research on fluid inclusions by Professor Jean Cline of the University of Nevada-Las Vegas.

The final paragraph of the comment refers to the statement, "The potential for flooding at the repository site is extremely small," in Section 4.1.3 of the EIS. As explained in the introduction to Chapter 4, this analysis deals with a period of 50 to 300 years after receipt of the first radioactive waste. Chapters 5 and 6 deal with the time after closure. The context of the statement is related to flooding by small intermittent streams in the vicinity of the proposed repository, namely Drill Hole Wash and its tributaries, where DOE would build the repository surface facilities. As described in Section 3.1.4.1.2, DOE has analyzed and mapped the potential for flooding. Even the largest floods would not affect the underground repository because the portals would be above potential flood levels. DOE would design surface facilities to accommodate predicted flood levels, so flooding impacts would be limited to temporary interruption of vehicle traffic during the short periods of stream flow.

7.5.3.2 (6735)
Comment - EIS001522 / 0004
The DEIS likewise is scientifically questionable because it substitutes scientific judgment or opinion in areas, like groundwater migration, in which there already is confirmed scientific evidence to the contrary. In the case of groundwater migration, the primary means whereby radionuclides would migrate offsite, the DEIS alleges that, given the groundwater at Yucca Mountain, there would be "minimal potential to involve substantial contaminant releases" (DEIS, 1999, 8-33). This opinion, however, is doubtful because even the DEIS (1999, 3-42) admits that the perched groundwater at Yucca Mountain is very young (and therefore that rapid groundwater migration has occurred): "The apparent age of the perched water based on carbon-14 dating indicates this recharge occurred during the past 6,000 years." If the Yucca Mountain groundwater was recharged during the last 6,000 years, and if the waste is above the groundwater, then it is reasonable to assert that groundwater, migrating through the waste, may recharge the groundwater in the next several thousand years, just as it did in the past. On a related point, the DEIS also admits that

Chlorine-36 analyses at Yucca Mountain have identified locations where water has moved fairly rapidly (in several decades) from the surface to the depth of the proposed repository. About 13 percent of the samples (31 samples) had high enough chlorine-31-to-total-chlorine ratios to indicate the water originated from precipitation occurring in the past 50 years (that is, nuclear age precipitation) (DOE, 1999, 3-47 and 3-48).

After thus noting that much of the groundwater, below the proposed repository, was 50 years old or less, the DEIS admitted that a continuous fracture path in the rock most likely caused this fast transit time (DOE, 1999,3-47). The DOE also noted that, because of the mineral concentrations in the groundwater, there was "strong evidence that flow through faults and fractures is the primary source of the perched water [at Yucca mountain]" (DOE, 1999, 3-48). It is interesting to note that a decade earlier, the DOE (1986, 6-32, 257, 298, 299) was maintaining, contrary to other geological reports, that the transit time from the surface to repository depths would be greater than 10,000 years and that fracture flow was virtually nonexistent. If a mere ten years of research have changed the DOE position on a crucial determinant of repository safety, one can only argue that more research is needed prior to building the repository and that, for now, no action is the best alternative.

It also is interesting to note that the DEIS concludes that, because of slow groundwater migration time, the radionuclides migrating from the Nevada Test Site would result in an individual's receiving only a maximum annual dose of about 0.2 rem, or less than .0l of normal annual background exposure. However, after drawing such a conclusion about minimal impact, the DEIS notes that "there is a high degree of uncertainty associated with this estimate" (DOE, 1999, 8-76). If there is so much uncertainty, then one wonders why the DEIS bothered to give a number that was virtually meaningless. In the same discussion, the DEIS admitted that "the underground tests are based on one data set from one well over a very short time (fewer than 50 years) and then extrapolated to 10,000 years" (DOE, 1999, 8-76). One wonders why the DOE bothered to use such a misleading number, based on one sample, and then extrapolated from less than 50 years to 10,000 years. Such one-well tests and extrapolations are contrary to all good practice in the science of geology (see Shrader-Frechette 1993, 42-50).

Response
As part of its site characterization program, DOE has used a variety of naturally occurring isotopic indicators, one of which is chlorine-36, to investigate the nature of infiltration and deep percolation of water at the site. Results from this program indicate elevated amounts of "bomb-pulse" chlorine-36 associated with nuclear testing during the 1950s and 1960s at a number of underground locations in the Exploratory Studies Facility. These locations are generally associated with known, through-going faults and well-developed fracture systems close to these faults. Detection of elevated levels of chlorine-36 in association with these features could be evidence of a connected pathway through which surface precipitation has percolated to depth within the last 50 years.

These results, however, must be viewed in their proper context regarding the question of whether waste can be stored safely at Yucca Mountain. Overall, most of the water that infiltrates into Yucca Mountain moves much more slowly through the matrix and fracture network of the rock. Only a small fraction has moved through the connected portion of the fracture network with relatively fast travel times. Carbon isotope data from water extracted from the matrix indicate residence times as long as 10,000 years.

The elevated values of bomb-pulse chlorine-36 detected in the subsurface correspond to increases of between about two to eight times the amount of naturally occurring background chlorine-36. This background signal is the amount observed in the regional aquifers and the matrix waters of rocks in the unsaturated zone. Furthermore, even elevated bomb-pulse values represent exceedingly minute increases in the amount of chlorine-36. Naturally occurring ratios of radioactive chlorine-36 to the other isotopes of chlorine (chlorine-35 and -37) are on the order of one chlorine-36 atom to approximately 2 trillion other chlorine atoms. Their detection is more a tribute to the precision of the analytical methods used in this study (accelerator mass-spectrometry) than it is an indication of an unsuitable environment for the emplacement of high-level radioactive waste. To ensure the correct interpretation of this subtle chemical signal, studies are under way to determine if independent laboratories and related isotopic studies can corroborate this detection of elevated amounts of chlorine-36.

Another important factor regarding the safety of emplaced waste concerns whether percolating water would actually come in contact with waste packages. The process of drift excavation creates a capillary barrier that would divert percolating water around the drift opening, further reducing the amount of water potentially capable of contacting waste packages. DOE is conducting experiments to determine the seepage threshold, which is the amount of water necessary to overcome the capillary barrier caused by excavation. Results to date suggest that the amounts of percolating water at the waste-emplacement level are insufficient to exceed the existing capillary barrier.

Additional evidence to the overall lack of observable fluid flow in the subsurface is the fact that throughout the excavation of more than 11 kilometers (6.8 miles) of tunnels and alcoves for the Exploratory Studies Facility, only one fracture was moist. No active flow of water was observed. Further observations from testing alcoves that have been isolated from the effects of tunnel ventilation for several years confirm the lack of seepage at the repository level. In summary, despite encountering millions of fractures in the course of excavation activities, there is scant evidence that even modest quantities of water penetrate to repository depths.

The presence of perched water above the regional water table is a positive factor in relation to the potential transport of radionuclides for the following reasons:

1. The fact that water is perched between the repository horizon and the water table indicates a barrier to flow. In this case, the perching layer possesses less matrix permeability and has a smaller fracture density than the overlying rocks.

2. The age of the perched water is thousands of years despite exhibiting a geochemical and isotopic signature that supports an interpretation of relatively rapid surface-to-depth recharge (tens to hundreds of years). In other words, the perching layer is so effective in impeding the downward flow of water that the water has aged

substantially (thousands of years) in its current location. This increased residence time affords greater opportunity for diffusion and sorption of radionuclides that are potentially released from a breached repository.

The change from the 1986 DOE position on the time it takes water to infiltrate from the surface to depth reflects the increased knowledge gained from more than a decade of surface and subsurface hydrogeologic investigations and associated flow and transport modeling.

The EIS includes an estimate of maximum annual dose from radionuclides migrating from the Nevada Test Site because this dose, even though it is small, contributes to the total dose. In addition, the apparent travel time associated with radionuclides from one nuclear test for which there are travel time data does not consider any effects from "prompt injection" attendant to the detonation of a massive nuclear device. Estimates of groundwater travel times based on isotopic evidence (carbon-14, stable isotopes of hydrogen, carbon, and oxygen) yield much greater travel times.

Although this estimate is based on sparse data, the intent of the effort is to produce a conservative calculation for potential effects due to activities at the Nevada Test Site.

7.5.3.2 (6860)
Comment - EIS001466 / 0006
About the Yucca Mountain site, I do want to say some things about my experience yesterday. I did see the water. It was at the test where the giant heater was heating the rock, and there was water on the floor, water on the walls. This is water in Yucca Mountain that's been driven out of the rock by the heat.

Response
The commenter describes an experience during a visit to the Exploratory Studies Facility Drift Scale Test and reports the presence of water that scientists expected to see during this test. The primary objective of the Drift Scale Test was to develop a more in-depth understanding of coupled thermal-mechanical-hydrological-chemical processes anticipated in the rock mass surrounding the proposed repository. As described in Section I.2.3 of the EIS, the heat generated by the decay of the radioactive materials in the repository would cause the temperature of the surrounding rock to rise. The water in the heated rock would be driven away as vapor from the repository during this period and condense back into water in cooler regions. The thermal output of the waste materials would decrease with time. Eventually, the rock would return to its original temperature, and the water and gas distribution would reach equilibrium with the ambient rock temperature.

The simulated waste packages of the Drift Scale Test in the Exploratory Studies Facility produce a rise in temperature to the surrounding rocks depicting the similar rise in temperature that the decay of radioactive material would cause in the repository. As described above, the commenter observed the condensation of water vapor back to water in the cooler region of the Exploratory Studies Facility.

7.5.3.2 (7277)
Comment - EIS001957 / 0002
Staff at Death Valley National Park have been informed that ongoing studies of the regional groundwater aquifer systems will be terminated with the completion of a steady state model of the Death Valley Groundwater Flow System (coincidental with permitting of the repository, if that results). Should this occur, we are alarmed that the benefit of a basic long-term baseline for continuing to understand environmental effects will be lost. We firmly believe the model studies not only should be maintained, but expanded to include several transient model analyses to enhance our knowledge of the regional groundwater flow system.

Response
DOE believes that a comprehensive steady-state model of the Death Valley regional groundwater flow system is necessary to understand and describe the hydrologic flow system at Yucca Mountain, as part of the repository licensing process. DOE also is aware of the benefits and desired uses of a transient regional groundwater flow model. DOE has supported the development of the steady-state model for use in the License Application, and supports the continued development of the transient model for use in the future.

7.5.3.2 (7296)
Comment - EIS001683 / 0003
There are so many reasons why nuclear waste should not be stored at Yucca Mountain. Groundwater travel time at Yucca Mountain is so short that the site cannot be considered.

Response
Extensive studies show that infiltration and percolation rates at Yucca Mountain are very low, groundwater-residence times are very long, and the waste emplacement horizon has been hydrologically stable for long periods.

DOE's original 1984 site suitability guidelines (10 CFR Part 960) have been superseded by Yucca Mountain-specific guidelines (10 CFR Part 963) promulgated by DOE in 2001. Even though 10 CFR Part 960 no longer applies to Yucca Mountain, DOE believes that information and analyses do not support a finding that the site would have been disqualified under the groundwater travel time disqualifying condition at 10 CFR 960.4-2-1(d). Under that condition, a site would be disqualified if the expected groundwater travel time from the disturbed zone (the area in which properties would change from construction or heat) to the accessible environment would be less than 1,000 years along any pathway of likely and significant radionuclide travel. The definition of groundwater travel time in 10 CFR 960.2 specifies that the calculation of travel time is to be based on the average groundwater flux (rate of groundwater flow) as a summation of travel times for groundwater flow in discrete segments of the system. (In this case, the geologic and hydrologic subunits comprising the unsaturated and saturated zones.) As a practical matter, this definition provides for the consideration of the rate at which most of the water moves through the natural system to the accessible environment.

As part of its site characterization activities, DOE has undertaken various studies to identify and consider characteristics of the unsaturated (above water table) and saturated (water table) zones, such as the flow of water and transport of radionuclides, that are relevant to analyzing groundwater travel times. DOE also has considered physical evidence such as the chemistries and ages of water samples from these zones. Because of the inherent uncertainties in understanding such natural processes as groundwater flow, DOE has developed numerical models to represent an approximation of these processes and to bound the associated uncertainties.

Based on these models, which incorporate the results of these studies and available corroborating physical evidence, DOE estimates that the median groundwater travel times would be about 8,000 years, and average groundwater travel times would be longer. These models indicate that small amounts of water potentially moving in "fast paths" from the repository to the accessible environment could do so in fewer than 1,000 years. However, the models and corroborating physical evidence indicate that most water would take more than 1,000 years to reach the accessible environment. Given this, DOE believes that the site would not have been disqualified under the groundwater travel condition at 10 CFR 960.4-2-1.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (7306)
Comment - EIS001653 / 0041
Groundwater section [3.1.4.2] needs a figure showing all springs in the area and a discussion of the relationship of the springs to the various aquifers, if any. There is also a need to describe baseline information on water chemistry in the region of influence.

Response
DOE believes that Section 3.1.4 of the EIS adequately describes the major springs in the region of influence and, although not shown specifically on figures, their general locations. The area of primary interest is the pathway that groundwater travels from beneath Yucca Mountain. As described in Section 3.1.4.2.1, this pathway is to Jackass Flats, to Amargosa Desert, and then to Death Valley. Section 3.1.4.2.2 describes the aquifers involved in this flowpath. The primary point of discharge along this path is Franklin Lake Playa in Alkali Flat, although some of the

flow from the Amargosa Desert might go to the Furnace Creek area of Death Valley. Figures 3-15 and 3-20 both show Alkali Flat and Furnace Creek. There are no other major springs or seeps along the pathway from Yucca Mountain.

The EIS mentions other well-known springs in the region, even though they are not in the groundwater pathway from Yucca Mountain. The most significant are in the Ash Meadows area. Section 3.1.4.2.1 describes these springs and Figures 3-15 and 3-20 show the location of Ash Meadows. In addition, the Saturated Zone Groundwater Quality discussion in Section 3.1.4.2.2 identifies two of the sampling points as springs in the Ash Meadows area. These springs are listed in Table 3-19 and shown in Figure 3-20 of the EIS.

The EIS contains several discussions of groundwater chemistry and quality. Section 3.1.4.2.1 discusses groundwater quality with regard to Drinking Water Standards established by the Environmental Protection Agency. Section 3.1.4.2.2 summarizes groundwater chemistry in the volcanic and carbonate aquifers in the saturated zone (Table 3-17) and the results of groundwater sampling and analysis for radioactivity (Table 3-18). This information establishes a baseline of groundwater quality and characteristics.

7.5.3.2 (7349)

Comment - EIS001957 / 0008

The proposed waste repository site is located in a volcanic rock sequence directly overlying carbonate rocks that comprise a regionally significant, deep Carbonate Rock Aquifer, and is also contained in the Death Valley Ground-Water Flow System. These are both known to discharge at Death Valley National Park. Ground-water discharge at park springs is the sole source of water for critical park water and water related resources and provides domestic water resources for park visitors and staff, the Furnace Creek Resort complex, state and county staff, and Tribal groups and areas.

The draft EIS inadequately addresses radionuclides leaking from the proposed repository, which will migrate to the water table and contaminate regional ground-water flow systems that ultimately discharge at springs in Death Valley National Park and at Devils Hole. The NPS [National Park Service] is mandated to protect resources entrusted to its care in perpetuity. Dangerous levels of radiation may exist long after the predicted 10,000-year life of the repository.

For example, Neptunium-237, which constitutes an important human health risk, is listed as a constituent of the waste packages that are planned to be disposed of in the Yucca Mountain repository. Neptunium-237 has a half-life of 2.1 million years. Leakages involving this element alone could result in serious contamination of park water resources.

Response

DOE disagrees with the National Park Service's contention that the EIS provided an inadequate evaluation of radionuclide migration in groundwater or that "dangerous levels of radiation" would exist long after 10,000 years. The calculations that the Department used to estimate the impacts described in Chapter 5 of the EIS are comprehensive. The analysis indicated that the predicted long-term levels of radioactive concentrations in groundwater and the resulting dose levels would be low, not "dangerous."

The long-term performance assessment calculations in Chapter 5 include neptunium-237. As the comment says, this is the most significant radionuclide, in terms of dose, in the 10,000- to 1-million-year period. Expected human health impacts in Chapter 5 (which include the contribution to dose from neptunium-237) for the first million years after repository closure would decline with distance from the repository (for example, see Section 5.4.2). Chapter 3 acknowledges that a small amount of groundwater might move beyond the primary groundwater discharge point at Alkali Flat (Franklin Lake Playa) to discharge in the Furnace Creek area of Death Valley. Even if this was the case, impacts in the Furnace Creek area would be less than the low impacts described in Chapter 5 for Franklin Lake Playa because impacts would decline with distance from the repository.

DOE is cooperating with the National Park Service and other Federal, state, and local agencies in a continuing effort to improve the regional groundwater modeling that supports the activities of these agencies as well as the Yucca Mountain performance assessments. This work is comprehensive, and has led to important refinements in modeling the regional groundwater system. However, nothing in this work has produced any change in the basic understanding of the regional groundwater flow regime.

7.5.3.2 (7353)
Comment - EIS001957 / 0010
Conclusions presented in the draft EIS and state of knowledge concerning the groundwater flow system are based on prevailing hydrologic conditions affecting the operation of the regional flow system. Additional transient modeling studies employing logical and predictable changes to significant parameters affecting the model outcome are necessary to determine the response of the flow system to continued development and increased groundwater withdrawals.

Such analyses utilizing variations in precipitation and groundwater recharge are essential to achieve anything approaching a reasonable understanding of response the flow system will have to those changes. Absent that data no reasonable conclusions can be derived concerning potential impacts associated with groundwater movement in the area of Yucca Mountain and the proposed repository. The NPS [National Park Service] recommends that conservation planning concluded thus far be modified to include the logical and necessary completion of these absolutely essential groundwater studies through full analysis via transient model studies.

Response
DOE (at both Yucca Mountain and the Nevada Test Site) has been supporting the development of a comprehensive regional flow model of the Death Valley groundwater system in cooperation with the U.S. Geological Survey, the National Park Service, Nye County, Inyo County, the U. S. Fish & Wildlife Service, and other entities for the last several years. Development of an updated, comprehensive steady-state model is nearing completion. The development of model capabilities to perform transient analyses on various aspects of the flow system has long been a desired objective. As long as the required level of funding is available, the Department's intent is to continue development on the regional model to achieve this capability (see Section 3.1.4.2.2 for more information).

7.5.3.2 (7396)
Comment - EIS001957 / 0018
Section 3.1.4.2.1 Groundwater, Regional Groundwater -- This section states:

"DOE has collected groundwater–level data from wells at Yucca Mountain and in neighboring areas on a routine basis since 1983, and has used the levels to which water rises in wells—called the potentiometric surface—to map the slope of the groundwater surface and to determine the direction of flow. Based on these and other data, groundwater in aquifers below Yucca Mountain and in the surrounding region flows generally south toward discharge areas in the Amargosa Desert and Death Valley (Figure 3-13)."

However, Figure 3-13 (p.3-38), which is modified from D'Agnese, et al., shows a question mark on the groundwater flow arrow from the Amargosa Desert area towards Death Valley NP [National Park]. Figure 32 in the referenced D'Agnese, et al. report (1997) is essentially identical to Figure 3-13 in the draft EIS, except that D'Agnese's Figure 32 does not have the question mark on the subject groundwater flow arrow.

Further, Figure 27 (p.60), in this same D'Agnese, et al. report, clearly shows, as the statement from the draft EIS above indicates, that the potentiometric surface indicates that the direction of flow in the regional ground-water flow system is from the Yucca Mountain area toward the Furnace Creek Wash area in particular, and to Death Valley NP [National Park] in general. This evidence of groundwater flow from the Yucca Mountain to the Furnace Creek Wash in Death Valley NP [National Park] is corroborated by other potentiometric-surface maps and ground-water flow direction maps published by other scientists, including: Thomas and others (1986), Plates 1 and 2; Harrill and others (1988), Plate 2; Dettinger, (1989), Figure 6; Dettinger and others (1991), Plate 2; Laczniak and others (1996), Plate 1; and Harrill and Prudic (1998), Figure 14.

Response
DOE has added a figure to Chapter 3 of the Final EIS to show the estimated potentiometric surface of the Death Valley region. As noted in the legend to Figure 3-13 in the Draft EIS, the question mark on the figure indicated uncertainty concerning a component of the groundwater flow path from the Amargosa Desert to the Furnace Creek area. To avoid confusion, DOE has removed the question mark and the legend note from the figure.

The natural discharge point for groundwater from beneath Yucca Mountain is Franklin Lake Playa. A small amount of groundwater might flow through fractures in the relatively impermeable rocks in the Funeral Mountains toward discharge points in Death Valley.

7.5.3.2 (7399)

Comment - EIS001957 / 0019

Figure 29 [of D'Agnese et al. 1997], "The three subregions of the Death Valley regional ground-water flow system that encompass the area modeled in the study" of the D'Agnese, et al., report indicates that there is ground-water flow out of the Central Death Valley Subregion into the Southern Death Valley Subregion, and thence northwestward into Death Valley NP [National Park], along the path of the Amargosa River; presumably in the alluvial aquifer of the Amargosa River drainage. This ground-water pathway for the migration of nuclear contamination is not considered in the draft EIS, which is a significant omission handicapping the adequacy of the preliminary environmental impact analysis with respect to environmental consequences within Death Valley NP.

Response

Section 3.1.4.2.1 of the EIS indicates that the primary discharge point for groundwater flowing beneath Yucca Mountain is Alkali Flat (Franklin Lake Playa) to the south (through the Amargosa Desert), but recognizes that some groundwater reaching this far might bypass the playa. The general path of the water that percolates through Yucca Mountain is south toward Amargosa Valley, into and through the area around Death Valley Junction in the lower Amargosa Desert. Groundwater from beneath Yucca Mountain would merge and mix with underflow from Fortymile Wash and then flow and mix into the very large groundwater reservoir in the Amargosa Desert, where it would move slowly due to the high effective porosity of basin deposits. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume might flow south toward Tecopa in the Southern Death Valley subregion. In addition, a fraction of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek area of Death Valley.

Several large springs (Texas, Travertine, and Nevares) in the Furnace Creek Wash area of Death Valley discharge about 3,250 acre-feet (4 million cubic meters) per year near Furnace Creek Ranch on the east side of Death Valley. This spring flow exceeds the potential local recharge, and the water from beneath the Amargosa Desert contributes to the flow.

Sparse potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. Such a divide would limit discharge from the shallow flow system, but would not necessarily affect the deeper carbonate flow system that could contribute discharge to the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and the deeper flow in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson, 1975). The groundwater in the northwestern part of the Amargosa Desert originates in the Amargosa River drainage in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend south from Yucca Mountain. Even if part of the flow from Yucca Mountain mixed into the carbonate pathway that supplies the Furnace Creek springs, it would be too little to affect the springflow chemistry noticeably. Considering the small fraction of water that would infiltrate though the repository footprint (approximately 0.2 percent or less) compared to the total amount of water flowing through the basin and the large distances involved [more than 60 kilometers (37 miles) from the source], any component from Yucca Mountain in this very long and complicated flow path would be diluted to such an extent that it would be undetectable.

Chapter 5 of the EIS does not specifically address impacts that could occur in Death Valley National Park from consumption of groundwater that flowed beneath the proposed repository. However, Chapter 5 clearly indicates that impacts would decrease with increased distance from the repository site. The assessment of long-term repository performance shows that the combination of natural and engineered barriers at the site would keep the doses resulting from releases of radionuclides well below the regulatory limits established by the Environmental Protection Agency in 40 CFR Part 197 and would keep any release small enough to pose no significant impact on the health and safety of people or the environment. If a small fraction of the water that percolated through the repository footprint flowed into the Furnace Creek area in Death Valley, the mean peak dose would be less than the dose calculated for Franklin Lake Playa. Sections 3.1.4.2.1, 3.1.4.2.2, and 5.4 of the EIS contain additional information.

7.5.3.2 (7400)

Comment - EIS001957 / 0020

Section 3.1.4.2.2 Groundwater at Yucca Mountain, Hydrologic Properties of Rock -- This section provides an overview of the hydrologic properties of various types of rock including their transmissivity and hydraulic conductivity. The discussion leads the reader to conclude groundwater moves extremely slowly in the area of Yucca Mountain; and leaves the reader to conclude little impact may arise from the relative movement of groundwater.

Dettinger in his 1989 report (p.16) states:

"Some zones within the central corridor (of the Regional Carbonate Aquifer) are highly transmissive, as indicated by large spring discharges that are fed by parts of the aquifers having imperceptibly sloping water tables, and by geologic mapping of ancestral flow paths. The highly transmissive zones may act as large-scale drains, collecting water from adjacent, less transmissive rock that underlies most of the study area."

He goes on to state:

"Results from tests of carbonate-rock aquifers throughout eastern and southern Nevada indicate that within 10 miles of regional springs, aquifers are an average 25 times more transmissive than they are further away."

The springs at Ash Meadows and Death Valley are high volume, constant discharge springs known to be supported by the regional aquifers. If Dettinger's observations are correct, then the areas surrounding them are typified by accelerated groundwater transmissivities. This occurrence is further supported by the recent discovery of subterranean amphipods being discharged from the groundwater aquifers at Death Valley. The presence of these organisms necessitates the occurrence of open space fractures or voids at some considerable distance from the springs. These fractures would result in enhanced groundwater flow.

These data indicate the rapid movement of groundwater surrounding the springs. If that area is of the magnitude theorized by Dettinger, any contamination originating at the Yucca Mountain site would be rapidly transported to Death Valley NP [National Park] and Ash Meadows springs. The environmental consequences of such an occurrence are not discussed in the draft EIS.

Response

DOE has conducted an extensive site characterization program to evaluate the proposed repository at Yucca Mountain. The general path of the water that percolates through Yucca Mountain is south toward the Amargosa Valley, into and through the area around Death Valley Junction in the lower Amargosa Valley. Groundwater from beneath Yucca Mountain would merge and mix with underflow from Fortymile Wash and then flow and mix into the very large groundwater reservoir in the Amargosa Desert, where it would move slowly due to the high effective porosity of basin deposits. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume might flow south toward Tecopa in the Southern Death Valley subregion. In addition, a fraction of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek area of Death Valley.

Sparse potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. Such a divide would limit discharge from the shallow flow system, but would not necessarily affect the deeper carbonate flow system that could contribute discharge to the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and the deeper flow in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson 1975). The groundwater in the northwestern part of the Amargosa Desert originates in the Amargosa River drainage in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend south from Yucca Mountain. Even if part of the flow from Yucca Mountain mixed into the carbonate pathway that supplies the Furnace Creek springs, it would be too little to affect the springflow chemistry noticeably. Considering the small fraction of water that would infiltrate though the repository footprint (approximately 0.2 percent or less) compared to the total amount of water flowing through the basin and the large distances involved [more than 60 kilometers (37 miles) from the source], any component from Yucca Mountain in this very long and complicated flow path would be diluted to such an extent that it would be undetectable.

The Dettinger (DIRS 105384-1989) report mentioned in the comment focuses on flow in the carbonate aquifer system. As discussed in Section 3.1.4.2.2 of the EIS, groundwater beneath the repository is in the upper portion of the volcanic aquifer and the alluvial aquifer systems; it is confined from interaction with the lower carbonate aquifer, which is deep below Yucca Mountain. The solution cavities discussed by Dettinger (1989) are only in the lower carbonate aquifer and the velocity changes are limited to this aquifer. These solution cavities are unlikely to affect flow in the volcanic and alluvial aquifers.

The assessment of long-term repository performance shows that the combination of natural and engineered barriers at the site would keep the doses resulting from releases of radionuclides well below the regulatory limits established by the Environmental Protection Agency in 40 CFR Part 197 and would keep any release small enough to pose no significant impact on the health and safety of people or the environment. If a small fraction of the water that percolated through the repository footprint flowed into the Furnace Creek area in Death Valley, the mean peak dose would be less than the dose calculated for Franklin Lake Playa. Sections 3.1.4.2.1, 3.1.4.2.2, and 5.4 of the EIS contain additional information.

7.5.3.2 (7439)

Comment - EIS001969 / 0002

The NWPA requires DOE to provide reasonable assurance that the environment will be protected from the hazards posed by the Yucca Mountain repository. In order to meet this requirement, DOE has conducted numerous detailed analyses of Yucca Mountain's geology and hydrology for the past 15 years. Through these and other activities associated with site characterization, DOE has amassed a large body of evidence to support the likely determination that Yucca Mountain is the most suitable site to store the nation's high-level nuclear waste. Despite the fact that the most advanced technology is being utilized to design a foolproof waste barrier system for the repository and given the fact that the waste would remain radioactive for many thousands of years, we continue to be concerned that a facility of this nature inherently poses some degree of risk to wildlife resources. Our primary concerns are as follows:

Groundwater flows in aquifers below Yucca Mountain are generally to the south. Therefore, radionuclides and toxic chemicals, if introduced to the groundwater either by a short-term catastrophic event (e.g., earthquake, flood) or through long-term (i.e., more than 1,000 years) degradation of the waste storage containers, could eventually migrate to environmentally sensitive areas such as Ash Meadows NWR [National Wildlife Refuge]. A recent study found that the plutonium compound PuO_2, once thought to be the most stable form of plutonium waste, can be oxidized by water making it more soluble and increasing the risk of groundwater contamination from storage facilities (Haschke et al. 2000).

We find these and other uncertainties with containment of high level radioactive waste to be cause for concern.

Response

DOE believes that the comments expressed by the U.S. Fish and Wildlife Service concerning risks to wildlife resources are addressed in the EIS. Section 4.1.8 of the EIS discusses the potential for catastrophic events (including earthquakes) occurring at the Yucca Mountain Repository during construction, operation and monitoring, and closure of the repository, and the consequences of these events. As described in Section 4.1.3, flooding would be unlikely to release contaminants because the design of critical surface facilities would withstand the most severe reasonably possible floods. Chapter 5 discusses impacts from the long-term performance of the repository. The evaluations included impacts from volcanic (Section 5.7.2) and seismic disturbances, as well as impacts from the slow degradation of waste packages over thousands of years. This slow degradation has the highest potential to spread contaminants as they are leached into the groundwater beneath Yucca Mountain.

Section 3.1.4.2.1 of the EIS shows that the flow path of groundwater from Yucca Mountain extends to Jackass Flats and the Amargosa Desert, and continues southward to the primary point of discharge at Franklin Lake Playa in Alkali Flat. The EIS recognizes that some groundwater reaching this far might bypass Franklin Lake Playa and continue into Death Valley. The EIS also recognizes that a fraction of the groundwater that reaches the Amargosa Desert might flow through the southeastern end of the Funeral Mountains to springs in the Furnace Creek Wash in Death Valley National Park. The springs in Ash Meadows (including Devils Hole) are not along the groundwater flow path from Yucca Mountain. As described in Section 3.1.4.2.1, groundwater beneath Yucca Mountain flows to the Amargosa Desert but does not discharge in Ash Meadows. From Ash Meadows to the low axis (Carson Slough) of the Amargosa Desert, the groundwater table declines about 64 meters (210 feet), indicating that the groundwater flows from Ash Meadows toward the Amargosa Desert, not the other way around.

Chapter 5 of the EIS does not specifically address the risks to people and natural resources in Death Valley National Park from the use and consumption of groundwater. However, it clearly indicates that risks would decrease with increased distance from the repository. Accordingly, impacts to the Park, because it is far from Yucca Mountain, would be negligible.

In Section 5.3 of the EIS, DOE concluded that the predicted long-term levels of radionuclide concentrations in groundwater and the resulting dose levels at the predicted discharge area in Amargosa Valley would be low. As a consequence, DOE does not expect that the dose rates to plants and animals would cause measurable detrimental effects in populations of any species because the rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of much less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992). The DOE interim technical standard, *A Graded Approach for Evaluating Dose to Aquatic and Terrestrial Biota*, which the Department made available for interim use on July 20, 2000, contains more information about potential effects of radiation on biota.

The comment also refers to a recent laboratory finding that a species of plutonium oxide has a higher solubility than the species most often considered to be the normal oxidized form of the metal (plutonium dioxide) (DIRS 150367-Haschke, Allen, and Morales 2000). Scientists working on the Yucca Mountain Project are aware of this finding. DOE believes that the finding is within the range of conservatisms built into the plutonium solubility model used to model the long-term performance of the repository.

7.5.3.2 (7578)
Comment - EIS001969 / 0034
Page 3-36, Section 3.1.4.2.1 Regional Groundwater.

There is insufficient data to fully characterize the site-scale hydrology of the area. Because of the complexity of the geology and inconsistencies between the Large Hydraulic Gradient and thermal data, additional boreholes, appropriately configured, that penetrate to the Paleozoic carbonates beneath the Tertiary tuffs should be considered.

There is a lack of data on the hydrologic interaction between the Tertiary tufts and the underlying Paleozoic carbonate aquifers.

Response
DOE, in cooperation with Nye County, has initiated a program (called the Early Warning Drilling Program) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the ongoing site characterization program and from the performance confirmation program (if Yucca Mountain is approved for a repository), would be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the Final EIS).

7.5.3.2 (7581)
Comment - EIS001969 / 0035
Page 3-39 and Page 3-51, Section 3.1.4.2 Groundwater.

The range of infiltration rates, hydraulic conductivities, etc. should be used rather than the average, especially in the case where the range is large. For example, apparent hydraulic conductivities range over 3 orders of magnitude (page 3-5 1). Also, the average infiltration rate of 6.5 mm/yr [millimeter per year] on page 3-39 is misleading because fracture systems allow much more rapid flow locally. The difficulty of Yucca Mountain hydrology is in the inability to predict which fractures or faults will act as highly transmissive zones. Care must be taken to show ranges of behavior so that best and worst case scenarios can both be evaluated.

Response
The EIS describes why the quantity of water moving through the proposed repository would be small compared to other sources of recharge in the region and to the amount of groundwater moving through the area. DOE believes that presenting ranges of infiltration rates in this case would add unnecessary complexity. More information, including temporal and spatial ranges of net infiltration, is in the Water Source and Movement discussion in Section 3.1.4.2.2 of the EIS.

DOE disagrees that description of an average net infiltration over the area of the repository is misleading. (It should be noted that the EIS now presents a different infiltration estimate due to the results of an updated infiltration study.) The EIS also considers smaller areas of higher and lower infiltration. Section 3.1.4.2.2 identifies infiltration rates over an order of magnitude higher in areas where thin alluvium overlies highly permeable rock. It would be misleading to imply that these higher infiltration rates occur over large areas.

DOE agrees that it is difficult to predict which fractures or faults would act as highly transmissive zones. However, much has been learned from studies, particularly chlorine-36 studies, that have suggested a correlation between subsurface locations where there is evidence of “fast pathways” (less than 50 years) and physical conditions in the mountain and on the surface. The Water Source and Movement discussion in Section 3.1.4.2.2 describes these correlations.

7.5.3.2 (7733)
Comment - EIS000817 / 0023
You also need to know how much water you are going to need for any of these operations -- for decontamination, etc. Your evaluation shows that demands (along with Nevada Test Site activities) would exceed lowest perennial yield estimates under the low thermal load for packaging scenarios. What about in retrieval? And have you evaluated how pumping that water out of the local supply affects that geological formation? Say you really deplete most of it, can areas of the aquifer dry out and cave in? Will air movement replace areas where water flowed before? What effect would this have on emissions and doses? Everything you could possibly have to do at the repository will affect everything else. You need to examine the scenarios of the unexpected and cask handling so far shows that the unexpected happens frequently. The track record is bad.

Response
Section 4.1.3.3 of the EIS discusses projected water needs for the repository. Table 4-11 lists the estimated annual water demand for each phase of the project (construction, operation and monitoring, and closure). These estimates include all the project’s water needs and include water for the decontamination of surface facilities, which is part of the monitoring period.

Section 4.2.1.2.3.2 of the EIS discusses impacts to groundwater if DOE undertook a retrieval action. The peak annual water demand for the retrieval option would be much less than the demand forecasted for the repository’s operational period when the emplacement of waste packages and the simultaneous development of new drifts would occur. (This would be the period with the highest annual water demand listed in Table 4-10.)

Land subsidence can accompany large withdrawals of groundwater that lower the water table. Where subsidence occurs, it is usually associated with fine-grained sediments, particularly silts and clays. Land subsidence above volcanic-rock aquifers, from which the repository would withdraw water, is not expected. In addition, significant lowering of the water table would require that substantial amounts of groundwater be pumped at a rate greater than the recharge rate. DOE compared water demands to the perennial yield of the area, and demonstrated that this would not occur. That is, there is no reason to believe that water demands for the repository would deplete the aquifer.

Chapter 5 of the EIS addresses the long-term performance of the repository, and includes estimates of doses from the slow release of radiological contaminants to both the atmosphere and groundwater. As indicated in Section 5.5, the repository rock is porous and allows gas to flow, establishing the need to evaluate the release of radionuclides with the potential for gas transport. As suggested by this comment, a temporary localized lowering of the groundwater table from pumping could aid air movement by causing air to move in as water moved out of an area. However, air movement in the rock is also driven by normal changes in barometric pressure caused by weather fronts moving in and out of the region.

With respect to the comment's concern for unexpected scenarios, the Yucca Mountain Project includes a major effort to identify, develop, and evaluate disruptive-event scenarios that could affect long-term repository performance. Section 5.7 of the EIS summarizes the results of this effort, and the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) contains a more detailed description.

7.5.3.2 (7854)
Comment - EIS001653 / 0037
Pg. 3-52 and Pg. 3-53 needs a figure showing ground water flow directions, depths, and aquifers. A figure should also show other groundwater wells used in the area.

Response
The Final EIS includes additional figures to support the groundwater hydrology discussions in Sections 3.1.4.2.1 and 3.1.4.2.2. A potentiometric surface map has been added that shows groundwater elevations of the Death Valley region. A figure has also been added showing a generalized hydrogeologic cross-section from Yucca Mountain to the northern portion of the Amargosa Desert. This figure shows a simplified representation of the groundwater level, aquifers, and confining units in this area.

A figure showing additional groundwater wells has not been included in the Final EIS. The current figure of well locations (Figure 3-17 of the EIS) depicts the primary wells as discussed, and DOE believes that it adequately represents the size of the area covered by monitoring and investigation wells. It is also recognized that it does not represent the number of wells in the area. It does not show all of the wells installed and monitored as part of the Yucca Mountain characterization work and it certainly does not show all of the water-extraction wells in the Amargosa Desert. A new figure showing more wells in Figure 3-17 would simply be too busy and would not add significant information.

7.5.3.2 (7861)
Comment - EIS001653 / 0040
Groundwater section [3.1.4.2] needs a map showing different aquifer systems in the region of influence.

Response
DOE agrees with the commenter. Section 3.1.4.2 of the Final EIS includes a simplified hydrogeologic cross-section from the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000). This figure shows a generalized representation of the relative positions of the volcanic, lower carbonate, and alluvium (or valley/basin-fill) aquifers in the area between Yucca Mountain and the Amargosa Desert. Figure 9.3-1 of the *Yucca Mountain Site Description* contains a more detailed hydrogeologic cross section across the Yucca Mountain site.

7.5.3.2 (8169)
Comment - EIS000817 / 0087
The "perched water" does not sound good. Have you ever watched water come out of a spring? We have a piece of land in a valley full of springs. I often watch the water flow down the valley sides and streamlets and springs and rockfall areas, and bluff areas uncovered, and think about how and where the water is going inside the rocky valley walls. You can picture it in your mind -- those fractures and faults and cavities holding the runoff until it comes out below. And it's obvious that over time, small passages become larger and fractures connect to form continuous pathways. The few tests you do now, and the limited sampling, can in no way predict when those passages will

connect in the future. Continuous pathways will lead to disaster eventually and you do not know when this will happen.

Response
The discovery and investigation of perched water bodies beneath the proposed repository horizon has provided a great deal of information on the movement of water in the unsaturated zone at Yucca Mountain. Data from these analyses represent primary pieces of evidence indicating faults and fractures in the rock that provide a relatively fast path for the vertical movement of some infiltrating water compared to the rate by which water travels through the rock matrix. Section 3.1.4.2.2 of the EIS discusses carbon-14 dating of the perched water, which indicates its age to be several thousand years. Water movement through the unsaturated zone probably is episodic, and very slow in the dry climate of the Yucca Mountain site in comparison to flowing surface water.

7.5.3.2 (8198)
Comment - EIS000817 / 0092
You think groundwater will dilute the radioactive waste in the end -- but will it? Is "dilution the solution"? Often not -- it causes more problems.

Response
DOE is not advocating dilution as the solution to managing spent nuclear fuel and high-level radioactive waste. However, the Department has to predict what would happen to these materials during the thousands of years following placement in a repository, during which its radiological hazards would still be of concern. The long-term performance of the repository described in Chapter 5 of the EIS is based on the premise that it is not reasonable to assume that the waste would stay contained and isolated forever. DOE believes it is reasonable that some dilution would occur as this material slowly entered the natural environment. The logic behind this belief is as follows: The presence of water, dripping or seeping on the waste packages, would be the most important factor controlling the longevity of the waste package. Even if packages were breached through other mechanisms, such as rockfalls, water would have to be present to carry contaminants any distance from the package. (The air pathway is of concern for the few radionuclides that might be available for gas transport, but the analysis shows this pathway to be of minor importance.) The contaminants would have to be soluble or in very small particles to move with the small-quantity, low-velocity water migrating through the unsaturated zone. As long as there was a saturated zone to receive the water moving down through the unsaturated zone, some mixing would occur when they joined, and there would be more opportunity for mixing the farther the water traveled in the saturated zone. Each of these steps involves the contaminants becoming part of a larger mass or volume of water (that is, dilution).

7.5.3.2 (8392)
Comment - EIS001023 / 0005
In its Draft Environmental Impact Statement, the Department of Energy admits that there could be low levels of contamination in the ground water in the Amargosa Desert for a long period. Do they mean for 10,000 years? The data presented by the Department of Energy in their 1998 "Viability Assessment" shows that water moves quickly through the rocks at Yucca Mountain. As a result when the containers begin to fail, radioactivity will also move quickly to contaminate the ground water in the region through the same fractures in the rock which allow carbon-14 to escape.

Response
Extensive studies at Yucca Mountain show evidence of low rates of infiltration and percolation, long groundwater-residence times, and a repository horizon that has been hydrologically stable for long periods. The proposed repository emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release.

Ongoing hydrogeochemical studies suggest that groundwater travel times for contaminants from the repository to the accessible environment (specified in 40 CFR Part 197) would be thousands to tens of thousands of years. The natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, more than 60 kilometers (37 miles) away, and travel times would be even longer.

After closure of the repository, there would be limited potential for releases to the atmosphere because the waste would be isolated far below the ground surface. DOE analyzed the potential for gas transport of carbon-14 because the repository host rocks are porous. Modeling analyses show negligible human health impacts due to releases of gas-phase carbon-14. Section 5.5 of the EIS contains more information on atmospheric radiological consequences.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

The EIS addresses long-term performance of the repository for both the 10,000-year regulatory period and for 1 million years. Results reported in the EIS are based on a state-of-the-art modeling technique that is internationally recognized as an adequate and proper approach. These results, as described in Chapter 5 of the EIS, indicate that impacts would be minor and that health effects would be thousands of times less than natural incidences of health problems in the population. Sections 3.1.4.2.1 and 5.4 contain more information.

7.5.3.2 (8410)
Comment - EIS000817 / 0126
P. 5-14. You say radionuclides would be more dispersed and the concentration of the nuclides in any volume of water would decrease. That is a big question, though. I wonder how concentrated the water really would be that carries this finally out into the public domain. Is there a scenario where the groundwater would be so little, but enough to flow out, that the concentration would be a lot more than predicted? How do we know how diluted it will really be long-term? Groundwater and aquifers will change over time.

Response
This comment is correct in identifying dispersion as one of the key elements in the effort to project (model) how contaminants might move in the environment. There was past concern over the amount of dispersion that would occur by the time water had infiltrated to the depth of the saturated zone and again as the water moved through the saturated zone. As a result of this concern, the DOE initiated an expert elicitation process, bringing together a number of experts in the field to determine what they felt would be appropriate dispersion and factors to use in projecting impacts from the proposed repository action. As described in the paragraph following the one identified in the comment, the factors recommended by the experts were used in the long-term performance modeling efforts described in the EIS. This process is further described in Section I.4 of the Draft EIS. Use of these dilution factors represented a significant departure from earlier modeling efforts for Yucca Mountain in which effective values of dilution were typically orders of magnitude higher. It should be noted that the long-term performance analysis in the Final EIS is somewhat different than that described in the Draft EIS. The analysis has been modified to conform to new requirements specified in 40 CFR Part 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*.

7.5.3.2 (8417)
Comment - EIS000817 / 0129
P. 5-15. I do not agree that Lehman and Brown's theory of flow paths will not come into effect because of the "long lived" waste packages. Don't depend on this. Work on the theory that the packages will not last as long as expected. Be prepared for that and know what to expect in that case.

Response
The comment refers to a statement in Section 5.2.3.4 of the Draft EIS. The EIS cites Lehman and Brown (DIRS 149173-1996), who propose an alternate conceptual model of saturated flow downgradient from Yucca Mountain, which could have some unquantified effect on dose estimates at a compliance point near the community of Amargosa Valley. The EIS maintains that such effects of alternative flow modeling would be relatively small, because dose rates are much more controlled by waste package failures than by rates of flow in the saturated zone.

The commenter argues that DOE should not place reliance on the long-lived waste packages. As discussed in Draft EIS Section 5.2.3, adequate performance of the repository is based on four key attributes: (1) limited water contacting waste packages, (2) long waste package lifetimes, (3) slow release of radionuclides from waste packages, and (4) reduction in the concentration of contaminants during transport to the point of human exposure. Each of these attributes is simulated in the Total System Performance Assessment that calculates dose rates at different times in the future. DOE recognizes that a great deal of uncertainty exists in the Total System Performance Assessment process as discussed in Section 5.2.4 of the Draft EIS, and uses alternative conceptual models and probability theory to deal with uncertainty and variability as described in Section 5.2.4.3.1 of the Draft EIS. While uncertainty exists in all aspects of performance assessment, it is important to realize what types of uncertainty will most influence overall results. Assessing this relative importance, termed sensitivity analysis, is described in Section 5.2.4.3.4 of the Draft EIS. Lehman and Brown's alternative model, and its potential effect on dose rates, cannot be analyzed quantitatively because their presentation is merely a brief summary of their work and does not provide a basis for judging its validity (DIRS 149173-Lehaman and Brown 1996).

DOE believes the issues related to uncertainty of the performance of the repository are treated adequately in Section 5.2.3 of the Draft EIS.

7.5.3.2 (8418)
Comment - EIS000817 / 0130
I'm thinking of something from "Civil Action" (book by Jonathan Harr), something about that the flow of the contaminated water could go under the river. I found that fascinating. This Darcy's Law about the quantity of water flowing through a given area is equal to the hydraulic conductivity of the material [through] which it flows multiplied by the size of the opening, multiplied again by the gradient or angle of incline. How does this fit in with the repository site, climate changes in rainfall rate, changes in size of continuous cracks and fissures in the surrounding rock by heat from the casks making them larger and connecting them, and the pressure changes and temperature changes affecting flow directions and the incline. All this, and where does the water really go? How much? When? How could you possibly predict all this? I don't think you can. What if the runoff flowed off laterally before it got to groundwater in the saturated zone and got out in surrounding land and air? Is this at all possible? Or could it get past the groundwater somehow without being diluted and flow out? In other words, is the groundwater level beneath the repository like a lake under there? No islands or peninsulas in it? I'm trying to picture just how it is under there. Don't assume it's one big flow and covers the whole space. Ever try to drill a well by hand and not hit water where it was supposed to be? We did this summer. It's a surprise. Could this be the case at Yucca in some areas and throw all your calculations off? Computers like to deal with "idealized" situations where sameness fits the calculations to make them "work" -- but nature is full of variation and diversity, so don't expect your neat little projections to be what is really there. It probably won't be the case. Water (and gases) seek any opening of escape they can find, and water tends to make its avenues of escape larger and more continuous as it goes along over time. Don't forget that. And -- water is a thief. It takes whatever it can along with it. Don't forget that, either. Sometimes I think scientists get so involved in their intricate computer models that they forget to look at the real thing, the total picture of how all of it works together. Often studies are so segmented that nobody puts them together to see if they really work together. That has happened in cask fabrication and can happen in water flow studies.

Response
This comment describes some of the complex issues and problems facing DOE scientists and engineers working to model the movement of water and contaminants in the subsurface environment. The conceptual model of water flow in Section 3.1.4.2.2 of the EIS shows both lateral and vertical flow in the unsaturated zone as water moves from the ground surface to the water table. The groundwater can be viewed simplistically as a lake (or very slow moving river) sitting underground in saturated rock. There could be islands or peninsulas where the water does not flow (or moves so slowly that it cannot be easily extracted from a well) due to faults and changes in rock characteristics. These would be areas of less permeable materials rather than areas where water might slip through from above.

The long-term performance assessment of the repository, as described in Chapter 5, includes evaluations of impacts from radioactive and nonradioactive materials released to the environment during the first 10,000 years after closure. The principal means by which these materials could be exposed over time to humans and the environment include movement through the unsaturated zone and then the groundwater (saturated zone). The Yucca Mountain site characterization effort is centered around learning enough about the site to make reasonable projections on how and when contaminants would move if the repository were to be constructed.

The long-term impact projections in the EIS are based in part on forecasts involving what the future environment will be like and how natural subsurface features vary over distance. These types of forecasts are associated with some uncertainty, particularly when they must consider thousands of years and long distances. Section 5.2.4 of the EIS addresses uncertainties associated with the analysis of the repository's long-term performance. This section also addresses the possible effects that uncertainties might have on the reported impact estimates. In the summary of the uncertainty discussion, DOE describes the current results of performance assessment as a "snapshot in time" that it will continue to refine with ongoing work. The Department believes the performance results presented in the EIS are conservative estimates and that ongoing work will increase confidence in those estimates.

7.5.3.2 (8454)
Comment - EIS000817 / 0134
P. 5-23, 5.3. You describe the general direction of groundwater movement NOW. But this could change. An earthquake or seismic event could remap this whole system. You have springs, alluvial aquifers -- connections between these and pressure differences that direct the flow. This could all change if land lifts or drops and pressures change. Rocks do strange things when they crack up or fracture. You can't predict what will happen. What if the volcanic aquifer ends up flowing into the carbonate aquifer??? What happens to Ash Meadows or Devils Hole then? And the Devils Hole pupfish?

Response
DOE shares the commenter's concern that it is not possible to predict precisely what would happen after significant seismic event at Yucca Mountain. Experts have studied records of historic seismic events and geologic evidence of ancient seismic events to help understand the possible size and frequency of future seismic events at and near Yucca Mountain. DOE has also examined the impacts to the long-term performance of the repository as from seismic activity. These analyses included possible changes to groundwater flow caused by seismic events. The results indicate that there would be little change in the pattern of groundwater flow from the creation of a permeable fault (a fault zone across which water can flow) and no effects if the fault was a barrier to water flow. Section 5.7.3 of the EIS and Section 4.4.3 of the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) describe the results of these analyses.

7.5.3.2 (8606)
Comment - EIS001256 / 0006
We would expect that your reply to our hydrologic and geologic concerns will include descriptions of the engineering barriers that have been designed, the most recent of which is a system of water shields to be placed over the storage casks. This presents a fundamental problem in itself. Yucca Mountain, or whatever site selected for long term storage, was supposed to offer a stable geologic barrier to protect people and the environment from high level nuclear waste. Instead, you are designing engineering barriers to provide the required protection. Why can't these engineering barriers be built at the point of origin of the waste? Why does the nuclear waste have to be transported thousands of miles, contaminating handling materials and jeopardizing health and safety all along the transportation routes?

Response
The NWPA (Section 114(f)(2) and (3)) provides that DOE need not consider in the EIS the need for a geologic repository or alternatives to geologic disposal. In addition, the EIS does not have to consider any site other than Yucca Mountain for development as a repository. For these reasons, this EIS did not consider constructing engineered barriers at existing waste sites similar in function to those proposed for the repository.

In the *Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste* (DIRS 104832-DOE 1980), DOE evaluated alternatives to mined geologic disposal including very deep borehole disposal, disposal in a mined cavity that resulted from rock melting, island-based geologic disposal, subseabed disposal, ice sheet disposal, well injection disposal, transmutation, space disposal, and no action. In a 1981 Record of Decision on that EIS, DOE decided to develop mined geologic repositories for the disposal of spent nuclear fuel and high-level radioactive waste.

7.5.3.2 (8678)
Comment - EIS001816 / 0002
Section 3.1.4 Hydrology (page 3-58): the statement about, “there is no reason to believe that radionuclides from nuclear tests could migrate as far as YM during the active life of the repository.” This statement is a belief and not a fact yet. Although there is a sizeable amount of data from the NTS testing program and more being collected simultaneous to YM, the Underground Test Area (UGTA) project has not established with credibility and acceptability that radionuclide contamination would reach the repository during its active life. The Tritium Transport Modeling (1997) by DOE on Pahute Mesa gave a range of arrival times for tritium to reach the Oasis Valley area from the present date to as little as 40 years from now. Possibly with the collection of more data from the data-sparse area between YM and Pahute Mesa, the DOE UGTA program will more confidently establish tritium transport times and pathways beneath YM. The Yucca Mountain Project and Underground Test Area Subproject must cooperate m [sentence incomplete]

Response
For the last several years, DOE, in close cooperation with the U.S. Geological Survey, the National Park Service, Nye County, Inyo County, and other entities, has supported the development of a regional model of groundwater flow that combines the data acquired by the Yucca Mountain Site Characterization Project and the Nevada Test Site (NTS). DOE (DIRS 103021-1997) used very conservative assumptions to show that tritium from nuclear testing moving in the groundwater could reach the boundaries of the Nevada Test Site and Nellis Air Force Range in a matter of decades. It should be noted that the flowpaths predicted in this study do not include paths from underground testing areas, including Pahute Mesa, to Yucca Mountain. Additionally, the Nevada Test Site study concluded that the results of groundwater sampling and analysis have shown that “…the conservative assumptions used to predict transport to Oasis Valley do not appear to be likely in reality” (DIRS 103021–DOE 1997). That is, monitoring has not shown tritium to be moving as rapidly as predicted even when using the conservative assumptions of the model. As additional data become available, the model will continue to be updated to analyze a variety of groundwater issues that are relevant to the Death Valley flow system and the performance of the repository.

DOE has modified Section 3.1.4 of the EIS to identify the tritium-transport study. This study recognizes that tritium from weapons testing could travel in the groundwater to locations at or near the boundary of the Nevada Test Site in tens of years, but that the predicted flowpaths would not pass beneath Yucca Mountain.

7.5.3.2 (8744)
Comment - EIS001816 / 0012
Section 3.1.4.2.2 (page 3-49): The study of fluid inclusions by Dublyansky (1998), and the conclusion that they were caused by warm upwelling of water and not percolation downward by surface water merits more questions. What relationship does the ongoing study by Dr. Jean Cline (UNLV) have to Dublyansky’s theory? Since YM is funding the investigation, the DEIS must define how and where the fluid inclusion study will be utilized as a contribution that is technically verifiable and reproducible, and that is in full transparent view of and inspection by the public.

Response
Based on the results of the analyses in Section 3.1.4.2.2 of the EIS, DOE does not believe that a credible rise of the water table would inundate the waste-emplacement areas. However, Section 3.1.4.2.2 does discuss evidence that the elevation of the water table at Yucca Mountain has fluctuated over time, due largely to changes in the climate. In addition, DOE examined the cumulative effects on the elevation of the water table from a wetter climate, earthquakes, and a volcanic eruption. Based on the evidence at hand, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate the waste emplacement areas at Yucca Mountain.

Section 3.1.4.2.2 of the EIS discusses several opposing views on fluctuations in the elevation of the water table at Yucca Mountain. Some investigators believe that the water table has risen in the past to elevations that are higher than the proposed waste emplacement areas. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened to examine this issue specifically (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level. Although DOE disagrees with the central scientific conclusions in Dr. Dublyansky's report (DIRS 104875-1998), it continues to support research in this area, as well as on other aspects of the geology and hydrology that enhances our understanding of the site. Dr. Cline's fluid inclusion study is viewed as a supplemental confirmatory research effort.

7.5.3.2 (8807)
Comment - EIS001907 / 0029
Groundwater contamination would deliver the worst doses of radioactivity to nearby residents, and because of this water quality must be protected to the fullest extent of the law, which this proposition fails to do. Yucca Mountain must have the most stringent of standards, for leakage will only increase over time, yet these standards are being lowered.

The only bulk source of Chlorine-36 in our atmosphere is from above ground nuclear weapons tests done in the Pacific, salt in the seawater was activated which formed the radioactive chlorine isotope. Its presence at repository depth proves that water has traveled there within the past 50 years, and proves a "fast flow" path for groundwater travel. The science has shown that water moves too fast through Yucca Mt. for it to qualify under 10 CFR 960.4-2-1. Now there is an attempt to change these standards. This act of trying to change the rules in the middle of the games is shameful.

Response
Section 1.3.2.4 of the EIS explains the legislative history of the repository program and the rationale for modifying the initial regulations that were applicable to a generic repository to the new regulations that are applicable only to Yucca Mountain. As reported in Chapter 5 of the EIS, modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at Yucca Mountain would keep doses resulting from any releases of radioactive contaminants well within the regulatory limits established by 40 CFR Part 197.

As part of its site characterization program, DOE has used a variety of naturally occurring isotopic indicators, one of which is chlorine-36, to investigate the nature of infiltration and deep percolation of water at the site. Results from this program detected elevated amounts (values above normal background measurements) of "bomb-pulse" chlorine-36 in several places in the Exploratory Studies Facility from nuclear testing conducted during the 1950s and 1960s. The locations where this bomb-pulse chlorine-36 has been detected in the Exploratory Studies Facility are associated generally with known through-going faults and well-developed fracture systems close to those faults. This suggests that there are connected pathways through which surface precipitation has percolated to the repository horizon within the last 50 years. These findings, however, must be viewed in the context of whether waste can be stored safely at Yucca Mountain. Overall, most of the water that infiltrates into Yucca Mountain moves much more slowly through the matrix and fracture network of the rock. Only a small fraction has moved quickly through the connected portion of the fracture network. Carbon isotope data from water extracted from the matrix correspond to residence times as long as 10,000 years.

7.5.3.2 (8927)
Comment - EIS001922 / 0004
Hydrology of the Site

A tremendous amount of scientific uncertainty currently surrounds hydrothermal incursions of groundwater at the site. It is unclear whether flooding has previously occurred, and if it has, how recently it occurred. The DEIS makes the assumption that the repository will remain unsaturated and its estimates of how long the container packages will last are based on that assumption. If the EIS [is] incorrect regarding hydrothermal incursions and the project continues, the consequences could be astronomical in terms of groundwater contamination and damage to the public and environment. The EIS should address the potential effects of water incursion on container packages.

The groundwater at the site currently is used for agriculture. The Amargosa Valley farming community relies directly upon the groundwater from the site for its livelihood and drinking water. The DEIS does not fully address the consequences of contamination of the groundwater and its impact on regional uses. It incorrectly assumes dilution will reduce concentrations of radiation to acceptable levels. Given that the longevity of the container and the mountain barrier have not been determined, this assumption is premature at best, woefully underestimated at worst.

The alarming and potentially devastating effects of upwelling and associated surface and groundwater contamination [were] not dealt with in the DEIS and should be addressed. An upwelling of contaminated water could impact a large land area and significantly alter the pathway and the maximum individual dose assumptions.

Response
Based on the results of analyses reported in Section 3.1.4.2.2 of the EIS, DOE does not believe that the waste emplacement areas would be inundated by a credible rise of the water table. This section does discuss evidence, however, that the elevation of the water table at Yucca Mountain has fluctuated over time. These fluctuations have been due largely to changes in the climate. DOE also examined the cumulative effects on the elevation of the water table from a wetter climate, earthquakes, and a volcanic eruption. Based on the evidence at hand, no reasonable combination of wetter climates, earthquakes, and volcanic eruptions could raise the elevation of the water table sufficiently to inundate the waste emplacement areas at Yucca Mountain.

Section 3.1.4.2.2 also discusses several opposing views concerning fluctuations in the elevation of the water table at Yucca Mountain. These investigators believe that the water table at Yucca Mountain has risen in the past to elevations that are higher than the waste-emplacement areas. DOE does not concur with these opposing views, nor did an expert panel that was convened by the National Academy of Sciences to examine this issue. DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level. Because DOE believes that this scenario is not credible and therefore not significant, DOE did not evaluate the impacts of groundwater inundation of the waste emplacement areas. This approach is consistent with regulations of the Council on Environmental Quality [40 CFR Part 1501.7(a)(3)], which directs agencies to identify and eliminate from detailed study those issues which are not significant. DOE believes that Section 3.1.4.2.2 of the EIS, which discusses dilution, adequately addresses the consequences of radionuclides in the regional groundwater system. As reported in Chapter 5 of the EIS, modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at Yucca Mountain would keep such releases within the regulatory limits established at 40 CFR Part 197.

7.5.3.2 (8941)
Comment - EIS001030 / 0003
Yucca Mt. is not adequate because of geological risks. Studies of the fissures in the rocks of the area indicate that both radioactive water and gas may escape. Heat from the waste itself may generate problems. Hot water from below the site associated with volcanic activity poses a risk. The site is riddled with seismic faults. The DEIS has not dealt adequately with these risks.

Response
Extensive studies conducted at Yucca Mountain show evidence of low rates of infiltration and percolation, long groundwater-residence times, and a repository horizon that has been hydrologically stable for long periods of time. The proposed waste-emplacement areas are located in areas away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide releases.

After closure of the repository, there would be a limited potential for releases to the atmosphere because the waste would be isolated far below the ground surface. The potential for gas transport of carbon-14 was analyzed because the repository host rocks are porous. Modeling shows negligible human-health impacts due to releases of gas-phase carbon-14. See Section 5.5 of the EIS for additional information on atmospheric radiological consequences.

The heat generated by the waste packages can be managed by using various options (e.g., blending, aging, waste package spacing, and ventilation). Under the higher-temperature operating mode flexible repository design, heat generated by the waste packages may add some increased uncertainty to possible effects of the repository on the hydrologic system. The heat generated by the waste packages may, however, be beneficial by driving water away from the drift wall rock for a period of about 1,500 years.

Intensive investigations by DOE identified no evidence or credible mechanism to account for a rise in groundwater to flood the potential repository horizon in the vicinity of Yucca Mountain. Szymanski (DIRS 106963-1989) proposed that during the last 10,000 to 1,000,000 years, hot mineralized groundwater was driven to the surface by earthquakes and volcanic activities. This hypothesis goes on to suggest that similar forces could raise the regional groundwater in the future and inundate the repository horizon.

DOE requested the National Academy of Science's National Research Council (NAS/NRC) render an independent evaluation of the issue. After reviewing available information, the NAS/NRC concluded in their 1992 report that no mechanism was known that could cause a future inundation of the repository horizon. The features cited by Szymanski (DIRS 106963-1989) as proof of groundwater upwelling in and around Yucca Mountain are related to the much older (13 to 10 million years old) volcanic process that formed Yucca Mountain and the underlying volcanic rocks. Significant water table excursions (exceeding tens of meters) to the design level of the repository due to earthquakes are unlikely. As discussed in EIS Section 3.1.3.1, the likelihood of volcanic activity in the area is low (one chance in 70 million annually), and it would raise the water table a few tens of meters, at most.

DOE scientists have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under extremely wet climatic conditions. The regional aquifer has been estimated to have been a maximum of 120 meters (390 feet) above present levels based on mineralogic data, isotopic data, discharge deposit data, and hydrologic modeling analysis. The occurrence of an earthquake under these extreme climatic conditions might cause an additional rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters (66 meters) or more between the water table and the level of the waste-emplacement drifts. The 1992 Little Skull Mountain earthquake (magnitude 5.6) raised water levels in monitoring wells at Yucca Mountain a maximum of less than 1 meter (3.3 feet) (DIRS 101276-O'Brien 1993). Water level and fluid pressure in continuously monitored wells rose sharply and then receded, over a period of several hours, to pre-earthquake levels. The water-level rise in hourly monitored wells was on the order of centimeters and indistinguishable after 2 hours (DIRS 101276-O'Brien 1993).

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm-water upwelling hypothesis. This study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. The report concludes that some of these crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of scientists with expertise in hydrology, geology, isotope geochemistry, and climatology did not concur with the conclusions in the report (DIRS 100086-Stuckless et al. 1998). Although the DOE has disagreed with the central scientific conclusions in this report, the DOE agreed to support continuing research. An independent Investigation by Jean Cline, at the University of Nevada, Las Vegas, is scheduled for completion in 2001. See Section 3.1.4.2.2 of the EIS for additional information.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

DOE based its analysis of impacts on a state-of-the-art modeling technique that has been reviewed by many oversight groups. The results of this analysis, described in Chapter 5 of the EIS, indicate that impacts would be low and that health effects would be thousands of times less than natural incidences of health problems in the population. Sections 3.1.4.2.1 and 5.4 provide additional information.

7.5.3.2 (8944)
Comment - EIS001030 / 0004
It is clear from research at Yucca Mt. and surrounding areas that we do not have a clear understanding of underground water dynamics. Further new information from other sites on the heretofore unknown rapidity at which radioactive substances can move in groundwater makes this issue even more troubling.

Response
Ongoing hydrogeochemical studies suggest that groundwater travel times for contaminants from the repository to the accessible environment, about 18 kilometers (11 miles) away, are from thousands to tens of thousands of years. The natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, more than 60 kilometers (37 miles) away, and travel times would be even greater.

At the Benham nuclear test site on the Nevada Test Site, testing has indicated rapid transport of colloidal-associated plutonium. The results of groundwater monitoring indicate that a small fraction of plutonium has migrated 1.3 kilometer (0.8 mile) from the blast site in 30 years. In fracture systems, colloids that are repelled from the wall rock can move faster than nonsorbing dissolved species because they remain in the faster flowing portions of the flow paths. DOE has included plutonium colloidal transport in the EIS analysis, and it will be the subject of continuing work.

Analysis of long-term repository performance shows that the combination of natural barriers and engineered barriers at the Yucca Mountain site would keep such a release small enough to pose no significant impact to the health and safety of people or the environment. See EIS Sections 3.1.4.2.2 and 5.4 for more information.

7.5.3.2 (9076)
Comment - EIS001887 / 0427
The Nuclear Waste Policy Act requires that an EIS, consistent with the National Environmental Policy Act (NEPA) be prepared and accompany a recommendation for site approval. The amended NWPA (1987) still requires consistency with NEPA, but does not require the DOE to consider:

1. The need for the repository
2. Alternatives sites to Yucca Mountain, or
3. Non-geological alternatives

NWPA Section 114(f) specifically states that all other provisions of NEPA apply. NEPA Section 1502.22 relates to incomplete or unavailable information. This section was developed as a result of dropping the "Worst case analysis" from previous NEPA provisions. NEPA regulations amended in 1986 now require that if information is available that would aid in evaluating uncertain effects, it must be obtained and analyzed unless it is too expensive to do so. If costs are prohibitive, then it must be disclosed as incomplete or unavailable information. Specifically, regulations require that if information cannot be obtained, the EIS must include:

1. A statement that such information is incomplete or unavailable.

2. A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment.

3. A summary of existing credible scientific evidence which is relevant to evaluating reasonably foreseeable significant adverse impacts on the human environment.

4. The agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.

The Yucca Mountain DEIS is not in compliance with numbers 2, 3 or 4 above. While the DOE has stated that information used in determining the groundwater flow model is incomplete or unavailable, the existing credible scientific evidence which is relevant to evaluating reasonably foreseeable significant adverse impacts has not been summarized nor has it all been utilized in developing flowpaths.

Also, the impacts evaluation assumed the same groundwater flowpaths and characteristics which were used in the DOE Viability Assessment and Total System Performance Assessment documents; i.e., a matrix type flow evaluation utilizing only 2D flow and 1D transport calculations. While these are generally accepted methods, they may not be representative of the saturated zone flow field that exists at Yucca Mountain today.

The DOE has not utilized all available and relevant data in their pathway identification or characterization. Because of this, the impacts in terms of dose to the Critical Group(s) or receptors may be misrepresented. While recognizing differing view points regarding groundwater flow, the DEIS fails to analyze flowpaths from a full data set that considers this information. Because all data that have been generated are not considered in the impacts evaluation, there may be significant differences in the groundwater impacts projected in the DEIS. Unless these analyses are considered, impacts projected in the DEIS are inadequate for NEPA compliance and their credibility questionable.

In addition, the requirement to disclose all credible scientific evidence extends to responsible opposing views provided these are supported by theoretical approaches or research methods generally accepted in the scientific community.

The Yucca Mountain DEIS recognizes differing viewpoints regarding groundwater flow (Section 3.1.4.2. and Section 5.2.3.4.) and references the State of Nevada study of Lehman and Brown, but it fails to evaluate the impacts and actually gives little credibility to this alternative flowpath model. The DEIS admits that the alternative flowpath could produce different results, however, it states the extent to which the different viewpoint would affect the impacts is unknown but speculates the effects would be minimal (due to long canister lifetimes). This may not be the case, and in terms of doses to populations of the State of Nevada, any credible alternative must be evaluated.

Response

DOE believes that the EIS is consistent with the National Environmental Policy Act, as amended (42 U.S.C. 4321 *et seq.*), and with the Nuclear Waste Policy Act, as amended (42 U.S.C. 10101 *et seq.*). DOE acknowledges in several places in the EIS that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, including incomplete or unavailable information, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Sections 3.1.4.2.1 and 3.1.4.2.2 discuss opposing views on groundwater conditions and groundwater boundaries. Although DOE disagrees with the central scientific conclusions of these opposing views, it continues to support research in several areas and on other aspects of the geology and hydrology of the region to enhance the Department's understanding of the site.

7.5.3.2 (9213)
Comment - EIS001938 / 0002
The DEIS completely fails to address potential impacts of the Yucca Mountain storage project on the water resources of Death Valley National Park and surrounding wildlands. It is clear that the repository may still constitute a dangerous source of radiation even after its projected 10,000 year life-span. The radionuclides in the proposed waste packages have half-lives ranging from 24,000 years (Plutonium 239) to 2,100,000 years (Iodine 129). Neptunium 237, which is projected to pose a serious health threat, has a half-life of 2.1 million years. The potential of this project, over time, to destroy the ecological integrity of DVNP and other wildlands must be addressed.

The DEIS does not address the fundamental question of overall risks of contamination of groundwater or downgradient natural resources from the repository site. Should a leak occur from the proposed repository site, it will likely migrate and contaminate groundwater and springs within Death Valley National Park, the Devils Hole Detached Management Unit of DVNP, the Ash Meadows National Wildlife Refuge, designated Wilderness areas, and the many natural resources contained in these specially-designated areas.

The DEIS admits there exists significant uncertainty over the actual risk of leakage of radioactive material into the groundwater aquifer that contains the Amargosa River system and which underlies portions of DVNP. Numerous studies demonstrate that the regional groundwater flow system runs from the Yucca Mountain area toward the Furnace Creek wash area in Death Valley National Park. This obvious pathway for groundwater contamination is not adequately considered in the DEIS; in fact the DEIS flatly and unjustifiably ignores the information contained in hydrological studies other than its own. Of particular note, studies conducted by Inyo, Esmeralda and Nye Counties have established a direct connection between the aquifer underlying Yucca Mountain and surface springs in Death Valley National Park. See, e.g., “An Evaluation of the Hydrology at Yucca Mountain The Lower Carbonate Aquifer and Amargosa River” (Inyo and Esmeralda Counties 1996), and “Death Valley Springs Geochemical Investigation” (Inyo County 1998). These same studies indicate that communities in Amargosa Valley utilize groundwater that may be hydrologically contiguous to the Yucca Mountain aquifer.

Additional study will clearly be necessary to fully understand the nature of the groundwater flow system. This basic knowledge will be required to accurately determine the potential environmental impacts of the Yucca Mountain repository project. Effective modeling must also consider a response of the flow system to a number of likely variables, including continued development, increased groundwater withdrawals, variations in precipitation, and groundwater recharge. Absent that kind of data and analysis, the DEIS will not be able to conclusively determine potential environmental impacts of the proposed project, and is therefore incomplete.

The DEIS implies that groundwater moves very slowly in the Yucca Mountain area, giving the false impression that impacts to the environment from groundwater movement will be negligible. Numerous studies, however, indicate that zones in this regional aquifer are highly transmissive. The constant discharge, high volume springs at Ash Meadows and Death Valley further indicate that the area around these springs may be surrounded by accelerated groundwater transmissivities. Any contamination originating at the Yucca Mountain Site could thus quickly be transported to Death Valley and Ash Meadows contrary to the claims of the DEIS.

The DEIS also fails to assess the impacts of expected climate change over the next 10,000 years on the transport of groundwater between the repository site and Death Valley National Park. In the past 10,000 years, there have been significant climatic changes, including periods much wetter than today. Studies that have reviewed the effects of increased filtration that may result from a wetter climate (e.g., global warming, as predicted by scientists) have direct bearing on the repository proposal. A wetter climatic regime could both increase the rate of corrosion of waste canisters and speed the travel of groundwater, which would result in greater and more rapid dispersal of radionuclides to the environment.

In addition to groundwater impacts, the project also poses a very real threat to surface water resources. The document fails to consider the potential impacts from radioactive leaks from the repository manifesting in surface-water springs, or from transportation-related accidents of shipments containing high-level radioactive waste, to the surface-water resources of Death Valley National Park, Ash Meadows NWR, designated Wilderness areas, and the Amargosa River. Nor have the impacts of such contamination of surface water on the wildlife, vegetative and human communities dependent on those surface waters been adequately assessed.

Response

Section 3.1.4.2.1 of the EIS shows that the flow path of groundwater from Yucca Mountain extends to Jackass Flats and the Amargosa Desert, and continues southward to the primary point of discharge at Franklin Lake Playa in Alkali Flat. The EIS recognizes that some groundwater reaching this far might bypass Franklin Lake Playa and continue into Death Valley. The EIS also recognizes that a fraction of the groundwater that reaches the Amargosa Desert might flow through the southeastern end of the Funeral Mountains to springs in the Furnace Creek Wash in Death Valley National Park.

Chapter 5 of the EIS does not specifically address the risks to people and natural resources in Death Valley National Park from the use and consumption of groundwater. However, it clearly indicates that risks would decrease with increased distance from the repository. Accordingly, impacts to the Park, because it is far from Yucca Mountain, would be negligible.

Section 5.9 of the EIS discusses the impacts to biological resources from the long-term performance of the repository. DOE did not quantify impacts to biological resources, but related them to the negligible impacts expected to humans from the use and consumption of groundwater.

The springs in Ash Meadows (including Devils Hole) are not along the groundwater flow path from Yucca Mountain. As described in Section 3.1.4.2.1 of the EIS, groundwater beneath Yucca Mountain flows to the Amargosa Desert but does not discharge in Ash Meadows. From Ash Meadows to the low axis (Carson Slough) of the Amargosa Desert, the groundwater table declines about 64 meters (210 feet), indicating that the groundwater flows from Ash Meadows toward the Amargosa Desert, not the other way around.

The EIS acknowledges that some of the groundwater beneath Yucca Mountain might flow to Furnace Creek Wash in Death Valley National Park. DOE is not aware of any evidence to indicate that this represents the regional groundwater flow system, as the commenter suggests. The studies by Inyo, Esmeralda, and Nye Counties cited by the commenter do not make this claim. The *Death Valley Springs Geochemical Investigation* (DIRS 147808-King and Bredehoeft 1999) cites evidence that a portion of the flow from the Furnace Creek springs must originate from the area of the Amargosa Desert. Based on the evidence, the study was unable to identify a specific source. Its conclusion states, “The water can come from recharge in 1) the area of NTS [Nevada Test Site] and Yucca Mountain; or 2) the Amargosa Basin fill deposits; or 3) the area to the east that includes the Ash Meadows springs, or some combination of all three.” The study identifies the quantity of water discharging at the springs in Furnace Creek, which is smaller than the estimates of water moving through the Amargosa Desert toward the discharge area at Alkali Flat. That is, the quantity of water moving toward Furnace Creek would not be the regional groundwater flow system; rather, it would be only a portion of the regional system. Finally, the EIS identifies Amargosa Valley and other parts of Amargosa Desert to the south as being over the primary groundwater flowpath from the area of Yucca Mountain. DOE believes that the information and conclusions in the cited studies are consistent (or at least are not inconsistent) with the model of groundwater flow described in the EIS.

DOE recognizes that the acquisition of additional data would reduce the uncertainty regarding some aspects of the long-term performance of the repository. But DOE also recognizes that some uncertainty is inherent to the process. The approach used by the Department to assess the long-term performance of the repository (summarized in Chapter 5 of the EIS) was to recognize the uncertainties that are important to the assessment and to identify which of these uncertainties could be minimized with additional data and which could not. With respect to those uncertainties that are the result of a data gap, the approach was to make conservative assumptions where necessary, realizing that information gained from ongoing studies may eventually support less conservative assumptions and less conservative estimates of impacts. The approach used by DOE to account for uncertainties associated with the long-term performance of the repository is discussed more fully in Section 5.2.4 of the EIS.

In summary, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Chapter 5 of the EIS describes how DOE modeled the movement of contaminants from the slow degradation of waste packages in the repository. The model included both the slow movement of water through the rock matrix and the relatively fast movement of water along rock fractures and faults. Although the rate at which groundwater moves is important to the model, it is not the only factor that would control the movement of contaminants. Section I.2.4 describes how DOE modeled waste package degradation and how the cladding and waste form degradation models would come into play before contaminants would actually become available for transport through the unsaturated and saturated zones. It also describes the various mechanisms that would affect how materials move through these zones, including movement with colloids and the sorption and desorption that would occur as individual radionuclides or chemicals interacted with the rock through which they were moving. These and other parameters used by DOE in the performance assessment model are conservative estimates, thereby tending to increase impacts to groundwater and downgradient users. As described above, some of the groundwater flow beneath Yucca Mountain could reach the Death Valley area (either as spring discharge in the Furnace Creek area or as underflow moving past the Alkali Flat area), but most of the flow goes no farther than Alkali Flat. The Ash Meadows area is not in this groundwater flowpath.

With respect to the commenter’s concerns about changes in the climate and the rate of infiltration, the amount of water moving through the mountain is one of the key parameters in the projection of contaminant movement. As described in Section 5.2.4.1 of the EIS, modeling the performance of the repository included a range of water fluxes corresponding to variations in rainfall over thousands to hundreds of thousands of years due to climate changes. Moreover, it was assumed that the current climate is the driest it will ever be at Yucca Mountain.

With respect to surface water, Section 4.1.3 of the EIS addresses potential impacts during the construction, operation and monitoring, and closure phases of the proposed repository. Sections 6.3.2 and 6.3.3 address potential impacts of transporting spent nuclear fuel and high-level radioactive waste on branch rail lines and heavy-haul truck routes in Nevada, respectively. These sections discuss potential impacts to both surface water and groundwater along the routes DOE evaluated. In all cases, DOE believes that there would be very little potential for release of radioactive constituents. Sections 4.1.8 and 6.2.4 address potential impacts at the repository and from transportation activities, respectively, from accidents. Such impacts would be in the form of exposures to people, which DOE believes would be the primary concern before the completion of response and cleanup actions. Consistent with this position, DOE assumed that transportation accidents would occur in an urban area where impacts would be greatest. It did not evaluate specific impacts to Death Valley National Park, Ash Meadows National Wildlife Refuge, Wilderness Areas, or the Amargosa River as a result of accidents. None of the transportation routes would go through the Death Valley National Park.

Addressing the commenter's concerns about radioactive leaks from the repository affecting surface-water springs, the assessment of long-term repository performance described in Chapter 5 does not address such a scenario primarily because there are no springs along the groundwater flow path between Yucca Mountain and Alkali Flat, which is the area farthest from the repository for which DOE estimated impacts. In addition, the use of spring water would not represent a higher risk to water users than that assumed for the groundwater exposure scenario examined by DOE. That scenario includes residents using and consuming groundwater and consuming crops and livestock watered with groundwater. Finally, springs in Death Valley that may discharge some water from the Yucca Mountain area are farther from the repository than Alkali Flat. As a consequence, potential contaminant levels and exposure impacts in Death Valley would be lower than those estimated at Alkali Flat (modeling shows that doses resulting from contaminant releases would be within the regulatory limits established by EPA in 40 CFR Part 197).

7.5.3.2 (9398)
Comment - EIS001653 / 0038
Groundwater section [Section 3.1.4.2]-There appears to be no discussion of baseline conditions associated with underground weapons testing program. This needs to be included in the DEIS. The DEIS does not account for all sources of chemically toxic constituents in groundwater, including documented background conditions (e.g. barium, manganese), and contributions from the Nevada Test Site.

Response
The last paragraph of Section 3.1.4.2.2 of the EIS describes the relationship between activities on the Nevada Test Site and groundwater conditions at Yucca Mountain. As indicated, there are no impacts to groundwater at Yucca Mountain from activities on the Test Site. In addition, Section 8.3.2.1 discusses the cumulative impacts of underground weapons testing at the Nevada Test Site. Section 8.3.2.1.1, which cites DOE (DIRS 101811-1996), addresses the transport of contaminants in groundwater and DOE (DIRS 101811-1996) contains a detailed discussion of underground weapons testing.

Regarding the assertion that the EIS does not account for all sources of chemically toxic constituents in groundwater, including background conditions, Sections 3.1.4.2.1 and 3.1.4.2.2 of the EIS discuss existing groundwater quality on a regional scale and at Yucca Mountain, respectively. Section I.6 addresses the potential for the repository to add toxic materials to the groundwater. As described in that section, DOE did a screening analysis to focus on realistic human health hazards from waterborne toxic chemicals. The repository would contain many materials that could result in impacts to human health. However, most of those materials would not be present in large enough quantities or would not dissolve readily enough in water to pose a risk. To evaluate the potential risk posed by these materials, an analysis could rigorously evaluate every material (at great cost), or could apply a screening analysis to identify materials with too little inventory or too little solubility to be of concern. The screening analysis that DOE applied was a simplified scoping calculation, which resulted in a short list of materials that merited further consideration. It treated preliminary concentrations predicted under the simplified assumptions as conservative estimates used only to determine if DOE should rigorously model the material again using the performance assessment model. For materials that the screening analysis indicated must receive further evaluation, DOE computed more realistic concentrations and impacts with the performance assessment model, as reported in Sections I.5 and I.6.

7.5.3.2 (9715)
Comment - EIS002151 / 0005
Scientific evidence confirms what the Shoshone Nation have taught all along, Yucca Mountain is moving. It's extremely unstable with thirty-three fault lines, a nearby active volcano, geothermal activity and fissures throughout the mountain. I've heard from scientists and watched the water from the rain go right through the mountain and this water will definitely reach where the nuclear waste is stored, and that's something that those openings at the

downpours can travel through, it shows how unstable that mountain is. It's not a safe place for nuclear waste. It's not a sane place for nuclear waste. It's a political place for nuclear waste.

Response
DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, which considered faults, earthquakes, volcanism, and fast-flow movement of water through the mountain, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

In 1987, Congress selected Yucca Mountain as a proposed location for a monitored geologic repository, and directed DOE to determine whether the site is suitable (Nuclear Waste Policy Amendments Act of 1987). Some of the reasons that Congress selected Yucca Mountain for study included a deep water table; favorable geology; a desert environment; and the fact that the Nevada Test Site was already a controlled area. Another reason for the decision to study only one site was the rising costs of the overall program. Congress recognized that costs could be reduced by selecting and studying the best site, rather than studying several sites simultaneously.

The Secretary of Energy will consider the results of site characterization, the Final EIS, and other project documents in determining whether to recommend to the President that Yucca Mountain be developed as a repository.

7.5.3.2 (9787)
Comment - EIS001888 / 0373
[Clark County summary of a comment it received from a member of the public.]

One commenter asked if the EIS will discuss monitoring of potential subsidence at the surface caused by underground excavations, and if numerical modeling of underground stresses will be conducted.

Response
DOE agrees that the potential effects of in-place stresses and of mining the underground waste emplacement openings are important aspects of the repository program. The design of the proposed repository requires knowledge of the magnitude, direction, and variability of preconstruction in-place stress. DOE needs this information to analyze and design stable underground openings and to predict short- and long-term rock-mass deformation. DOE has been modeling in-place stress and the potential effects of thermal loading on the waste isolation properties of Yucca Mountain since the early 1980s (DIRS 101314-DOE 1986). At that time, data indicated that the repository host rock "can accommodate expected mechanical and thermal stresses after closure" (DIRS 101314-DOE 1986). Analyses also indicated that the heat load "can be adjusted to account for unforeseen problems."

The *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) cites reports that contain the results of in-place stress tests at and near Yucca Mountain. That document also summarizes estimated in-place stress at the repository level and the results of more recent testing in the Drift Scale Test block. Section 11 of the Site Description describes the integrated system response to the heat generated by emplaced waste. That section considers the part of the natural system, the near-field environment zone, that thermal effects would permanently alter. Although the far-field environment could have slightly elevated temperatures, it would remain essentially unaltered (DIRS 151945-CRWMS M&O 2000).

DOE would continue to monitor and analyze rock-mass response and deformation around the emplacement drifts as part of the performance confirmation program. Specifically, instrumentation at the surface over the repository would monitor uplift caused by thermal loading (DIRS 150657-CRWMS M&O 2000). Because the stresses at Yucca Mountain are so low, DOE would measure deformation around the emplacement drifts using stress-change gauges (DIRS 150657-CRWMS M&O 2000).

7.5.3.2 (9791)
Comment - EIS001888 / 0376
[Clark County summary of comments it has received from the public.]

Three commenters stated that the subsurface rock at Yucca Mountain is rotten (crumbles easily during tunneling), or has been fractured from underground testing of nuclear weapons, and that radioactive releases into this rock must to be evaluated.

Response
Although the rock at Yucca Mountain is fractured, experience gained during the excavation of the Exploratory Studies Facility indicates that tunnel openings remain relatively stable. DOE used extra support at several locations in the Exploratory Studies Facility (particularly along portions of the north and south ramps), but found no zones of crumbly rock in the 8-kilometer-long (5-mile-long) tunnel.

Rock fractures at the Yucca Mountain site are primarily natural features created by cooling of volcanic ash-flow deposits, crustal stresses in the Earth's crust, and near-surface stress release caused by erosion. DOE also noted that drilling induced some fracturing of the rock during rock-core recovery and logging. Rubble zones in several boreholes might be due to closely spaced fractures in the relatively brittle welded tuffs. Sections 4.6.6 and 4.7.3 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) discuss fractures in greater detail.

There is no evidence that past underground detonations of nuclear weapons on the Nevada Test Site have fractured the rock at Yucca Mountain or that radioactive releases from weapons testing have migrated outside the Nevada Test Site.

7.5.3.2 (9796)
Comment - EIS001888 / 0381
[Clark County summary of comments it has received from the public.]

Commenters requested that the EIS evaluate the impacts from reasonable changes in the level, and the potential for elevated temperatures, of the water table at Yucca Mountain. To support this issue, commenters cited the presence of "calcite opal mineral formations" along fractures as evidence of upwelling hot water, which could leach radionuclides into the environment, flash to corrosive steam in an already hot repository, and increase the risks of criticality. Another commenter noted the groundwater temperature of the Amargosa River as evidence of high temperature groundwater.

Response
Based on the results of analyses reported in Section 3.1.4.2.2 of the EIS, DOE does not believe that the waste emplacement drifts would be inundated by a credible rise of the water table. However, this section discusses evidence that the elevation of the water table at Yucca Mountain has fluctuated over time. The fluctuations have been due largely to changes in the climate. DOE examined the cumulative effects from a wetter climate, earthquakes, and a volcanic eruption on the elevation of the water table. Based on the evidence, no reasonable combination of these conditions could raise the elevation of the water table sufficiently to inundate the emplacement drifts at Yucca Mountain.

Section 3.1.4.2.2 of the EIS discusses several opposing views on fluctuations in the elevation of the water table at Yucca Mountain. Some investigators believe that the water table has risen in the past to elevations higher than the waste emplacement horizon. DOE does not concur with these views, nor did an expert panel that the National Academy of Sciences convened specifically to examine this issue (as described in Section 3.1.4.2.2). DOE believes that the geologic evidence strongly indicates that over the past several million years, water levels at Yucca Mountain have not been more than about 120 meters (390 feet) higher than the present level. Although DOE disagrees with the central conclusions in this report (DIRS 104875-Dublyansky 1998), it continues to support research in this area and other aspects of geology and hydrology that enhances the understanding of the site. DOE considers this additional research on fluid inclusions to be supplemental confirmatory research.

The temperature of groundwater generally varies with depth; deeper groundwater is usually warmer than shallow groundwater throughout the world. The temperature of the Amargosa River in the few areas where groundwater discharges to the surface does not indicate a deep subsurface source of geothermal energy or magma, but rather reflects the ambient temperature of the groundwater.

7.5.3.2 (9882)
<u>Comment</u> - EIS001888 / 0428
[Clark County summary of comments it has received from the public.]

Commenters requested that the EIS describe the seismic design and its basis, including deterministic evaluation of maximum credible seismic events based on ground motion, as well as resulting secondary effects such as transient or long-term changes to the water table.

<u>Response</u>
DOE is designing the surface and underground facilities at Yucca Mountain to withstand ground motion from earthquakes that were identified in the seismic hazard analysis. The analysis determined that for the 10,000-year earthquake, facilities would be designed to withstand ground motions from a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain and a magnitude 7.5 or greater earthquake in Death Valley 50 kilometers (31 miles) away. DOE regards this annual frequency to be appropriate and conservative because it reflects the annual probabilities of ground motions for nuclear powerplants in the western United States, and the surface facilities at Yucca Mountain pose less risk compared to nuclear powerplants.

Table 4-36 of the EIS describes earthquake accident scenarios with a recurrence frequency of once in 50,000 years. This is roughly equivalent to a magnitude 7 earthquake occurring within 5 kilometers (3 miles) of Yucca Mountain with a mean peak ground acceleration of approximately 1.1g at the repository level (not the surface). DOE considers these to be very conservative calculations that indicate the maximum impact of such an event.

The waste emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide releases. Additional fault displacements from post-emplacement seismic activity would probably be along existing faults. DOE developed its hydrologic models of Yucca Mountain on a fault-fracture dominant flow system. The generation of new faults and associated earthquakes would have minor or no effects on fault and fracture pathways, and therefore would be unlikely to alter repository performance. Modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at Yucca Mountain would keep doses resulting from any contaminant releases well below the regulatory limits established by 40 CFR Part 197.

DOE has maintained a network of boreholes to monitor water levels at and near Yucca Mountain over the past two decades. Measurements of water-level elevations under normal conditions show only minor annual changes (a few tenths of a meter) due to seasonal variations in precipitation. Several boreholes record water levels continuously or for short intervals (several times an hour). These boreholes have recorded the response of the water table to both local earthquakes (including the magnitude-5.6 Little Skull Mountain earthquake in 1992) and regional earthquakes (some as large as magnitude 7.3, such as the Landers, California, earthquake, on June 28, 1992). In general, departures from long-term average water-table elevations are minor, usually limited to a few centimeters to about 1 meter. These changes are generally short-lived, with most monitored boreholes showing a return to pre-earthquake water levels within a few hours to a few days. In no instance has the network recorded any large permanent departures from pre-earthquake water levels.

7.5.3.2 (10082)
<u>Comment</u> - EIS001465 / 0008
When they got down in Yucca Mountain, my friend saw that there was water dripping from cracks in the ceiling and that there were puddles of water on the ground. And the Department of Energy tells us that Yucca Mountain is completely dry, that there’s no water that moves through it, and yet they found contamination from above ground testing 500 feet below the surface of Yucca Mountain. How does this contamination get there from above ground testing if it’s not carried there by the water? The Department of Energy is lying to us.

<u>Response</u>
Without knowing where in the exploratory studies facility the water was observed, DOE cannot respond with precision. However, water is used to wash the tunnel walls before sampling and testing, and for dust control. The

water observed may have been from such activities. It seems more likely, however, that the dripping water was in Alcove 5 where the Drift Scale Heater Test is being conducted. One of the main objectives of the heater test is to monitor the response of the repository host rock to heat from simulated waste packages. An important and expected result of the heater test is that water in the pores of the rock is converted to water vapor. The water vapor then migrates through connected fractures in the rock until it finds an outlet in more remote, cooler portions of the rock mass. Encountering cooler rock causes the water vapor to condense into water. In the vicinity of the heater test, the most accessible location in which this recondensed water can accumulate is the air-conditioned visitors' gallery adjacent to the heater drift. Any water observed dripping into the visitors' gallery does not originate from percolating surface infiltration; it is entirely the result of this anticipated response of the rock pore water to the imposed heat load.

Regarding the infiltration of surface water to the depth of the waste emplacement area, DOE specifically acknowledges in Section 3.1.4.2.2 that post-1952 infiltration of surface water has reached the waste emplacement area. The Department believes that such rapid movement of water occurs along faults and fracture zones. This phenomenon has been factored into modeling of fluid flow in the unsaturated zone and total system performance analysis.

7.5.3.2 (10083)
<u>Comment</u> - EIS001465 / 0009
One of my friends reached out and touched the wall of Yucca Mountain, the tunnel, and with his hand he took off a big chunk of rock and crumbled it. That's not a solid rock. That's like sandstone or something. There's no way that Yucca Mountain can contain the nuclear waste [that] is going to be contained for a lot more than 10,000 years, and under this process DOE is only looking at 10,000 years.

<u>Response</u>
The Exploratory Studies Facility at Yucca Mountain extends from the surface to the waste-emplacement area. The rock between the surface and the waste-emplacement area consists of layers of welded and nonwelded tuff. Without knowing the particular rock layer or depth at which the rock from the wall was handled, it is difficult to specifically address this comment. However, the rock layers above the waste-emplacement area could be considerably different. Moreover, a rock's resistance to crumbling might indicate little about its ability to isolate waste. For example, the salt in which the Waste Isolation Pilot Plant in New Mexico was constructed can be crumbled by hand, but the formation has been stable for an exceptionally long period of time. DOE has studied the physical characteristics of many rock samples at Yucca Mountain, as well as how the entire mountain responds to large-scale processes and events, including precipitation and infiltration, erosion, earthquakes, and heat build-up.
Chapter 5 of the EIS describes impacts to human health from radioactive and nonradioactive materials released to the environment during the first 10,000 years after closure. This chapter also describes the peak radiation dose during the first 1 million years after closure.

7.5.3.2 (10123)
<u>Comment</u> - EIS002076 / 0001
I believe the draft EIS does not sufficiently address the geology and water issues. Therefore, my concerns are the stability of the geological structure of Yucca Mountain and the potential contamination of ground water by any type of contamination, including and especially nuclear waste. In the event of a major earthquake and possible damage to and leakage of waste, which could contaminate the underground water, is my greatest concern. Contamination of underground water which eventually through underground rivers, streams, or connecting aquifers could end up in the Colorado River, thus contaminating the waters of Havasu Lake and reservations.

<u>Response</u>
DOE has conducted an extensive site characterization program to evaluate the proposed repository at Yucca Mountain. Yucca Mountain is in the Death Valley regional groundwater flow system. This basin is a closed hydrologic basin, which means its surface water and groundwater can leave only by evaporation from the soil and transpiration from plants. This area is characterized by a very dry climate, limited surface water, and very deep aquifers. The regional slope of the water table (potentiometric surface) indicates that the groundwater from beneath Yucca Mountain flows southward toward Amargosa Valley. The central Death Valley subregion is comprised of three groundwater basins that are divided into smaller sections.

Yucca Mountain is in the Alkali Flat-Furnace Creek groundwater basin. In this basin, only a small potion of total basin recharge actually infiltrates through Yucca Mountain. The small fraction of water that does infiltrate through Yucca Mountain eventually recharges the groundwater, then flows towards Fortymile Wash and merges with the rest of the groundwater in the Fortymile Canyon section of the groundwater basin. Flow then continues south toward Amargosa Valley and mixes into the very large groundwater reservoir in the Amargosa River section, as shown in Figure 3-15 of the EIS. The natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, 60 kilometers (37 miles) away. None of the groundwater in the Death Valley regional groundwater flow system enters the Colorado River or Lake Havasu.

Extensive studies conducted at Yucca Mountain show evidence of low infiltration and percolation rates, long groundwater residence times, and a repository horizon that has been hydrologically stable for long periods. The proposed waste-emplacement areas would be in areas away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Additional fault movements and associated seismic activity would probably be along existing fault planes.

Hydrology models, derived from studies conducted at Yucca Mountain, are based on a fault-fracture dominant flow system. The addition of a few new faults by earthquakes would have negligible effects on the current fault- and fracture-flow pathways, and would not be likely to alter the long-term performance of the repository. DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 for more information).

7.5.3.2 (10264)
Comment - EIS002204 / 0001
Just a few years ago at Yucca Mountain itself, they found contaminated tritium from above-ground testing 500 feet below the surface of Yucca Mountain.

This contaminated tritium was from the nuclear explosions that would explode into the air, the contamination would come down, fall on the surface and then with the rain water that was falling on the mountain would be carried 500 feet below the surface of the ground. The water is moving through Yucca Mountain. Friends of mine went out to Yucca Mountain just a couple weeks ago, about a month ago, actually, and took a tour of the Yucca Mountain, and where the gentleman was talking about where they're heating up the rocks, there is water pouring out of those rocks.

There are puddles of water on the floor, condensation all over the tunnel, and the people at Yucca Mountain were trying to shield it, trying to put up these aluminum shields to hide that water so that it would go around these shields and underneath the walkway so that the people walking through there couldn't see the water.

Response
One of the main objectives of the heater test is to monitor the response of the host rock at Yucca Mountain to the effects of heat imposed on the rock from simulated waste packages. An important and expected result of the imposed heat is to cause the water in the pores of the rock to be converted into water vapor. The mobilized water vapor then migrates through the connected portion of the rock fracture network until it finds an outlet in more remote, cooler portions of the rock mass. Encountering cooler rock causes the water vapor to recondense into liquid. In the area of the heater test, the most accessible location for this recondensed water to accumulate is the air-conditioned visitors gallery adjacent to the heater drift. Water seen dripping into the visitors gallery originates from this process.

The purpose of the aluminum shielding is not to hide the water that becomes mobilized. The aluminum shielding, along with insulation behind the shielding, creates an acceptably cool environment that allows visitors and scientists alike, to be in the immediate vicinity of the heater test.

As part of its site characterization activities, DOE has conducted a variety of investigations into the nature of water falling as precipitation on Yucca Mountain and passing through the unsaturated zone to the groundwater beneath.

One such study has been to quantify the concentrations of certain radioisotopes in the Exploratory Studies Facility. Isotopes, such as chlorine-36 and tritium, which occur naturally and as a byproduct of atmospheric nuclear weapons testing, serve as indicators of the rate of flow through the unsaturated zone (see Section 3.1.4.2.2 of the EIS for details).

Results from preliminary studies have identified these isotopes in concentrations that tend to suggest that there are connected pathways through which surface precipitation has percolated to the repository horizon within the last 50 years. However, these isotopes have been found at locations that are almost exclusively associated with known, through-going faults and well-developed fracture systems close to the faults at the proposed repository horizon.

To ensure the correct interpretation of this chemical signal, DOE instituted additional studies to determine if independent laboratories and related isotopic studies can corroborate the detection of elevated concentrations of these radioisotopes. Results of the validation studies to this point have not allowed firm conclusions and, thus, the evaluations continue.

DOE believes that these findings do not indicate that the Yucca Mountain site should be declared unsuitable for development as a repository. Most of the water that infiltrates Yucca Mountain moves slowly through the matrix and fracture network of the rock, and isotopic data from water extracted from the rock matrix indicates that residence times might be as long as 10,000 years. Furthermore, after excavating more than 11 kilometers (8.4 miles) of tunnels at Yucca Mountain, DOE determined that only one fracture was moist (there was no active flow of water). This observation has been confirmed in test alcoves that are not subject to the effects of drying from active ventilation.

Nevertheless, the total system performance assessment incorporates the more conservative water movement data as well as information from other water infiltration and associated hydrogeological studies. As a result of this evaluation, DOE would not expect the repository (combination of natural and engineered barriers) to exceed the prescribed radiation exposure limits during the first 10,000 years after closure.

7.5.3.2 (10349)
Comment - EIS002176 / 0002
We believe that the DEIS for Yucca Mountain is unacceptable for a number of reasons. Saturation of the Yucca Mountain repository is possible given numerous scientific findings including the detection of atmospheric bomb testing nuclides at repository depths and the inconsistent groundwater levels near the site. The DEIS must be rewritten to include the environmental impact of groundwater infiltration and saturation.

Response
DOE agrees that evidence of "nuclear-age" water reaching the depth of the proposed repository has shown that water at the surface moves through rock fractures and faults at Yucca Mountain and is a component of the long-term performance of the Yucca Mountain site. While evidence of such water is an indication of the rate at which water can percolate through the unsaturated zone, it is not evidence of saturation. DOE believes there is no evidence that groundwater beneath Yucca Mountain would ever rise as high as the level of the proposed repository. Section 3.1.4.2.2 of the EIS discusses geologic evidence at the site indicates that during wetter geologic times, groundwater was as much as 120 meters (394 feet) higher than it is today. Nevertheless, this would still be below the level of the proposed repository. Section 3.1.4.2.2 also recognizes that there are opposing views concerning the past elevation of the water table beneath Yucca Mountain. The text summarizes these opposing views and the reasons why DOE does not concur with them.

It is unclear what this comment means by "inconsistent groundwater levels near the site." Section 3.1.4.2.2 of the EIS describes groundwater levels at Yucca Mountain, which have been very stable since site characterization studies began in the early 1980s. If the comment is referring to the large hydraulic gradient north of the site, this feature is described in Section 3.1.4.2.2. An expert panel convened by DOE addressed this issue and narrowed the theories of its origin to two credible scenarios. Under one scenario, the gradient is the result of flow through the upper volcanic confining unit where water moves very slowly. Under the other scenario, the gradient is actually a perched or semiperched water body above the water table where flow is essentially vertical. Under this second scenario, the elevation and location of the perched water could change quickly if it drained downward into the lower volcanic aquifer. The consensus of the panel favored the perched water theory. However, the experts were in agreement that the issue was only of technical curiosity because there is no evidence to suggest that this large hydraulic gradient would affect the performance of the repository.

7.5.3.2 (10464)
Comment - EIS002221 / 0002
The other thing I say is I demand they stop this Yucca Mountain Project because the water has been denied to the project.

The environmental assessment says nothing about, you know, what kind of impact having all these trucks and all this water being trucked in, and without the water, the project is a dead duck, and, you know, if it looks like a duck and walks like a duck, figure it out.

Response
On February 22, 2000, the Nevada State Engineer denied DOE's water-appropriation request for 430 acre-feet of water per year for repository construction and operation. DOE filed suits on March 2, 2000, in U.S. District Court for the District of Nevada, and on March 3, 2000, in Nevada's Fifth Judicial District Court, for injunctive relief to overturn this ruling (Nevada State Engineer's Ruling #4848). The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest.

On September 21, 2000, the U.S. District Court granted the State's motions to dismiss the DOE lawsuit. DOE appealed this ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE's suit. The case is pending.

DOE has not developed any other plans to acquire water for construction and operation of the proposed repository. Depending on the final ruling of the State court, the Department might consider other options to carry out its responsibilities under the NWPA.

7.5.3.2 (10595)
Comment - EIS002147 / 0003
But I do know the water's a thousand foot down. We have radioactive devices right over there at the test site saying they're cooking, will cook for who knows how many thousands of years. They are in the water table. What's going to be stored in Yucca Mountain is not a problem with the water table. Nothing like what's already out there.

Response
Chapter 8 of the EIS evaluates impacts from other Federal, non-Federal, and private actions that could be cumulative with those from the proposed repository. Section 8.3.2.1 addresses the impacts from activities at the Nevada Test Site, including the magnitude of contaminants from past weapons testing that could migrate through the same locations, or pathways, as those evaluated for the long-term performance of the repository.

7.5.3.2 (10711)
Comment - EIS000088 / 0004
We all know in this valley here the water moves. It's not like what the DOE geologists are telling us, it only moves an inch a year.

If it moves more than that. When this earth of ours rotates, what does it do to that water inside of it just like in the jug? That's what it does. It keeps on moving and on moving.

It's got so much radiation in our water throughout the world today, there's no safe water anymore left.

Response
Studies at Yucca Mountain suggest that contaminants in groundwater would travel from the repository to the accessible environment 20 kilometers (12 miles) away in many thousands to tens of thousands of years. It would take even longer for this groundwater to reach natural discharge areas at Franklin Lake Playa more than 60 kilometers (37 miles) south of the repository.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (10756)
Comment - EIS001886 / 0009
Draft EIS does not analyze the potential impact of inundation of the repository zone by upwelling water.

Draft EIS acknowledges that inundation of the repository zone by upwelling water, if happens, would have great impact on the long-term repository performance.[1] The possibility of such inundations was suggested by a number of scientists (Szymanski, 1989; Hill et al., 1995). Draft EIS explicitly states, however, that "DOE does not agree with the inundation scenario" (p. 5-15). This dismissal heavily rests on the findings of the 1992 NAS/NRC panel (National Research Council, 1992). The latter document is outdated, because much new data have became available since 1992. Below we summarize some of this evidence.

Fluid inclusion evidence

By rejecting "inundation scenario", DOE rejects new scientific information indicating the presence of waters with elevated temperature in what is now Yucca Mountain unsaturated zone in the past, obtained by studies of fluid inclusion in secondary minerals.[2] "Justification" of this rejection is given on pp. 3-49 - 3-50 of the Draft EIS as follows: "DOE, given the opportunity to review a preliminary version of the report, arranged for review by a group of independent experts, including U.S. Geological Survey personnel and a university expert. This review group did not concur with the conclusion in the report by Dublyansky (1998 all)..."

The quotation above reflects lack of objectivity in the DOE's handling of the controversy. First, experts who conducted the review for the DOE may hardly be called "independent," since all these scientists were promoting the "non-inundation" scenario for years.[3] Second, it is unfair and misleading not to mention written opinions of three truly independent experts from the Europe (selected for their outstanding scientific expertise in fluid inclusions and non-involvement in the Yucca Mountain studies),[4] attached to the report. All three reviewers concurred in the opinion that the fluid inclusion work is of high quality, and interpretations are reasonable.

Further, the U.S. NWTRB has agreed with the "thermal water" interpretation of the fluid inclusion data.[5]

Finally, a DOE-sponsored verification fluid inclusion research project presently underway at University of Nevada at Las Vegas, UNLV, has already (as of July, 1999) confirmed the presence of the two-phase fluid inclusions, yielding elevated homogenization temperatures in secondary calcite and quartz from ESF.

Other evidence

Besides fluid inclusions, the presence of hot waters in what is now unsaturated zone at Yucca Mountain is suggested by a host of other methods.

a). The USGS geologists inferred elevated, up to 120ºC, temperatures for paragenetically early secondary silica from ESF on the basis of stable isotopic studies.[6]

b). Based on yet another method, structural studies of calcite, Mary Beth Gray with co-authors (contractors to NRC) concluded that calcite in fault rock in the ESF were formed at elevated temperatures (probably, 150-200ºC), and there have been more than one event of calcite deposition (Gray et al. 1998).

c). Terry Else with co-authors (1999) have found viable moderately thermophilic calcite-depositing bacteria (temperatures of habitat 40-60ºC) in calcite sample that yielded homogenization temperatures of 35-50ºC; adjacent bedrock tuffs did not contain such bacteria.

d). Preliminary data on stable isotopic gradients in surficial calcite at Yucca Mountain suggest the progressive evaporation, CO_2 degassing and perhaps cooling -- features consistent with travertine origin and inconsistent with pedogenic origin of these deposits (Dublyansky and Szymanski 1996; Dublyansky et al. 1998). Prof. John Valley, who evaluated this work for the U.S. NWTRB [Nuclear Waste Technical Review Board], concurred with this interpretation (with one reservation that the presence of these trends needs to be verified).[7]

Hydrothermal activity at Yucca Mountain -- Summary

The status of the issue was best summarized by former consultant to U.S. NWTRB, Prof. Robert Bodnar, at the 1999 Spring Meeting of the American Geological Society in Boston, Massachusetts: "Those scientists who have examined the recent data are in general agreement that waters of unknown but, presumably, deep origin have entered the repository horizon at some time during the geologic past.... The problem as it relates to the suitability of Yucca Mountain as a nuclear waste repository concerns the timing of fluid infiltration." (Bodnar 1999).

Elevated temperatures of secondary minerals deposition imply inundation of the Yucca Mountain unsaturated zone by upwelling water, provided two alternative sources of heat -- residual heat of cooling bedrock tuffs and conductive heat transfer from deep-seated magmatic bodies -- are ruled out. In the case of Yucca Mountain this requirement is met. Different researchers at different times have ruled out magmatic rocks as a potential source of hydrothermal activity at Yucca Mountain.[8] Isotopic dating by USGS researchers have shown that the oldest secondary minerals at Yucca Mountain were deposited 2 to 3 million years after the emplacement of the tuffs (Neymark et al. 1998; Whelan and Moscati, 1998), which means the latter have already cooled down.

Timing of hydrothermal inundation

Frequency of occurrence of the hydrothermal activity and, therefore, the probability of its occurrence in the future cannot presently be established with confidence due to lack of the data. The DOE-sponsored Project[9] which is presently underway at University of Nevada at Las Vegas, will, hopefully, substantially advance our knowledge on the timing of hydrothermal activity at Yucca Mountain.

Nevertheless, there is already enough evidence suggesting that thermal fluids were present in the repository zone, constantly or intermittently, during the extended time span of ~9-10 million years, with youngest occurrences being only few thousand years old. These young isotopic ages have been measured for calcite from the ESF by the USGS researchers (e.g., Paces et al. 1996).[10] Based on the preliminary data, the hydrothermal activity has probability of occurrence greater than the lower limit of 1×10^{-8} per year adopted by DOE as the level of concern (DOE 1998, p. 4-81).

Why it is important?

Water is the primary means by which radionuclides disposed of at Yucca Mountain could reach the accessible environment. The present repository concept critically relies upon the following factors: (a) small amounts of water (seepage in repository drifts) that may contact waste canisters; (b) small fraction of waste canisters that would contact with this water (because seepage is restricted to individual fractures); (c) high corrosion resistance of waste canisters in the predicted repository environment (moderate temperatures, oxidizing water, etc.); and (d) long pathway between the repository and accessible environment (including 175 to 365 m of the unsaturated zone beneath the drifts and about 20 km of saturated-zone flow to Amargosa Valley; with dispersal of radionuclides along the way).

However, if inundation scenario is considered, these factors are not the most important ones, for the following reasons:

Amount of water, contacting waste canisters. Instead of small amounts of seepage water contacting some waste canisters, all canisters will be completely submerged in water with composition totally different from today's meteoric water.

Corrosion resistance of waste canisters. Since the composition and the temperature of upwelling water will differ from meteoric water, the present assessment of waste package degradation rates cannot, therefore, be used for such dramatically different environment.[11] Preliminary data indicate that corrosion-resistant component of the base-case canister, alloy C-22, "...is susceptible to localized corrosion...when wet in a critical temperature range. If C-22 remains passive in this range, its anticipated life, prior to penetration, is thousands of years. If it is not passive, then its life, prior to penetration, is as little as a few tens of years" (Whipple et al., 1998).

Long radionuclide pathway. Long pathway of water, contaminated with radionuclides from repository zone through 175 to 365 m of the lower part of the unsaturated zone, and then through some 20 km of saturated zone to the extraction wells in Amargosa Valley, will be replaced by a 200 to 425 m-long "shortcut" right to the land surface, where these waters would discharge as springs.

"Hot repository" consequences. If inundation occurs during the period when the repository zone is still hot due to the radioactive decay (a period that may last several thousand years), the consequences may change dramatically. Much will depend on the temperature of rocks and waste canisters, with which water comes into contact. This temperature will depend on time elapsed since emplacement, as well as the chosen thermal load. A set of scenarios may be constructed for water invasion in the repository zone when: (1) the temperature is well above water boiling point; and (2) when it is below boiling, but still higher than the temperature of upwelling fluids. Vigorous boiling and steam venting may be envisaged for the first scenario and enhanced convection of water for the second. Both these scenarios envisage faster failure of the canisters, thereby enhancing the ability of radionuclides to migrate.

Summary on inundation scenario

We have demonstrated that:

a. There presently exists significant body of evidence, indicating that inundation of the repository zone by upwelling hot waters.

b. The ages of these events are presently not known with certainty; extensive preliminary data indicate, however, that they occurred intermittently between 9 million years and 8 thousand years ago.

c. Based on the present evidence, it is reasonable to conclude that the probability of occurrence of inundation is greater than the 1×10^{-8} per year DOE level of concern, which means that the hydrothermal hazard probabilistic analysis must be carried out.

d. Potential consequences of inundation of the repository filled with high-level nuclear waste may be disastrous for the environment and people.

e. Draft EIS does not consider the inundation scenario.

In our judgement, the failure to consider this important scenario makes the present Environmental Impact Statement completely inadequate and cannot be used for evaluating real environmental impact of the planed facility. "Inundation" issue must be explicitly resolved prior to any decision regarding the fate of the Yucca Mountain site.

[1]"There has been no analysis to determine the effect; however, if such an event occurred, the long term impacts would probably increase greatly." (p. 5-11) [5-15]

[2]Dublyansky and Reutsky 1995 and 1998; Dublyansky et al. 1996; Dublyansky 1998-a and -b.

[3]Authors of the review, arranged by DOE are: J.Whelan, J.Paces, B.Marshall, Z.Peterman, J.Stuckless, L.Neymark of USGS and E.Roedder of Harvard University.

[4]Independent experts who evaluated Dublyansky 1998 report are: Dr. Larryn Diamond, University of Leoben, Austria; Dr. Bruce Yardley, University of Leeds, UK; and Dr. Jean Dubessy, CNRS, France.

[5]"... fluid inclusions found in mineral deposits at Yucca Mountain do provide direct evidence of the past presence of fluids at elevated temperatures ... in the vicinity of the proposed repository" (letter of the Chairman of the U.S.

NWTRB Jared Cohon to Acting Director of the U.S. DOE Office of Civilian Radioactive Waste Management Lake Barrett; July 24, 1998, p. 2)

[6]"Delta-^{18}O values of the silica phases quartz, chalcedony, and opal indicate that some of the early massive-silica-stage phases must have formed from heated water..." Whelan et al. 1998, p.21.

[7]"These trends deserve close examination. If such trends are reproducible and are in fact different from local elevation effects, this would be strong evidence favoring progressive evaporation and COsubscript2 out-gassing (and perhaps cooling) as fluids move down slope." Letter from Prof. J.Valley to L.Reiter of NWTRB; Dec. 18, 1997. p.4.

[8]"Silicic volcanism located close enough to Yucca Mountain to have provided heat to the local hydrologic regime ended more than 11 Ma. Magma bodies below larger calderas (>10 km diameter) cool slowly and may be heat source for up to 2 Ma (Wohlentz and Heiken, 1992). Calculations based on theoretical cooling model (Smith and Shaw, 1978) indicate that magma chambers associated with calderas of the central zone of the Southwestern Nevada Volcanic field would have completely crystallized and cooled to ambient temperature several million years ago." Flynn et al., 1995, p. 27.

[9]The project term begun in April, 1999 and is scheduled to end by April, 2001.

[10]The authors interpret this calcite as being deposited from rain waters percolating downwards through interconnected fractures. Recent results of Dublyansky (1999) and UNLV Committee have shown that 40 to 70 % of calcite from the ESF (including calcite from some occurrences dated by USGS), as well as some quartz, contain two-phase fluid inclusions indicating elevated, up to 60-80ºC, depositional temperatures.

[11]"No rational materials selection can be made without knowledge of the characteristics of the waters in contact with the waste packages. These characteristics include: temperature, pH, Eh and ionic concentrations (Cl, SO_4, NO_3, CO_3, Fe_{all+++}, Ca, etc.)" Third Interim Report of the Peer Review Panel on the TSPA 1998.

Response

In addition to the findings of the 1992 report by the National Academy of Sciences (DIRS 105162-National Research Council 1992), DOE scientists have reviewed documents and data on groundwater inundation that have become available since 1992.

In January 1997, the Nuclear Waste Technical Review Board (NWTRB) received 11 reports from Jerry Szymanski with new information that the Academy had not considered, as well as three additional reports the Nevada Attorney General's Office. The NWTRB reviewed this new information, after which the it concluded: "The material reviewed by the Board does not make a credible case for the assertion that there has been ongoing, intermittent hydrothermal activity at Yucca Mountain or that large scale earthquake-induced changes in the water table are likely at Yucca Mountain. This material does not significantly affect the conclusions of the 1992 NAS report." DOE does not disagree that inundation of the proposed repository with hot water would be a condition adverse to performance, but based on the arguments and information presented in response to specific allegations, DOE scientists do not consider such an event a viable possibility.

With regard to fluid inclusions, the report by Dublyansky (DIRS 104875-1998) ignores all data that are contrary to the thesis of upwelling water. These data form a major part of the basis for rejecting the upwelling or inundation hypothesis. The opinions of three outside experts who were not familiar with all the data pertinent to Yucca Mountain should not be used to unequivocally support the conclusion of Dublyansky (DIRS 104875-1998). The fact that the fluid inclusion data may be of high quality and consistent with Dr. Dublyansky's conclusion does not prove that the conclusion is correct, because other, much different conclusions are also consistent with the fluid inclusion data. Furthermore, a large body of data exists that are in conflict with the inundation theory.

With regard to the NWTRB agreeing with the thermal-water interpretation of fluid-inclusion data, the Board noted that the timing of a thermal event is critical to evaluating the hypothesis of intermittent thermal activity. DOE agrees that there has been past thermal activity, but there is currently no evidence of such activity beyond the early stages of secondary mineral formation, in which case the heat source was probably the igneous activity that formed the southwest Nevada volcanic field. Furthermore, late calcite, as defined by textural, chemical and age determinations, spans at least the past 2 million years and contains no evidence of thermal activity.

With regard to hot water in what is now the unsaturated zone at Yucca Mountain, the early secondary silica referred to is older that 8 million years and is not of concern to the performance of a repository now or in the future.

With regard to the structural studies of calcite by Mary Beth Gray and others, the presence of elevated temperatures within a fault zone, if confirmed, does not seem surprising because frictional heating can be locally important. Furthermore, without a constraint of time, these deposits might have formed close to the time of volcanism when faulting was most active and igneous heat sources were available. The current thermal regime is similar to and perhaps part of the Eureka low, which is an adjoining area of anomalously low heat flow.

With regard to the study by Terry Else and others (1999), this reference was not provided and therefore could not be evaluated. However, as stated above, elevated temperatures do not demonstrate inundation, and the timing of the thermal pulse apparently is not constrained.

With regard to that part of the comment suggesting that travertine did not originate from a pedogenic source, the trend referred to was described by the NWTRB as one of the “Examples [that] include the very tenuous fits of lines to scattered small data sets showing presumed stable-isotope changes with depth and distance.” The Board later concluded that “…because of the lack of any substantive evidence of ongoing hydrothermal activity, the Board views additional research on this subject (if not already carried out) as generally having a lower priority than more important issues in the evaluation of repository performance.”

With regard to Bodnar (1999), DOE scientists who are familiar with the data do not agree with the assertion that the water is of “presumably, deep origin.” Professor Bodnar’s statement is printed in the supplement to *EOS, Transactions of the American Geophysical Union*, dated April 27, 1999. The same abstract notes “if the waters entered the horizon after the Timber Mountain Caldera event (10-13 MA), and if no heated waters have subsequently entered the site, then the fluids have little relationship to assessing the probability of future hot water at Yucca Mountain.” DOE concurs that the early thermal activity described by Professor Bodnar is substantiated by available data.

With regard to the assertion that elevated temperatures of secondary mineral deposition implies inundation of the unsaturated zone by upwelling water, footnote 8, cited in the comment, says “cooled to ambient temperature several million years ago.” The temperatures calculated from fluid inclusions are only slightly above ambient. Thus, secondary minerals could have formed anytime up to several million years ago and still have formed above the modern ambient temperature, which is in accord with DOE’s position. Again, formation at elevated temperature does not require inundation as assumed here. A warm 2-phase environment (unsaturated zone) is in better accord with the observed assemblages of fluid inclusions that have highly variable liquid-vapor ratios than a saturated environment.

With regard to the frequency of occurrence of hydrothermal activity, DOE has developed a very large database on the ages and isotopic compositions of the secondary minerals and is confident that the current geochronologic effort will substantiate current results.

With regard to evidence suggesting that thermal fluids were present in the repository zone, constantly or intermittently, during the extended time span of about 9 million to 10 million years, secondary minerals have formed throughout the last 10 million years. However, no minerals have been found that formed in a saturated environment, and no minerals younger than a few million years have been found that formed at elevated temperatures. Furthermore, available data indicate deposition of secondary minerals during a long-term cooling period, rather than cycles of hydrothermal pulses.

7.5.3.2 (10899)
Comment - EIS000447 / 0007
The natural barriers of Yucca Mountain and its world class engineering will keep it away from the water. I’ve been there, and I’ve heard the comments on water. When they are talking about water, they are talking about a drip in dozens and dozens and dozens in hundreds and thousands of years. This is not a flow of water. This is moisture.

Response
DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (11021)
Comment - EIS001896 / 0018
Section 4.1.3.3

There could be potential impacts on groundwater due to construction, operation, maintenance and closure of the Yucca Mountain facility.

Response
As described in Section 4.1.3.3 of the EIS, DOE expects that the impacts to groundwater during the construction, operation and monitoring, and closure of the repository would be minor. Groundwater pumping for use at the repository would decrease groundwater availability to some extent in downgradient areas. Section 4.1.3.3 points out, however, that the quantity of groundwater that would be needed for the repository would be small compared to the quantities currently being withdrawn in downgradient areas. Therefore, the Proposed Action would have very little effect on the availability of groundwater in these downgradient areas.

7.5.3.2 (11028)
Comment - EIS000475 / 0003
According to DOE, scientific determination of the rate at which water seeps into the Yucca Mountain repository is crucial to the facility's projected ability to meet performance objectives, i.e., containment of the HLRW. Rate of water seepage, according to DOE, directly impacts the period of time waste packages/containers will prevent release of radioactive materials into groundwater as well as the manner radioactive materials will eventually reach the groundwater table beneath the site. Heat generated by the waste within the repository likewise will affect the movement of water through the facility and the durability of the waste containers. Yet, DOE has shown considerable reluctance to scientifically investigate these areas. According to U.S. Geological Survey scientists, the large drop in the elevation of the water table (discovered in 1981) at the northern end of Yucca Mountain is the most striking hydrologic feature in the area and U.S.G.S. lacks data to explain its cause. Yet, no new boreholes and limited testing of groundwater to collect scientific data necessary to explain the hydrology of Yucca Mountain was done by U.S.G.S. for DOE from 1987-1997. In the alternative, DOE observed test pumping in an existing well indicated the drop in the water table at the northern end of Yucca Mountain has no effect on the flow of groundwater in the aquifer underneath the HLRW repository. It sounds like science, however, DOE has failed to investigate/collect data to determine the validity of the agency's preliminary observations concerning the hydrology of the site which is supposedly designed to secure HLRW for 10,000 years! Ref.: NUCLEAR WASTE, IMPEDIMENTS TO COMPLETING THE YUCCA MOUNTAIN REPOSITORY PROJECT, GAO/RCED-97-30, January 1997.

Response
DOE has used many methods to assess percolation or seepage rates in the unsaturated zone at Yucca Mountain and has collected more information on this topic than the EIS can present. The *Yucca Mountain Site Description* summarizes the methods DOE has used to characterize percolation, including generating estimates of percolation flux using borehole temperature and heat-flow data, chloride mass-balance methods, effective hydraulic conductivity or potential gradient methods, calcite accumulation rates, and perched-water volumes and residence times (DIRS 151945-CRWMS M&O 2000). In addition, the Site Description devotes a section to the studies and modeling to characterize how the natural system would respond to the thermal loading associated with the placement of radioactive waste, including thermohydrologic behavior, geomechanics, and geochemistry, as well as the results of thermal field testing in the Exploratory Studies Facility and how results of those studies compare to model predictions (DIRS 151945-CRWMS M&O 2000).

Section 3.1.4.2.2 of the EIS discusses the large hydraulic gradient. An expert elicitation panel addressed this issue and narrowed the theories of its cause to two credible scenarios: (1) flow through the upper volcanic confining unit where water movement is very slow or (2) measuring the surface of a perched or semiperched water system above the water table, where flow is essentially vertical. Under the second scenario, the water level could change quickly by depth and location as water was lost to downward seepage to the lower volcanic aquifer, and would be difficult to interpret. The panel favored the perched water theory. However, the experts agreed that the issue was only one of technical credibility. As stated in the DOE response to the General Accounting Office report referenced in the comment, “there is no evidence that the large hydrologic gradient will impact waste isolation.” Further, the probability of a large transient change in the configuration of the large gradient is extremely low, and the long-term transient readjustment of gradients was of very low probability (DIRS 100116-CRWMS M&O 1996). The Site Description discusses the investigations of the large hydraulic gradient (DIRS 151945-CRWMS M&O 2000).

DOE has conducted an extensive site characterization program to evaluate the proposed repository site at Yucca Mountain. Through this program DOE has gained valuable knowledge of the flow system in the saturated and unsaturated zones. DOE recognizes that additional data would further define and reduce uncertainty about the long-term performance of the repository. The evaluation of the repository’s long-term performance (summarized in Chapter 5 of the EIS) made conservative assumptions where necessary, realizing that information gained from ongoing studies could eventually support less conservative assumptions and estimates of impact. Section 5.2.4 discusses this philosophy for dealing with the uncertainties associated with evaluating the long-term performance of the repository.

7.5.3.2 (11088)
Comment - EIS002273 / 0003
Now, Yucca Mountain is a live mountain. The people that roam that part of the country drink from that mountain. The snake moves -- it’s got a movement to it. It’s going to get worser and worser. I know I have been told by my people long ago, when you are thirsty going through that part of the country, you could suck water from it.

And today the Nuclear Energy Department should realize there is water coming in. They don’t know where it is coming from. But they are saying the rain is the reason why it’s going through the mountain site, but it’s not. It’s a snake that lays there, carries water for the people. But it’s hard for you people to understand.

Response
DOE is required to describe the affected environment and potential impacts from the Proposed Action in widely acceptable scientific terms and parameters. This comment nevertheless presents an apt analogy with respect to groundwater. The scientific facts recognize that water moves through the ground beneath Yucca Mountain, that its movements are complex and accompanied by many uncertainties, and that it makes itself available in this arid environment at springs and at shallow depths to those who understand its movements. Without considering the religious connotations of the comment, it is not difficult to associate these attributes of movement, complexity, and benevolence with a living thing. It is impressive that people, without benefit of data from subsurface exploration, would have historically linked these types of attributes to something they could not see.

Based on years of gathering data, DOE believes that the source of water moving through the unsaturated zone at Yucca Mountain is precipitation falling in the immediate area. The data in Section 3.1.4 of the EIS show that groundwater moving in the saturated zone beneath Yucca Mountain is the result of recharge from precipitation falling locally and in areas upgradient from the site. The data also show that much of the recharge to this underground reservoir probably happened tens of thousands of years ago in this region.

7.5.3.2 (11103)
Comment - EIS002135 / 0009
This DEIS fails to adequately address the seismic and hydrology issues of Yucca Mountain. Five years ago, the DOE was saying that there was no water flow through the mountain and there was no sustained movement in the ground, but now it’s been proven that there is a lot of water migration through the mountain and that the mountain is indeed moving, as the Western Shoshone have claimed all along.

Response
DOE has conducted an extensive program to characterize the seismic hazards in the Yucca Mountain region (see Section 3.1.3.3 of the EIS for details). Using seismic hazard information gathered from this program, surface facilities at the repository that are important to safety would be designed to withstand ground motion from a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain and from a magnitude 7.5 earthquake or greater in Death Valley within 50 kilometers (31 miles) of Yucca Mountain.

Subsurface facilities would be built in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less an effect on subsurface facilities than surface facilities. Inspection of existing tunnels in the Yucca Mountain area has revealed little evidence of disturbance after earthquakes. The subsurface facilities would be designed to withstand the effects of earthquakes during the long postclosure period (thousands to tens of thousands of years).

With regard to groundwater, DOE has conducted an extensive program to characterize the hydrology of Yucca Mountain and its relationship to the regional hydrologic system (see Sections 3.1.4.2.2 and 5.4 of the EIS for details). Extensive studies conducted at Yucca Mountain show evidence of low rates of water infiltration and percolation, long groundwater residence times, and a repository horizon that has been hydrologically stable for long periods of time. The waste emplacement areas are away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Additional fault movements or displacements from postemplacement seismic activity would probably be along existing fault planes.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for additional information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for additional information).

7.5.3.2 (11268)
Comment - EIS001814 / 0003
[Sections] 4.1.3 to 4.1.3.3 Effects on Water Resources

The DEIS consistently underestimates the potential of leaching from the site to adversely impact surface and groundwater in the region. The site drains into the Amargosa River system which drains an area of 3,100 square miles. The area encompassed by these water resources includes Death Valley National Monument as well as many small and growing communities in Nevada and California: Tecopa Springs, Pahrump and Amargosa Valley. Furthermore, the area is subject to flash flooding and volcanic activity which can alter the water courses in unexpected ways. The DEIS minimizes the possibility of high rainfall events and assumes that the meteorology in the area will remain stable for centuries. Such absurd assumptions cannot be used as the basis for a purportedly scientific assessment of the risks to water resources.

Response
Section I.2.2 of the EIS discusses future climates. One of the basic premises of Total System Performance Assessment is that the climate over the next 100,000 years will be considerably wetter than the current climate of Yucca Mountain. DOE built this assumption of wetter conditions into models that simulated infiltration and flux in the unsaturated zone and recharge to, and flow and transport of contaminants in, the saturated zone. These submodels feed into the Total System Performance Assessment to predict the exposure of individuals to radionuclides at specific distances from the repository and at specific future times.

DOE believes Chapter 5 of the EIS and the cited references treat this issue in a balanced fashion, and that further explanation is unnecessary.

7.5.3.2 (11269)
Comment - EIS001814 / 0004
The DEIS sections on the environmental consequences of construction, operation and closure of the proposed facility fail to acknowledge the potential impacts to water resources. Rather, the DEIS assumes that any and all

accidental releases of radioactive waste will be contained immediately and cleaned up promptly throughout the lifetime of the project. Such an assumption defies reality. Further, this renders the DEIS internally inconsistent in that the assessment of potential environmental consequences over the long-term acknowledges that impacts on water will be the dominant impacts. See [Section] 5.10 at [page] 5-49.

Response

The EIS discusses radiological accidents during three phases of the project. Chapter 4 concerns the active phase of the project, when radioactive waste is processed at the surface and placed in the subsurface. DOE does not assume that accidental release of radioactive waste would be contained immediately and cleaned up promptly without consequences. Section 4.1.3.2 specifically discusses the potential for the spread of contaminants to surface waters and Section 4.1.3.3 discusses the potential for the spread of contaminants to groundwater. Furthermore, Section 4.1.8 discusses the impacts from potential accidents during the preclosure period and estimates dose rates to both onsite and offsite populations from a variety of accidents. Appendix H of the EIS contains a detailed description of accident scenarios and consequences, including the analytical methods used to evaluate the accidents.

Section 6.2.4 of the EIS describes accident scenarios during transport of radioactive waste to the repository and described in greater detail in Section J.1.4.

Finally, Chapter 5 of the EIS addresses the environmental consequences of long-term repository performance after closure. Section 5.4 examines waterborne radiological consequences of the repository. This section discusses that over thousands of years the repository would leak small amounts radioactive contaminants, which would then be transported in groundwater to the Amargosa Desert where people could be exposed to radioactivity through the use of this groundwater. Doses to individuals are presented, as well as the risk of contracting fatal cancers. Appendix I contains supporting information on long-term consequences.

In summary, the EIS acknowledges and describes the consequences to water resources from releases of radioactive materials from the repository. The consequences of accidents during the transportation of waste to the proposed repository and during the preclosure phase of the repository would be minimized through the use of controls, monitoring, spill response plans and procedures, and regulatory requirements. Chapter 5 of the EIS discusses that the groundwater downgradient from the repository would be contaminated to some extent due to releases from the repository over the long term (thousands to millions of years after closure). However, DOE believes that the combination of natural and engineered barriers at Yucca Mountain would keep such releases well below the radiation-protection standards at 40 CFR Part 197.

7.5.3.2 (11412)

Comment - EIS002251 / 0010

We have 27 active volcanos that you can see from the top of Yucca Mountain. You may not think they are active, but the Shoshone people, since the 1900's have seen two volcanos erupt there. They have a lot of historic knowledge and we haven't been around long enough. We know now there's 33 earthquake faults, and they have yet to really be consulted with the history around Yucca Mountain and the fact that there have been these recent eruptions -- there's hot springs in the area, which we know the mineral waters migrate; they aren't stable like cool water springs might tend to be.

The people that drilled the Yucca Mountain exploratory hole, quote, said that it is the worst possible material that you could go in. If you go down the hole, you will see areas where the rock is fractured not much bigger than a two-inch gravel, being held back by iron I-beams. And it's like how are you expecting with all of this heat from radioactive waste to keep it from affecting the iron and allowing for a cave-in?

Response

There is no geologic evidence of eruptions from volcanoes in the Yucca Mountain vicinity since the 1900s. Based on extensive research, there are no warm springs in the immediate vicinity of Yucca Mountain. The closest warm springs to Yucca Mountain are at Beatty, 20 kilometers (12 miles) west of the site. Warm springs in the Amargosa Desert to the south are nearly 50 kilometers (31 miles) from the site, although there are warm-water wells about 20 kilometers to the south (DIRS 112530-Flynn et al. 1996).

This comment implies that faults at the site are pathways for hot spring deposits. Flynn et al. (DIRS 112530-1996) conducted a literature review to identify any mention of siliceous or calcareous spring deposits within 80 kilometers (50 miles) of the Yucca Mountain site. Such deposits are indicators of past or present hot-water systems with subsurface temperatures of more than 180°C (356°F). There is no evidence to suggest that thermal fluids have discharged at the surface during the Quaternary Period (the last 1.6 million years).

Data from drilling and excavation of the Exploratory Studies Facility do not support the comment's contentions regarding rock mass characteristics. DOE has not used extensive underground supports throughout the Exploratory Studies Facility, but only where the rock is fractured by closely spaced joints (particularly along portions of the north and south ramps). Ongoing thermal mechanical testing in the Exploratory Studies Facility will provide data that the Department can use as input to repository design. DOE does not anticipate that the heat generated by the waste would affect the integrity of the walls and ceilings of the waste emplacement drifts.

7.5.3.2 (11665)
Comment - EIS000044 / 0001
I am the author of two documents cited in the Yucca Mountain Draft Environmental Impact Statement. Copies of this report are available on the Yucca Mountain home page and portions of these reports have been quoted, and misquoted, in the Draft EIS.

Response
DOE cited the documents referred to by the commenter four times in the EIS, three times in Section 3.1.11.1 and once in Section 4.1.3.3. DOE evaluated information from many sources while compiling the EIS. In considering this comment, the Department verified that the citations in Section 3.1.11.1 to Buqo (DIRS 101542-1996) are accurate and supported by the text. The first citation refers to the purpose of the report as stated in its title. The second citation refers to the perennial yield of 19,000 acre-feet (about 23.4 million cubic meters) for the Pahrump Valley Basin. This quantity is in the table of water budget parameters as cited in the EIS.

DOE has corrected the citation in Section 3.1.11.1 of the EIS from "Buqo (1999, page 34)" to "Buqo (1999, p. 36)." In Section 4.1.3.3 of the EIS, DOE has corrected the citation from "(Buqo 1999, pages 37 and 51)" to "(Buqo 1999, pp. 37, 38, 52)."

7.5.3.2 (11737)
Comment - 010382 / 0001
This is to acknowledge receipt of recent materials referring to the draft environmental impact statement (EIS) for Yucca Mountain. Unfortunately, I was moving to a new job in Oklahoma and did not have time to respond. Your last flyer about the deadline on public comments reached me at my new address after the deadline. But I want to assure you that there is still plenty of opportunity for you to make it into the textbooks as the example of a program manager who allowed the credentials of those who gave him the answers he wanted to hear to trump the math that he did not.

If you refer to the following web site:

http://www.uark.edu/depts/agronomy/scott/research.html

you will find a set of draft papers that describe a new quasi-analytic exact solution to Richards' equation for unsaturated flow. Saying that it is a "general" solution is my mistake, not Dr. Scott's. The approach only works for inflow wetting fronts that are monotonic in space. Nevertheless, it works for a variety of boundary conditions, including constant head and constant inflow in both the horizontal and vertical.

You may recall that Drs. Liu and Bodvarsson claimed that the circumstance of constant vertical inflow demonstrated my work to be non-physical and invalid. Funny thing about that -- the draft papers include a comparison of the vertical constant inflow exact solution to a finite difference model using one of my approaches to Darcian intergrid conductivity means. The agreement is quite good, and can easily be verified by anyone with a sufficient background in graduate-level math. As for my work being physically invalid, it is as physically valid as any exercise in applied math can be. My math does not become non-physical just because I did not seek the almighty permission of your domestic reviewers to get it right. It does not become invalid just because you apparently have neither the background nor the will to challenge your reviewers on the math. It does not become inapplicable just because it may thwart some of the forgone conclusions of the Nuclear Club.

Response
For more than two decades, DOE, along with other Federal agencies, has conducted a rigorous evaluation of the suitability of Yucca Mountain for a geologic repository. During this period, the Department's efforts have been periodically reviewed by the Nuclear Waste Technical Review Board, the National Academy of Sciences and, most recently, the public during the EIS process. The Department appreciates the views and interest of the commenter on this national program.

7.5.3.2 (11745)
Comment - EIS002299 / 0003
In 1989, California's Interagency High-Level Waste Task Force, coordinated on by the California Energy Commission, provided comments on DOE's Site Characterization Plan regarding its adequacy for evaluating potential groundwater impacts in California from the proposed Yucca Mountain project. We identified as a major concern the potential migration of radionuclide contaminants into eastern California aquifers, including the Death Valley groundwater basin, resulting from an accidental radionuclide release at the Yucca Mountain site. We also recommended scientific analyses that were necessary to help evaluate such potential impacts. However, the Draft EIS does not reflect California's recommendations for evaluating these potential groundwater impacts from the proposed repository. We consider the inadequacies of the Draft EIS's discussion and analyses regarding potential groundwater impacts in California to be seriously deficient.

Response
Section 3.1.4.2.1 of the EIS shows that the flow of groundwater from Yucca Mountain is south toward Jackass Flats and the Amargosa Desert, and continues southward to the primary point of discharge at Franklin Lake Playa in Alkali Flat. The EIS recognizes that some groundwater reaching this far might bypass Franklin Lake Playa and continue southward as underflow beneath the channel of the Amargosa River toward surface discharge areas in the channel near Tecopa, California, about 42 kilometers (26 miles) south of Alkali Flat.

In addition, the EIS acknowledges that a fraction of the groundwater flow beneath the Amargosa Desert may flow through the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek Wash area of Death Valley. Several large springs (Texas, Travertine, and Nevares) discharge about 4 million cubic meters (3,250 acre-feet) per year near Furnace Creek Ranch on the east side of Death Valley. It is generally accepted that this spring flow exceeds local recharge and that the water from beneath the Amargosa Desert contributes to the flow. Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and deeper flow in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson 1975). The groundwater in the northwestern Amargosa Desert originates in the Amargosa River drainage in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flowpaths that extend southward from the Yucca Mountain repository area. Even if part of the flow from Yucca Mountain mixes into the carbonate pathway that supplies the Furnace Creek springs, it is too little to noticeably affect the springflow chemistry. Considering the small fraction of water that would infiltrate though the repository (approximately 0.2 percent or less), compared to total amount of water flowing through the basin, and considering the large distances involved [more than 60 kilometers (37 miles) from the source], any component of the flow from Yucca Mountain would be diluted to such an extent that it would be undetectable.

As described in Section 3.1.4 of the EIS, the Death Valley regional groundwater flow system is a terminal hydrologic basin. That is, there is no natural pathway for water (groundwater or surface water) to leave the basin other than by evaporation or transpiration through plants. Death Valley is the low point in the hydrologic basin. A primary focus of the EIS is the evaluation of potential groundwater impacts along this flow path. Chapter 5 of the EIS summarizes the modeling of the long-term performance of the repository. The results show that the combination of natural and engineered barriers at Yucca Mountain would keep doses resulting from such releases well below the regulatory limits established at 40 CFR Part 197.

The farthest distance evaluated in the EIS is at Alkali Flat because that is as far as most of the flow travels. However, it can be clearly seen in the evaluation in Chapter 5 that risks would decrease with increasing distance from the repository. Accordingly, potential impacts to locations beyond Alkali Flat, because they would be farther away on the groundwater flow path, would be less than those for the furthest distance evaluated in the EIS (Alkali Flat). See Appendix I of the EIS and the *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) for additional information.

7.5.3.2 (11935)

Comment - EIS001107 / 0003

The Draft EIS fails to address whether the groundwater in the Franklin Lake Playa and Death Valley areas could migrate to other aquifers in the region. Death Valley is clearly the lowest point in the area, but evidence collected by the Department of Energy (DOE) and presented in the Draft EIS suggests that due to differences in underground pressure water can ingrate upwards. Considering the important of water supplies to both humans and the environment region, much more specific information regarding the ground water flow is necessary before the geologic repository can be recommended. The lack of such information makes it difficult to comment on the Draft EIS because the risks are not clear.

Response

DOE has conducted an extensive site characterization program to evaluate the suitability of Yucca Mountain as the site for the proposed repository. Through this characterization program, DOE has gained valuable knowledge of the flow system in the saturated and unsaturated zones. DOE recognizes that additional data would further define and reduce uncertainty regarding the interactions of the alluvial, volcanic, and carbonate aquifers in the saturated zone.

To establish more confidence in its understanding of the regional and site-scale flow systems, DOE has supported Nye County with development of it's Early Warning Drilling Program. Information from a performance confirmation program (if the site was recommended and approved), could be used in conjunction with that from the Early Warning Drilling Program to refine the DOE understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information, which is described in Section 3.1.4.2.1 of the EIS.

Groundwater beneath Yucca Mountain is part of the Death Valley Regional Groundwater Flow System. As described in Section 3.1.4 of the EIS, Death Valley is a terminal hydrologic basin; that is, there are no natural pathways for groundwater or surface water to leave the basin other than by evaporation or transpiration through plants. The routes and pathways through which the basin's groundwater moves are complex. There are places where several aquifers are on top of one another, and water moves up or down based on the relative pressures in the aquifers. There are also places where water moves horizontally as one aquifer pinches out and another becomes the flow path. These complexities make it very difficult, if not impossible, to know each and every path in the regional flow system. However, there is little uncertainty that the general direction of groundwater flow in the regional system is to the south. Groundwater flows toward Death Valley unless it is removed from the system by evaporation or transpiration, or by man (for example, by pumping).

The general path of the water that percolates through Yucca Mountain is south toward Amargosa Valley, into and through the area around Death Valley Junction and lower Amargosa Valley. Groundwater from beneath Yucca Mountain merges and mixes with underflow from Fortymile Wash and then flows and mixes into the very large groundwater reservoir in the Amargosa Desert, where it is expected to move slowly due to the high effective porosity of the basin deposits in the Amargosa Desert. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa, an area of extensive evapotranspiration, although a minor volume might flow south toward Tecopa into southern Death Valley. A small amount of the groundwater might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains and discharge at springs near Furnace Creek in Death Valley. Sparse potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. Such a divide would limit discharge from the shallow flow system, but not necessarily affect the deeper carbonate flow system that also could contribute discharge to the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and the deeper water in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson 1975). Groundwater in the northwestern Amargosa Desert originates in the Amargosa River drainage in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend southward from Yucca Mountain. Even if part of the flow from Yucca Mountain also mixes into the carbonate pathway that supplies the Furnace Creek springs, it is too little to noticeably affect the springflow chemistry. Considering the small fraction of water that would infiltrate though the repository footprint (approximately 0.2 percent or less) compared to the total amount of water flowing through the basin and the large distances involved [more than 60 kilometers (37 miles) from the source], any component of the flow from Yucca Mountain that flowed in this very long and complicated path would be diluted to such an extent that it would be undetectable.

7.5.3.2 (12132)
Comment - EIS001887 / 0433
The distribution of infiltration across the Yucca Mountain block is questioned. The distribution of infiltration used in the DEIS is highest at the crest. There are indicators which would suggest that peak infiltration is on the western flank of the mountain block. Infiltration in this western block region may be underestimated and its effect unknown.

Response
The infiltration maps of Yucca Mountain were prepared using data from a combination of weather stations, precipitation gauges, soil type/thickness maps, and an extensive network of neutron boreholes. The neutron boreholes are located wherever reasonable access for borehole drill rigs supported the installation of such instrumentation. Due to the steepness of the western flank of Yucca Mountain, installation of boreholes was not attempted. Section 3.1.4.2.1 of the EIS and the references cited in that section contain additional information about water infiltration at Yucca Mountain.

Investigations of the potential for the western side of Yucca Mountain to have significant infiltration are being addressed through activities in the cross-drift. The portion of the cross-drift that underlies the possible high-infiltration zone under the crest of the mountain, and areas under the steep western flank, has been isolated behind dual-bulkheads. The objective of such isolation (that is, free from the influence of tunnel ventilation) is to measure any natural infiltration. These activities will determine whether the present infiltration map of Yucca Mountain requires any modification.

7.5.3.2 (12139)
Comment - EIS001887 / 0431
As we commented on the VA [Viability Assessment], there are serious concerns about the selection of groundwater pathway and its associated hydrologic and geochemical parameters used for compliance assessments. As stated earlier there has been considerable debate over the actual flow paths which would be followed by the radionuclides released from the repository. We most likely have several different groundwater pathways for radionuclide travel and several differing populations to consider in the compliance determination, i.e., Lathrop Wells and Amargosa Valley. These flow path directions range from approximately 90º to 180º south, roughly. The flow pathways are complicated to model accurately, because they are diverse, chemically and hydrologically and could be significantly different in terms of calculating radionuclide transport via the groundwater and concentrations at a given point. Further, EPA [Environmental Protection Agency] has not defined the Critical Group or receptor as yet.

Response
DOE has conducted extensive studies of the saturated and unsaturated zones at Yucca Mountain. But, as pointed out by the commenter and the EIS, the groundwater system in the Death Valley region is very complex and there are areas of uncertainty with respect to its characterization. As with the study of most natural systems, it is simply not possible to know everything. The Department recognizes that the acquisition of additional data would reduce the uncertainty regarding some aspects of the long-term performance of the repository, but also recognizes that some uncertainty is inherent to the process. The approach used by DOE to assess the long-term performance of the repository (summarized in Chapter 5 of the EIS) was to recognize the uncertainties that are important to the assessment and to identify which of these uncertainties could be minimized with additional data and which could not. With respect to those uncertainties that are the result of a data gap, DOE made conservative assumptions where necessary, realizing that information gained from ongoing studies may eventually support less conservative assumptions and less conservative estimates of impacts. The approach for dealing with the uncertainties of long-term performance of the repository is discussed more fully in Section 5.2.4 of the EIS.

DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Regarding the significance of the flow path in modeling the performance of the repository, Chapter 5 of the EIS explains that because groundwater would be the primary mechanism of contaminant transport, the impacts would be along the groundwater flow path downgradient of the repository. Accordingly, the direction of flow is very important in the model. The best available information indicates that the direction of flow is toward the community of Amargosa Valley (formerly known as Lathrop Wells) at about 20 kilometers (12 miles) of the repository site. If a different groundwater flow path were to be assumed, groundwater (and contaminants) would have to travel further to reach a populated area and, accordingly, projected risks to inhabitants of the area would go down. In other words, the groundwater flow direction used in the performance assessment model maximizes the estimated impacts to nearby populations.

The analysis of long-term repository performance contained in the Final EIS is somewhat different than what was described in the Draft EIS. Under direction of the Nuclear Waste Policy Act, as amended (42 U.S.C. 10101 *et seq.*), the Environmental Protection Agency and Nuclear Regulatory Commission are directed to develop standards for the performance of the Yucca Mountain Repository. The analysis in the Final EIS conforms to the final requirements set by the Environmental Protection Agency (40 CFR Part 197). These standards would be used to judge the performance of the repository as part of the Nuclear Regulatory Commission licensing process. The Final EIS includes an individual exposure scenario for the repository as required in 40 CFR Part 197. Under 40 CFR Part 197, an exposed individual is designated as one living at a point of maximum contaminant concentration 18 kilometers (11 miles) from the repository. This person would have a diet and living style representative of people now living in Amargosa Valley, Nevada, and would drink 2 liters of water per day from wells tapping the groundwater at the person's place of residence. The Final EIS (Chapter 5) also addresses a groundwater protection standard established in 40 CFR Part 197. In this case though, specific water standards are to be met by a segment of groundwater identified by volume (that would be used annually by a hypothetical community) and location (with respect to the groundwater flow path from Yucca Mountain) by the regulation. Based on these new standards, the direction of the groundwater flow path has little impact on the ability to show compliance with the Environmental Protection Agency standards because the standards are based on a critical distance from the repository where the contaminant concentrations would be highest (that is, along the flow path, whatever its direction).

7.5.3.2 (12313)
Comment - EIS001521 / 0063
Page 3-52, second paragraph--(Water Source and Movement) Reference the tectonic event and water-table slope figures. Also, water-table gradients are big, small, huge, tiny, and large, etc., but never "steep" as stated. Again, the potentiometric surface discussion in this paragraph, on the rest of this page, and on page 3-53 would be greatly enhanced by showing a simple potentiometric-surface map. The reader could see the described features instead of trying to figure out where they are located by textual descriptions.

Response
DOE has added a figure to this section of Chapter 3 of the EIS to show the estimated potentiometric surface of the Death Valley region.

In response to this comment, DOE has changed the term "steep gradient" to "large gradient."

7.5.3.2 (12314)
Comment - EIS001521 / 0076
Page 4-28, second paragraph--Why introduce a water-level-decline value here (12 centimeters) that was not used in the section 3.1.4.2.2, Ground Water at Yucca Mountain discussion? The maximum decrease discussed on page 3-56, Table 3-16, and in related text was 6 centimeters (calculated below the average deviation about the median). Numbers related to water level declines and/or increases should be consistent throughout the DEIS.

Response
The maximum water-level decrease cited is not inconsistent with Table 3-17, which shows a 12-centimeter (4.7-inch) difference at well J-13. The 6-centimeter (2.4-inch) difference referred to in the last bullet on page 3-56 of the Draft EIS is 6 centimeters below the normal ± 6-centimeter average deviation for well J-13, hence a total of 12 centimeters. Because this caused confusion, DOE has changed the text in Section 4.1.3.3 to show a range of 6 to 12 centimeters, so a comparison to Table 3-17 can indicate that the range of elevation decrease does or does not consider the average deviation.

7.5.3.2 (12402)
Comment - EIS001887 / 0165
Page 3-39; Section 3.1.4.2.1 - Regional Groundwater

The distribution of infiltration across the Yucca Mountain block is questioned. The distribution of infiltration used in the Draft EIS is highest at the crest. There are indicators which would suggest that peak infiltration is on the western flank of the mountain block. Infiltration in this western block region may be underestimated and its effect unknown.

Response
DOE used data from a combination of weather stations, precipitation gauges, soil type/thickness maps, and an extensive network of neutron boreholes to prepare the estimates of infiltration at Yucca Mountain in Section 3.1.4.2.1 of the EIS. DOE placed the neutron boreholes wherever reasonable access for borehole drill rigs supported the installation of such instrumentation. Due to the steepness of the western flank of Yucca Mountain, installation of boreholes was not attempted.

Investigations of the potential for the western side of Yucca Mountain to have significant infiltration are being addressed through activities in the cross-drift. The portion of the cross-drift that underlies the possible high-infiltration zone under the crest of the mountain, and areas under the steep western flank, have been isolated behind dual bulkheads. The objective of such isolation (that is, free from the influence of tunnel ventilation) is to measure natural infiltration. These activities will determine whether the present infiltration map of Yucca Mountain requires modification.

7.5.3.2 (12406)

Comment - EIS002299 / 0006

Inyo County, California, testified before DOE regarding the long-term threat that the Yucca Mountain repository poses to regional groundwater supplies and to communities east of Owens Valley. They noted that hydrologic studies conducted by Inyo County and Nye and Esmeralda Counties in Nevada point to the existence of a continuous aquifer running from beneath Yucca Mountain south to Tecopa, Shoshone and Death Valley Junction. These studies indicate that water flowing beneath Yucca Mountain flows generally south to become surface water and groundwater flowing into Death Valley that is used for commercial and domestic purposes and supports natural habitats. Some of these springs also support populations of a number of threatened or endangered species.

California agencies concluded that DOE should more fully evaluate potential pathways for radionuclides reaching regional groundwater supplies in eastern California, such as in the Death Valley region. The EIS should also evaluate the effect of DOE's proposed groundwater extraction in Jackass Flats on the flow of groundwater to discharge areas of the regional aquifer in California. DOE's proposed groundwater extraction at Jackass Flats will decrease the amount of water that flows through the aquifer and is discharged at down-gradient springs and wetlands. Better data and more realistic models are needed to evaluate groundwater flow and radionuclide migration toward California aquifers. In addition, DOE needs to describe how they will monitor or detect migration of radionuclides from the repository.

Proposed Yucca Mountain design considers the possibility of radionuclide containment failure, and incorporates engineered barriers, as well as reliance on natural barriers to mitigate the consequence of radionuclide leakage. We agree that the possibility of failure should be considered in the repository design, and in the evaluation of potential environmental consequences. However, additional data coupled with more realistic models of radionuclide migration are needed to make an adequate determination on potential impacts. Further, the Draft EIS does not describe future monitoring of groundwater flow with the goal of detecting any migration of radionuclides from the repository. Similar to the status of groundwater transport modeling, there is very limited data that supports only elementary models of barrier performance. These give rise to significant uncertainties regarding long-term performance of each barrier to radionuclide contamination. The degree of scientific uncertainty surrounding the repository appears to be too high to support a reasonable decision on the adequacy of the Yucca Mountain site. These uncertainties include: 1) the corrosion rate of waste packages, 2) disagreement on groundwater levels and aquifer conductivity estimates, 3) the influence of heat on water movement, 4) differing opinions about the solubility and release of radionuclides into the environment, and 5) uncertainty regarding water seepage through the walls of the repository.

Response

DOE recognizes that the groundwater flow path from Yucca Mountain includes the locations identified by the commenter, with the exception of the Owens Valley area. Section 3.1.4.2.1 of the EIS indicates that the primary discharge point for groundwater flowing beneath Yucca Mountain is Franklin Lake Playa in Alkali Flat. The EIS also recognizes that a small amount of groundwater reaching this far might bypass Franklin Lake Playa flow south toward Tecopa, California. A fraction of the groundwater may also flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in Furnace Creek area of Death Valley. Several large springs (Texas, Travertine, and Nevares) in the Furnace Creek Wash area of Death Valley discharge about 4 million cubic meters (3,250 acre-feet) per year near Furnace Creek Ranch on the east side of Death Valley. This springflow exceeds the local recharge, and the water from beneath the Amargosa Desert contributes to the flow. Sparse potentiometric data indicate that a divide could exist in the Funeral Mountains between the Amargosa Desert and Death Valley. Such a divide would limit discharge from the shallow flow system, but not necessarily affect the deeper carbonate flow system that also may contribute discharge to the Furnace Creek area (DIRS 100465-Luckey et al. 1996). Geochemical, isotopic, and temperature data indicate that water discharging from springs in the Furnace Creek area is a mixture of water from basin-fill aquifers in the northwestern Amargosa Desert and the deeper water in the regional carbonate aquifer (DIRS 101167-Winograd and Thordarson 1975). Groundwater in the northwestern Amargosa Desert originates in the Amargosa River drainage in Oasis Valley and from the eastern slope of the Funeral Mountains, both of which are west of the flow paths that extend southward from Yucca Mountain. Even if part of the flow from Yucca Mountain also mixes into the carbonate pathway that supplies the Furnace Creek springs, it is too little to noticeably affect the springflow chemistry. Considering the small fraction of water that would infiltrate though the repository (approximately 0.2 percent or less), compared to total amount of water flowing through the basin, and considering the large distances involved [more than 60 kilometers (37 miles) from the source], any component of flow from Yucca Mountain that traveled in this long and complicated path would be diluted to such an extent that it would be undetectable.

Chapter 5 of the EIS does not specifically address risks in Death Valley National Park from the use and consumption of groundwater. However, the evaluation in Chapter 5 clearly indicates that risks would decrease with increasing distance from the repository. For all closer areas that were examined, modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at Yucca Mountain would keep doses resulting from any releases of radioactive materials within the regulatory limits established by the Environmental Protection Agency in 40 CFR Part 197.

Section 5.9 of the EIS addresses impacts to biological resources during the long-term performance of the repository. As indicated in that section, DOE did not quantify impacts to biological resources from exposures to contaminated groundwater, but related them instead to the minimal impacts likely for humans through the use and consumption of groundwater. Section 3.1.4 of the EIS describes the Death Valley groundwater flow system as a terminal hydrologic basin. That is, there is no natural pathway for water (groundwater or surface water) to leave the basin other than by evaporation or transpiration through plants; Death Valley is the lowest part for the basin. With this in mind, impacts to groundwater in the area east of Owens Valley from the repository would be unlikely. Depending on the specific location of concern, groundwater in Owens Valley would be either outside the Death Valley groundwater flow system (DIRS 100131-D'Agnese et al. 1997), or the groundwater flows toward the Death Valley groundwater flow system. That is, groundwater from Yucca Mountain would have to flow down to Death Valley and then back upgradient to reach areas east of Owens Valley that are outside the Park.

Section 4.1.3 of the EIS addresses the short-term impacts from the extraction of groundwater for construction, operation and monitoring, and closure of the repository. It considers these impacts to be short-term compared to those impacts dealing with the long-term, postclosure performance of the repository discussed in Chapter 5. Section 4.1.3.3 states that groundwater withdrawals at Jackass Flats would, to some extent, reduce the amount of underflow that would reach downgradient areas. However, Section 4.1.3.3 also states that the area first experiencing such an impact would be the Amargosa Desert, and the amount of water required by repository activities would be very small compared to the amount of groundwater already being withdrawn in the Amargosa Desert.

As a result of the monitoring concerns expressed by many commenters, DOE has supported Nye County with it's program (called the *Early Warning Drilling Program*) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the performance confirmation program (if the site is approved for a repository), could be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information, which DOE has incorporated in the EIS in Section 3.1.4.2.1.

Chapter 5 of the EIS describes how DOE modeled the movement of contaminants potentially released from the slow degradation of waste packages in the repository. The model incorporated the slow movement of water in the rock matrix and the relatively fast movement of water along rock fractures and faults. Although the rate at which groundwater moves is important to the model, it is not the only factor that controls the movement of contaminants. Section I.2.4 describes how DOE modeled waste package degradation and how the cladding and waste form degradation models come into play before the contaminants would become available for transport through the unsaturated zone and eventually the saturated zone. It also describes the mechanisms that would affect how these materials would move through the zones, including movement with colloids and the sorption and desorption that would occur as individual radionuclide or chemical species interacted with the rock through which they were moving. The performance assessment model includes these and other parameters in the estimate of impacts to the groundwater and downgradient users of that groundwater.

DOE has conducted extensive studies of the saturated and unsaturated zones at Yucca Mountain. The Department recognizes that the acquisition of additional data would reduce the uncertainty regarding some aspects of the long-term performance of the repository, but also recognizes that some uncertainty is inherent to the process. Section 5.2.4 discusses how DOE dealt with uncertainties concerning evaluations of the long-term performance of the repository. The same section addresses variability issues (as opposed to uncertainties) associated with the natural features of the system being modeled. It describes the techniques, such as sensitivity analysis, used in the modeling effort to analyze various parameter uncertainties and variabilities and to gauge their effects on modeling results. In summary, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.
2. Consideration of features, events and processes that could affect repository performance over the long-term.
3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.
4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.
5. Parameter distributions that represent the possible change of the system over the long term.
6. Use of conservative assessments that lead to an overestimation of impacts.
7. Performance of sensitivity analyses.
8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3.2 (12517)
Comment - EIS000029 / 0001
How can you draft an impact statement when you haven't accounted for all the modeling errors?

Recent work (publications and draft papers on www.aquarien.com) in numerical methods for modeling the vertical unsaturated flow of water in porous media has uncovered previously unrecognized errors in standard methods. These errors may affect the validity and reliability of models that attempt to predict the flow of water and the transport of hazardous and nuclear waste on the scale of tens to thousands of years. The following questions and three-point grid test demonstrate how the common arithmetic mean of intergrid unsaturated hydraulic conductivity violates Darcy's law for vertical unsaturated flow in all but a few trivial conditions, and can even violate the mathematical minimum-maximum principle for elliptic boundary value problems (steady-state flow problems). By contrast, a Darcian intergrid conductivity mean for the exponential pressure-conductivity relation solves such problems perfectly. The numerical examples in the appendix compare parallel models of a relaxing wet pulse in a long, vertical fracture, using the exponential pressure-conductivity relation. One model uses the arithmetic mean, and the other the analytic Darcian mean, with exactly the same adaptive time steps for both. The arithmetic mean model exhibits a dry spike that grows with the logarithm of time, and oscillations similar to numerical dispersion, both associated with space steps where the arithmetic mean can violate the min-max principle. By contrast, the Darcian mean model is smooth and well-behaved.

[Comment included a detailed analytical discussion of modeling methodologies.]

Response
Because conductivity is a function of pressure and saturation, and because saturation and pressure may vary between adjacent nodes or elements, then one must use some average of the conductivities of adjacent elements in a model to calculate the flow between those elements. Warrick (DIRS 155154-1991) and more recently Baker, Arnold, and Scott (DIRS 155155-1999) pointed out that some choices for averaging methods can produce erroneous results, especially arithmetic averages. DOE's unsaturated flow codes do not use arithmetic averages nor most of the averaging methods Baker describes. As discussed in Pruess (DIRS 100413-1991) and Oldenburg and Pruess (DIRS 141594-1993) the appropriate method to use is upstream weighting though specific conditions such as capillary barriers may warrant other choices. Baker, Arnold, and Scott (DIRS 155155-1999) developed methods to resolve the averaging issue, though he points out that upstream weighting does not produce the same errors as most other averaging methods and is efficient computationally. Averaging problems are most severe when the model uses constant pressure conditions between nodes, and there are large pressure differences between adjacent nodes or elements. The unsaturated zone modeling is performed under conditions of specified infiltration rate (fixed-flux, hence flow errors cannot be greater than the fixed flux value), and fine discretization of regions of high-pressure change to mitigate the potential averaging problems. The use of these conditions along with upstream weighting is sufficient to ensure acceptable accuracy in the unsaturated zone simulations.

In summary, DOE has evaluated a wide range of modeling methods and believes that the modeling methods selected are appropriate for long-term performance analyses.

7.5.3.2 (12615)
Comment - EIS001816 / 0001
Section 3.1.4 Hydrology: description of the current system of groundwater flow in the Death Valley region is inadequate at this time because it is based largely on the oversized, data sparse, regional flow model. This model is presently being redone and adjusted to make use of new and ongoing data collection. The understanding of the lower carbonate aquifer hydraulic relationship to overlying volcanic and alluvial units beneath and down gradient of YM is inadequate and necessitates more than a single well test to define the transmissivity of this important, regional unit. The DEIS must do further analysis to determine what information will be collected and analyzed to more completely characterize the hydrologic character and structure of the carbonate aquifer system in the area of the repository footprint.

There is an inadequate to lack of a description of the hydraulic character and sorptive capability for radionuclides in the alluvial units in Fortymile Wash based on actual field data. More information is required and must be collected to determine the ability of this part of the natural barrier system to retard radionuclide migration.

Apparent hydraulic conductivity measurements are not very reliable on a large scale. Until the DOE can perform more hydraulic analysis of units in the vicinity of the repository footprint and downgradient based on multiple well drawdown tests with a pumping well and a monitor well, the apparent hydraulic conductivity values are inadequate. Apparent hydraulic conductivity values must be refined and the level of confidence greatly improved so that groundwater travel times in the repository area can be more reasonably estimated and technically defended.

Response
DOE continues to characterize the saturated alluvium and valley fill and carbonate aquifers south of the Yucca Mountain site. DOE has supported Nye County with it's program (called the Early Warning Drilling Program) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the

relationships among the volcanic, alluvial, and carbonate aquifers. Information from the performance confirmation program (if Yucca Mountain is approved for a repository), could be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

In addition, DOE has installed a series of test wells along the groundwater flow path between the Yucca Mountain site and the Town of Amargosa Valley as part of an alluvial testing complex. The objective of this program is to better characterize the alluvial deposits beneath Fortymile Wash along the east side of Yucca Mountain. Single- and multi-well tracer tests have begun and the results thus far have strengthened the basis of the site-scale saturated flow and transport model. Information from this program has been incorporated in the EIS.

DOE realizes that the data obtained from the Nye County Early Warning Drilling Program are important to an understanding of the saturated zone system and performance assessment calculations south of Yucca Mountain. All data obtained from this program would be used to the extent possible for the enhancement of the saturated zone models. DOE scientists would perform sorption studies on lithologic material extracted from Nye County boreholes for incorporation into the saturated-zone transport model and abstraction into performance assessment calculations. Chemical data would enhance current studies on the understanding of saturated flow systems and various hydrochemical facies. Groundwater elevation data would continue to be determined from all wells and would be used to define flow and transport paths, calibrate models, and support the geologic framework model.

7.5.3.2 (13534)

Comment - 010390 / 0001

Although the S&ER provides detailed hydrogeologic information on the Yucca Mountain site, specific data on the hydrogeology of down-gradient areas is lacking. The final EIS should include any pertinent, hydrogeologic information obtained from the Nye County Early Warning Drilling Program.

More specifically, the hydrogeologic characterization of the carbonate aquifer in the vicinity of the Yucca Mountain repository is insufficient. The characterization, based on data from a single well, is not sufficient to provide a reliable interpretation of basic hydrogeologic parameters such as hydraulic conductivity and ground water flow direction. Further, it is recommended that additional monitoring wells be installed in the carbonate aquifer to further assess the hydraulic conditions within this aquifer, as well as to examine the hydraulic gradient between the volcanic and carbonate aquifers. Additional data would significantly improve the present hydrogeologic model and its ability to predict potential plume migration. The current computer models attempt to predict the fate and transport of radionuclides 10,000 years into the future. However, without an accurate representation of the present hydrogeologic parameters of the aquifer, it is difficult to judge the model's reliability.

Response

Since the Draft EIS was issued, a second well has penetrated the carbonate aquifer in Fortymile Wash (described further in Section 3.1.4.2.2 of the Final EIS). Similar to the first well, water in this second well had an upward hydraulic gradient. DOE nevertheless recognizes that additional information would refine DOE's understanding of the regional groundwater flow system and further reduce uncertainties. To provide additional information, DOE has supported Nye County with it's program (called the Early Warning Drilling Program) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the ongoing site characterization program and from the performance confirmation program (if Yucca Mountain is approved for a repository), would be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

If the Secretary recommends the site to the President, DOE would continue to implement a "performance confirmation program," elements of which would address the hydrologic system. The purpose of this program would be to evaluate the accuracy and adequacy of the information used to determine whether long-term performance objectives have been met. The performance confirmation program, which would continue through closure of the repository (possibly up to 300 years or more), would improve the understanding of the hydrologic system and reduce uncertainties.

7.5.3.3 Seismicity

7.5.3.3 (369)
Comment - EIS000045 / 0002
The draft EIS does not consider the risk of a major subterranean plate shift despite the very recent history of seismic activity. It only considers the actual movement of the ground at the site and the effect it will have on the processing facility and the canisters. The effect of a major plate shift on the water table was not considered. The last 20 years of history shows that the ability to predict such occurrences is not reliable. An example would be (within that 20 years) The earthquake near Arco, Idaho. The valley floor dropped 5 feet or more, water from the under ground aquifer sprang up as springs and lakes that never existed prior. Waverly Person, chief of the US Geological Survey's Earthquake Information Center, says "...There is no scientific way of predicting or forecasting." When speaking about earthquakes.

Response
DOE has maintained a network of water level monitoring boreholes in the area of the proposed repository site and the surrounding region since the early days of site characterization. Observations of water level elevation under normal conditions (that is, not transiently seismically influenced) indicate very minor changes (a few tenths of a meter) annually due to seasonal climatic variation in precipitation in this region. Several of the boreholes record water levels continuously or at short intervals (several times an hour), and thus have recorded the response of the water table to both local earthquakes (Little Skull Mountain, magnitude 5.6) and regional earthquakes (some as large as magnitude 7.3, such as the Landers, California, earthquake, on June 28, 1992) for almost two decades. In general, departures from long-term average water table elevation are minor, usually limited from a few centimeters to, at most, about 1 meter. These changes tend to be short-lived, with most monitored boreholes showing a return to pre-earthquake water levels within a few hours to a few days. In no instance has the network recorded any large permanent departures from pre-earthquake water levels.

DOE has gained additional confidence in this conclusion from other site characterization activities. Evidence from paleodischarge sites in the vicinity of Yucca Mountain and mineralogical data from deep boreholes at the site indicates that at no time in the geologic past has the regional water table been more than about 120 meters (390 feet) higher than it is at present. Given that the general elevation of the proposed repository would be at least 160 and up to 400 meters (520 up to 1,300 feet) above the present water table elevation, effects in response to earthquakes would be expected to be relatively minor and would not pose problems for repository safety.

7.5.3.3 (596)
Comment - EIS000127 / 0013
They consider earthquakes to be strong enough to completely demolish both the waste handling and the waste -- the other waste building that they plan on running the waste throughout there.

They figure both those buildings would collapse in an earthquake on top of the waste that's in 'em, and yet nothing is going to happen to a single one of those holes that they bored through that porous rock that's full of all those holes -- all these fissures per meter. It's not even considered at all.

Response
An extensive seismic hazard analysis was completed in 1998 involving 25 experts from industry, academia, and government. The expert assessments indicate that the geologic fault displacement hazard is generally low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes. The surface and underground facilities at Yucca Mountain are being designed to withstand ground motion from earthquakes. The analysis determined that an annual frequency of 1×10^{-4}, or the 10,000-year earthquake, is an appropriate level for preclosure design of structures that are important to safety. At Yucca Mountain, these structures will be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. For the 10,000-year earthquake, the design motions are dominated by the contribution of

a normal-fault type earthquakes of magnitude 6.3 with an epicenter within 5 kilometers (3 miles) of Yucca Mountain that respond to higher structural frequencies. At lower frequencies, contributions from strike-slip type earthquakes of magnitude 7.5 or greater events in Death Valley [within 50 kilometers (31 miles) of Yucca Mountain] are also important contributors to ground motions. The uncertainties in the magnitude and location of the earthquakes are incorporated into these analyses. DOE regards this annual frequency as appropriate and conservative because it reflects the annual probabilities of design ground motions for nuclear powerplants in the western U.S. In addition, surface facilities at Yucca Mountain pose less risk than nuclear powerplants. Table 4-36 of the EIS presents earthquake-accident scenarios that use an earthquake frequency of once in 50,000 years. This is roughly equivalent to an earthquake of 7 magnitude on the Richter scale within 5 kilometers of Yucca Mountain, with a mean peak ground acceleration of 1.1 *g*, where *g* is acceleration due to gravity (980 centimeters per second squared) at the waste-emplacement depth. These are very conservative calculations that give an indication of the maximum impact of such an event. Subsurface facilities would be built in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less affect on subsurface facilities than on surface facilities. Inspection of existing tunnels in the Yucca Mountain area has revealed little evidence of disturbance after earthquakes. Vibratory ground motion from earthquakes that might occur along faults in the Yucca Mountain region will propagate through the rock at wavelengths that are very long compared to the dimensions of emplacement drifts, boreholes, and fissures. For instance, a 1-Hertz seismic shear wave propagating with a velocity of 610 meters (2,000 feet) per second (an approximate value for the near-surface rocks) has a wavelength of 610 meters; a 10-Hertz wave has a wavelength of 61 meters (200 feet). Even wavelengths as long as 61 meters are much larger than the diameter of the proposed emplacement drifts and any previously drilled boreholes. This implies that significant strains associated with the passage of earthquake-excited seismic waves are not set up across the drifts or boreholes. An excavation tends to move as a unit and therefore the impact is minimal.

7.5.3.3 (724)
Comment - EIS000210 / 0002
It is my hypothesis that as greenhouse gasses continue to be added to the atmosphere over the next several hundred years, global climate change will be exacerbated by ever increasing severe weather events with very large water mass shifts geographically. So what? You might say ... What has that got to do with Yucca Mountain? Well, as the continental plates experience large mass load shifting, does it not stand to reason that there will be an increased incidence of seismic activity? But nuclear power does not produce any CO2, you might add; but it does produce Pu238 which may be released to the biosphere during a seismic cataclysm.

Response
DOE used several geophysical methods, including seismic reflection, gravity, and magnetic surveys, to characterize the subsurface geologic structure of Yucca Mountain. A single magnetotelluric line and several vertical seismic profiles provided supplementary information.

DOE conducted a 32-kilometer (20-mile)-long seismic reflection survey across Bare Mountain, Crater Flat, Yucca Mountain, Midway Valley, and Fortymile Wash. Where this regional profile crosses the repository site, the reflection data show a series of west-dipping normal faults that displace volcanic rocks and the Tertiary/pre-Tertiary contact at depth. DOE collected gravity data along geophysical survey lines and used them to interpret general regional structure and to aid in interpretation of the shallow structure at Yucca Mountain, such as the location and displacement of faults. The Department conducted ground magnetic surveys to infer fault locations and displacements. Because buried faults and geologic heterogeneities at Yucca Mountain are a concern for the long-term performance of the repository, DOE used magnetotelluric methods to detect and characterize these features.

DOE combined information from these geophysical studies with results from other field studies, included extensive surface mapping of geologic features and mapping in the Exploratory Studies Facility. In addition, boreholes provided information on the vertical and lateral distribution of hydrogeologic units, hydrologic properties of the rocks, thermal and other geophysical conditions and properties, chemistry of the contained fluids, pneumatic pressure, and water content and potential. Additional data for some of these parameters came from the excavations for the Exploratory Studies Facility and from boreholes drilled from the drifts or alcoves in the Exploratory Studies Facility.

Using this combined data set, DOE derived detailed geologic and hydrologic models to describe the spatial models of rock layers, faults, rock properties, and mineral distributions in the subsurface and to simulate three-dimensional fluid flow and support site-performance models of Yucca Mountain. For a more complete discussion of site-scale geophysical studies, see Section 4.6.5 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000).

Internal processes in the earth, rather than climate, drive the tectonic plates. The different land and ocean configurations resulting from continental drift, along with the location and height of mountain ranges, that affect the climate occur over thousands of millennia. Conversely, shorter-term climatic variations caused by such things as the Earth's orbital cycle and solar output cycles can occur over decades to thousands of years. These shorter-term changes have the potential to affect the long-term performance of a repository. A number of phenomena affect the energy budget of the atmosphere on short time scales, ranging from decades to several centuries. These events include perturbations such as solar variability, volcanism, carbon dioxide variations, and the El Niño Southern Oscillation. Human-caused increases in carbon dioxide have generated much scientific and public concern, because higher concentrations of atmospheric carbon dioxide act as a trap for outbound long-wave radiation, thus warming the Earth.

The consequences of a warmer Earth will almost certainly result in greater amounts of water vapor entering the atmosphere, which should increase precipitation in some areas. However, it is not known if climate changes affect carbon dioxide levels or vice versa. Section 6.2 of the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) documents the timing, magnitude, and character of past climate changes in the Yucca Mountain area and establishes the rationale for projecting such changes into the future. Based on this information, a model of climate change has been developed in which the modern-day climate at Yucca Mountain would persist for another 400 to 600 years, followed by a warmer and much wetter monsoon climate for 900 to 1,400 years, followed by a cooler and wetter glacial-transition climate for 8,000 to 8,700 years.

The commenter refers to the structural evolution of the site and surrounding area and to tectonic processes operating in the vicinity of Yucca Mountain that have the potential to cause events that could affect the performance of a repository. The commenter is particularly concerned about the possibility of increased seismicity caused by plate tectonics. As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring earthquake activity in the Nevada Test Site region since 1978. The Yucca Mountain Program investigates faults and earthquakes to assess seismic hazards at the site.

DOE recognizes that the effect of earthquakes on a repository at Yucca Mountain is a major concern, and has conducted an extensive seismic hazard analysis. The analysis, completed in 1998, involved 25 experts from industry, academia, and government. The expert assessments indicate that the hazards of geologic fault displacement are low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes. Using this seismic hazard information, DOE would design surface facilities at the repository to withstand the effects of earthquakes that could occur during the lifetime of these facilities. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain. Section 3.1.3.3 of the EIS contains more information.

Subsurface facilities would be built in solid rock. Because vibratory ground motion decreases with depth, earthquakes would affect subsurface facilities less than surface facilities. Inspection of existing tunnels in the Yucca Mountain area has revealed little evidence of disturbance after earthquakes. Sections 3.1.3.3 and 5.7.3 of the EIS contain more information.

After closure of the proposed repository, there would be a limited potential for releases to the atmosphere because the waste is isolated far below the ground surface. The potential for gas transport of carbon-14 was analyzed because the repository host rocks are porous. Modeling shows negligible human health impacts due to releases of gas-phase carbon-14. See Section 5.5 of the EIS for additional information on atmospheric radiological consequences.

7.5.3.3 (856)
<u>Comment</u> - EIS000173 / 0015
Geologic factors, in addition to rapid groundwater flow in the unsaturated zone, increase the risk and uncertainty about loss of waste containment and isolation at the Yucca Mountain site. Seismic risk is said by project officials to be “acceptably low,” but it is acknowledged that the potential exists during the hazardous lifetime of the waste, for the repository to be impacted by an earthquake nearby in the magnitude range of 7.0 to 7.5.

The potential for large nearby earthquakes exists during the operational life of the surface facility of the repository. An unexpected magnitude 5.6 earthquake occurred at Little Skull Mountain, adjacent to the study site in June 1992. This quake was associated with a much larger event in Southern California.

Operation of a nuclear waste repository at Yucca Mountain will require three irradiated fuel pools to facilitate waste transfer operations. The faulting and earthquake history of the area is such that a nuclear power reactor with its irradiated fuel pools could not be licensed there. Therefore, on what basis does the Department intend to locate multiple irradiated fuel pools at the Yucca Mountain site? This unresolved issue is of critical importance.

<u>Response</u>
An extensive seismic hazard analysis was completed in 1998 involving 25 experts from industry, academia, and government. The expert assessments indicate that the fault-displacement hazard is generally low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes. The surface and underground facilities at Yucca Mountain are being designed to withstand ground motion from earthquakes. The analysis determined that an annual frequency of 1×10^{-4}, or the 10,000-year earthquake, is an appropriate level for preclosure design of structures that are important to safety. At Yucca Mountain, these structures would be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. For the 10,000-year earthquake, the design motions are dominated by the contribution of normal-fault type earthquakes of magnitude 6.3 with an epicenter within 5 kilometers (3 miles) of Yucca Mountain that respond to higher structural frequencies. At lower frequencies, contributions from strike-slip type earthquakes of magnitude 7.5 or greater events in Death Valley [within 50 km (31 miles) of Yucca Mountain] are also important contributors to ground motions. The uncertainties in the magnitude and location of the earthquakes are incorporated into these analyses. DOE regards this annual frequency as appropriate and conservative because it reflects the annual probabilities of design ground motions for nuclear powerplants in the western U.S. In addition, surface facilities at Yucca Mountain pose less risk than nuclear powerplants. Tables 4-36 and 4-37 of the EIS present earthquake-accident scenarios that use an earthquake frequency of once in 50,000 years. This is roughly equivalent to a 7 magnitude on the Richter scale within 5 kilometers (3 miles) of Yucca Mountain, with a mean peak ground acceleration of 1.1*g* at the waste-emplacement depth. These are very conservative calculations that give an indication of the maximum impact of such an event.

7.5.3.3 (972)
<u>Comment</u> - EIS000230 / 0001
The recent 7.1 magnitude Hector Mine earthquake of 10-16-99 occurred on the Lavic Lake fault, which was previously mapped by Thomas Dibblee Jr. of the USGS approximately 30 years ago. At the time the fault was not named.

Previous evaluations of the Lavic Lake fault by the California Division of mines and Geology showed the fault had not produced a large earthquake within the last 10,000 years. The Hector mine quake created a rupture of 40 km with a maximum offset of 3.8 to 4.7 meters.

The Landers earthquake, with a magnitude of 7.4, and the Joshua Tree quake occurred 7 years previous to the Hector Mine quake. These three faults are all included in the same fault zone area, and the California Division of mines stated in their report this could not occur, but it did.

The current USGS view is that these faults remain inactive for thousands of years and then become active for several hundred years before returning to quiescence. This information was obtained from various USGS websites.

Could this same pattern of activity occur in the Yucca Mountain area?

The Skull Valley earthquake of June 1992, with a magnitude 5.6 was triggered by the Lander quake. This scenario will occur again.

If the Lavic Lake and Landers faults are creating more stress on the Yucca area faults further and immediate study is needed to determine the new risks and hazards. Just based on Wernicke's work the current DEIS is not sufficient and requires further study.

Response
Since the advent of worldwide seismograph networks, seismologists have observed that many large fault systems around the world remain inactive for long periods and then become active for relatively brief periods before returning to relative quiescence. Periods between major faulting episodes vary and are generally related to rates of large-scale plate motions. This episodic pattern of fault displacements is probably true for the Yucca Mountain region as well, where trenching investigations indicate that many of the faults in the region have relatively long recurrence intervals (time periods between successive displacements). Monitoring of these faults indicate that the seismicity associated with displacement is of low intensity and the recurrence rate is approximately 20 times less than a typical area of comparable size in the southern Great Basin.

There is fairly reliable evidence that the Landers earthquake (magnitude 7.3) triggered the June 1992 Little Skull Mountain earthquake (magnitude 5.6). The evidence suggests that the passage of large surface waves over the pending rupture zone at Little Skull Mountain triggered foreshocks that were followed about 20 hours later by the magnitude 5.6 mainshock. In other words, the surface waves from the Landers earthquake provided the incremental stress required to initiate rupture and, if the Landers earthquake had not occurred, the Little Skull Mountain fault zone would have ruptured at another time.

7.5.3.3 (973)
Comment - EIS000230 / 0002
According to Caltech, since the Hector Mine quake faults have been "talking" to one another. By this they mean that since the Hector Mine quake stress has increased on some faults and decreased on others and at this point it is impossible to tell where the stress has increased. Has it increased in the Yucca Mountain area?

Since the western Mojave desert faults are now "talking" to other faults the public needs to know the consequences. Further study is needed in this area immediately.

Response
The magnitude 7.1 Hector Mine earthquake of October 1999 occurred about 240 kilometers (150 miles) from Yucca Mountain. While it is unlikely that major displacements or changes in the stress field at Yucca Mountain were associated with this earthquake, it would require a resurvey of the 14-station geodetic network that the U.S. Geological Survey installed in 1983 to be able to make a quantitative statement. The geodetic network would not be sensitive to any rigid-body motion of the network as a whole, but would have to experience relative station-to-station displacements (strains) above ambient noise levels.

Ground accelerations recorded at a network of three-component strong-motion instruments operating in the Yucca Mountain area during the Hector Mine earthquake did not exceed 0.014*g*, where *g* is acceleration due to gravity (980 centimeters per second squared). These levels of acceleration are more than 10 times smaller than the anticipated earthquake-design levels for surface and underground facilities at the repository.

7.5.3.3 (977)
Comment - EIS000230 / 0006
One must also consider what a magnitude 7 earthquake would do to the Yucca Mountain area. It would certainly disrupt road and rail lines as well as power and communications.

Response
In 1998, 25 experts from industry, academia, and government completed an extensive seismic-hazard analysis of the Yucca Mountain area. These assessments indicate that the fault-displacement hazard at Yucca Mountain is generally low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes. Using the seismic hazard information, the surface and underground

facilities at Yucca Mountain are being designed to withstand ground motion from earthquakes. The analysis determined that an annual frequency of 1×10^{-4}, or the 10,000-year earthquake, is an appropriate level for preclosure design of structures that are important to safety. At Yucca Mountain, these structures would be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. For the 10,000-year earthquake, the design motions are dominated by the contribution of a normal-fault earthquakes of magnitude 6.3 with an epicenter within 5 kilometers (3 miles) of Yucca Mountain that respond to higher structural frequencies. At lower frequencies, contributions from strike-slip type earthquakes of magnitude 7.5 or greater events in Death Valley [within 50 kilometers (31 miles) of Yucca Mountain] are also important contributors to ground motions. The uncertainties in the magnitude and location of the earthquakes are incorporated into these analyses. DOE regards this annual frequency as appropriate and conservative because it reflects the annual probabilities of design ground motions for nuclear powerplants in the western U.S. In addition, surface facilities at Yucca Mountain pose less risk than nuclear powerplants.

Earthquakes can disrupt power transmission, communications, roads, and rail lines. Tables 4-36 and 4-37 of the EIS present earthquake-accident scenarios that use an earthquake frequency of once in 50,000 years. This is roughly equivalent to a 7 magnitude on the Richter scale within 5 kilometers (3 miles) of Yucca Mountain, with a mean peak ground acceleration of 1.1*g*, where *g* is acceleration due to gravity (980 centimeters per second squared) at the waste-emplacement depth. These are very conservative calculations that give an indication of the maximum impact of such an event. Appendix H contains additional analysis of accidents due to seismic activity.

7.5.3.3 (1045)

Comment - EIS000315 / 0002

Speaking of shake and bake or the ground movement when nuclear waste is present, the earthquake issue continues to astound us Nevadans, and I was surprised to hear that there's no definitive answer that was given today about what standard the repository is going to be designed for, whether it's a 6.5 or whether it's other standards; those still haven't been made yet. And you know why? It's because of the same thing, you know, that what we've heard earlier. Just like the groundwater travel time, once they find that -- Standards are set, but once the mountain can't meet those standards, they go back and change the standards. Well, at least with earthquakes, you know, now you're not going to set them yet; first, you're going to see what the math would be, and then you're going to say, "Oh, our repository can withstand that." You know, also just last week, only a short distance from Yucca Mountain in the Mojave Desert, we had a 7.0 earthquake. High-rise buildings in Las Vegas were evacuated. A train was forced off of its tracks.

Response

DOE has not proposed to "change the standards" in 10 CFR Part 960 by which the suitability of the Yucca Mountain is evaluated. Rather, the purpose of the new Yucca Mountain-specific guidelines (10 CFR Part 963) is to implement the NWPA, consistent with the current regulatory framework and technical basis for assessing the ability (or performance) of a geologic repository to isolate spent nuclear fuel and high-level radioactive waste from the environment.

The Nuclear Waste Policy Act of 1982 [Section 112(a)] directed the Secretary of Energy (and by extension, DOE) to issue general guidelines for the recommendation of sites for characterization, in consultation with certain Federal agencies and interested Governors, and with the concurrence of the NRC. These guidelines (issued in 1984 at 10 CFR Part 960) were to include factors related to the comparative advantages among candidate sites located in various geologic media, and other considerations such as the proximity to storage locations of spent nuclear fuel and high-level radioactive waste, and population density and distribution.

In 1987, amendments to the Nuclear Waste Policy Act specified Yucca Mountain as the only site DOE was to characterize. For this reason, DOE proposed in 1996 to clarify and focus its 10 CFR Part 960 guidelines to apply only to the Yucca Mountain site (which would be codified at 10 CFR Part 963), but never issued these guidelines as final. In 1999, DOE proposed further revisions to the draft Part 963 guidelines for three primary reasons:

1. To address comments that criticized the omission of essential details of the criteria and methodology for evaluating the suitability of the Yucca Mountain site.

2. To update the criteria and methodology for assessing site suitability based on the most current technical and scientific understanding of the performance of a potential repository, as reflected in the DOE report, *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998).

To be consistent with the then-proposed site-specific licensing criteria for the Yucca Mountain site issued by the Nuclear Regulatory Commission (the Commission has since finalized these criteria at 10 CFR Part 63), and the then-proposed site-specific radiation protection standards issued by the Environmental Protection Agency (the Agency has since finalized these standards at 40 CFR Part 197). DOE issued final 10 CFR Part 963 in 2001.

Earthquakes can disrupt power transmission, communications, roads, and rail lines. Table 4-35 of the EIS presents earthquake-accident scenarios that use an earthquake frequency of once in 50,000 years. This is roughly equivalent to a 7 magnitude on the Richter scale within 5 kilometers (3 miles) of Yucca Mountain, with a mean peak ground acceleration of 1.1*g*, where *g* is acceleration due to gravity (980 centimeters per second squared) at the waste-emplacement depth. These are very conservative calculations that give an indication of the maximum impact of such an event. Appendix H contains additional analysis of accidents due to seismic activity.

7.5.3.3 (1070)
<u>Comment</u> - EIS000287 / 0003
Furthermore, is it genuinely a better move to place waste in an area which is rocked with considerable seismic activity?

<u>Response</u>
In 1987, Congress selected Yucca Mountain as a potential location for a monitored geologic repository, and directed DOE to determine whether the site is suitable. Some of the reasons Congress selected Yucca Mountain for study include a deep water table, favorable geology, a desert environment, and the fact that the Nevada Test Site is already a controlled area. Based on the results of analyses reported in Chapter 5 of the Draft EIS, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with the Environmental Radiation Protection Standards for Yucca Mountain, Nevada, 40 CFR Part 197. DOE also believes that the impacts of leaving the waste at 77 sites throughout the country (the No-Action Alternative) outweigh the impacts of permanent disposal at Yucca Mountain. See Section 2.4 of the EIS for more information.

7.5.3.3 (1375)
<u>Comment</u> - EIS000432 / 0003
The DOE also wants the construction and emplacement of waste packages in a mass of volcanic rock. Again the DOE states that it is "unlikely" that any additional silicic activity would occur. However in 1992, there was an earthquake at Little Skull Mountain measuring 5.6 on the Richter scale. Little Skull Mountain is located 12 miles southeast of the proposed site. Of course the DOE estimates that after closure there is a 1 in 7,000 chance of volcanic disruption for the first 10,000 years. But how long does it take before this spent nuclear fuel and radioactive waste is no longer hazardous or dangerous to humans and the environment?

<u>Response</u>
As discussed in Section 3.1.3 of the EIS, Yucca Mountain consists of lithified volcanic ash that fell and flowed onto the site from eruptions of calderas to the north of the site (see Figure 3-5 and Table 3-7). These explosive volcanic eruptions occurred during development of the Southwestern Nevada volcanic field. Basaltic volcanism that began later marked the end of the period of explosive volcanic eruptions. These basaltic eruptions originated deep in the upper mantle and flowed onto Crater Flat. DOE's estimate of a 1-in-7,000 chance of volcanic disruption of the repository during the first 10,000 years is based on detailed investigations of the basalts. This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

Section 3.1.3.3 of the EIS describes the Little Skull Mountain earthquake, which occurred in an area of persistent recent seismicity that has been monitored by instruments in the Southern Great Basin Seismic Network. This might be a zone of stress concentration, accommodating strain from fault systems throughout the south central Nevada Test Site area. This earthquake appears related to the Rock Valley fault system and not to any volcanic or magmatic activity.

Section 5 of the EIS describes the components and summarizes the results of DOE's assessments of long-term repository system performance over the 10,000-year period of regulatory interest and for the longer 1-million-year period for potential volcanic events. The performance assessments considered the inventory of long-lived radionuclides and their potential pathways to the accessible environment. The analysis of long-term repository performance shows that the combination of natural and engineered barriers at the site would keep doses resulting from any releases of radionuclides well below the regulatory limits established by the Environmental Protection Agency in 40 CFR Part 197. While the potential consequence (dose) related to a volcanic event can never be completely eliminated, it would be greatly diminished after 1,000 years. Section 5.7.2 of the EIS presents the annual risk over a 10,000-year period.

7.5.3.3 (1475)
Comment - EIS000485 / 0003
The reactors where the waste is now stored are licensed by the NRC [Nuclear Regulatory Commission] and are on solid, stable ground with negligible earthquake activity. By contrast, the area where they propose to ship the waste is among the most seismically active in the country and would not meet the same NRC licensing standards for reactors. Since site characterization studies for the Yucca Mountain dump began, there have been dozens of earthquakes, including a magnitude 5.2 quake in 1992 which caused over a million dollars in damage to government buildings at the Yucca Mountain site. There have been 621 seismic events of a 2.5 magnitude or greater in the last 20 years.

Response
DOE recognizes that the effect of earthquakes on the proposed repository at Yucca Mountain is a major concern, and has conducted extensive analyses. The EIS analyzes the probability of earthquake occurrence and the environmental consequences. To support this analysis, DOE and the U.S. Geological Survey performed a comprehensive evaluation of the seismic hazards in the Yucca Mountain region using standard practices of mapping, trenching, age-dating, and monitoring of contemporary seismicity. Then DOE-sponsored groups of experts from inside and outside the Project used this site data to assess the seismic hazard potential of major seismic sources in the region. Another group of experts used numerical modeling methods and data from recent earthquakes to estimate ground motion attenuation relationships appropriate for Yucca Mountain.

Using the seismic hazard information, DOE would design repository surface facilities to withstand the effects of earthquakes that could occur during the lifetime of these facilities. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

DOE has determined that an annual frequency of 10^{-4}, or the 10,000-year earthquake, is an appropriate level for preclosure design of structures important to safety, so it would design these structures to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. DOE regards this annual frequency as appropriate and conservative because it reflects the annual probabilities of design ground motions for nuclear powerplants in the western United States. (Originally, utilities developed design bases for nuclear powerplants deterministically, but recently have determined the annual probability of design events. The range is 10^{-3} to 10^{-4}.) The annual frequency of 10^{-4} is more conservative than that for the powerplants licensed by the Nuclear Regulatory Commission. Also, surface facilities at Yucca Mountain would be inherently less dangerous facilities.

DOE would build subsurface facilities in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less effect on subsurface facilities than surface facilities. Inspections of tunnels in the Yucca Mountain area have revealed little evidence of disturbance following earthquakes. DOE would design the subsurface facilities and waste package to withstand the effects of earthquakes for the long-term performance of the repository.

Recent earthquakes at Scottys Junction, Nevada [August 1, 1999, magnitude 5.7, about 80 kilometers (50 miles) from Yucca Mountain] and at Hector Mine, California [October 16, 1999, magnitude 7.1, about 250 kilometers (155 miles) from Yucca Mountain] had no effects at Yucca Mountain. These events produced ground motions recorded at Yucca Mountain that were more than 20 times smaller than seismic design motions for the proposed surface facilities, as would be expected given their distance from the site. The Scottys Junction earthquake had a similar magnitude, depth, and normal focal plane solution as the Little Skull earthquake in 1992, which was the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain (a Richter magnitude 5.6). The Little Skull Mountain earthquake, with an epicenter 20 kilometers (12 miles) to the southeast, caused no damage at Yucca Mountain. It did damage the Yucca Mountain Field Operations Center in Jackass Flat, about 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic-design specifications planned for surface facilities at Yucca Mountain. This earthquake caused less than $100,000 damage, although DOE spent additional funds on structural modifications to bring the building into compliance with existing codes. The Department would design Yucca Mountain facilities for a similar earthquake centered near the site. Section 3.1.3.3 of the EIS contains more information.

7.5.3.3 (1484)
Comment - EIS001521 / 0023
Page 3-29, 3.1.3.3 MODERN SEISMIC ACTIVITY, first paragraph--References are needed for all the assertions made in this paragraph. For instance, it is not common knowledge that regional earthquake epicenters do not correlate with Quaternary faults in the Yucca Mountain area (a figure would also be nice).

Response
Section 3.1.3 of the EIS is based on information contained in the *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000). DOE cited this broad-based reference in the EIS because it has collected an enormous amount of baseline environmental data that are contained in many separate reports. To cite a separate report in the EIS each time a reference to such a report was made would have been very cumbersome for the reader. Instead, the Department cited the *Yucca Mountain Site Description,* which references these other, detailed reports.

With respect to the example cited by the comment ("...regional earthquake epicenters do not correlate with Quaternary faults in the Yucca Mountain area..."), this statement is from Section 12.3.5 of the Site Description. This reference supports the assertion with a figure showing epicenters and focal mechanisms of earthquakes and known and suspected Quaternary faults near Yucca Mountain. DOE agrees that such a figure would be of interest to readers with specific interest or expertise in seismic activity, but DOE believes that this level of detail is not needed for the EIS.

7.5.3.3 (1520)
Comment - EIS000474 / 0001
People who do not understand geology, and who believe one state is like another, as long as it is land, are likely to seize upon Circular 1184 as indication that Yucca Mountain would be feasible for radioactive waste burial. But the one thing DOE, nor any other organization, could not possibly prepare against is a catastrophic event. Such cannot be predicted or prepared for, and when the time came it would be too late. This is a catastrophic event country. This is the wrong kind of an environment for such burial. The likelihood of catastrophic events is too great for such a major risk. I believe the Survey needs to point out the risks to the people of this country. And the million of dollars already spent at Yucca Mountain has largely been a waste of funds. That site is one of the worst decisions ever made by Congress, for it does not consider geology.

Response
DOE prepared this EIS under the requirements of the Nuclear Waste Policy Act and consistent with the National Environmental Policy Act, and the regulations of the Environmental Protection Agency and the Nuclear Regulatory Commission related to the proposed repository. Geologic stability is one of many criteria that DOE applied in consideration of the Yucca Mountain site.

The EIS analyzes impacts that could arise from catastrophic natural events such as earthquakes and volcanic activity. While DOE cannot predict such events exactly, it can deal with them statistically and incorporate them in the risk analysis. Chapter 5 of the EIS contains an assessment of the probability and effect of such events on long-term radionuclide release and the resultant impacts. The consideration of the combined likelihood and consequences of such events indicate the potential risk.

7.5.3.3 (1832)
Comment - EIS000206 / 0011
Question that is not answered by DOE: Seismic activity -- a particularly important issue in relation to interim storage -- continues to be very active. Yucca Mountain, and the NTS, lie within the second most active seismic area in the continental United States. Well over 600 earthquakes registering over 3.0 on the Richter scale have been recorded in the area in the past twenty years.

Response
DOE does not plan to construct or use interim storage facilities at the proposed repository at Yucca Mountain. The Department would design surface facilities at the repository to withstand the effects of earthquakes that could occur during the lifetime of these facilities. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain. Section 3.1.3.3 of the EIS contains more information.

In addition to these seismic design requirements, DOE evaluated sixteen accident scenarios for the repository, including the potential for seismic events beyond the design basis. Of these scenarios, the maximum reasonably foreseeable accident was a seismic event, beyond the design basis, with an annual frequency of occurrence of 2×10^{-5} (once in 50,000 years) that results in the collapse of the Waste Handling Building and damage to 375 fuel assemblies. Details of the accident analysis are presented in Section 4.1.8 of the EIS.

7.5.3.3 (2009)
Comment - EIS000559 / 0002
If you put it in, it will affect the ground water, which will affect the whole state, even nearby states. If we have earthquakes, they will go into the water.

If we have an earthquake as well, it can also affect it into the air. And that will affect Idaho, it will affect Oregon, it will affect California, it will affect us.

Response
As discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring earthquakes in the Nevada Test Site region since 1978. The site characterization program studies faults and earthquakes to assess seismic hazards at the site. DOE used panels of experts with access to all available information to complete a probabilistic seismic-hazard assessment. The results of this study indicated that the probability of reactivating faults at the site is very small. Additional fault movements or displacements from postemplacement seismic activity probably would occur on existing fault planes. Using the seismic-hazard information, DOE would design repository facilities to withstand the effects of earthquakes that could occur during the lifetime of the facilities. The seismic-design requirements for the repository specify that structures, systems, and components important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years).

There is no direct relationship between earthquake occurrence and potential radionuclide releases from the waste package. The current design calls for waste packages to be placed on pallets and not in boreholes drilled into the repository walls or floors. If an earthquake occurred at or near the site, fault displacements would not result in waste package failure because the emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Calculations show that there would be almost no effect on repository performance from rockfall by vibratory ground motion.

DOE based its hydrology models, derived from extensive studies conducted at Yucca Mountain, on a fault-fracture dominant flow system. The hypothetical addition of new faults would have very minor or no effect on the current fault and fracture flow pathways. Such potential faults and fractures, therefore, would be unlikely to alter repository performance.

As discussed in Section 3.1.4 of the EIS, Yucca Mountain is in a closed hydrologic basin. Surface water and groundwater can leave the basin only by evapotranspiration. The regional slope of the water table (potentiometric surface) indicates that groundwater flows southward toward Amargosa Valley. The Central Death Valley subregion is comprised of three groundwater basins that are subdivided into smaller sections. Yucca Mountain is in the Alkali Flat-Furnace Creek groundwater basin. In this basin only a small portion of total basin recharge actually infiltrates through Yucca Mountain. The small fraction of water that does infiltrate and becomes groundwater recharge and then flows towards Fortymile Wash and discharges with the rest of the groundwater in the Fortymile Canyon section of the groundwater basin. Flow then continues south toward Amargosa Valley in the Amargosa River section as shown in Figure 3-13 of the EIS. The natural discharge of groundwater from beneath Yucca Mountain is probably farther south at Franklin Lake Playa more than 60 kilometers (37 miles) away and therefore would not affect groundwater in the entire state. Modeling of the long-term performance of the repository shows that the combination of natural and engineered barriers at the site would keep such a release small enough to pose no significant impact on the health and safety of people or the environment. See Section 3.1.4.2.2 and 5.4 of the EIS for additional information.

After closure of a proposed repository, there would be a limited potential for releases to the atmosphere because the waste would be isolated far below the ground surface. The potential for gas transport of carbon-14 was analyzed because the repository host rocks are porous. Modeling analyses show negligible human-health impacts due to releases of gas-phase carbon-14. See Section 5.5 of the EIS for additional information on atmospheric radiological consequences. DOE does not expect any health effects due to atmospheric releases in Oregon, Idaho, and California. Moreover, there is no indication that the vibratory ground motion and fault-displacement hazard would affect these analyses.

7.5.3.3 (2031)
Comment - EIS000564 / 0004
And that also brings us to the earthquake question. Last month only a short distance from Yucca Mountain in the Mojave Desert, a 7.0 earthquake forced a train to jump from its tracks and some high rise buildings were evacuated in Las Vegas, even though the earthquake occurred about 150 miles away.

Now the earthquake specifications for Yucca Mountain are still being talked about. And that brings us to the point of standards.

Response
As mentioned by the commenter, on October 16, 1999, the magnitude 7.1 Hector Mine earthquake occurred in the Mojave Desert approximately 240 kilometers (150 miles) from Yucca Mountain. Peak ground accelerations recorded in the Yucca Mountain area during that earthquake did not exceed 0.014*g*, where *g* is acceleration due to gravity (980 centimeters per second squared). These levels of acceleration are more than 10 times smaller than anticipated design levels for the surface and underground facilities at the repository, which would, therefore, withstand the effects of ground motion from earthquakes of this size at that distance. The design basis earthquake for ground motions in the frequency range 1 to 2 hertz corresponds to earthquakes of magnitude 7 or larger at a distance of about 48 kilometers (30 miles).

7.5.3.3 (2199)
Comment - EIS000608 / 0001
Nevada per area square miles is probably the most seismic state in the nation. This is an extension area here that as the earth cools off, there are going to be more problems form or you have more earthquakes happening.

This is ridiculous that they want to bury nuclear waste here. It really is. They should put it out in the plains of Nebraska or something where it's more stable.

Response
The State of Nevada ranks third, behind Alaska and California, in terms of seismic activity. Its reputation as a highly active state comes primarily from the occurrence of major historic earthquakes (a Richter-scale magnitude of 7 or higher) along the Central Nevada Seismic Belt in western Nevada (DIRS 151945-CRWMS M&O 2000). This seismic belt, which is characterized by geologically young faults, appears on seismicity maps to be an extension into Nevada of fault systems in southwestern California (such as the Death Valley-Furnace Creek fault system). The Central Nevada Seismic Belt splits near the California-Nevada border. One belt of seismic activity enters the Reno-Carson City area, and the other belt heads approximately due north from the border and crosses the western tip of Nye County on its way to central Nevada. While earthquakes do not occur at regular intervals, the average

frequency of magnitude 6 and greater earthquakes in western Nevada is about one every 10 years, while earthquakes of magnitude 7 and greater average about one every 27 years.

In contrast, the largest recorded earthquakes within 100 kilometers (60 miles) of Yucca Mountain were the June 29, 1992, magnitude 5.6 Little Skull Mountain earthquake, and the August 1, 1999, magnitude 5.7 Scottys Junction earthquake. DOE recognizes the potential seismic hazard at Yucca Mountain and has conducted extensive geologic and geophysical investigations in the region over the past 20 years. More than 50 trenches have been excavated along mapped faults in the Yucca Mountain area. The data obtained from trenching indicate that the faults have not ruptured the surface for thousands of years. In 1998, the Project ended a multiyear study of the seismic hazard at Yucca Mountain. This study involved 25 earth scientists from academia, industry, and government who reviewed project data and information from many organizations and arrived at an estimate of the hazard associated with ground motion and fault displacement at Yucca Mountain. This estimate, in conjunction with targeted geotechnical investigations (to define the properties of the rocks close to the surface), will form the seismic-design bases of surface and underground facilities at Yucca Mountain that are important to safety.

7.5.3.3 (2256)

Comment - EIS000362 / 0001

I want to relate a little story of living over here and the kind of geology we have. I had the pleasure a year or so ago of having a couple of Ph.D. geologists stay with me and my wife at our home, which overlooks the Owens Valley. Over a period of a couple days, they spent most of their time out on our terrace discussing what they saw, discussing earthquake faulting, discussing -- who knows what they were discussing. It wasn’t real clear to us what they were discussing. But after a couple days of this, two white-haired Ph.D. geology professors, both worked for the oil companies at one point in their lives, my wife asked one of them, the older one, she says, “So, Claude, what is it you see when you look out here at what’s around this area in the Owens Valley?” He says, “I see a real mess.” And it seems to me that says a lot about what you can know of geological processes and about what’s out here, and what’s here between here and Yucca Mountain, and that that should temper the kind of judgments you make about how stable and how reliable the country is for what’s being proposed to be done to it.

While you’re here, if you haven’t done so already, I would urge you to go about one-third of a mile up the road and visit the graveyard of the earthquake for the victims of the 1872 earthquake in Lone Pine, which I don’t see in your Draft EIS. It was one of the two or three, or perhaps, the largest earthquake ever in the United States. It would certainly have been very well felt at Yucca Mountain.

And I’m troubled that you’ve limited your earthquake evaluation to 30 kilometers of the mountain. We know. We feel them all the time, large earthquakes, and we’re only 100 miles by air from Yucca Mountain. I would like to see that scale in time and space of your evaluation relative to hydrology and volcanism and earthquakes expanded to an area that certainly could impact the Yucca Mountain site in the not-too-distant future.

Response

The region of interest for assessing seismic hazards at Yucca Mountain is a function of earthquake magnitude and the rate of earthquake occurrence. Because earthquake ground motions lessen with distance, the farther an earthquake occurs from Yucca Mountain, the larger it must be to contribute significantly to the hazard at the site. At a distance of 100 kilometers (62 miles) from Yucca Mountain, earthquakes must reach an estimated magnitude of about 8 on the Richter scale to produce horizontal accelerations of $0.1g$, where g is acceleration due to gravity (980 centimeters per second squared), at the site (DIRS 151945-CRWMS M&O 2000).

Although the focus of the seismic hazard analysis was the area within 100 kilometers (62 miles) of Yucca Mountain, the analysis also considered the historic seismicity between 1868 and 1996 within 300 kilometers (about 185 miles) of Yucca Mountain. This extension of the area of consideration includes many of the major historic earthquakes in California, including the 1872 Owens Valley earthquake, and enables an evaluation of the seismicity of the Yucca Mountain vicinity within a broader regional context. This approach was the basis for the characterization of background earthquakes as part of the probabilistic seismic hazard analyses (DIRS 151945-CRWMS M&O 2000).

7.5.3.3 (2701)
Comment - EIS000956 / 0005
This site should be rejected as unsuitable since it is classified in the highest risk category for earthquakes. Further, it will not retain radioactive gases, such as Carbon-14 and thus cannot meet the original repository standards set by the EPA. IT ALSO SITS ON TOP OF A MAJOR AQUIFER SHARED BY A NEARBY FARMING COMMUNITY, INCLUDING A LARGE DAIRY, SERVING LOS ANGELES MARKETS.

Response
One of the primary objectives of DOE's characterization of the Yucca Mountain area is to identify faults with known or suspected Quaternary activity (during the past 1.6 million years) that could affect the design and performance of the repository. As discussed in Section 3.1.3.3 of the EIS, DOE has monitored earthquakes in the Nevada Test Site region since 1978. The site characterization program studies faults and earthquakes to assess seismic hazards at the site. The identification and documentation of earthquakes occurring before recorded history is possible by studying the geologic record of past events. DOE has constructed the prehistoric earthquake record at Yucca Mountain from the results of paleoseismic and geochronologic studies.

In 1998, 25 experts from industry, academia, and government completed an extensive seismic-hazard analysis of the Yucca Mountain area. These assessments indicate that the fault-displacement hazard at Yucca Mountain is generally low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes. Using this seismic hazard information, DOE would design repository facilities that are important to safety to withstand appropriate levels of ground motion and fault displacement. To the extent practical, the location of such facilities would avoid faults that could rupture the surface. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain. Section 3.1.3.3 of the EIS contains more information.

The 1992 Little Skull Mountain magnitude 5.6 earthquake is the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain. This event damaged the Yucca Mountain Field Operations Center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic design specifications planned for the facilities at Yucca Mountain. The waste-emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Additional fault movements or displacements from postemplacement seismic activity would probably be along existing fault planes.

DOE would build subsurface facilities in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less effect on subsurface facilities than on surface facilities. Inspections of existing tunnels in the Yucca Mountain area have revealed little evidence of disturbance following earthquakes. The subsurface facilities would be able to withstand the effects of earthquakes for the long-term performance of the repository. Sections 3.1.3.3 and 5.7.3 of the EIS contain more information.

After closure of the proposed repository, there would be a limited potential for releases to the atmosphere because the waste is isolated far below the ground surface. The potential for gas transport of carbon-14 was analyzed because the repository host rocks are porous. Modeling showed negligible human health impacts from releases of gas-phase carbon-14. See Section 5.5 of the EIS for additional information on atmospheric radiological consequences. There is no indication that the vibratory ground motion and fault displacement hazard would alter the results of these analyses.

The EIS did not indicate that there would be no groundwater contamination caused by the repository. Chapter 5 describes the modeling of the long-term performance of the repository which predicts impacts from radioactive and nonradioactive materials released to the environment during the first 10,000 years after closure. The principal means, or pathways, by which these materials would travel to humans and the environment include gradual container failure and leaching of contaminants through the unsaturated zone beneath the repository, then to the groundwater. The Yucca Mountain site characterization effort has gathered sufficient information about the site to make reasonable projections on how and when contaminants would move from the repository.

7.5.3.3 (3523)
Comment - EIS001150 / 0003
Was there any study of the major earthquake of 1992 or 1993, whichever year that took place, at Yucca Flat?

Response
On June 29, 1992, a Richter-magnitude 5.6 earthquake occurred at Little Skull Mountain, about 20 kilometers (12 miles) from Yucca Mountain. This earthquake, the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain, yielded a large amount of data that DOE has used in the assessment of the seismic hazard at Yucca Mountain. Studies based on seismic recordings from the Little Skull Mountain mainshock and aftershocks include the determination of near-surface attenuation of seismic waves, in particular shear waves that are so important in the seismic design of structures, comparison of earthquake source models, focal mechanism of the mainshock and larger aftershocks, and the depth distribution of the earthquake sequence. Other investigations included examination of a 125-meter (410-foot)-deep tunnel within 3 kilometers (2 miles) of the Little Skull Mountain event for possible damage associated with the earthquake. There was no significant damage in the tunnel, which is consistent with observations at underground excavations throughout the world after earthquakes.

7.5.3.3 (3751)
Comment - EIS001029 / 0001
The Department of Energy's process of elaborate technical studies is complex and involves much scientific work but it also involves predictions. In fact, geological estimates or predictions are based on what has happened in the past. But a prediction that earthquakes occur 1,000 to 10,000 years apart is hard to relate to human experience. A 21-year study tells us much about the structure of Yucca Mountain but does not tell us when earthquakes will happen there, exactly where they will happen or how they will change the rocks and fissures that exist. Since 1910, there have been over 600 earthquakes of greater than magnitude-2.5 within a 50-mile radius of Yucca Mountain.[i] How many earthquakes will happen within 50-miles of Yucca Mountain before 1,000 years is over? This Basin area is a dynamic area.[ii]

[i] In the Aug Las Vegas Review-Journal Steve Frishman stated that more than 600 earthquakes of magnitude 2.5 or more, large enough to feel if one is near the epicenter, have been measured within 50 miles of Yucca Mountain since 1910.

From a brochure *Earthquakes in Nevada & how to survive them* by Craig dePolo, Alan Ramelli, & Diane dePolo "Although earthquakes don't occur at regular intervals, the average frequency of earthquakes of magnitude 6 and greater in Nevada has been about one every ten years, while earthquakes of magnitude 7 and greater average once every 27 year."

Response
The frequency and magnitude of seismic disturbances in the vicinity of the Yucca Mountain site have been the focus of a great deal of study by DOE and others. The *Probabilistic Seismic Hazard Analysis for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada* (DIRS 103731-Wong and Stepp 1998) estimated earthquake occurrence frequencies, fault displacement, and vibratory ground motion hazards in the Yucca Mountain vicinity. The safety analyses for construction and operation of the repository as well as the long-term performance models specifically included the effects of seismic events of varying magnitude.

Based on the results of analyses reported in Chapter 5 of the EIS on the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with the Environmental Protection Agency's 40 CFR Part 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*. Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes the impacts from accident scenarios associated with earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. DOE believes that the EIS adequately describes geology, geologic hazards, and the effects of these hazards on the repository.

With regard to the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Figures 1 (a plot of Nevada earthquakes between 1852 and 1988) and 2 (active faults in Nevada) from the brochure, *Earthquakes In Nevada and How to Survive Them,* indicate that the highest rate of activity, in terms of number of events and magnitude, occurs in the western portion of Nevada. As noted in a paper by dePolo and other scientists from the University of Nevada, Reno ("Earthquake Occurrence in the Reno-Carson City Urban Corridor," available at www.seismo.unr.edu), 13 earthquakes of magnitude 6 or greater have occurred in the Reno-Carson City region since 1850. In contrast, the largest earthquake within about 40 kilometers (25 miles) of Yucca Mountain recorded to date by a seismic network installed in the area in 1978 was the magnitude 5.6 Little Skull Mountain event on June 29, 1992.

7.5.3.3 (4267)
Comment - EIS001521 / 0024
Page 3-29, 3.1.3.3 MODERN SEISMIC ACTIVITY, fourth paragraph--Did the Probabilistic Seismic Hazard Analysis produce a hazard map? If so, including it as a figure would greatly clarify this discussion. Also, an example of a hazard curve showing ground motion/fault displacement/annual frequency relationships would be helpful.

Response
The probabilistic seismic hazard analysis did not produce a hazard map. Figure H-1 in Appendix H of the EIS is the summary hazard curve for horizontal peak ground acceleration. DOE has added a reference to Figure H-1 for clarification.

7.5.3.3 (4502)
Comment - EIS001455 / 0003
Well, what about the fact that Yucca Mountain is right on two intersecting earthquake faults—the "Ghostdance" fault and the "Sundance" fault? Aw, shucks, there ain't been an earthquake in those parts since 1992, and it was only 5.6 on the Richter scale and it was centered at Little Skull Mountain—that's 12 whole miles away—it "caused no detectable in tunnels at either the Yucca Mountain site or the Nevada Test Site." (P. S-37).

Response
Section 3.1.3.2 of the EIS discusses the north-trending Ghost Dance fault as an intrablock fault that occurs approximately in the middle of the repository block. The Sundance fault intersects the Ghost Dance fault in the northern part of the repository block, but cannot be traced across the fault. Neither fault shows any evidence of Quaternary displacement (last 1.6 million years) (see Table 3-8). Section 3.1.3.3 summarizes the seismic hazard assessment of the site, including information on these faults and other faults in the region.

DOE would design repository facilities that are important to safety to withstand appropriate levels of ground motion and fault displacement. To the extent practicable, the repository design would locate such facilities away from faults that could displace the surface.

The Little Skull Mountain earthquake of 1992, Richter-magnitude 5.6, is the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain. That earthquake, with an epicenter 20 kilometers (12 miles) to the southeast, caused no damage at Yucca Mountain. The event did damage the Yucca Mountain Field Operations Center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic-design specifications that are planned for the facilities at Yucca Mountain.

7.5.3.3 (4841)
Comment - EIS001340 / 0002
The possibility of volcanic like eruptions from the masses of overheated waste is a very possible scenario too.

Response
There is no credible mechanism for the scenario mentioned in this comment. Temperatures would never rise high enough to melt the rock of the drift walls. Drift wall temperatures would approach 200°C (390°F) for the present above-boiling repository design. The major effect from the heat generated by the waste packages would be to drive water away from the drift wall for a period of about 1,500 years. The repository design and operational parameters now described in the EIS include low-temperature options that would keep repository temperatures much lower (that is, below boiling).

7.5.3.3 (4884)
Comment - EIS000337 / 0024
Pg. 5-43 [5-45], Seismic Disturbances, 2nd par: "probably would" and "would have to be larger" have no meaning when one attempts to quantify a problem. What is larger to one may be insignificant to another. We can't at this time quantify an earthquake with any uncertainty but DOE clearly attempts to quantify earthquakes 1,000 years in the future. I am sure the insurance companies and FEMA would like to have their software program.

Response
The commenter refers to wording concerning two aspects of uncertainty about failure of the waste package from rockfalls caused by earthquakes. In the first sentence, "probably would" refers to the uncertainty associated with whether the waste package outer wall would have to be completely corroded following a rockfall impact or whether failure would occur after only partial corrosion or as a result of another mechanism, such as pit corrosion. The second sentence indicates that, based on detailed mapping and measurements, it is highly likely due to waste package design that a rock "would have to be larger" than rocks observed in the Exploratory Studies Facility for a rockfall to cause failure in a recently emplaced, uncorroded waste package.

DOE agrees that we cannot quantify earthquake hazards with uncertainty. The methodology documented in the *Probabilistic Seismic Hazard Analysis* (DIRS 103731-Wong and Stepp 1998) is a state-of-the-practice approach for assessing the vibratory ground motion from earthquakes. The report explicitly addresses uncertainties from lack of data and imperfect understanding of earthquake mechanisms and the resulting ground motion. This approach enables DOE to test uncertainties using sensitivity analysis and allows impartial reviewers and regulators from the Nuclear Regulatory Commission to conduct an independent review of DOE's assessment.

The methodology that DOE used in Wong and Stepp (DIRS 103731-1998) is a site-specific approach based on associating earthquakes with specific geologic structures (faults) or specific regions in the earth's crust. The U.S. Geological Survey uses a non-site-specific probabilistic methodology to assess seismic hazards on a national scale. The results form the basis for the Federal Emergency Management Agency's (FEMA) nationwide approach (FEMA 302). This approach is incorporated in HAZUS, a computer program used by FEMA to assess potential risks (losses) or consequences resulting from earthquakes.

7.5.3.3 (5490)
Comment - EIS001887 / 0158
Page 3-29 to 30; Section 3.1.3.3 - Modern Seismic Activity - Seismic Hazard

Given the large uncertainty in fault lengths shown in Table 3-8, there should be a discussion in the text regarding the uncertainty that this introduces into the estimates of seismic risk.

Response
In 1998, DOE completed an extensive *Probabilistic Seismic Hazard Analysis* (DIRS 103731-Wong and Stepp 1998), involving 25 experts in seismology, paleoseismology, geology, and geophysics. The objectives were to assess available information and provide a probabilistic assessment of the vibratory ground motion and fault-displacement hazards at Yucca Mountain, along with the uncertainties associated with the assessment. Figure H-1 of the EIS shows an example of the results from the Probabilistic Seismic Hazard Analysis. The curves on this figure represent the mean, median, and 85th- and 15th-percentile estimates of the annual probability of exceeding horizontal components of peak ground acceleration. The analysis used a logic-tree approach in which different interpretations form different branches of a logic tree with expert-assigned probabilities to quantify the uncertainties in earthquake source parameters (such as fault length, slip rate, cumulative slip, individual fault-displacement events, and timing of events). The hazard curves in Figure H-1 represent the total uncertainty in parameters and models.

7.5.3.3 (5521)
Comment - EIS001887 / 0179
Page 3-59; Section 3.1.4.2.2 - Groundwater at Yucca Mountain

Define the "active life of the repository."

Response
"Active life" refers to the construction, operation and monitoring, and closure of the repository. DOE has added a parenthetical statement to Section 3.1.4.2.2 of the EIS to clarify this meaning.

7.5.3.3 (5919)
Comment - EIS001619 / 0005
Geologically, the site is clearly, clearly, clearly unsound. In the final EIS I would like to see comments about the recent studies that have proved that the earth's crust near Yucca Mountain is stretching more rapidly than average, and that this could cause unease in the containment facility within the ground.

I would also like to know who can guarantee me that in the next 10,000 years, there's not going to be a gigantic earthquake, which could potentially set this stuff free and do who knows to the planet. Currently the site is on 33 known fault lines, which are active.

Response
As reported in Section 3.1.3.3 of the EIS, Wernicke et al. (DIRS 103485-1998) claims that the crustal strain rates in the Yucca Mountain area are at least an order of magnitude higher than the tectonic history of the area would predict. This study speculates that higher strain rates would indicate underestimation of potential volcanic and seismic hazards on the basis of the long-term geologic record.

As discussed in Section 3.1.3 of the EIS, Yucca Mountain is part of a volcanic plateau that formed between 14 million and 11.5 million years ago as a result of explosive silicic volcanic activity originating from a complex of volcanic centers north of the site. About 11 million years ago, this explosive activity began to wane and was replaced by less explosive and much less voluminous basaltic eruptions in the Yucca Mountain region. The most recent basaltic eruption occurred between 70,000 and 90,000 years ago at Lathrop Wells, about 16 kilometers (10 miles) south of the site. A panel of non-DOE experts examined the data, models, and related uncertainties and concluded that the probability of a volcanic dike disrupting the repository during the first 10,000 years after closure is 1 chance in 7,000 (1 chance in 70 million annually). This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

DOE has been monitoring earthquake activity in the Nevada Test Site region since 1978 (see Section 3.1.3.3). It has investigated faults and earthquakes as part of the site characterization program to provide information to assess seismic hazards at the site. Using this information, the Department would design repository surface facilities to withstand the effects of earthquakes that could occur during their lifetimes. The seismic design requirements for the repository specify that structures, systems, and components important to safety would be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (1 in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

In May 1998, U.S. Geological Survey scientists reassessed seismic strain rates (DIRS 118952-Savage, Svarc, and Prescott 1999). The principal strain rates determined during the 1983-1998 survey confirmed previous analyses and were significantly less than those reported by Wernicke et al. (DIRS 103485-1998). The scientists concluded that the residual strain rate in the Yucca Mountain area is not significant at the 95-percent confidence level after removal of effects of the 1992 Little Skull Mountain earthquake and the strain accumulation on faults in Death Valley.

DOE is continuing to fund additional investigations on the regional crustal strain rate in the Yucca Mountain region as specified in a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to the DOE that conclusions from this study would be available in 2002. This study involves 30 geodetic monument sites with continuous Global Positioning System satellite measurements, a significant improvement over the study reported in *Science* in 1998. The Department will report conclusions as they become available. If the higher crustal strain rates are confirmed, DOE will reassess the volcanic and seismic hazard at Yucca Mountain.

DOE based the hydrology models, which are derived from extensive studies at Yucca Mountain, on a fault-fracture dominant flow system. The hypothetical addition of a few new faults created by future seismic events would have minor or no effects on the current fault and fracture flow pathways. Potential new faults and fractures, therefore, would be unlikely to alter repository performance. However, if there is confirmation of higher crustal strain rates, DOE will reassess the effect on radionuclide transport and total system performance.

DOE agrees that it cannot quantify earthquake hazards without any uncertainty. The methodology documented in the *Probabilistic Seismic Hazard Analysis* (DIRS 103731-Wong and Stepp 1998) is a state-of-the-practice approach for assessing the vibratory ground motion resulting from earthquakes. That report explicitly addresses uncertainties resulting from both lack of data and our imperfect understanding of earthquake mechanisms and the resulting ground motion. This approach enables DOE to test uncertainties using sensitivity analysis and allows impartial reviewers and regulators on the Nuclear Regulatory Commission staff to conduct an independent review of the DOE assessment.

7.5.3.3 (6242)
<u>Comment</u> - EIS001921 / 0008
The selection of a storage site for deadly nuclear waste in an area of seismic activity like Yucca Mountain was unwise. The rapidly expanding population of Las Vegas and vicinity (now well over a million) 90 miles from the repository are surely at risk.

Response

In 1987, Congress selected Yucca Mountain as a potential location for a monitored geologic repository, and directed DOE to determine whether the site is suitable. Some of the reasons that Congress selected Yucca Mountain for study included a deep water table, favorable geology, a desert environment, and the fact that the Nevada Test Site was already a controlled area.

Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future seismic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with 40 CFR Part 197, *Environmental Radiation Protection Standards for Yucca Mountain, Nevada*). Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes the impacts from accident scenarios associated with earthquakes during operation of the repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. With the exception of some factual changes and clarifications in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository, have been adequately described and analyzed.

With regard to the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the EIS devotes almost seven pages of text explaining how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

Based on the results of site characterization, and in consideration of this EIS, the Secretary of Energy will make a recommendation to the President about whether Yucca Mountain is a suitable site for a geologic repository.

7.5.3.3 (6863)
Comment - EIS001466 / 0008
I looked around and there was a seismograph measuring the earthquakes at the small field office near the mountain. There was a flying buttress that had been built after the '92 earthquake which was 5.6 and damaged that building at the foot of Yucca Mountain. So that seismograph is still up there to keep track of all the earthquake activity.

Response
DOE recognizes that a seismic hazard exists at Yucca Mountain. But with the proper design, a repository could operate in compliance with the requirements of 40 CFR Part 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*. As discussed in Section 3.1.3.3 of the EIS, the Department has monitored earthquakes in the Nevada Test Site region since 1978. The site characterization program has investigated faults and earthquakes to assess seismic hazards at the site. Using the seismic hazard information, DOE would design repository facilities that are important to safety to withstand appropriate levels of ground motion and fault displacement. To the extent practical, the location of surface facilities would avoid faults that could rupture the surface. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (1 in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain. The Little Skull Mountain earthquake of 1992, Richter-magnitude 5.6, is the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain. That earthquake, with an epicenter 20 kilometers (12 miles) to the southeast, caused no damage at Yucca Mountain. The event did damage the Yucca Mountain Field Operations Center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic-design specifications that are planned for the facilities at Yucca Mountain.

7.5.3.3 (7003)
Comment - EIS000402 / 0002
We are the third most earthquake state behind Alaska and California our neighbor on the west. How do you justify financially continuing the existing work with the earthquake tremors occurring almost daily. We, also, have had major earthquakes in the last couple of years in Southern California and in Western Nevada. No reports have been made to the media/public about the injuries/damage to the Yucca Mountain area or the cost to repair the damage. The [secrecy] deeply concerns me as it is almost like the 50's and the testing in southern Nevada, the deadly effects to us, lack of concern by the government and the appalling lying done.

How do you plan to financially deal with the continuing cost of damage by earthquakes and the resulting tremors? The lack of informing the public about the damage to people and Yucca Mountain dump?

Response
Because earthquake ground motions lessen with distance, the farther an earthquake occurs from Yucca Mountain, the larger it would have to be to contribute to the hazard at the site. At a distance of 100 kilometers (62 miles) from Yucca Mountain, earthquakes would have to reach an estimated magnitude of 8 to produce horizontal accelerations of 0.1*g*, where *g* is acceleration due to gravity (980 centimeters per second squared), at the site (DIRS 151945-CRWMS M&O 2000). The Little Skull Mountain earthquake of 1992, which is the largest recorded earthquake within 50 kilometers (31 miles) of Yucca Mountain (Richter magnitude 5.6), caused no damage at Yucca Mountain. It did damage the Yucca Mountain Field Operations Center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), but this facility was not built to the seismic-design specifications planned for the facilities at Yucca Mountain. This earthquake caused less than $100,000 damage, although DOE spent additional funds on structural modifications to bring the building into compliance with existing codes. Earthquakes can disrupt power transmission, communications, roads, and rail lines. Tables 4-36 and 4-37 in the EIS present earthquake-accident scenarios that use an earthquake frequency of once in 50,000 years. This is roughly equivalent to a 7 magnitude on the Richter scale within 5 kilometers (3 miles) of Yucca Mountain, with a mean peak ground acceleration of 1.1*g* at the waste-emplacement depth. These are very

conservative calculations that give an indication of the maximum impact of such an event. Appendix H contains additional analysis of accidents due to seismic activity.

One of the primary objectives of DOE's characterization of the Yucca Mountain area is to identify faults with known or suspected Quaternary activity (during the past 1.6 million years) that could affect the design and performance of the repository. The identification and documentation of earthquakes occurring before recorded history is possible by studying the geologic record of past events. Larger events that ruptured the surface often leave geologic evidence in the form of offset strata and characteristic earthquake-related deposits. Geologic studies of fault-related deposits are the basis for identifying the occurrence of past large-magnitude, surface-rupturing displacements and evaluating their size, age, and occurrence rate.

In 1998, 25 experts from industry, academia, and government completed an extensive seismic hazard analysis of the Yucca Mountain area. These assessments indicate that the fault displacement hazard at Yucca Mountain is generally low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes. Using the seismic hazard information, the surface and underground facilities at Yucca Mountain are being designed to withstand ground motion from earthquakes. The analysis determined that an annual frequency of 1×10^{-4}, or the 10,000-year earthquake, is an appropriate level for preclosure design of structures that are important to safety. At Yucca Mountain, these structures would be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. For the 10,000-year earthquake, the design motions are dominated by the contribution of a normal-fault type earthquakes of magnitude 6.3 with an epicenter within 5 kilometers of Yucca Mountain that respond to higher structural frequencies.

The repository emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide release. Additional fault displacements and associated postemplacement seismic activity probably would be on existing fault planes.

DOE would build subsurface facilities in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less effect on subsurface facilities than on surface facilities. Inspections of tunnels in the Yucca Mountain area revealed little evidence of disturbance following earthquakes. The subsurface facilities would be able to withstand the effects of earthquakes for the long-term performance of the repository. Sections 3.1.3.3 and 5.7.3 of the EIS contain more information.

7.5.3.3 (7075)
Comment - EIS000995 / 0004
Have the plans for shipment or storage for the huge amount of radioactive waste changed at all in light of the recent seismic activity in the area around Yucca Mountain?

Response
DOE has incorporated data from the recent earthquakes near Yucca Mountain in its seismic hazard assessments. With the proper design, a repository could operate safely and in compliance with *Environmental Radiation Protection Standards for Yucca Mountain, Nevada*, 40 CFR Part 197). As discussed in Section 3.1.3.3 of the EIS, the Department has monitored earthquakes in the Nevada Test Site region since 1978. The site characterization program has investigated faults and earthquakes to assess the seismic hazards at the site. Using this seismic hazard information, DOE would design repository facilities that are important to safety to withstand ground motion from earthquakes and fault displacements. To the extent practical, the location of such facilities would avoid faults that could rupture the surface. The seismic design requirements for the repository specify that structures, systems, and components important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years).

7.5.3.3 (7389)
Comment - EIS001957 / 0016
Section 3.1.3.2 Modern Seismic Activity – The narrative indicates that the DOE has monitored seismic activity associated with the Nevada Test Site since 1978. In the section on "Seismic Hazard," it is stated that:

"DOE based the design on ground motion and fault displacement that could be associated with future earthquakes at Yucca Mountain on the record of historic earthquakes in the Great Basin, evaluation of prehistoric earthquakes based on investigations of the faults at Yucca Mountain, and observations of ground motions associated with modern earthquakes...”

Later in this section, it is stated that:

“DOE needs to complete additional investigations of ground motion site effects before it can produce the final seismic design basis for the surface facilities.”

Further, it is stated in this same section that:

“A recent study...claims that the crustal strain rate in the Yucca Mountain area are at least an order of magnitude higher than would be predicted from the Quaternary volcanic and tectonic history of the area. If higher strain rates are present, the potential volcanic and seismic hazards would be underestimated on the basis of the long-term geologic record. If the higher strain rates are confirmed, DOE will reassess the volcanic and seismic hazard at Yucca Mountain.”

It would appear from these statements the DOE has potentially underestimated the potential volcanic and seismic hazards at the proposed site. The DOE acknowledges the need for additional studies before it is able to assess the effects of the earthquake hazard on the proposed repository. The NPS [National Park Service] is concerned what this deficiency might mean for the assessment of potential risks of release of radionuclides into the environment (specifically the regional ground-water flow system that underlies the proposed repository) and exposure to down gradient springs in Death Valley NP [National Park].

Response

DOE would base its design, in part, on input from the probabilistic seismic hazard assessment and from further evaluations of ground motion. The completed hazard studies provide probabilities of ground motion exceedance for different return periods. These results are in terms of ground motion in rock and are applicable to subsurface repository design.

DOE needs to complete geotechnical engineering investigations and ground motion studies before it can complete the designs of potential surface facilities. These data and analyses are necessary to determine ground motions at the foundation levels of the surface facilities for surface-facility foundation design. This does not affect the probabilistic hazard assessment for ground motion at the repository level or for fault displacement.

A March 1998 study of seismicity in the Yucca Mountain region (DIRS 103485-Wernicke et al. 1998) was based on baseline measurements using the Global Positioning System from 1991 through 1997 at five stations in the Yucca Mountain area. While the authors discussed the possible effects on their network from displacements associated with the June 1992 Little Skull Mountain earthquake, they did not correct the station-to-station distances for earthquake displacements.

In May 1998, scientists from the U.S. Geological Survey used the Global Positioning System to resurvey a network of 14 geodetic stations originally installed in 1983 (DIRS 118952-Savage, Svarc, and Prescott 1999) [DIRS 103485-Wernicke et al. (1998) used only 2 of the 14 stations in their study]. Based on the larger number of stations, the longer survey period (1983 to 1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake, the scientists concluded (DIRS 118952-Savage, Svarc, and Prescott 1999) that the strain rate in the Yucca Mountain region is significantly less (a factor of 20 or more) than the rate reported by Wernicke et al. (DIRS 103485-1998). The Geological Survey results are consistent with a large body of geologic and paleoseismological (fault-trenching investigations) data collected in the Yucca Mountain region over the past two decades.

Wernicke et al. (DIRS 103485-1998) speculated that magmatic inflation at depth could drive the high strain accumulation across the Yucca Mountain area. They pointed to an early seismic tomographic study by Oliver, Ponce and Hunter (DIRS 106447-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study by Biasi (DIRS 105358-1996), based on more accurate seismic arrival times and a deeper inversion model than that used by Oliver, Ponce and Hunter (DIRS 106447-1995), demonstrated rather conclusively that there is no low-velocity zone under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

DOE is continuing to fund investigations on crustal strain in the Yucca Mountain region through a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to the DOE that conclusions from this study would be available in 2002. This study involves 30 geodetic monitoring sites with continuous Global Positioning System measurements, a significant improvement over the Wernicke et al. (DIRS 103485-1998) study.

7.5.3.3 (7460)
Comment - EIS001969 / 0012
Pages S-37, 5.4.1.3 [S.4.1.3] Geology, first paragraph.

Point (3) states that the Topopah Spring Tuff was chosen because of "...its location away from major faults that could adversely affect the stability of underground openings..." This statement implies that the Topopah Spring Tuff is not intersected by major faults, which it most assuredly is. Faults cut through all of the Tertiary volcanic units in the proposed repository area, including the Topopah Spring Tuff. Solitario Canyon fault and several other known faults cut through the Topopah Spring Tuff, some immediately adjacent to the underground facilities.

The relationship between faulting and the selection criteria of the Topopah Spring Tuff as the repository host rock in the Summary and the Draft EIS itself (page 3-24) is unclear and needs more detailed and accurate explanation. The selection of Topopah Spring Tuff cannot be predicated on its lack of proximity to seismically active faults. If so, the site would not be viable. Clarification is needed.

Response
DOE agrees that it cannot predicate its selection of the Topopah Spring Tuff for the repository on the lack of proximity to seismically active faults. The Department has changed the statement in the Summary and Section 3.1.3 of the EIS to indicate that it chose the repository emplacement area because of its location away from major faults that could adversely affect the stability of underground openings.

7.5.3.3 (7464)
Comment - EIS001969 / 0013
Page S-37, second paragraph.

The statement, "The Solitario Canyon fault forms the major bounding fault on the west side of Yucca Mountain, and volcanic units in the mountain tilt eastward as a result of displacement along this and lesser faults through the mountain...," needs clarification. There are faults on the east side of Yucca Mountain. The faults that bound the eastern side of the proposed repository area, the Bow Ridge and Paintbrush Canyon faults, to name just two (see Table 3-8, Characteristics of major faults at Yucca Mountain, v. 1 -Impact Analysis, Draft EIS), need to be mentioned here. Additionally, because these latter two north-trending faults dip to the west beneath the repository area and the adjacent material handling facilities that would be built at the north and south portals, understanding the seismic hazard potential of these faults is extremely important.

In addition, easterly tilts are not the result of movement on the Solitario Canyon fault and "lesser faults through the mountain." These tilts are the result of movement on a whole series of block-bounding faults, of which the Solitario Canyon fault is one.

Response
The comment is correct that the Solitario Canyon fault is not the only block-bounding fault identified in the EIS. However, DOE did not modify the text of the Summary in order to keep it understandable to a wide range of readers. DOE has, however, clarified the text in Section 3.1.3.2 of the EIS, which also refers readers to numerous reference materials on the subject.

7.5.3.3 (7520)
Comment - EIS001969 / 0025
Page 3-25, Section 3.1.3.2 Geologic Structure, fifth paragraph.

It is stated here that the "...total estimated displacement on the most active block-bounding faults...during the past 1.6 million years is less than 50 meters...(Simonds and others, 1995)." This statement is from the Conclusion section of Simonds and others (1995) and is misleading when taken out of context. All measurements of Quaternary (1.6 Ma to present) displacement on these faults range from 0 to 6 m with most displacement in the 1-2.5 m range, as reported in Table 2 of Simonds and others (1995). Reference Table 3-8 in this paragraph to help clarify this point.

Response
DOE has clarified this paragraph in Section 3.1.3.2 of the EIS, as suggested by the comment.

7.5.3.3 (7529)
Comment - EIS001969 / 0026
Page 3-25, Section 3.1.3.2 Geologic Structure, sixth paragraph.

The statement, "The Solitario Canyon fault along the west side of Yucca Mountain is the major block-bounding fault...," is incorrect. The Solitario Canyon fault is one of numerous block-bounding faults that are shown on Figure 3-10. These include the Northern Windy Wash, Fatigue Wash, Solitario, Iron Ridge, Dune Wash Bow Ridge, Midway Valley, Paintbrush Canyon faults, just to name those within 4 km radius of the proposed perimeter of the repository.

Response
The comment is correct; text in Section 3.1.3.2 has been revised for clarity. The Solitario Canyon fault is not the only block-bounding fault identified.

7.5.3.3 (7536)
Comment - EIS001969 / 0027
Page 3-25, Section 3.1.3.2 Geologic Structure, last paragraph.

This short treatment of intra block faults (the subsidiary faults between the block bounding faults) places undue emphasis on NW-trending faults by discussing them first. Within the central block, where the repository would be sited, the intra block faults with the longest map traces and the largest amounts of displacement are the Ghost Dance Fault (splitting the center of the block) and the block-margin faults ("Imbricate Zone" of Scott, 1990) that are just west of the Bow Ridge Fault. Day and others (1998, USGS Map I-2601) and Scott and Bonk (1984) also document this. The NW-trending faults, such as the Sundance Fault, though characterized correctly, are relatively minor in comparison (Potter and others, USGS OFR 98-266, in press). It would be more appropriate to mention the much larger Ghost Dance fault first.

Response
DOE has reorganized the paragraph in question to discuss the Ghost Dance fault, which occurs in the middle of the repository block, before discussing the northwest-trending faults.

7.5.3.3 (7538)
Comment - EIS001969 / 0028
Page 3-26, Figure 3-9, Types of geologic faults.

For clarity, definitions of normal and reverse faults need to uniquely specify the correct sense of motion. For a normal fault reword the description, "dip-slip fault where one block has moved downdip relative to the other," to "dip-slip fault where the upper block has moved downdip relative to the lower block." For reverse fault, reword "dip-slip fault where one block has moved updip relative to the other" to "dip-slip fault where the upper block has moved updip relative to the lower block."

A diagram is needed for low-angle normal faults, such as in Calico Hills east, and Bare Mountain west, of Yucca Mountain.

Response
The description of faults in Figure 3-9 of the Final EIS has been clarified.

7.5.3.3 (7573)
Comment - EIS001969 / 0032
Page 3-30, fifth paragraph.

The correct statement is that there is no observable strain measured within the error of the data.

Response
DOE believes the paragraph is correct as written. The main point of this paragraph is that the strain rate is significantly less than the rate reported by Wernicke et al. (DIRS 103485-1998), which did not account for the coseismic and postseismic effects of the 1992 Little Skull Mountain earthquake.

7.5.3.3 (8148)
Comment - EIS000817 / 0082
P. 3-29 -- The 1992 Little Skull Mt. earthquake is proof of modern seismic activity. Wernicke's study in "Science" magazine 1998 shows concerns of accuracy of your studies. I predict you have, in fact, underestimated potential volcanic and seismic hazards. And, frankly, I don't see why this issue isn't given main priority for it could halt everything. Why aren't your ground motion site effects studies done before you put out this draft EIS? You need to reassess this before you go further, and it should have been done by now.

Response
The geodetic study reported in the March 1998 issue of *Science* (DIRS 103485-Wernicke et al. 1998) was based on measurements from 1991 through 1997 at five stations in the Yucca Mountain area using the Global Positioning System. While the authors discussed the possible effects on their network from displacements associated with the June 1992 Little Skull Mountain earthquake, they did not correct the station-to-station distances for earthquake displacements.

In May 1998, scientists from the U.S. Geological Survey used the Global Positioning System to resurvey a network of 14 geodetic stations originally installed in 1983. Wernicke et al. (DIRS 103485-1998) used two of the 14 stations in their study. Based on the larger number of stations, the longer survey period (1983 to 1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake, the U.S. Geological Survey scientists concluded (DIRS 118952-Savage, Svarc, and Prescott 1999) that the strain rate in the Yucca Mountain region is significantly less (by a factor of 20 or more) than the rate reported by Wernicke et al. (DIRS 103485-1998). The results of the U.S. Geological Survey are consistent with a large body of geologic data and fault-trenching investigations in the Yucca Mountain region over the past two decades.

Wernicke et al. (DIRS 103485-1998) speculated that magmatic inflation at depth could be the cause of the high strain accumulation across the Yucca Mountain area. They pointed to an early seismic tomographic study by Oliver, Ponce, and Hunter (DIRS 106447-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study (DIRS 105358-Biasi 1996), based on more accurate seismic arrival times and a deeper inversion model, demonstrated rather conclusively that there is no low-velocity zone under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

With regard to ground motion studies, as discussed in Section 3.1.3.3 of the EIS, DOE has been monitoring earthquakes in the Nevada Test Site region since 1978. Faults and earthquakes have been investigated as part of the site characterization program to assess seismic hazards at the site. DOE recognizes that the effect of earthquakes on a repository at Yucca Mountain is a major concern and we have conducted extensive analysis. The EIS analyzes the probability of earthquake occurrence and the consequences to the repository and the environment. To support this analysis, DOE and the USGS first completed a comprehensive evaluation of the seismic hazards in the Yucca Mountain region using standard practices of mapping, trenching, age dating, and monitoring of contemporary seismicity. Then DOE-sponsored groups of experts from within and outside the Project used these site data to assess the seismic hazard potential of all significant seismic sources in the Yucca Mountain region. Another group of experts used numerical modeling methods and data from recent earthquakes to estimate ground motion attenuation relationships that are appropriate for Yucca Mountain.

Using this seismic hazard information, repository surface facilities would be designed to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety would be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

Subsurface facilities would be built in solid rock, and because vibratory ground motion decreases with depth, earthquakes would have less an affect on subsurface facilities than surface facilities. Inspection of existing tunnels in the Yucca Mountain area has revealed little evidence of disturbance following earthquakes. The subsurface facilities would also be designed to withstand the effects of earthquakes for the long-term performance of the repository.

7.5.3.3 (8443)
Comment - EIS001397 / 0011
In the third most seismically active place on the North American Continent, the issues of earthquakes and land drift are extremely important. They are glossed over in this DEIS. There are 32 fault lines near Yucca Mountain. This DEIS shows tunnels drilled through them, next to them, and with fault lines ending within tunnel structures. The Earth tried to make an obvious point in June of 1992 when over 1.25 million dollars of damage was sustained to the building for the project research at Yucca Mountain. Since then hundreds of earthquakes of significant magnitude have occurred in the immediate area. The final EIS must adequately address this important concern.

Recent satellite research indicates that the earth is moving apart in the Yucca Mountain region at the rate of six inches every hundred years, or 50 feet over the 10,000 year lifespan of this project. A whole lot of casks could fall into a 50 foot chasm, or even serious shift and risk breaching with six inches of motion. Recent research that will not be finished for several years indicates hot water flow upward through the mountain. This, combined with earth crust movement, may indicate that Yucca Mountain is actually directly over a magma pocket. This DEIS does not adequately address these concerns at all. Full information must be made available, reviewed by the public after that time, and then considered in its entirety for potential licensing of this facility.

Response
DOE agrees that earthquake occurrence in the context of plate tectonics is an important consideration. The Department recognizes there is a seismic hazard at Yucca Mountain, but with the proper design a repository could operate safely and provide adequate long-term performance. As discussed in Section 3.1.3.3 of the EIS, the Department has monitored earthquake activity in the Nevada Test Site region since 1978. The site characterization program has investigated faults and earthquakes to provide information needed to assess seismic hazards at the site. Using the seismic hazard information, DOE would design repository facilities important to safety to withstand appropriate levels of ground motion and fault displacement. To the extent practical, the location of such facilities would avoid faults that could produce surface displacement. The seismic design requirements for the repository specify that structures, systems, and components important to safety would be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (1 in 10,000 years). The results of the seismic hazard analysis for Yucca Mountain indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

The 1992 Little Skull Mountain magnitude 5.6 earthquake is the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain. The epicenter was 20 kilometers (12 miles) to the southeast of the site and caused no damage at Yucca Mountain. DOE built the facilities in Jackass Flat that were damaged in that earthquake, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility), in the 1960s and did not design them to accommodate the levels of ground motion for which it would design repository facilities. Section 3.1.3.3 of the EIS contains more information.

As part of site characterization activities, DOE monitors the seismic activity in the Yucca Mountain region. Since 1975, more than 1,500 earthquakes with magnitudes greater than 2.5 have occurred within 80 kilometers (50 miles) of the site, including the Little Skull Mountain earthquake. Some small-magnitude events (about 2.5 magnitude) are attributed to the Little Skull Mountain earthquake. Other small-magnitude events might not represent an increase in seismicity but rather the greater sensitivity of new instrumentation.

In May 1998, U.S. Geological Survey scientists conducted a reassessment of crustal strain and published their findings in the Journal of Geophysical Research (DIRS 118952-Savage, Svarc, and Prescott 1999). The principal strain rates determined over the 1983-1998 survey interval, confirmed previous analyses, and were significantly less than reported by Wernicke et al. (DIRS 103485-1998). The scientists concluded that the residual strain rate in the Yucca Mountain area is not significant at the 95-percent confidence level after removal of effects of the 1992 Little Skull Mountain earthquake and the strain accumulation on faults in Death Valley.

DOE is continuing to fund additional investigations on the regional crustal strain rate in the Yucca Mountain region as specified in a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to the DOE that conclusions from this study would be available in 2002. The Department will report the conclusions as they become available. If the higher crustal strain rates were confirmed, DOE would reassess the volcanic and seismic hazard at Yucca Mountain.

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm water upwelling hypothesis. This study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. The report concludes that some of the crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of scientists with expertise in hydrology, geology, isotope geochemistry, and climatology did not concur with the conclusions in the report (DIRS 100086-Stuckless et al. 1998). Although DOE has disagreed with the central scientific conclusions in this report, it agreed to support continuing research. An independent investigation by Jean Cline, University of Nevada, Las Vegas, will be completed in Fiscal Year 2001. Section 3.1.4.2.2 of the EIS contains more information.

DOE agrees that full information must be made available to the public. The *Yucca Mountain Site Description* (DIRS 151945-CRWMS M&O 2000) contains more complete technical information. By definition, the licensing process must consider all available information.

7.5.3.3 (8586)

<u>Comment</u> - EIS001256 / 0005

Our original comments expressed concern about geologic stability, citing the earthquake event of October 1999. Now it comes to our attention that there is a theory being investigated by scientists that predicts earthquakes as large as 7.0 or 8.0 on the Richter scale that could be located as near as 20 miles from Yucca Mountain. The siting of Yucca Mountain is being called into question more vigorously every day.

<u>Response</u>

As described in Section 3.1.3.3 of the EIS, the largest recorded earthquake within 50 kilometers (30 miles) of Yucca Mountain was the Little Skull Mountain event in 1992 with a magnitude of 5.6. This event occurred about 20 kilometers (12 miles) southeast of Yucca Mountain. Based on many studies of current and past seismicity, the surface facilities at the repository would be designed to withstand an earthquake with a Richter-scale magnitude of 6.3 that would occur within 5 kilometers (3 miles) of Yucca Mountain. Because vibratory ground motion from earthquakes decreases with depth, earthquakes would have less of an effect on subsurface facilities than on surface facilities.

7.5.3.3 (8700)

<u>Comment</u> - EIS001660 / 0053

Ongoing seismic studies being conducted for the Yucca Mountain region by the University of Nevada and seismic studies for each of the 10 affected counties should be completed before DOE makes a decision whether to recommended Yucca Mountain as a geologic repository.

<u>Response</u>

Section 3.1.3.3 of the EIS incorporates the best, most recent information that was available at the time the document was prepared. To analyze the probability of occurrence and the consequences from earthquakes at Yucca Mountain, DOE and the U.S. Geological Survey first completed a comprehensive evaluation of the seismic hazards in the Yucca Mountain region using standard practices of mapping, trenching, age-dating, and monitoring of contemporary seismicity. DOE then convened groups of experts from within and outside the Yucca Mountain Site Characterization Project to assess the seismic hazard of all significant seismic sources in the Yucca Mountain region. Another group of experts used numerical modeling methods and data from recent earthquakes to estimate ground motion attenuation relationships that are appropriate for Yucca Mountain.

The expert assessments concluded that the fault-displacement hazard is low. Assessment of the long-term performance of the repository indicated that earthquakes would not significantly affect waste isolation. Using the seismic hazard information, surface facilities would be designed to withstand the effects of earthquakes that might occur during the lifetime of the facilities. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be designed to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (1 in 10,000 years). The seismic design basis would continue to be updated, as necessary.

7.5.3.3 (8787)
Comment - EIS001671 / 0003
Hasn't anyone noticed the change in the earth movements? If we get earthquakes results, your concrete, around the cask full of waste, it will break, then what?

Response
DOE recognizes there is a seismic hazard at Yucca Mountain, but with the proper design a repository can operate safely. Site characterization activities include studies to quantify the seismic hazard so that facilities that are important to safety can be designed to withstand maximum ground motions and fault displacement.

There are no plans to encase the waste packages in concrete. Section 2.1.2.2.4.1 of the EIS describes the design of the waste package. This design incorporates the potential for an earthquake-induced rockfall from the ceiling of the repository. The *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998) considers repository performance at 10,000-, 100,000- and 1-million-year periods. Over 10,000 years, the probability of an earthquake-induced rockfall causing a waste package to split open is almost zero because the waste package would be thick enough to withstand the impact from most slabs of rock. There is less than a 1-percent probability that falling rocks would accelerate corrosion during this period. Over 1 million years, earthquake-induced rockfalls could breach about 30 percent of the waste packages in the repository. When added to expected failures from corrosion, these rock-induced failures would not produce a major change in the overall probability of failure because most would occur after 500,000 years (DIRS 101779-DOE 1998).

In addition, the waste emplacement areas would be away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide releases.

7.5.3.3 (8826)
Comment - EIS000869 / 0007
The site at Yucca Mountain is very precarious due to the increasing number and severity of earthquakes in the southern California, southern Nevada and even Yucca Mountain areas. Regarding S.4.1.3 Geology, in the draft Environmental Impact Statement, paragraph 4 on page S-37 states that the 5.6 earthquake in 1992 caused no detectable damage ... at the Yucca Mountain site. This is a false statement as there was significant damage to some buildings at the Yucca Mountain site. If one of those buildings had been the nuclear waste transfer area, it could have the potential to create a nuclear nightmare for surrounding communities including southern Nevada, southern Utah, and possibly, areas of southern California. At the present time, these are relatively low populated areas, but all the potentially affected areas are experiencing phenomenal growth in population and tourism. The draft summary repeatedly references a population of about 28,000 within 80 kilometers (50 miles) of the Yucca Mountain site. However, when the population within 100 miles of the Yucca Mountain site is considered, as it should be, the number of population would increase dramatically. If there were an accidental exposure via air or water, it would definitely impact many more people that the 50-mile radius claims.

Response
There is no evidence to suggest that the number and severity of earthquakes in the Yucca Mountain area and adjacent southern California is increasing. Recent earthquakes at Scottys Junction, Nevada [August 1, 1999, magnitude 5.7, approximately 80 kilometers (50 miles) from Yucca Mountain], and at Hector Mine, California [October 16, 1999, magnitude 7.1, approximately 250 kilometers (155 miles) from Yucca Mountain], had no effect at Yucca Mountain. Recordings of these events at Yucca Mountain indicated ground motions that were more than

10 times smaller than the seismic design to which the surface facilities at Yucca Mountain would be constructed. The Scottys Junction earthquake had a magnitude, depth, and normal focal-plane solution similar to those recorded for the Little Skull Mountain earthquake in 1992, which at 5.6 on the Richter scale is the largest earthquake recorded within 50 kilometers (30 miles) of Yucca Mountain. The Little Skull Mountain earthquake, with an epicenter 20 kilometers (12 miles) to the southeast, caused no damage at Yucca Mountain. It did damage the Yucca Mountain Field Operations Center in Jackass Flat, approximately 2 kilometers (1.2 miles) from the epicenter (about 4 miles from the Exploratory Studies Facility). That facility was not built to the seismic design specifications planned for the facilities at Yucca Mountain.

The seismic design requirements for the repository specify that structures, systems, and components important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis indicate that this is the equivalent of about a magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain.

DOE would build the subsurface facilities in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less of an effect on subsurface facilities than on surface facilities. Inspections of existing tunnels in the Yucca Mountain area have revealed little evidence of disturbance following earthquakes. In addition, DOE would design the subsurface facilities to withstand the effects of earthquakes for the long-term performance of the repository. Section 3.1.3.3 of the EIS contains more information.

The 80-kilometer (50-mile) radius is the established precedent for calculating the potential population (collective) dose around a nuclear facility. Potential impacts from all accident scenarios to the population beyond 80 kilometers would be negligible.

7.5.3.3 (9073)
Comment - EIS001936 / 0003
We are concerned that a March 1998 study by the Nuclear Regulatory Commission showed that the ground around Yucca Mountain could stretch over three feet in the next 1,000 years. This movement could crush any canisters of waste buried there, exposing a wide area of the Southwest to deadly radiation. Earthquakes and volcanism in the area could also disturb the canisters.

Response
Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with 40 CFR Part 197). Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region.

The 1998 study referred to by the commenter is probably the article published in *Science* magazine (DIRS 103485-Wernicke et al. 1998) that concludes that crustal strain rates in the Yucca Mountain area are at least an order of magnitude higher than would be predicted from the tectonic history of the area. The authors speculated that higher strain rates indicate that the potential volcanic and seismic hazards are underestimated based on the long-term geologic record. U.S. Geological Survey scientists (DIRS 118952-Savage, Svarc, and Prescott 1999) reported that all geodetic surveys indicated no large strain accumulation and therefore do not support the claims of Wernicke et al. (DIRS 103485-1998).

DIRS 103485-Wernicke et al. (1998) was based on measurements using the Global Positioning System (GPS) over the period from 1991 to 1997 at five stations in the Yucca Mountain area. While the authors discussed the possible effects on their network from displacements associated with the June 1992 Little Skull Mountain earthquake, they did not correct the station-to-station distances for earthquake displacements.

In May 1998, scientists from the U.S. Geological Survey resurveyed (also using the Global Positioning System) a network of 14 geodetic stations that was originally installed in 1983 (DIRS 118952-Savage, Svarc, and Prescott 1999). [Only two of the 14 stations were used by Wernicke et al. (DIRS 103485-1998) in their study.] Based on the greater number of stations, the longer survey period (1983 to 1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake, the Survey scientists concluded (DIRS 118952-Savage, Svarc, and Prescott 1999) that the strain rate in the Yucca Mountain region is significantly less (a factor of 20 or more) than the rate reported by Wernicke et al. (DIRS 103485-1998). The Survey results are consistent with a large body of geological and paleoseismological (fault-trenching investigations) data that have been collected in the Yucca Mountain region during the past two decades.

Wernicke et al. (DIRS 103485-1998) speculated that the high strain accumulation across the Yucca Mountain area could be driven by magmatic inflation at depth. They pointed to an early seismic tomographic study by Oliver, Ponce, and Hunter (DIRS 106557-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study (DIRS 105358-Biasi 1996), based on more accurate seismic arrival times and a deeper inversion model than that used by Oliver, Ponce, and Hunter (DIRS 106557-1995), demonstrated rather conclusively that there is no low-velocity zone (such as a magma pocket) under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

Section 4.1.8 of the EIS describes the impacts from accident scenarios associated with earthquakes during operation of the repository. Several sections in Chapter 5 of the EIS consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. Except for some factual changes and clarifications that have been included in the Final EIS, DOE believes that the information in the Draft EIS on geology, geologic hazards, and the effects of these hazards on the repository have been adequately described and analyzed.

With regard to the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3.3 (9248)
Comment - EIS001684 / 0004
Why has the DOE selected a site (Yucca Mountain) that is seismically unstable?

Response
In 1987, Congress selected Yucca Mountain as a potential location for a monitored geologic repository, and directed DOE to determine whether the site is suitable. Some of the reasons that Congress selected Yucca Mountain for study included a deep water table, favorable geology, a desert environment, and the fact that the Nevada Test Site was already a controlled area.

7.5.3.3 (10114)
Comment - EIS002155 / 0003
Secondly, seismic activity. Why in God's name would we pick the most active seismic state to put the waste?

Response
In 1987, Congress selected Yucca Mountain as a potential location for a monitored geologic repository, and directed DOE to determine if the site is suitable. Some of the reasons Congress selected Yucca Mountain for study included a deep water table, favorable geology, a desert environment, and the fact that the Nevada Test Site was already a controlled area.

It is true that Nevada ranks third, behind Alaska and California, in seismic activity. Its reputation as a highly active state comes from major historic earthquakes in western Nevada with magnitudes greater than 7 on the Richter scale. Yucca Mountain does not lie within this highly active seismic belt.

Based on the results of analyses reported in Chapter 5 of the EIS concerning the long-term performance of the repository, which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with 40 CFR Part 197. Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 of the EIS describes the impacts from accident scenarios associated with earthquakes during operation of the repository. Several sections in Chapter 5 of the EIS consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository.

7.5.3.3 (10452)
Comment - EIS002126 / 0002
Newsweek January 31st, 1994 quoted the Southern California Research Earthquake Center, which consists of geologists from Caltech, the USGS, UCLA, U.S.C. and they predict that LA is overdue for an earthquake 125 times as strong as the one they had in 1994.

Science Magazine January 13th, '95 quoted four articles presented from a symposium at Caltech and they -- the consensus was that LA would have had to have had a 6.7 earthquake every eleven years for the past 200 years not to be overdue for earthquakes in the 7s, and once it's in that category, it could go from one fault system to another causing more 7s. That could be like fifteen 7s plus, and for a hundred miles around, and when you read the footnotes, it says they've underestimated the probabilities and dangers in every case and also that they have not included the San Andreas in their scenario. And how would this impact on the solidity of the land above and below the Yucca Mountain site and on the casks themselves? I knew about the potential earthquakes when I bought my house in Henderson, but the nuclear waste is another thing.

Response
Repository facilities that are important to safety would be designed to withstand ground motion from a Richter-scale magnitude 6.3 earthquake with an epicenter within 5 kilometers (3 miles) of Yucca Mountain and from a magnitude 7.5 earthquake or greater in Death Valley within 50 kilometers (31 miles) of Yucca Mountain.

While large earthquakes are possible in the region surrounding Yucca Mountain, geologic evidence does not support the view that any would be as large as the largest that can occur along the San Andreas Fault system in southern California. In addition, the recurrence interval for large earthquakes near Yucca Mountain is longer than the recurrence interval for large earthquakes along the San Andreas Fault system.

DOE's seismic hazard assessment incorporated all pertinent information on earthquake sources that might affect Yucca Mountain. Most earthquake sources are closer to the site than Los Angeles. Seismicity in the Los Angeles area, no matter how intense, is unlikely to affect the seismic hazard at the Yucca Mountain site because Los Angeles is so far away.

7.5.3.3 (11844)
Comment - EIS001788 / 0001
A 21 year study tells us much about the structure of Yucca Mountain, but does not tell us when earthquakes will happen there, exactly where they will happen or how they will change the rocks and fissures that exist. Since 1910 there have been over 600 earthquakes of greater than magnitude 2.5 within a 50 mile radius of Yucca Mountain. How many earthquakes will happen within 50 miles of Yucca Mountain before 1,000 years is over? This basin area is a dynamic area.

Response
Based on the results of analyses on the long-term performance of the repository (Chapter 5 of the EIS), which considered the effects of future seismic and volcanic activity, DOE believes that a repository at Yucca Mountain would operate safely (in compliance with 40 CFR Part 197). Section 3.1.3 describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including faults, seismicity, and the volcanic history of the region. Section 4.1.8 describes the impacts from accident scenarios associated with earthquakes during the operation of the repository. Several sections in Chapter 5 consider earthquakes and volcanic eruptions and their effects on the long-term performance of the repository. DOE believes that the information in the EIS adequately describes and analyzes the geology, geologic hazards, and the effects of these hazards on the repository.

With regard to the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the EIS explains how DOE dealt with these issues. Briefly, DOE acknowledges that it is not possible to predict with certainty what will occur thousands of years into the future. The National Academy of Sciences, the Environmental Protection Agency, and the Nuclear Regulatory Commission also recognize the difficulty of predicting the behavior of complex natural and engineered barrier systems over long time periods. The Commission regulations (see 10 CFR Part 63) acknowledge that absolute proof is not to be had in the ordinary sense of the word, and the Environmental Protection Agency has determined (see 40 CFR Part 197) that reasonable expectation, which requires less than absolute proof, is the appropriate test of compliance.

DOE, consistent with recommendations of the National Academy of Sciences, has designed its performance assessment to be a combination of mathematical modeling, natural analogues, and the possibility of remedial action in the event of unforeseen events. Performance assessment explicitly considers the spatial and temporal variability and inherent uncertainties in geologic, biologic and engineered components of the disposal system and relies on:

1. Results of extensive underground exploratory studies and investigations of the surface environment.

2. Consideration of features, events and processes that could affect repository performance over the long-term.

3. Evaluation of a range of scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as the use of water supply wells, irrigation of crops, exploratory drilling; and low probability events such as volcanoes, earthquakes, and nuclear criticality.

4. Development of alternative conceptual and numerical models to represent the features, events and processes of a particular scenario and to simulate system performance for that scenario.

5. Parameter distributions that represent the possible change of the system over the long term.

6. Use of conservative assessments that lead to an overestimation of impacts.

7. Performance of sensitivity analyses.

8. Use of peer review and oversight.

DOE is confident that its approach to performance assessment addresses and compensates for various uncertainties, and provides a reasonable estimation of potential impacts associated with the ability of the repository to isolate waste over thousands of years.

7.5.3.3 (12035)

<u>Comment</u> - EIS000540 / 0007

Frequent seismic events in the proximity of both sites make it impossible to predict the protection of the public's health and safety from the risk of radioactive release (621 earthquakes greater than 2.5 within a 50-mile radius since 1976;[4] and

Recognizing that this level of seismic activity exceeds current Nuclear Regulatory Commission regulations for allowing licensure as a nuclear reactor with on-site waste storage.[5]

[4]Nevada Agency for Nuclear Projects. Earthquakes: magnitude 2.5 and Greater in the Vicinity of the Proposed Yucca Mountain Nuclear Waste Storage and Disposal Sites from 1976-1996. (Data Source: Council of the National Seismic System Composite Catalog, 1976 to present, Southern Great Basin Seismic Network) *Nevada Nuclear Waste Policy News*, Volume 7, Issue 1. Carson City, Nevada, July 1997.

[5]Nuclear Regulatory Commission. 10 CFR 100: Reactor Site Criteria. *Federal Register*, Washington, DC, December 11, 1996.

<u>Response</u>

DOE completed an extensive seismic-hazard analysis involving 25 experts from industry, academia, and government in 1998. The expert assessments indicated that the fault-displacement hazard at Yucca Mountain is generally low. Results of long-term performance assessments of the subsurface repository indicated no significant effects on waste isolation from earthquakes.

DOE would design the surface and subsurface facilities at Yucca Mountain to withstand ground motion from earthquakes. The analysis determined that an annual frequency of 1×10^{-4}, or the 10,000-year earthquake, is an appropriate level for preclosure design of structures that are important to safety. At Yucca Mountain, DOE would design these structures to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. For the 10,000-year earthquake, design motions would be dominated by the contribution of a normal-fault type earthquake of magnitude 6.3 with an epicenter within 5 kilometers (3 miles) of Yucca Mountain that responded to higher structural frequencies. At lower frequencies, contributions from strike-slip type earthquakes of magnitude 7.5 or greater events in Death Valley [50 kilometers (31 miles) distance] are important contributors to ground motions. The analyses include uncertainties in the magnitude and location of the earthquakes. DOE regards this annual frequency as appropriate and conservative because it reflects the annual probabilities of design ground motions for nuclear powerplants in the western United States. In addition, surface facilities at Yucca Mountain would pose a lower risk than nuclear powerplants.

7.5.3.3 (12328)

<u>Comment</u> - EIS001957 / 0009

Adequate discussion is not provided in the draft EIS regarding the proposed repository container's vulnerability to damage from seismic disturbances (i.e., earthquake hazards) common to this area. We recommend the Department of Energy obtain from the U.S. Geological Survey the predicted earthquake scenario for this area, over the next century at a minimum. The NPS [National Park Service] is concerned that any seismic damage may contribute to potential release of radionuclides into the environment (specifically the regional ground-water flow system that underlies the proposed repository) and thence discharged at down-gradient springs (specifically water flows in Death Valley NP [National Park]).

Response
The EIS analyzes the probability of occurrence and the potential environmental impacts from earthquakes at the proposed repository. To support this analysis, DOE and the U.S. Geological Survey completed a comprehensive evaluation of the seismic hazards in the Yucca Mountain region using standard practices of mapping, trenching, age-dating, and monitoring contemporary seismicity. Then DOE-sponsored groups of scientific experts from inside and outside the Yucca Mountain Site Characterization Project used the site data to assess the seismic hazard potential of all significant seismic sources in the Yucca Mountain region. Another group of experts used numerical modeling methods and data from recent earthquakes to estimate ground motion attenuation relationships appropriate for Yucca Mountain.

The expert assessments indicated that the hazard associated with fault displacements is generally low. Results of long-term performance assessments of the repository indicated no significant effects on waste isolation from earthquakes. Calculations show that there would be almost no effect on repository performance from rockfalls. Section I.2.1.7 of the EIS discusses the updated waste package design and the vulnerability of drip shields to damage from seismic disturbances.

Using the seismic hazard information, DOE would design repository surface facilities to withstand the effects of earthquakes that could occur during the lifetime of the facility. The seismic design requirements for the repository specify that structures, systems, and components that are important to safety must be able to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4} (once in 10,000 years). The results of the seismic hazard analysis indicate that this is the equivalent of an earthquake with a magnitude of about 6.3 located about 5 kilometers (3 miles) from Yucca Mountain.

DOE would build the subsurface facilities in solid rock. Because vibratory ground motion decreases with depth, earthquakes would have less effect on subsurface facilities than on surface facilities. Inspection of tunnels in the Yucca Mountain area has revealed little evidence of disturbance following earthquakes. In addition, DOE would design the subsurface facilities to withstand the effects of earthquakes for the long-term performance of the repository. The emplacement areas would be in areas away from faults that could adversely affect the stability of the underground openings or act as pathways for water flow that could lead to radionuclide releases. Additional fault displacements from postemplacement seismic activity probably would be on existing fault planes. Section 3.1.3.3 of the EIS contains more information.

7.5.3.3 (12405)
Comment - EIS001888 / 0377
[Clark County summary of comments it has received from the public.]

Many commenters asked that the EIS evaluate the impacts of seismicity, geologic structure, and volcanism on radionuclide containment and repository operations. Issues raised for consideration included: (1) the proximity of Yucca Mountain to the Walker Lane/Las Vegas Shear Zone, (2) the relationship between the Walker Lake/Las Vegas Shear Zone and the San Andreas fault, (3) the pattern of earthquakes and volcanism in the region, (4) the classification of the region as a high earthquake-hazard zone, (5) and active plate tectonics. Several commenters stated that the faults at Yucca Mountain need additional study for inclusion in the EIS, because they are pathways (through rupture or breach) for gases and fluids to enter and exit the repository and transport radionuclides. Some commenters questioned the reliability of predicting the size and location of earthquakes, and the accuracy and recency of geologic mapping in the region. Others wanted a detailed description of the seismic design of the facility, and an evaluation of the consequences from the largest credible earthquake, including changes in the water table. One commenter said that large volcanic eruptions have covered Yucca Mountain and asked that the EIS examine the likelihood of similar eruptions in the future.

Response
In 1998, 25 experts from industry, academia, and government conducted a seismic hazard analysis at Yucca Mountain. The experts assessed the potential hazard at Yucca Mountain from vibratory ground motion from possible earthquakes along local and regional faults. The assessment was based on available geologic, paleoseismic, historic seismicity, and geophysical data. The experts also assessed the hazard at Yucca Mountain from displacement on local faults.

DOE is designing the surface and underground facilities at Yucca Mountain to withstand ground motion from earthquakes that were identified in the seismic hazard analysis. The analysis determined that an annual frequency of 1×10^{-4} (the 10,000-year earthquake) is an appropriate level for preclosure design of structures that are important to safety; so DOE would design these structures to withstand horizontal ground motion with an annual frequency of occurrence of 1×10^{-4}. For the 10,000-year earthquake, ground motions are likely to be dominated by the contribution of a normal-fault earthquake of Richter magnitude 6.3 with an epicenter within 5 kilometers (3 miles) of Yucca Mountain that responds to higher structural frequencies. At lower frequencies, contributions from strike-slip earthquakes of magnitude 7.5 or greater in Death Valley [50 kilometers (31 miles) away] are important contributors to ground motions. DOE regards this annual frequency to be appropriate and conservative because it reflects the annual probabilities of ground motions for nuclear powerplants in the western United States. The annual frequency of 1×10^{-4} is more conservative than the nuclear powerplants that the Nuclear Regulatory Commission has licensed, and the surface facilities at Yucca Mountain pose less risk compared to nuclear powerplants.

Table 4-36 of the EIS describes earthquake accident scenarios with a recurrence frequency of once in 50,000 years. This is roughly equivalent to a Richter magnitude 7 earthquake occurring within 5 kilometers (3 miles) of Yucca Mountain with a mean peak ground acceleration of approximately 1.1*g*, where *g* is acceleration due to gravity (980 centimeters per second squared), at the repository level (not the surface). DOE considers these to be very conservative calculations that indicate the maximum impact of such an event.

As discussed in Section 3.1.3 of the EIS, Yucca Mountain consists of lithified volcanic ash that fell and flowed onto the site during eruptions from calderas to the north (see Figure 3-5 and Table 3-7). This explosive silicic volcanic activity occurred between about 14 million and 11.5 million years ago during the emplacement of large bodies of siliceous magma that formed in the middle and upper crust. These eruptions are part of the Southwestern Nevada volcanic field, which consists of five voluminous and many smaller eruptions that occurred on a regional scale. Smaller-volume basaltic volcanism began about 11 million years ago, and continued intermittently to between 70,000 and 90,000 years ago. This basaltic volcanism originated from much greater depths than the siliceous volcanism. The northeast-trending basaltic cinder cones in Crater Flat formed about 1 million years ago. DOE based its estimate of a 1-in-7,000 chance of a volcanic disruption at the repository during the next 10,000 years on detailed investigations of the volcanoes in the region. This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000).

Intensive investigations by DOE found no evidence or credible mechanism to account for a rise in groundwater to flood the waste-emplacement horizon at Yucca Mountain. Szymanski (DIRS 106963-1989) proposed that during the last 10,000 to 1,000,000 years, hot mineralized groundwater was driven to the surface by earthquakes and volcanoes. This hypothesis goes on to suggest that similar forces could raise the regional groundwater table in the future and inundate the waste-emplacement horizon.

DOE requested the National Academy of Sciences to conduct an independent evaluation. The Academy concluded in its 1992 report (DIRS 105162-National Research Council 1992) that no known mechanism could cause a future inundation of the repository horizon. The features cited by Szymanski as proof of groundwater upwelling in and around Yucca Mountain are related to the much older (10 million to 13 million years old) volcanic process that formed Yucca Mountain and the underlying volcanic rocks. Major water table excursions (exceeding tens of meters) to the design level of the repository due to earthquakes are unlikely.

DOE scientists have estimated that the water table could rise by 50 to 130 meters (160 to 430 feet) under extremely wet climatic conditions. The regional aquifer has been estimated to have been a maximum of 120 meters (390 feet) above the present level beneath Yucca Mountain during the past million or more years based on mineralogic data, isotopic data, discharge deposit data, and hydrologic modeling. The occurrence of an earthquake under these extreme climatic conditions might cause an additional rise in the water table of less than 20 meters (66 feet), still leaving a safety margin of 20 meters (66 feet) or more between the water table and the level of the waste-emplacement drifts. The 1992 Little Skull Mountain earthquake (magnitude 5.6) raised water levels in monitoring wells at Yucca Mountain a maximum of less than 1 meter (3.3 feet) (DIRS 101276-O'Brien 1993). Water level and fluid pressure in continuously monitored wells rose sharply and then receded over a period of several hours to pre-earthquake levels. The water-level rise in hourly-monitored wells was on the order of centimeters and indistinguishable after 2 hours (DIRS 101276-O'Brien 1993).

Dublyansky (DIRS 104875-1998) proposed another line of data in support of the warm-water upwelling hypothesis. This study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. The report concludes that some of these crystals were formed by rising hydrothermal water and not by percolation of surface water. A group of Yucca Mountain Project scientists with expertise in hydrology, geology, isotope geochemistry, and climatology did not concur with Dr. Dublyansky's conclusions (DIRS 100086-Stuckless et al. 1998). Although DOE has disagreed with the central scientific conclusions of Dr. Dublyansky's report, DOE agreed to support continuing research. An independent investigation by Jean Cline, University of Nevada, Las Vegas, should be completed in Fiscal Year 2002. See Section 3.1.4.2.2 of the EIS for more information.

After closure of the repository, there would be a limited potential for releases to the atmosphere because the waste would be isolated far below the ground surface. The potential for gas transport of carbon-14 was analyzed because the repository host rocks are porous. Modeling shows that there would be negligible impacts to human health from releases of gas-phase carbon-14. Section 5.5 of the EIS contains more information on atmospheric radiological consequences.

DOE recognizes that some radionuclides and toxic chemicals could eventually enter the environment outside the repository. Modeling of the long-term performance of the repository, however, shows that the natural and engineered barriers at Yucca Mountain would keep the release of radioactive materials during the first 10,000 years after closure well below the limits established by 40 CFR Part 197 (see Sections 5.4 and 5.7 of the EIS for more information). Modeling also shows that the release of toxic chemicals would be far below the regulatory limits and goals established for these materials (see Section 5.6 of the EIS for more information).

The EIS addresses the performance of the repository for the 10,000-year regulatory period and the period between 10,000 years and one million years. DOE based its analysis of impacts on a state-of-the-art modeling technique that is internationally recognized as an adequate and proper approach. The results of this analysis, described in Chapter 5 of the EIS, indicate that impacts would be low and that health effects would be thousands of times less than natural incidences of health problems in the population.

7.5.3.4 Volcanism

7.5.3.4 (368)
<u>Comment</u> - EIS000045 / 0001
The data gathered by Nye County in its oversight program was not entered into this draft. An example is the geothermal activity found not too far from Yucca Mountain. The EIS does not even consider the risk of volcanic activity at Yucca despite Nye County's findings and the fact that there is a very young cinder cone from a recent eruption under 20 miles from Yucca Mountain.

<u>Response</u>
During the preparation of this EIS, DOE considered all pertinent data, including data from Nye County. Furthermore, DOE has supported Nye County with it's program (called the Early Warning Drilling Program) to characterize further the saturated zone along possible groundwater pathways from Yucca Mountain, as well as the relationships among the volcanic, alluvial, and carbonate aquifers. Information from the ongoing site characterization program and from the performance confirmation program (if Yucca Mountain is approved for a repository), would be used in conjunction with that of the Early Warning Drilling Program to refine the Department's understanding of the flow and transport mechanics of the saturated alluvium and valley-fill material south of the proposed repository site, and to update conceptual and numerical models used to estimate waste isolation performance of the repository. When DOE published the Draft EIS, only limited information from the Early Warning Drilling Program was available. Since then, however, this program has gathered additional information (see Section 3.1.4.2.1 of the EIS).

A panel of recognized experts in volcanism reviewed extensive information on volcanic activity in the Yucca Mountain region to assess the probability of disruption of a repository at Yucca Mountain by a volcanic event. The results of the hazard assessment indicated that the aggregate expected annual frequency of intersection of the repository footprint by a volcanic event is 1.5×10^{-8}, or approximately 1 chance in 7,000 during the first 10,000 years after closure (1 chance in 70 million annually). This estimate was recalculated in Section 3.1.3.1 of the Final EIS to account for the current footprint of the proposed repository. The revised estimate increases to about 1 chance in 6,300 during the first 10,000 years with the current repository layout, considering both primary and contingency blocks (DIRS 151945-CRWMS M&O 2000). The rocks at Yucca Mountain were formed 7 to 15 million years ago by large silicic ash flows that were erupted during a period of intense tectonic activity. The volcanism that produced these ash flows is complete and, based on the geology of similar volcanic systems in the Great Basin, additional large volume silicic activity is unlikely. Less explosive and much smaller volume basaltic volcanism in the Yucca Mountain region began about 11 million years ago as silicic eruptions waned and continued as recently as 70,000 to 90,000 years ago (see Section 3.1.3.1 of the EIS).

The EIS analyzes two disruptive volcanic event scenarios as part of the postclosure performance assessment—(1) the volcanic eruption release scenario or direct release scenario where radioactive material is transported directly to the surface and atmosphere by a magma or pyroclastic flow and (2) the igneous intrusion groundwater release or enhanced source term scenario where radioactive material is entrained in magma that remains in the emplacement drift. Section 5.7.2 of the EIS contains more information.

7.5.3.4 (975)
Comment - EIS000230 / 0004
Of further interest is the Long Valley Caldera in the Mammoth Lakes area. According to USGS's [US. Geological Survey's] website, the Yucca Mountain facility is in the path of ash flow when the caldera erupts. Also it may not be known when an eruption would occur. According to the USGS, there is an increased chance of an eruption occurring in the near future. A 5cm [centimeter] ash fall would occur at Yucca Mountain when an eruption occurs at the Long Valley Caldera. Such an ash fall would turn day into night as we witnessed after Mt. St. Helen erupted. The ash itself is highly corrosive causing severe damage to casks stored above ground, as well as disrupting transportation.

The current DEIS is deficient because it never considered the Long Valley Caldera and its eventual eruption.

Response
The EIS evaluated potential impacts from a regional volcanic eruption. Section H.2.1.3 of the EIS concludes that 3 centimeters (about 1.2 inches) is the maximum thickness of tephra (solid material; ash) from a "regional volcanic eruption, which is more likely," that could deposit on repository facilities. Analyses to date indicate that such an event would not affect structures such as the Waste Handling Building, where DOE would process casks.

The EIS analysis used the same data (DIRS 152166-Miller et al. 1982) presented on the U.S. Geological Survey Internet web site. The thickness-versus-distance curve shows that ash from the Long Valley Caldera/Mono-Inyo Volcanic area [250 kilometers (155 miles) from Yucca Mountain] would deposit about 1 centimeter (0.4 inch) of ash at the proposed repository. The same volume of material from an eruption in the closer Coso Volcanic Field [150 kilometers (93 miles) distant] would deposit 2 to 3 centimeters (0.8 to 1.2 inches) of volcanic ash at the repository (DIRS 102889-Perry and Crow 1987).

7.5.3.4 (1831)
Comment - EIS000206 / 0010
Question that is not answered by DOE: volcanic activity in the area appears to have been far more recent than previously estimated.

Response
Section 3.1.3 of the EIS describes the geologic setting of Yucca Mountain and the surrounding region in great detail, including the volcanic history of the region. The youngest volcanic center in the region is the Lathrop Wells cinder cone, which is between 70,000 to 90,000 years old.

7.5.3.4 (4535)
Comment - EIS001521 / 0048
Page 3-42--(Hydrologic Properties of Rock, second paragraph) What is an igneous versus volcanic flow? Is this referring to an igneous-intrusive sill? Or should the discussion center on the differences between ash-fall versus

ash-flow tuffs? Volcanic flows may be silicic to basaltic (or anything in between) in mineralogical composition, but igneous is not a correct descriptor.

Response
The point of this discussion was to differentiate between a hydrographic and stratigraphic unit. DOE has clarified the text of Section 3.1.4.2.2.

7.5.3.4 (5475)
Comment - EIS001887 / 0156
Page 3-24; Section 3.1.3.1 - Physiography - Potential for Volcanism at the Yucca Mountain Site

Again, there is uncertainty associated with the age of the Lathrop Wells volcano. The latest activity could have been thousands of years more recent than the 75,000 year age indicated.

Response
Studies at Lathrop Wells, combining geochronology and field studies, indicate that the Lathrop Wells cone formed during a single eruption about 80,000 years ago (DIRS 138732-Perry, Phillips, and Chung 1988). DOE has added information to Section 3.1.3.1 of the EIS to indicate the uncertainty of these dates.

7.5.3.4 (5484)
Comment - EIS001887 / 0154
Page 3-21; Section 3.1.3.1 - Physiography (Characteristic Landforms)

There is uncertainty associated with the age of the last eruption of the Lathrop Wells cone. The range of the uncertainty should be stated here.

Response
Studies at Lathrop Wells, combining geochronology and field studies, indicate that the Lathrop Wells cone formed during a single eruption about 80,000 years ago (DIRS 138732-Perry, Phillips, and Chung 1988). DOE has added information to Section 3.1.3.1 of the EIS to indicate the uncertainty of these dates.

7.5.3.4 (5487)
Comment - EIS001887 / 0157
Page 3-25; Section 3.1.3.1 - Physiography - Potential for Volcanism at the Yucca Mountain Site

The estimated probability of a dike disrupting the repository during the first 10,000 years after closure has uncertainty associated with it. The expert panel members' estimates of the annual probability ranged over about three orders of magnitude, and the probability indicated here represents an aggregation of the members' estimates.

Response
The objective of the expert elicitation on the volcanic hazards at Yucca Mountain was to assess the probability of disrupting the repository by a volcanic event, and to quantify the uncertainties associated with the assessment. In this context, "disruption" means the physical intersection of magma, such as a dike, with the repository, and "probability" refers to an annual frequency.

A major goal of the expert elicitation was to capture the uncertainties in the assessment, including uncertainties associated with the models used to represent the key physical controls on volcanism and the parameter values used in the models. The resulting probability distribution, therefore, provides a reasonable representation of the state of knowledge and uncertainty about the volcanic hazard at the Yucca Mountain site.

Expert elicitation concluded that the aggregate expected annual frequency of repository disruption by a dike is 1.5×10^{-8} for the repository design described in the Draft EIS, with a 90-percent confidence interval of 5.4×10^{-10} to 4.9×10^{-8}. The annual frequency of repository disruption was recalculated for the flexible design considered in the Final EIS and found to be 1.6×10^{-8} if contingency blocks are included in the calculation. The major contributors to the uncertainty in the frequency of disruptions are the statistical uncertainty in estimating the rate of occurrence of volcanic events and the uncertainty in modeling the spatial distribution of future events. Although there were major differences between the interpretations of the 10 panel members, most of the uncertainty in the computed frequency of intersection was due to the average uncertainty that an individual expert expressed in developing the appropriate model.

7.5.3.4 (6564)
Comment - EIS001632 / 0051
Page 5-44, first paragraph: It is difficult to understand the first part of this paragraph. Please explain the sentence: "Because of its low velocity, the magma would not be removed from the waste package."

Response
This is a valid point. The sentence in question is confusing and has been deleted from the EIS.

7.5.3.4 (7388)
Comment - EIS001957 / 0015
Section 3.1.3.1, Geology, Physiography, Potential for Volcanism at the Yucca Mountain Site – The narrative indicates that during 1995-96:

"...DOE convened the panel of recognized experts...to assess uncertainties associated with the data and models used to evaluate the potential for disruption of the potential Yucca Mountain Repository by a volcanic intrusion (dike). The panel estimated the probability of a dike disrupting the repository during the first 10,000 years after closure to be 1 chance in 7,000."

However, the draft EIS does not evaluate the effects from such a disruption occurring. No discussion is included as to the structural integrity of radioactive waste canisters if such an event should occur, and what such disruption might mean for the possibility of leakage and transport of radioactive constituents away from the proposed repository and into the regional groundwater flow systems.

Response
Section 5.7.2 of the Final EIS describes an igneous event that could disrupt the repository. The evaluation showed that it is unlikely that liquid magma or other igneous material would intersect the repository. However, because there is a finite probability of such an occurrence, it was analyzed. As described in Section 5.7.2.3 of the Final EIS, the mean annual probability of this event occurring is 1.6×10^{-8} during the next 100,000 years. The impacts from such an event are described in Section 5.7.2.3.

7.5.3.4 (7455)
Comment - EIS001969 / 0010
Page S-36, 5.4.1.3 [S.4.1.3] Geology, first paragraph.

Most of the faulting that affected Yucca Mountain occurred during the 11.4 to 14 Ma [million years ago] interval of volcanic activity and not subsequent to the activity, as stated in the text.

Response
DOE agrees that most of the faulting occurred during this period and Section S.4.1.3 of the EIS Summary has been changed to, "Yucca Mountain is a product of volcanic and seismic activity that occurred 14 million to 11.5 million years ago."

7.5.3.4 (7507)
Comment - EIS001969 / 0018
Page 3-21, last paragraph.

The statement, "Volcanic rocks younger than the Tertiary units...," is incorrect. Most of the volcanic rocks are Tertiary in age, including the Skull/Little Skull lava flows, the lava flow at the south edge of Crater Flat, the 10 Ma basaltic dike, and the 3.7-Ma cones and flows in Crater Flat.

Response
DOE has revised Section 3.1.3.1 of the EIS to state that volcanic rocks younger than Tertiary age pertain only to the four northeast-trending cinder cones in the center of Crater Flat, dated at about 1 million years old, and the Lathrop Wells basaltic cinder cone, dated at 70,000 to 90,000 years old.

7.5.3.4 (8828)
Comment - EIS000869 / 0009
Paragraphs one and two of S.4.1.3. Geology, address the lack of volcanic activity in the area. The Cascade mountain range was inactive until Mount St. Helens erupted in May 1980. There has also been increased volcanic activity worldwide. The assurances of "the chance of volcanic disruption ... during the first 10,000 years after closure would be 1 in 7,000" are probably similar to what residents of Mount St. Helens were told for years prior to the eruption. I believe that these are misleading numbers and assumptions on the geology of the Yucca Mountain area.

Response
DOE considered several types of volcanic disturbances and conducted extensive assessments for the EIS. The volcanic rocks exposed at Yucca Mountain formed between 7 and 15 million years ago during eruptions of large, silicic ash flows. The volcanism that produced these ash flows ended millions of years ago and, based on the geology of similar volcanic systems in the Great Basin, additional large-volume silicic activity is unlikely. Less explosive and much smaller-volume basaltic volcanism in the Yucca Mountain region began about 11 million years ago, as silicic eruptions waned, and has continued to as recently as 70,000 to 90,000 years ago. Based on these data, volcanic disruption of a repository at Yucca Mountain would be highly unlikely. The chance of a disruption at or near the repository would be 1 chance in 7,000 during the first 10,000 years after closure (1 chance in 70 million annually).

The volcanic history of Mount St. Helens is quite different from the volcanic history of the Yucca Mountain region. Mount St. Helens is a large volcano along the Pacific "Ring of Fire." It is associated with a highly active subduction zone. Yucca Mountain, on the other hand, is within a region of crustal extension. The estimated rate of convergence of the Juan de Fuca Plate with western Washington is about 4 centimeters (1.6 inches) per year compared to a strain rate of 0.1 millimeter (0.004 inch) per year or less in the Yucca Mountain region (DIRS 118952-Savage, Svarc, and Prescott 1999). While Mount St. Helens is a relatively young volcano (40,000 to 50,000 years old), it has an extensive history of eruptions. The penultimate major eruption occurred in 1800 and, as the U.S. Geological Survey pointed out in an article on the Internet, the "eruption in 1980 came as no surprise" [http://vulcan.wr.usgs.gov/Volcanoes/ PacificNW/AGU-T106/msh.html]).

7.5.3.4 (10424)
Comment - EIS001927 / 0031
The Western Shoshone Nation, which by the way has the rightful claim to Yucca Mountain by the 1863 Treaty of Ruby Valley which the U.S. government signed, has a different name for the site. It translates as "Serpent Swimming Westward." Indeed, global positioning satellite studies, published in Science magazine in 1998, have confirmed that the crust at Yucca Mountain is expanding westward, and at a rate an order of magnitude greater than previously believed. (Another recent finding, published in Scientific American in the last month or two, is that plutonium is much more soluble in water than previously believed, which may account for its unexplained mobility in the soil of the Nevada Test Site. This finding challenges the very concept of long-term geologic isolation of plutonium. This issue should be addressed in the EIS, for it holds great import for the ability of Yucca Mountain to contain plutonium).

This observation is consistent with the presence of a magma pocket beneath Yucca Mountain. Indeed, standing atop Yucca Mountain, one can see a line of lava cones extending westward. The youngest cone is closest to Yucca Mountain. This too is striking evidence of the presence of a magma pocket beneath Yucca Mountain – like the formation of the Hawaiian Islands, these lava cones are like the squirts from a gigantic subterranean pastry bag.

Perhaps the biggest danger from the presence of lava beneath Yucca Mountain is the possibility that it could drive hot groundwater up into the repository, flooding the waste casks. Indeed, recent analyses of gas trapped in crystals that are abundant inside Yucca Mountain shows that these crystals were formed by HOT water welling up into the mountain from below. The question scientists are currently examining is how recently this took place. Hot water flooding the repository could quickly deteriorate the casks, and could even lead to a steam or chemical explosion or nuclear criticality event. In any case, the radiation release would be catastrophic.

Response
The geodetic study reported in the March 1998 issue of Science (DIRS 103485-Wernicke et al. 1998) was based on baseline measurements using the Global Positioning System from 1991 to 1997 at five stations in the Yucca Mountain area (discussed in Section 3.1.3.3 of the EIS). While the authors discussed the possible effects on their network from displacements associated with the June 1992 Little Skull Mountain earthquake, they did not correct the station-to-station distances for earthquake displacements.

In May 1998, scientists from the U.S. Geological Survey used the Global Positioning System to resurvey a network of 14 geodetic stations originally installed in 1983 (DIRS 118952-Savage, Svarc, and Prescott 1999). Wernicke et al. (DIRS 103485-1998) used only two of the 14 stations in their study. Based on the greater number of stations, the longer survey period (1983 to 1998), and the removal of the effects of the 1992 Little Skull Mountain earthquake, the scientists concluded (DIRS 118952-Savage, Svarc, and Prescott 1999) that the strain rate in the Yucca Mountain region is considerably less (by a factor of 20 or more) than the rate reported by Wernicke et al. (DIRS 103485-1998). The survey results are consistent with a large body of geologic data collected in the Yucca Mountain region over the past two decades.

Wernicke et al. (DIRS 103485-1998) speculated that magmatic inflation at depth could be the cause of the high strain accumulation across the Yucca Mountain area. They pointed to a seismic tomographic study by Oliver, Ponce, and Hunter (DIRS 106447-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study (DIRS 105358-Biasi 1996), based on more accurate seismic arrival times and a deeper inversion model than that used by Oliver, Ponce, and Hunter (DIRS 106447-1995), demonstrated conclusively that there is no low-velocity zone under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

The line of cones in Crater Flat to the west of Yucca Mountain trends north-northeast. From south to north the line consists of Little Cone, Red Cone, Black Cone, and Makani Cone (DIRS 151945-CRWMS M&O). These cones are the sites of basaltic eruptions that are approximately 1 million years old (DIRS 151945-CRWMS M&O 2000). The youngest cone in the area is near Lathrop Wells; it erupted between 70,000 and 90,000 years ago.

Dublyansky (DIRS 104875-1998) proposed another line of evidence in support of the warm-water upwelling hypothesis (discussed in Section 3.1.4.2.2 of the EIS). This study involved fluid inclusions in calcite and opal crystals deposited at Yucca Mountain. It concludes that some of the crystals were formed by rising hydrothermal water and not by the percolation of surface water. A group of project scientists with expertise in hydrology, geology, isotope geochemistry, and climatology did not concur with the conclusions in the Dublyansky report (DIRS 100086-Stuckless et al. 1998). Although DOE has disagreed with the central scientific conclusions in that report, it did agree to support continuing research. Section 3.1.4.2.2 contains more information.

7.5.3.4 (10707)
Comment - EIS002197 / 0003
The site is possibly situated on the Pacific Ring of Fire. I bring that up because you have your Mt. St. Helens explosions and you can come all the way around and do you realize southwest of here is a big field of magna?

We don't even go to visit it, but you know there's been volcanic activity in this region many, many times.

We also know about the fissures, we know about the earthquakes, we know about all that stuff.

We don't know how hot stuff can stay a solid. We have no idea the exponential rate of putting hot with hot, with hot with hot, and what it might do.

Response
Yucca Mountain is in the southern Great Basin, on a block of continental crust. The "Ring of Fire," which is a relatively narrow belt of crustal subduction along the edge of the Pacific basin, has a much higher rate of faulting and volcanic activity compared to the Yucca Mountain area. The explosive nature of eruptions at Mt. St. Helens is

characteristic of the Ring of Fire. In contrast, the most recent volcanic eruption near Yucca Mountain occurred near Lathrop Wells between 70,000 and 90,000 years ago where small volumes of basalt and ash were erupted. Wernicke et al. (DIRS 103485-1998) speculated that magma at depth below Yucca Mountain could drive the high strain accumulation across the area. They pointed to an early seismic tomographic study by Oliver, Ponce, and Hunter (DIRS 106447-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study by Biasi (DIRS 105358-1996), based on more accurate seismic arrival times and a deeper inversion model than that used by Oliver, Ponce, and Hunter (DIRS 106447-1995), demonstrated rather conclusively that there is no low-velocity zone under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

DOE has been evaluating several heat management strategies for the proposed repository at Yucca Mountain. None of the design alternatives would produce heat that would increase the potential volcanic hazard at the site.

7.5.3.4 (12413)
Comment - EIS001888 / 0429
[Clark County summary of comments it has received from the public.]

Commenters also requested deterministic evaluations of both direct and indirect effects on the repository from volcanic activity.

Response
Section 5.7.2 of the Final EIS describes an igneous event that could disrupt the repository. The evaluation showed that it is unlikely that liquid magma or other igneous material would intersect the repository. However, because there is a finite probability of such an occurrence, it was analyzed. As described in Section 5.7.2.3 of the Final EIS, the mean annual probability of this event occurring is 1.6×10^{-8} during the next 100,000 years. The impacts from such an event are described in Section 5.7.2.3.

7.5.3.4 (12445)
Comment - EIS001898 / 0015
Additional documentation or analysis should be provided in the FEIS to support the characterization of impacts and the description of environmental parameters in some areas of the FEIS.

Section H.2.1.3 (Potential Repository Accident Scenarios: Analytical Methods and Results External Events) of the DEIS concludes that 3cm is the maximum thickness of volcanic tephra that could be deposited on repository facilities from a basaltic volcano that erupts within the area around the proposed repository site. The basis for this conclusion is a statement (DOE, 1998) that 3cm of volcanic tephra is the worst-case event being considered. The conclusion appears not to be supported by data or analyses.

Reference:

U.S. Department of Energy. Viability assessment of a repository at Yucca Mountain. *Volume 2: Preliminary Design Concept for the Repository and Waste Package.* DOE/RW-0508. Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. 1998.

Response
The EIS evaluated potential impacts from a regional volcanic eruption. Section H.2.1.3 of the EIS concludes that 3 centimeters (about 1.2 inches) is the maximum thickness of tephra (solid material; ash) from a "regional volcanic eruption, which is more likely," that could be deposited on repository facilities. Analyses to date indicate that such an event would not affect structures such as the Waste Handling Building, where DOE would process casks.

The EIS analysis used a thickness-versus-distance curve from Miller et al. (DIRS 152166-1982). This curve shows that ash from the Long Valley Caldera/Mono-Inyo Volcanic area [about 250 kilometers (155 miles) west of Yucca Mountain] would deposit about 1 centimeter (0.4 inch) of ash at the proposed repository. The same volume of material from an eruption in the closer Coso Volcanic Field [about 150 kilometers (93 miles) southeast of Yucca Mountain] would deposit 2 to 3 centimeters (0.8 to 1.2 inches) of volcanic ash at the repository (DIRS 102889-Perry and Crow 1990).

7.5.3.4 (12735)

Comment - EIS001022 / 0001

One important concern is the possibility of volcanic activity. Yucca Mountain itself was formed by a violent series of eruptions 12 to 15 million years ago. The last violent eruption was 8.5 million years ago, but there have been small peaceful eruptions, the last one only 10,000 years ago. The two nearest cones are 9 and 15 km from the boundary of the waste emplacement area. Based on this information, many questions arise. Could a volcano erupt while the waste is still active? What would be the effects?

The area was assessed as low risk, but there has been an important study since then. Geologist Brian Wernicke and colleagues conducted a study using the Global Positioning System (GPS). Between 1991 and 1997, they used the GPS to measure crustal expansion between two different satellites on Yucca Mountain. This study produced results very different than the results from previous studies. According to previous studies, the distance between the two satellites was not supposed to change at all. However, the distance between the two satellites changed 1.7 mm, showing that the movement of the Earth's crust in this area is much greater than previously thought and accelerating. Wernicke suggested that the possibility of a volcano could be ten times higher than previously thought.

Because the measurement values were so small, this study does not provide conclusive proof, but it does raise many important questions. More research is needed to determine whether this new study is accurate. This evidence is consistent with the possibility of a magma pocket under Yucca Mountain. With the new evidence, the low-risk status is under question. If these findings are correct, there is a much greater chance of volcanic eruptions than previously thought. This raises important questions about the safety of our nuclear wastes. The Department of Energy is planning to send 70,000 tons of nuclear waste that will remain radioactive in Yucca Mountain for over 10,000 years. Before they do this, this study must be pursued further. The possible effects of a volcano through Yucca Mountain are too dangerous to ignore. We need to do more research about this possibility.

The Western Shoshone tribe, that has a rightful claim to this land, have another name for this land. They call it "Serpent Swimming West." This could be a metaphor for magma swimming under Yucca Mountain. Along with the recent study, ancient wisdom speaks of the danger of radioactive waste at Yucca Mountain. Both ancient wisdom and recent studies are warning us to proceed with caution. If this study is proven correct, sending radioactive waste to Yucca Mountain is a dangerous choice. This study shows how more research is needed before we could send waste to Yucca Mountain.

Response

The most recent volcanic eruption in the Yucca Mountain region occurred at Lathrop Wells between 70,000 and 90,000 years ago. DOE based the estimated age of this eruption on several geochronologic dating techniques that indicate that the earlier estimate of 10,000 years is not valid. DOE has updated this material in Section 3.1.3.1 of the Final EIS.

The postclosure performance assessment in Section 5.7.2 of the EIS analyzes two disruptive volcanic event scenarios. The first is the volcanic eruption release scenario or direct release scenario, where radioactive material is transported directly to the surface and atmosphere by a magma or pyroclastic flow. The second, called the igneous intrusion groundwater release or enhanced source term scenario, is where radioactive material is entrained in magma that remains in the emplacement drift. The analyses include a discussion on the structural integrity of the waste packages, and what these scenarios could mean for the possibility of leakage and transport of radioactive constituents away from the proposed repository. DOE has updated this material in the EIS.

The geodetic study reported in the March 1998 issue of *Science* (DIRS 103485-Wernicke et al. 1998) was based on baseline measurements obtained from 1991 to 1997 using the Global Positioning System at five stations in the Yucca Mountain area. While the authors discussed possible effects on their network from displacements associated with the June 1992 Little Skull Mountain earthquake, they did not correct the station-to-station distances for earthquake displacements.

In May 1998, scientists from the U.S. Geological Survey used the Global Positioning System to resurvey a network of 14 geodetic stations originally installed in 1983. Wernicke et al. (DIRS 103485-1998) used two of the 14 stations in their study. Based on the larger number of stations, the longer survey period (1983 to 1998), and the removal of the effects of the June 1992 Little Skull Mountain earthquake, the U.S. Geological Survey scientists concluded

(DIRS 118952-Savage, Svarc, and Prescott 1999) that the strain rate in the Yucca Mountain region is significantly less (by a factor of 20 or more) than the rate reported by Wernicke et al. (DIRS 103485-1998). The results of the U.S. Geological Survey are consistent with a large body of geologic data and fault-trenching investigations in the Yucca Mountain region over the past two decades.

Wernicke et al. (DIRS 103485-1998) speculated that magmatic inflation at depth could be the cause of the high strain accumulation across the Yucca Mountain area. They pointed to an early seismic tomographic study by Oliver, Ponce, and Hunter (DIRS 106447-1995) that hinted at the presence of a low-velocity zone beneath Crater Flat that could be consistent with basaltic magma. A subsequent study by Biasi (DIRS 105358-1996), based on more accurate seismic arrival times and a deeper inversion model, demonstrated rather conclusively that there is no low-velocity zone under Crater Flat or Yucca Mountain that would suggest a major volcanic hazard.

DOE is continuing to fund studies on crustal strain in the Yucca Mountain region through a cooperative agreement with the University of Nevada. Dr. Wernicke, the principal investigator of one study, recently estimated in a quarterly report to the DOE that conclusions from this study would be available in 2002. This study involves 30 geodetic monument sites with continuous GPS measurements, which is a major improvement over the study reported in *Science* (DIRS 103485-Wernicke et al. 1998).

7.5.3.4 (13220)
Comment - 010244 / 0019
The SDEIS should consider what, if any, effect closer spacing of waste packages has upon the probability and consequence of a volcanic dike encountering one or more waste packages.

Response
These concepts are addressed in both the Draft EIS and the Final EIS. In very general terms, spacing the waste packages further apart increases the repository footprint and, as a result, increases the associated probability of a volcanic dike intersecting the footprint. (The probability of such an event occurring, however, is very small and the change in probability is also very small.) On the other hand, putting waste packages closer together would decrease the footprint size (and the probability of a volcanic dike intersection), but would increase the potential for waste package damage should such an event occur. That is, an intersecting volcanic dike would be more likely to come into contact with waste packages the more tightly grouped they are.

Section 3.1.3.1 of the EIS describes the probability of a volcanic dike intersecting the footprint area of the proposed repository. The Draft EIS identified a potential of 1 chance in 7,000 that such an event would occur during the first 10,000 years after repository closure. A revised estimate of 1 chance in 6,300 during the first 10,000 years is included in the Final EIS as a result of a recalculation to account for changes in the layout of the proposed repository and to include contingency blocks in addition to the primary repository block. As would be expected, the larger the size of the repository, the higher the probability that a volcanic dike could intersect the footprint (even though this probability is still very small).

Potential consequences from volcanic activity are described in Chapter 5 of the EIS (Environmental Consequences of Long-Term Repository Performance). Modeling long-term performance of the repository begins with the probability value for a volcanic dike to intersect the repository footprint, then incorporates estimates of how such an intrusion could affect the repository drifts and waste containers. With approximately 80 meters between drifts, a dike could intersect the repository without contacting either the tunnels or the containers, but it could also enter the drifts and breach or otherwise damage waste containers. Because of the uncertainties involved in evaluating how a volcanic dike could affect the repository, sensitivity analyses were performed that include a range of intrusion scenarios where the number of drifts and waste packages that could be involved are varied. The long-term performance analysis also covers the fate of contaminated materials released from containers as a result of the very low probability of a volcanic dike intrusion. This includes materials that could be immediately released into the air and the environment from magma and ash reaching the surface, as well as materials slowly migrating to groundwater if the igneous activity remained below the surface. Results of these analyses are summarized in the EIS, but the supporting documents, referenced in Chapter 5 and Appendix I of the EIS, should be reviewed for detailed information on how volcanic disturbances were evaluated.

7.5.3.5 Minerals and Energy

7.5.3.5 (4952)
Comment - EIS001946 / 0010
There are numerous technical concerns regarding Yucca Mountain:

The presence of mineral resources could result in human intrusion into the repository.

Significant scientific uncertainty surrounds this issue. It is not adequately explored in the DEIS.

Response
Section 5.7.1 of the EIS examines the consequences of inadvertent and deliberate intrusion of the repository by drilling. With regard to the inherent uncertainty associated with geologic data, analyses, and models, and the confidence in estimates of long-term repository performance, Section 5.2.4 of the EIS explains how DOE dealt with these issues.

7.5.3.5 (5492)
Comment - EIS001887 / 0160
Page 3-30; Section 3.1.3.4 - Mineral and Energy Resources

The EIS should show the locations of existing mining claims in the proposed withdrawal area, despite DOE's belief that economic mineral potential of the area is low.

Response
Section 3.1.1.2 of the EIS mentions that there are unpatented mining claims and one patented mining claim in the right-of way reservation granted to DOE by the Bureau of Land Management for site characterization. This right-of-way is roughly coincident with the withdrawal area shown in Figure 1-6 of the EIS.

Because the status of unpatented claims can change rapidly, it was decided not to identify the location of unpatented claims in the EIS or to develop a strategy for dealing with claimants. If existing unpatented claims were still viable at the time of a land withdrawal, it is reasonable to assume that such claims could be obtained through compensation or otherwise dealt with before repository closure. Because the exact number and location of unpatented claims does not affect the EIS analyses, the addition of this information serves no purpose at this time.

The single patented mining claim in the area is used to mine volcanic cinders for raw material to manufacture cinderblocks (see Section 3.1.1.3 of the EIS). It is expected that this claim would be exhausted before permanent closure of the repository.

Only Congress has the power to withdraw Federal lands permanently for the exclusive purposes of specific agencies. Congress can authorize and direct a permanent withdrawal of lands such as those required for a repository at Yucca Mountain. The extent and conditions of the withdrawal would be determined by Congress.

7.5.3.5 (5493)
Comment - EIS001887 / 0161
Page 3-31; Section 3.1.3.4 - Mineral and Energy Resources

The text should read, "...no currently economic deposits.." As any geologist will tell you, technology and demand can change a currently uneconomical deposit into an economical one almost overnight.

Response
DOE agrees that the economics of a mineral or energy deposit can change over time. However, Section 3.1.3.4 of the EIS asserts that the potential for economically useful mineral or energy resources is low, and would continue to be low for the foreseeable future.

7.5.3.5 (7574)
<u>Comment</u> - EIS001969 / 0033
Page 3-30, Section 3.1.3.4 Mineral and Energy Resources.

There is no discussion of energy resources in this section. The Yucca Mountain site is about 200 km SW of producing oil fields in Railroad Valley (one of two valleys in the state that have produced commercial oil). Published literature on the presence or absence of oil resources in the Yucca Mountain/NTS area include Chamberlain (1991 AAPG abstract), who suggested that Yucca Mountain is situated over a billion-barrel oil field, and Trexler and others (1996, AAPG Bulletin v. 80, no.1), who disputed this, as did Grow and others (Hi-Level Waste Proceedings, 1994). Although it appears that there is a low potential for mineral and energy resources in the context of today's recovery technology, a discussion of the potential resources should be included here.

<u>Response</u>
The EIS presents the results of various investigations on mineral and energy resources. DOE considers the likelihood of finding oil or gas to be low in the vicinity of the proposed repository. Drilling of numerous boreholes to depths beyond 1829 meters (6,000 feet) in the area found no indications or shows of oil of gas. Therefore, DOE decided not to include a detailed discussion of mineral and energy resource potential in the EIS, but rather to refer the reader to the numerous references that discuss these issues. This approach is consistent with the regulations of the Council on Environmental Quality [40 CFR Part 1501.7(a)(3)] that direct agencies to identify and eliminate from detailed study those issues which are not significant.

7.5.3.5 (9793)
<u>Comment</u> - EIS001888 / 0378
[Clark County summary of comments it has received from the public.]

Two commenters requested that the EIS assess the impacts to mineral exploration and development from the withdrawal of lands for the repository.

<u>Response</u>
Only Congress has the power to withdraw Federal lands permanently for the exclusive purposes of a specific agency. Through legislative action, Congress can authorize and direct a permanent withdrawal of lands such as that needed for the proposed Yucca Mountain Repository. In addition, Congress would determine any conditions associated with the land withdrawal. Regulations issued by the Nuclear Regulatory Commission (10 CFR Part 63) require that the repository operations areas and postclosure controlled areas be free and clear of all encumbrances, if significant, such as (1) rights arising under the general mining laws, (2) easements or rights-of-way, and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise. If Congress approved the withdrawal of lands for the repository, any other use of those lands would be subject to conditions of the withdrawal.

7.5.3.5 (13455)
<u>Comment</u> - 010296 / 0041
As noted on page 3-18, the titanium drip shields would not be needed until repository closure. However, page 3-19 notes that the titanium for drip shields would require from 47,000 to 66,000 tons of titanium, depending on spacing between waste packages. The annual requirement would be almost 8 percent of current U.S. production capacity. This is a huge percentage of a commodity supply, and methods to assure availability of supply, etc. should be reviewed. The environmental impacts of mining, smelting and purifying such a volume are large, and especially considering that it will be needed at a time when the easiest supplies have already been produced. The reference in the DSElS is to a 1997 Minerals Yearbook.

The FEIS should have an analysis of titanium availability, deposits, price trends, etc. to demonstrate when the optimum time to stockpile titanium will be, the price, etc. Alloy-22 and titanium drip shield performance are critical elements of the engineered barriers, limiting exposure especially in the l0,000-year time frame. For this reason, work needs to continue on Alloy-22 corrosion and decay experiments. There is substantial risk regarding availability of titanium 100s of years in the future, and a strategic assessment of titanium use, capability, reserves, etc. should be undertaken. The YMP may need a strategic titanium reserve to assure the availability of titanium when it is needed. The environmental impact of titanium mining and recovery were not addressed.

Response
DOE recognizes that a substantial amount of titanium would be required for the drip shields. The specific impacts of acquiring the titanium were not examined in the Supplement to the Draft EIS because this material would not be required for almost 100 years. As the repository program continues to evolve, the impacts of acquiring titanium would, as appropriate, be examined in future National Environmental Policy Act documents when further information became available.

7.5.4 BIOLOGY AND SOILS

7.5.4 (341)
Comment - EIS000052 / 0002
Microscopic parasite was discovered in the Yucca Mountain proposed Repository site. Are they harmful to this project?

Response
There are no known microscopic parasites in Yucca Mountain, but there are bacteria. DOE considered the possible effects of bacteria and of microbial communities in general on waste packages in the calculation of rates at which those packages could degrade. This was part of the near-field geochemistry model used to predict long-term performance of the repository in Chapter 5 of the EIS. The environmental consequences of long-term repository performance described in Chapter 5 include the possible effects of microbes on the project, which would be negligible.

7.5.4 (1131)
Comment - EIS000270 / 0014
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Failure to provide for the protection of all components of the biosphere -- of the environment for its own sake -- from radiation-related harm.

Response
Sections 4.1.4 and 5.9 of the EIS examine potential impacts to biological resources for repository operations and for long-term repository performance, respectively. DOE expects impacts to biota to be low or very low. The analyses looked at potential impacts to individual members of threatened or endangered species such as the desert tortoise population and populations of other organisms. Current recommendations from national and international radiation protection advisory organizations (DIRS 157314-NCRP 1991; DIRS 101836-ICRP 1991; DIRS 101075-ICRP 1977) indicate that if humans are protected from radiation, other biota in the same area with similar exposure pathways are also protected. This is based on extensive scientific observations showing that more developed organisms (that is, humans) are more sensitive to radiation than less developed organisms. DOE has determined that radiation effects to plants and animals would be unlikely because the dose in all cases would be much lower than the 100-millirad-per-day level at which there is no convincing evidence that chronic radiation exposure would harm plant or animal populations (DIRS 103277-IAEA 1992).

7.5.4 (1508)
Comment - EIS000505 / 0008
We find many problems with the DEIS, factors that give rise to public concerns about opposition to approval of the Yucca Mountain site for example failure to provide for the protection of all components of the biosphere, of the environment for its own sake, from radiation related harm, failure in dose calculation to account for the addictive, multiplicative and synergistic relationship of radiological and other biologically hazardous pollutant factors and conditions ultimately affecting recipients.

Response
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The EIS presents the risks of exposure to ionizing radiation and hazardous chemicals separately, where the potential for these exposures exists. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not exist at present, even if target tissues might be the same, because exposure pathways and cellular and molecular mechanisms of cancer induction can differ. The low levels of exposure to radiation and hazardous substances expected to occur from Yucca Mountain operations (Sections 4.1.2 and 4.1.8 of the EIS) and long-term performance (Sections 5.4 and 5.6 of the EIS) are such that the most likely impacts would be no impacts.

7.5.4 (4090)
Comment - EIS001482 / 0008
And I'm here tonight to speak for the animals, because there are no animals here tonight speaking. We're all talking about humans and human impacts and all that kind of stuff. But the fact of the matter is, there's an incredible population of flora and fauna out there we need to take care of, and if you have an accident it's going to affect the environment. You're going to have human impacts, but you're also going to have impacts to the natural areas and also to the animals as well that never created this waste and never got any benefits from it.

Response
Section 3.1.5.1 of the EIS describes the flora and fauna of the affected environment at Yucca Mountain. Section 4.1.4 of the EIS analyzes impacts that repository construction, operation and monitoring, and closure could have on resident species. The primary impacts of repository construction and operation on desert plants and animals would be the disturbance of about 3 to 7 square kilometers (about 800 to 1,700 acres) of land, the continuation of human presence and activities, including traffic. Those impacts have been thoroughly analyzed based upon a large amount of research and information about the desert environment at Yucca Mountain.

7.5.4 (5523)
Comment - EIS001887 / 0180
Page 3-59; Section 3.1.5 - Biological Resources and Soils

This section only briefly addresses Biological Resources and Soils, referring to the Environmental Baseline Files (TRW 1999k and TRW 1991). The discussion in this section omits the physical environment that, together with the biological components, comprise the ecosystem involved. Ecosystems are not discussed at all, and that level of ecological organization is ignored. The same is true for the discussions of Biological Resources related to transportation on pages 3-107 and 3-127. With respect to ecosystems, the Draft EIS states on page 3-59 that many of its studies for this aspect of the document "....did not use an integrated ecosystem approach and, therefore, are of little value for evaluating impacts of the repository." This deficiency negates the sufficiency and credibility of the biological and ecological aspects of the entire Draft EIS. Further discussion of this matter appears in Westman (1985), Wiesner (1995), Salk and others (1998), Caldwell (1998), Clark and Canter (1997), Ortolano (1997), Gilpin (1997), and Bartlett and Malone (1993), as well as in Attachments D, E, F, and N to these comments.

Response
The physical environment was not included in Section 3.1.5 of the EIS because it is described in Sections 3.1.2, 3.1.3, and 3.1.4 of the EIS. The evaluation of impacts to biological resources concentrated primarily on the species and community levels of ecological organization because the potential impacts on biological resources would be localized and most likely to occur at those levels. Section 4.1.4 of the EIS concluded that the removal of vegetation from the small area required for the Proposed Action and the very small impacts to some species would not affect regional biodiversity or ecosystem function. Section 3.1.5 of the EIS, as cited by the commenter, was revised to clarify that the material summarized is an opposing view expressed by the State of Nevada. DOE disagrees with that view for reasons expressed in Section 3.1.5 of the EIS. DOE has studied the biological resources at Yucca Mountain in detail and has concluded that there is sufficient information available to evaluate potential impacts of repository construction on those resources.

7.5.4 (5582)
Comment - EIS001887 / 0206
Page 4-1; Section 4 - Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure

The fact that DOE did not address the ecosystem level of organization for the Draft EIS renders an accurate interpretation of ecological impact assessment impossible. Attachments [to this comment document] G, F, H, I, J, K, and L discuss this issue, as do Westman (1985), Bartlett and Malone (1993), Salk and others (1998), Wiesner (1995), Caldwell (1998), Clark and Canter (1997), Ortolano (1997), and Gilpin (1997).

An equally important issue is that biological field studies conducted by DOE and used for the EIA process were improperly designed and statistically analyzed, thereby negating much of the information in the Draft EIS, Section 4. Study design and statistics are discussed in Attachments G and Q.

Performance confirmation is not an option. The use of the term "could" is incorrect, and the statement conflicts with the statement in Section 4.1.

Response
The EIS evaluation of impacts to biological resources concentrated primarily on the species and community levels of ecological organization because the potential impacts on biological resources would be localized and most likely to occur at those levels. DOE concluded in Section 4.1.4 that the removal of vegetation from the small area required for the Proposed Action and the very small impacts to some species would not affect regional biodiversity or ecosystem function.

DOE disagrees that biological field studies conducted at Yucca Mountain were improperly designed and analyzed and negate the analysis in Chapter 4 of the EIS. The numerous surveys and studies of biological resources conducted by DOE from 1981 through 1998 provide a detailed understanding of the species composition and community structure at Yucca Mountain. That information is used in Chapter 4 to conclude that there are no rare species or species with restricted distribution at Yucca Mountain that would be unduly affected by the Proposed Action. Results of the studies that were conducted to detect impacts indicate that site characterization had very little effect on biological resources at Yucca Mountain. Although the statistical ability to detect impacts was low for some of those studies, they were not improperly designed for characterizing the site and evaluating the most likely potential effects of site characterization activities. DOE therefore believes that the results of these studies are useful for understanding and predicting possible impacts from similar activities during repository construction and operation and support the conclusion that impacts from repository construction would not jeopardize species, communities, or ecosystems.

DOE agrees that the word "could" is incorrect when referring to performance confirmation and has modified the introduction to Chapter 4 appropriately.

7.5.4 (5756)
Comment - EIS001887 / 0361
Page 10-3; Section 10.1.1.4 - Biological Resources and Soils

This section addresses biological and soil resources for Yucca Mountain. No meaningful or substantive information is given and addressed, so the short section is meaningless.

Response
The purpose of Section 10.1 of the EIS is to identify unavoidable adverse impacts to the Yucca Mountain environment, provided pursuant to regulations from the Council on Environmental Quality (40 CFR 1502.16). Section 4.1.4 of the EIS provides meaningful and substantive information on impacts to biological resources, which DOE used to develop the conclusions in Section 10.1.1.4.

7.5.4 (5916)
Comment - EIS001619 / 0004
I understand that the EIS and the NEPA [National Environmental Policy Act] process is designed to protect the human environment and our role in that environment. Perhaps stepping away from that and speaking on behalf of the animals and the plants of the area, there needs to be more analysis of what will happen to the natural ecosystem, which is, unfortunately, near the Nevada Test Site. So I am sure it's not necessarily untainted, but there needs to be more attention paid to the effects of the actual land area around Yucca Mountain.

In the summary EIS I just have a small passage, surface soil temperatures could increase by as much by as 5.4° Fahrenheit in dry soil at a depth of 3.3 feet, which could affect root growth and the growth of microbes or nutrient availability. Potential impacts from the repository on biological resources would consist of an increase of heat tolerant species and a decrease of less heat tolerant species.

In general, the areas affected by repository heating could experience a loss of shrub species and an increase in annual species. So there needs to be more attention paid to those nonhuman victims of this disaster waiting to happen.

Response
Section 3.1.5 of the EIS describes the flora and fauna of the affected environment, which includes the analyzed land withdrawal area that surrounds Yucca Mountain. Section 4.1.4 analyzes impacts that repository construction, operation and monitoring, and closure could have on resident plant and animal species. The primary impacts of repository construction and operation on desert plants and animals would be the disturbance of about 3 to 7 square kilometers (about 800 to 1,700 acres) of land and the continuation of human presence and activities, including vehicle traffic. Those impacts have been analyzed based upon a large amount of research and information about the desert environment at Yucca Mountain (DIRS 104593-CRWMS M&O 1999). Section 5.9 describes the possible effects on biological resources and soils because of repository heating of near-surface soils. The magnitude of soil temperature increase predicted by models indicates that for most soil conditions, increases are within the range of natural temperature variation experienced by local plant and animal species (DIRS 105031-CRWMS M&O 1999). Because of this, and the small size of the affected area, DOE believes that impacts to biological resources from heat generated by the various repository operating modes would be minimal. DOE believes that the EIS provides sufficient information on the potential impacts of repository heat on biological resources at Yucca Mountain (Section 5.9 of the EIS; DIRS 103618-CRWMS M&O 1999; and DIRS 105031-CRWMS M&O 1999).

7.5.4 (5951)
Comment - EIS001622 / 0053
There is no evaluation of potential long-term impacts to animals and plants. All the long-term evaluations are based upon human health considerations. The DEIS makes the faulty assumption that relatively few predicted latent cancer fatalities will result in no impacts to aquatic, wildlife, and plant populations dependent upon the water resources affected by the project. These resources have taken tens to hundreds of thousands, and millions of years to adapt to their current habitats. These time scales should be considered in determining potential impacts to those resources.

Response
Section 5.9 of the EIS discusses the long-term impacts to plants and animals that were considered in the analysis and were determined to be largely restricted to impacts from heat generated at the repository. DOE did not assume that relatively few predicted latent cancer fatalities would result in no impacts to aquatic, wildlife, and plant populations. Instead, DOE based its conclusion on the results of calculations that estimated dose rates to native species would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992).

7.5.4 (6046)
Comment - EIS001898 / 0012
Additional documentation or analysis should be provided in the FEIS to support the characterization of impacts and the description of environmental parameters in some areas of the FEIS.

The DEIS assessments of impacts on faunal resources in Section 4.1.4 (Environmental Consequences of Repository Construction Operation and Monitoring and Closure-Impacts to Biological Resources and Soils) that are classified as “low,” “very small,” or “minimal and largely undetectable” are not supported by quantitative data. Individuals of a population that occur near the edge of its range (e.g., desert tortoises in the vicinity of Yucca Mountain) are living in marginal conditions, and therefore environmental stressors caused by the Proposed Action might have amplified effects in these edge areas.

Response
DOE does not believe that quantitative analysis is either missing or required to conclude that the Proposed Action would have little effect on biological resources at Yucca Mountain. As stated in Section 4.1.4 of the EIS, the most important impacts of repository construction and operation on desert plants and animals would be the disturbance of about 3 to 7 square kilometers (about 800 to 1,700 acres) of land and the continuation of traffic and human presence. These activities would occur in a region with few other disturbances and would affect species that are common and widespread throughout the region. DOE based the conclusion that the Proposed Action would have little effect on desert tortoises on detailed site-specific research on the tortoise populations at Yucca Mountain during site characterization. That research confirmed that activities similar to those proposed have little effect on adjacent populations. DOE has modified Sections 4.1.4.1 and 4.1.4.2 of the EIS to better explain its conclusions about impacts to desert tortoises.

The withdrawal of land surrounding the repository would protect a substantial area near the edge of the range of the tortoise from potential stressors that could occur if the land in the withdrawal area was developed for other uses.

7.5.4 (6072)
Comment - EIS000817 / 0182
P. E-16. Could you plant a prairie above the repository? Would there be a benefit to these long-rooted, long lasting grasses and [forbs]? Would they help hold water in the soil?

Response
It would not be possible to establish a successful “prairie” at this site because environmental conditions (precipitation, soils, temperatures, etc.) are not conducive to growth of typical prairie species. For example, annual rainfall in this area averages approximately 12 centimeters (5 inches), which is less than half that required to support prairie vegetation. Native perennial plants at Yucca Mountain are primarily shrubs but include grasses and forbs, and many native annual species are present when higher than average precipitation occurs. Shrubs are generally more deeply rooted and longer lived than grasses or forbs at the site, but all native species that occur there help prevent erosion. Section 9.2.4.2 of the EIS describes mitigation measures being considered to conserve and stockpile topsoil, and when disturbed areas are no longer needed, to spread topsoil over them and revegetate using a seed mixture that includes appropriate native species.

7.5.4 (7104)
Comment - EIS001106 / 0004
Section 3.1.5, page 3-59, only briefly addresses Biological Resources and Soils, referring to the Environmental Baseline Files (TRW 1999k and TRW 1991). The discussion in this section of the DEIS omits the physical environment, which together with the biological components comprise the ecosystem involved. Ecosystems are not discussed at all, and that level of ecological organization is ignored. The same is true for the discussions of Biological Resources related to transportation on page 3-107 and 3-127. With respect to ecosystems, the DEIS states on page 3-59 that many of its studies for this aspect of the document “...did not use an integrated ecosystem approach and, therefore, are of little value for evaluating impacts of the repository.” This deficiency negates the sufficiency and credibility of the biological and ecological aspects of the entire DEIS.

Response
The physical environment was not included in Section 3.1.5 of the EIS because it is described in Sections 3.1.2, 3.1.3, and 3.1.4. The evaluation of impacts to biological resources concentrated primarily on the species and community levels of ecological organization because the potential impacts on biological resources would be localized and most likely to occur at those levels. Section 4.1.4 concludes that the removal of vegetation from the small area required for the Proposed Action and the very small impacts to some species would not affect regional biodiversity or ecosystem function. Section 3.1.5, as cited in this comment, has been revised to clarify that the

material summarized is an opposing view expressed by the State of Nevada. DOE disagrees with that view for the reasons expressed in Section 3.1.5. DOE has studied the biological resources at Yucca Mountain in detail and has concluded that there is more than enough information available to evaluate potential impacts on those resources of repository construction.

7.5.4 (7106)

Comment - EIS001106 / 0005

The fact that the DOE did not address the ecosystem level of organization for the DEIS renders an accurate interpretation of ecological impact assessment impossible. It is interesting, however, that the DOE did acknowledge the potentially adverse consequences to the ecosystem from different thermal loading schemes (Table 4-11, page 4-31). The thermal loading issue with respect to biological resources is avoided in Table 4-12, page 4-35, which summarizes overall impacts from the repository by stopping the summary after repository closure and ignoring the critical long-term ecosystem impacts.

Response

The evaluation of impacts to biological resources concentrated primarily on the species and community levels of ecological organization, because the potential impacts on biological resources would be localized, and most likely to occur at those levels. Section 4.1.4 of the EIS concluded that the removal of vegetation from the small area required for the Proposed Action and the very small impacts to some species would not affect regional biodiversity or ecosystem function. Table 4-11 documents that construction activities associated with different operating modes would disturb different amounts of land-cover types. Table 4-12 does not address possible impacts after closure because Section 4.1 focuses on short-term impacts, ad indicated by its title. Section 5.9 addresses potential long-term consequences to biological resources.

7.5.4 (7107)

Comment - EIS001106 / 0006

Biological field studies conducted by the DOE and used for the EIA process were improperly designed and statistically analyzed thereby negating much of DEIS Section 4, Environmental Consequences.

Response

DOE conducted numerous surveys and studies of biological resources from 1981 through 1998 using recognized scientific methods to provide a detailed understanding of the species composition and community structure at Yucca Mountain. That information is used in Chapter 4 of the EIS to conclude that there are no rare species or species with restricted distribution at Yucca Mountain that would be substantially affected by the Proposed Action. Results of the studies that were conducted to detect impacts indicate that site characterization had very little effect on biological resources at Yucca Mountain. Although the statistical power to detect impacts was low for some of those studies, they were not improperly designed for characterizing the site and evaluating the most likely potential effects of site characterization activities. DOE believes that the results of these studies (see Section 3.1.5 of the EIS) are useful for understanding and predicting possible impacts from similar activities during repository construction and operation and support the conclusion that impacts from repository construction would not jeopardize species, communities, or ecosystems.

7.5.4 (7116)

Comment - EIS001106 / 0011

Mitigation Actions: Biological Resources and Soils are addressed in Sections 9.2.3 (page 9-6) and 9.3.4 (page 9-19). In each case the focus is almost exclusively focused on the desert tortoise and not on other components of the ecosystem or on the ecosystem itself. Additionally, there is no consideration of risks associated with mitigation.

Response

The primary focus in Sections 9.2.4 and 9.3.4 of the EIS is the desert tortoise because it is the only Federally listed threatened species at the Yucca Mountain site and because few other impacts to biological resources or the ecosystem identified in the EIS would require mitigation. The proposed mitigation measures have been developed in consultation with the U.S. Fish and Wildlife Service, are commonly used on DOE projects and those of other agencies or have been developed and evaluated during site characterization, and have no known risks that require evaluation in the EIS.

7.5.4 (7117)
Comment - EIS001106 / 0012
Unavoidable, Irreversible, or Irretrievable Impacts: Section 10.1.1.4, page 10-3, addresses biological and soil resources for Yucca Mountain. No meaningful and substantive information is given and addressed, so the short section basically is meaningless.

Response
The purpose of Section 10.1 of the EIS is to identify unavoidable adverse impacts (Council on Environmental Quality regulations at 40 CFR 1502.16) to the Yucca Mountain environment. Previous sections (such as Section 4.1.4) provide meaningful and substantive information on impacts to biological resources, which DOE used to develop the conclusions in Section 10.1.1.4.

7.5.4 (7118)
Comment - EIS001106 / 0013
References: There were 27 references that are important cited in the DEIS regarding biological, ecological, and soil resources. Of these, only three were professional publications reflecting work of the NWPO [Nuclear Waste Project Office], when in fact there are many other NWPO and NWPO-related professional publications not included among the references cited in the DEIS. Among the DOE's 24 references are 10 reports issued by TRW regarding environmental information for the Yucca Mountain Project. Of these, four are Environmental Baseline Files that themselves draw upon additional sources of information. The key DOE citation in the DEIS that is of interest here is: "TRW 1999k. Environmental Baseline File for Biological Resources." In TRW 1999k, Section 4 on Opposing Views and Section 5 on Major Issues and Data Needs are attached to these comments. Section 4 identifies six opposing views to the DOE's field studies raised by NWPO and by NWTRB [the Nuclear Waste Technical Review Board]. These are key DEIS issues regarding the Yucca Mountain biological and ecological programs, and no dispute of them is made in the DEIS. This is consistent with the earlier statement on DEIS page 3-59 that the DOE failed to use an integrated ecosystem approach thereby negating many of its field studies for the biological and ecological resource aspects of the DEIS. There are many publications concerning EIA [environmental impact analysis] and NEPA [National Environmental Policy Act] processes that should have been used as guidance by the DOE, cited, and referenced in the DEIS. Thus, the documentation used for the DEIS was cryptic and poor.

Response
The opposing views identified in Chapter 4 of the Environmental Baseline File for Biological Resources (DIRS 104593-CRWMS M&O 1999) that are applicable to the EIS analysis are identified and discussed in Section 3.1.5. DOE modified that section to clarify that these are opposing views expressed by the State of Nevada and to identify DOE's opinion about those views. DOE did not include one opposing view identified in the Environmental Baseline File (concerning ethics and professional practice) because it is beyond the scope of the EIS.

DOE carefully reviewed relevant publications prepared by the Nevada Nuclear Waste Project Office and concluded that they generally dealt with site characterization studies or were not applicable to the level of analysis appropriate for this EIS.

The Environmental Baseline Files include detailed summaries of existing information on resources, including information developed by the State of Nevada and others. The Environmental Baseline Files are often cited in the EIS instead of original reports to eliminate the need for summarizing reports in the EIS and to make the EIS concise and easier to read.

7.5.4 (7162)
Comment - 010379 / 0003
It is also important to consider impacts on other living organisms in the surrounding ecosystems.

Response
Sections 4.1.4 and 5.9 of the EIS and Section 3.1.4 of the Supplement to the Draft EIS describe the expected impacts to biological resources from the construction, operation and monitoring, closure, and long-term performance of the repository.

7.5.4 (7438)
Comment - EIS001969 / 0001
The Department's [U.S. Department of the Interior] Fish and Wildlife Service (Service) is responsible for protection of trust resources which include species listed as threatened or endangered under the Endangered Species Act of 1973 (ESA), as amended, birds protected under the Migratory Bird Treaty Act, and other biological resources managed under the National Wildlife Refuge (NWR) System. The Service is concerned with possible adverse effects to these and other resources that could result from the operation of the Yucca Mountain facility. Trust resources on or in the vicinity of the proposed waste storage facility include the following:

Yucca Mountain is at the northern edge of the range for the desert tortoise (*Gopherus agassizii*) which is listed as threatened under the ESA. On July 23, 1997, the Service issued a biological opinion to DOE for programmatic activities associated with site characterization studies at Yucca Mountain (File No. 1-5-96-F-307R).

Rainfall runoff accumulating in low lying areas at the NTS such as Frenchman Flat, attract migratory birds to the area.

The Desert National Wildlife Range, located approximately 30 miles to the east of the proposed repository, provides habitat for numerous wildlife species that are unique to the Mojave Desert ecosystem.

The Ash Meadows NWR is located approximately 25 miles south of Yucca Mountain and provides habitat for 12 species listed under the ESA, including the Devils Hole pupfish (*Cyprinodon diabolis*) and Ash Meadows Amargosa pupfish (*Cyprinodon nevadensis mionectes*). Ash Meadows also provides aquatic and riparian habitat essential for other sensitive species of plants and invertebrates and for migratory and resident bird species. These and other wildlife species are dependent upon several free-flowing springs within the boundary of the refuge.

Response
On December 17, 1998, DOE requested a species list from the U.S. Fish and Wildlife Service and initiated consultation to evaluate whether the Proposed Action could affect the threatened desert tortoise or protected species at Ash Meadows, Devils Hole, or along transportation corridors. In a Biological Assessment submitted to the U.S. Fish and Wildlife Service on April 24, 2000, DOE concluded that the Proposed Action would not affect the listed species in the Ash Meadows or Devils Hole areas because these areas are in a different regional groundwater sub-basin from Yucca Mountain. The Fish and Wildlife Service concurred with this conclusion during consultation on the effects of repository construction, operation and monitoring, and closure on threatened and endangered species (see the Fish and Wildlife Service Final Biological Opinion in Appendix O of the EIS). Furthermore, there are no playas in the vicinity of Yucca Mountain where surface water could accumulate and attract migratory birds. The playa at Frenchman Flat is located approximately 35 kilometers (22 miles) east of Yucca Mountain and would be unaffected by the Proposed Action.

DOE did determine that the Proposed Action could affect the desert tortoise and consequently has proposed mitigation measures to minimize effects. If the Secretary of Energy recommends approval of the Yucca Mountain site to the President, and Yucca Mountain is ultimately authorized for the disposal of spent nuclear fuel and high-level radioactive waste, DOE would implement all reasonable and prudent mitigation measures and comply with the terms and conditions of the Final Biological Opinion from the U.S. Fish and Wildlife Service. See Appendix O of the EIS for the Opinion.

The Desert National Wildlife Range, approximately 48 kilometers (30 miles) east of the repository, would be unaffected by the Proposed Action unless the Valley Modified Corridor, which could be on, or adjacent to, the southern boundary of the Range, was selected. With regard to the transportation implementing alternatives in the State of Nevada, DOE believes this EIS is sufficient for the determination of the relative merits and a selection decision among the various corridors and shipment modes discussed in the EIS, but acknowledges additional environmental review would be required to assess the potential impacts of specific route alignment within a corridor. DOE would continue discussions with the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act, as amended, on any corridor or alignment within a corridor determined to require further environmental review and would implement the terms and conditions of any subsequent Biological Opinions.

7.5.4 (7744)
Comment - EIS000817 / 0024
In your summary you refer to bats, tortoises, beetles, etc. -- and your effect on them. Have you evaluated the possible effect of them on your project? Bats for example. What a perfect home for bats I would think. (Ever been to Carlsbad Caverns? -- full of millions of them.) So can bats survive in the repository in later years as things cool down and cave in? What could bats do in there? Effect of bat guano for example? And what happens to bats reproduced after they are irradiated and come out into the public domain? What about other animals -- burrowing things? Lizards, snakes, prairie dogs --whatever you have in Nevada -- and the minute plants and animals (like beetles) that can raise havoc in great numbers? What can happen to species in there over time? Can they dig into the repository? How could it affect them and how could they affect it? Nature loves to fill in spaces with whatever can get in there -- how secure will all openings to the tunnels be? Ventilation systems for example -- once bats get in there -- how would you get them out? These things have to be considered long term when fractures form and rock tunnels cave in and water seeps, etc. There will be cavities formed and new channels to the tunnels. So often it's the unexpected that causes huge problems in such scenarios, especially for such a long time prediction in the future. Considering exotic species come in so easily nowadays with trade all over the world. Who knows what could get started growing or becoming active in those tunnels? Have plant and animal experts done close evaluation and predictions for future possible conditions -- not just for big things like bats -- but for small microscopic worms, or whatever could be in there? We don't want a surprise in 100 years or later that the repository is full of poisonous snakes or something that loves the habitat later on. What is possible?

Response
Some animals, such as bats, occasionally enter the tunnels at Yucca Mountain, but cause no operational problems. This probably would continue during the operation and monitoring phase of the repository, and standard pest management practices would minimize impacts to operations and to the animals. Steel isolation doors at the emplacement drift entrances would prevent animals from entering the waste disposal areas. During the closure phase, DOE would seal the main drifts and ventilation shafts to prevent all access. The repository would be too deep underground for animals to dig into the tunnels.

7.5.4 (8057)
Comment - EIS002001 / 0004
By putting nuclear waste into Yucca Mountain you're not only hurting people, but wildlife and plants. Think of all that will be damaged by it. Please reconsider putting the nuclear waste in Yucca Mountain.

Response
No significant impacts to people, wildlife or plants were identified, as discussed in Section 4.1.4 of the EIS.

7.5.4 (8654)
Comment - EIS001889 / 0007
The DEIS may have overlooked wilderness values under the potential Caliente-Chalk Mountain rail route. According to your map (Figure 2-48), it looks like the Caliente Rail Corridor would possibly pass through Weepah Spring Wilderness Study Area (WSA). If it does not pass through the WSA, this would be the preferred route of the Ely Field Office.

Response
Section 6.3.2.2.1 of the EIS has been modified to state that the Caliente-Chalk Mountain Corridor is north and east of the Weepah Springs Wilderness Study Area. As suggested in the Foreword to the EIS and Chapter 6, DOE would conduct additional government consultations and would prepare National Environmental Policy Act reviews, if the repository was approved, to consider alternative alignments within any selected corridor. These would include consultations with the Department of the Interior and other Federal agencies as appropriate to ensure that the alignment posed minimal threats to the Weepah Springs Wilderness Study Area and other areas of concern.

7.5.4 (9360)
Comment - 010259 / 0006
Death Valley National Park will be endangered, as will the delicate plant and animal life that can only be found in that region.

Response
The results of analyses reported in the EIS (Chapters 4, 5, 6, and 8) demonstrate with reasonable expectation that the groundwater, surface water, wildlife, air quality, cultural resources, and aesthetics of Death Valley would not be adversely affected by a repository at Yucca Mountain.

7.5.4 (9799)
Comment - EIS001888 / 0385
[Clark County summary of a comment it received from a member of the public.]

One commenter requested that the nature and duration of changes in the surface ecosystem at Yucca Mountain from waste-generated heat and refluxing water vapor be examined in the EIS for each alternative.

Response
DOE estimated surface temperature changes that could occur as a result of residual heat and presented this information in Section 5.9 of the EIS. The analysis assumed the highest heat case. The nature and areal extent of possible changes to the surface ecosystem were summarized from cited references (DIRS 103618-CRWMS M&O 1999; DIRS 105031-CRWMS M&O 1999). Some repository designs could affect larger areas, but the temperature effects would be smaller in those cases.

7.5.4 (10381)
Comment - EIS001927 / 0016
The DEIS does address certain impacts on other living beings, such as wildlife – although far from adequately. However, one impact conspicuous by its absence is the affect of radioactivity from a Yucca Mountain repository on non-human life forms. Perhaps the human embryo is not the most vulnerable living being to radiation's harmful effects –- perhaps the embryo of another animal species is. These kinds of radiation impacts go unaddressed in the DEIS. What ecological affect would radiation have on the gene pool of threatened or endangered species such as the desert tortoise that live close to Yucca Mountain? In addition, what affect will the emplaced waste's high thermal heat have on species such as the desert tortoise, that lay their eggs in the ground, and on plant species that inhabit the surface of the desert land above and near to Yucca Mountain? These are environmental impacts that need to be addressed in an environmental impact statement.

Response
Sections 4.1.4.2 and 5.9 of the EIS discuss the possible impacts of radiation on plants and animals. Releases of radioactive materials, largely noble gases that cannot be incorporated into biological systems, would cause very little exposure to radiation for the plants and animals near the repository (see Section 4.1.4.2). As discussed in Section 5.9 of the EIS, DOE does not expect that the dose rates to plants and animals from groundwater would affect the gene pool or otherwise cause measurable detrimental effects in populations of any species because the rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992).

Section 5.9 also discusses the possible ecological changes that could result from increased soil temperatures.

7.5.4 (11780)
Comment - EIS000622 / 0003
There is a proposal for withdrawing 230 square miles for the Yucca Mountain repository, additional to the lands that have already been withdrawn that are bigger than the size of the state of Rhode Island for the Nevada Test Site itself. And as pointed out earlier, there are many, many issues of impacts on plants that are used for medicines and foods, animals that are hunted and used in other ways in the community, things that are used for building, such as willow and that kind of thing, and they seem extremely inadequate. So I would ask that these things be addressed.

Response
Section 4.1.4.2 of the EIS describes the impacts to plants and animals, which would be largely limited to destruction of vegetation and habitat on approximately 3 to 7 square kilometers (about 800 to 1,700 acres) of land within a very large area of similar, undisturbed habitat. None of the plants and animals found at Yucca Mountain are rare or are

restricted to that site, so those resources used for medicines, foods, and other uses still would be widely available at other, more accessible locations.

7.5.4 (11958)
Comment - EIS000851 / 0006
I am against a waste depository at Yucca Mountain because:

Yucca Mountain is the habitat of many endangered species, which will cease to exist if radiation poisoning occurs. Waste sites have historically become toxic wastelands.

Response
As described in Section 3.1.5.1.3 of the EIS, the only threatened or endangered species at Yucca Mountain is the desert tortoise, which is classified as threatened. The primary impacts to this and other species would be the loss of about 3 to 7 square kilometers (about 800 to 1,700 acres) of habitat and the continuation of traffic and human presence. Based on site-specific research, DOE has concluded that construction and operation of the proposed repository would have little effect on the tortoise population in the region, although individuals could be killed. Spent nuclear fuel and high-level radioactive waste would be contained inside facilities and the repository, and would not affect plants and animals or turn the site into a wasteland. DOE and the U.S. Fish and Wildlife Service have completed consultation on the potential effects of repository construction, operation, and closure on threatened and endangered species. In its Biological Opinion, the Fish and Wildlife Service concluded that these actions would not jeopardize the continued existence of the Mojave population of the desert tortoise. See Appendix O for the Final Biological Opinion, which includes an unlimited-take provision of tortoises along roads at Yucca Mountain, in part because deaths due to vehicles are anticipated to be infrequent.

7.5.4 (12015)
Comment - 010244 / 0037
The surface aging facility would require an additional 1,600 acres of habitat disturbed. The increase in land disturbance under the S&ER flexible design would cause additional loss of desert tortoise habitat. Microclimate in the immediate vicinity could be affected. Human activities could result in harmful effects, both intentionally and unintentionally, to those fragile resources in the area. How can DOE be so sure disturbing 150,000 acres for the entire repository will not cripple the biodiversity and ecosystem?

Response
The staging area by itself would not require the disturbance of an additional 6.5 square kilometers (1,600 acres) of land, nor would a total of 61 square kilometers (150,000 acres) be disturbed for development of a repository. The maximum amount of previously undisturbed land that would be cleared of vegetation for construction of a repository (for the lower-temperature operating mode, including a surface aging facility), would be about 3.4 to 6.6 square kilometers (840 to 1,620 acres). Those disturbances would be centered in a 150,000-acre area withdrawn from public access. Most of that withdrawal area would remain undisturbed. As described in Section 3.1.4 of the Supplement to the Draft EIS, and in Section 4.1.4 of this EIS, construction of the surface aging facility and other repository facilities would result in additional losses of desert tortoises and other plant and animal species. However, because these species are widespread throughout the region, and that region has large tracts of undisturbed land, the additional loss of those biological resources would not significantly affect the regional biodiversity or ecosystem.

7.5.4 (12922)
Comment - 010281 / 0007
Uncertainties. The DEIS and the Supplement fail to address the future impact of changes taking place in the biosphere, such as the extinction of species and/or the extension of the range of species.

Response
Changes to the biosphere, such as extinction or expansion in the range of a species, were not considered because such events are very uncertain and would require speculative analyses that would not be meaningful to decisionmakers.

7.5.4.1 Vegetation

7.5.4.1 (118)
Comment - 6 comments summarized
Commenters state that the Draft EIS fails to adequately address the impacts of the Proposed Action on vegetation in affected Nevada counties. Noxious weeds are a major problem in Nevada and the western United States. They threaten the livelihood of everyone who depends on the use of the range. They are easily spread by motor vehicles, humans, wind, and livestock, and they are difficult or impossible to control once established. Disturbed soils are especially vulnerable to colonization by noxious weeds. The EIS fails to include a detailed analysis of potential impacts from the spread of noxious or invasive weeds with regard to the repository, transportation, highway improvements, and other possible activities. In addition, Executive Order 13112 states, in part, that no Federal agency shall authorize, fund, or carry out actions that it believes are likely to cause or promote the spread of invasive weed species unless, pursuant to guidelines that it has prescribed, the benefits of the action outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk or harm be taken in conjunction with the actions.

Commenters also state that the Draft EIS must analyze the potential impacts of the Proposed Action on the spread of noxious weeds, including their potential effects on native flora, during both construction and operation of the repository. Specifically, it must identify vectors that would be created or enlarged for the spread of such weeds, and the consequences of possible infestations. The EIS must also describe the known habitats and sites of rare and sensitive plants and identify potential disturbance during construction and operation as a result of the establishment of access to alternative transportation routes. The EIS must also address efforts to prevent the spread of noxious weeds.

Response
DOE added a description of potential impacts from exotic species or noxious weeds to the Final EIS. Section 3.1.5 identifies exotic species that are present and abundant in the Yucca Mountain area. Sections 4.1.4.2, 6.3.2.1, and 6.3.3.1 identify impacts from construction of a repository, branch rail line, and heavy-haul truck route. Sections 4.1.4.2 and 9.2.4 describe mitigation for preventing or reducing the spread of exotic species or noxious weeds. Sections 4.1.4.2, 6.3.2.1, and 6.3.3.1 contain information about potential impacts on rare and sensitive plants.

7.5.4.1 (4560)
Comment - EIS001521 / 0073
Page 3-61, Figure 3-18--What does the boundary designation “between two individual vegetation coverages” mean? It is not discussed in the text. Why not use the “analyzed land withdrawal area” as noted on page 3-60, first paragraph? Also, the analyzed area on this figure does not match that on page 1-16, Figure 1-6, which was used for other proposed-repository studies--why not?

Response
The land cover types of the analyzed land withdrawal area, as defined in Section 1.4.1 of the Draft EIS, were adapted from two sources referenced in Section 3.1.5.1.1. The “boundary” in Figure 3-21 defined the sources of the land cover types. The land cover types within the boundary and closer to the proposed repository location (adapted from DIRS 104589-CRWMS M&O 1998) were mapped in greater detail than the rest of the land withdrawal area (adapted from DIRS 103670-Utah State University 1996). Land cover types within the boundary have a higher degree of accuracy because of this detail and because they were validated in the field (DIRS 104589-CRWMS M&O 1998). The land withdrawal area is essentially the same in Figures 1-6 and 3-21. In the Final EIS, the boundary line has been removed from this figure to avoid confusion.

7.5.4.1 (5604)
Comment - EIS001887 / 0230
Page 4-31; Table 4-11 - Land cover types in the analyzed land withdrawal area and the amount of each that repository construction and disposal of excavated rock would disturb (square kilometers).

It is interesting that the DOE did acknowledge potentially adverse consequences to the ecosystem from different thermal loading schemes in this table. However, the thermal loading issue with respect to biological resources is avoided in Table 4-12, page 4-35, which summarizes overall impacts from the repository, by stopping the summary after repository closure and ignoring the critical long-term ecosystem impacts. This is further discussed in Attachments G, F, O, and P.

Response
DOE did not avoid the thermal loading issue in the Draft EIS as described in the comment and elaborated on in the attachments. Chapter 4 of the Draft EIS and the Final EIS describes only impacts from repository construction, operation and monitoring, and closure. Table 4-12 documents the construction activities associated with the thermal loading scenarios that would disturb different amounts of land cover types. Table 4-13 has consistent information. Section 5.9 of the EIS discusses potential long-term impacts to the ecosystem from thermal loading. These sections have been modified in the Final EIS to reflect the flexible design in the supplement to the Draft EIS.

7.5.4.1 (6665)
Comment - EIS001878 / 0043
The DEIS underestimates the difficulty of storing topsoil, returning it to a site, and revegetating disturbed areas in Nevada's arid climate. (p. 4-23)

Response
DOE spent several years during site characterization conducting reclamation feasibility studies designed to identify and improve methods of reclamation in arid environments (DIRS 146287-CRWMS M&O 1999) and understands the difficulties associated with the process. These studies were focused on identifying and improving the techniques for site preparation, revegetation, soil stabilization, and topsoil stockpiling. Methods for maintenance of topsoil viability stockpiled for both short term (up to 6 months) and long term (several years) were examined. From these studies, an array of standard reclamation techniques were identified that could be selected from, and applied to, sites based on type of disturbance, soil type and depth, vegetation community, and topography. DOE has used these techniques to reclaim disturbances caused by site characterization activities in Mojave and Great Basin desert upland plant communities.

7.5.4.1 (12074)
Comment - EIS002311 / 0003
In section 5.9, the DEIS is arguably incorrect about the statement "A shift in plant species composition, if any, would be limited to the area within 500 meters of the repository footprint [that is, as much as 8 square kilometers (2,000 acres)], with greatest change within the central 3 square kilometers (740 acres) for the high thermal load scenario," because it fails to consider that the new heat tolerant plants that out-compete the native species within the aforementioned area, will likely continue to spread beyond this area as its biomass increases, and the chemical reactions carried out by the plant itself could further change the soil composition. This could make it more difficult for native species to thrive.

Response
The EIS does not suggest that there would be "new" heat tolerant plants. The suggested shift in species composition refers to plant species that currently exist and are adapted to naturally warmer and dryer sites (for example, low elevation, south slopes) in the Yucca Mountain area. Many of these are native plant species (DIRS 105031-CRWMS M&O 1999). An increase in heat tolerant species within the affected area does not mean that those species would have a competitive advantage in cooler areas beyond the repository footprint.

7.5.4.1 (12085)
Comment - EIS002307 / 0002
The DEIS is incorrect in saying that there will be few human health impacts from the repository because the effects on vegetation due to temperature changes (cited in Section 5.10 of the DEIS) are not taken into account.

Response
Section 5.9 of the EIS discusses the effects on vegetation due to temperature changes from repository heat. If they occurred, they would be localized to the area just above and adjacent to the repository, an area that would remain remote from human activities. Because there is no reasonable way that possible changes to small areas of native vegetation could affect human health, they were not included in Section 5.10 of the EIS, where DOE concluded that any potential impacts to human health in the future would be dominated by impacts from radioactive materials in the waterborne pathway.

7.5.4.2 Wildlife

7.5.4.2 (39)
Comment - 2 comments summarized
Commenters state that the Draft EIS does not adequately assess possible impacts of the proposed project on desert bighorn sheep in the region. Threats to bighorn sheep include ingesting contaminated water at surface springs in Death Valley and surrounding wetlands and fragmentation of habitat from the transport of spent nuclear fuel and high-level radioactive waste. Currently, there are no major barriers such as roads or fences to movement by bighorn sheep in the area lying north (and west) of Interstate 15 in California, Nevada, Arizona, and Utah. The EIS should evaluate the impacts to bighorn sheep from the creation of barriers and habitat modification or fragmentation caused by the proposed Project. Impacts of increased volumes and speed of traffic should also be examined.

Response
Except for possible upgrading, DOE does not plan to modify existing public highways in California or elsewhere that would be used to transport materials, personnel, or legal-weight truck shipments of spent nuclear fuel and high-level radioactive waste to Yucca Mountain. Therefore, additional information on those routes is not necessary. Transportation-related habitat fragmentation would occur only if a highway in Nevada would have to be upgraded for heavy-haul trucks or during construction of a branch rail line in Nevada. The *Environmental Baseline File for Biological Resources* was used to compile the biological sections of the EIS (DIRS 104593-CRWMS M&O 1999) describes and maps bighorn sheep populations and migration patterns near the routes being considered and Sections 3.2.2.1.4 and 3.2.2.2.4 of the EIS highlight the sheep populations most likely to be affected. DOE acknowledges in Section 9.3.4.2 and elsewhere in the EIS that construction of some transportation routes could disrupt movements of game animals.

DOE agrees that additional, site-specific information would be necessary prior to construction of a branch rail line or road upgrades to support heavy-haul shipping. However, DOE believes that the EIS provides sufficient information on impacts to biological resources to make decisions regarding the basic approaches (for example, mostly rail or mostly truck shipments), as well as the choice among alternative transportation corridors in the State of Nevada. DOE anticipates that the project plan and design would continue to evolve, creating additional opportunities for mitigation and potentially eliminating the need for some mitigation measures currently under consideration. Chapter 9 of the EIS identifies DOE-determined impact-reduction features, procedures and safeguards, and mitigation measures under consideration for inclusion in the project plan and design. Chapter 9 also identifies ongoing studies that could eventually influence mitigation measures related to the project plan and design. As noted in the EIS Foreword, Chapter 6, and elsewhere, if a repository was constructed at Yucca Mountain, DOE would conduct a more detailed assessment of the potential impacts on wildlife habitat and wildlife movements along transportation routes in Nevada. Impacts to bighorn sheep and other wildlife resources would be more fully evaluated at that time and mitigation measures would be developed.

7.5.4.2 (117)
Comment - 4 comments summarized
Commenters stated that the Draft EIS did not sufficiently analyze impacts of repository construction and operation on animals, especially the desert tortoise. The Draft EIS notes that five tortoises were killed on roads during site characterization activities, and that death or displacement of individual members of some animal species, including the desert tortoise, as a result of site clearing and vehicle traffic would be unavoidable. Commenters wanted to know what the impacts would be from an increase in traffic and other activities on desert tortoises and other animals and whether this would cause tortoises to become extinct.

Response
Impacts of repository construction and operation on desert plants and animals would result from the disturbance of about 3 to 7 square kilometers (about 800 to 1,700 acres) of desert habitat, the continuation of human presence and activities, and an increase in traffic to Yucca Mountain. Those impacts have been analyzed based upon a large amount of research and information about the desert environment at Yucca Mountain (DIRS 104593-CRWMS M&O 1999). As summarized in Section 10.1.1.4 of the EIS, adverse impacts on regional populations of animals, including the desert tortoise, would be minimal and largely undetectable in part because the impacts would be restricted to a small area and the animal species found at Yucca Mountain are widespread throughout the region. Traffic and other site characterization activities during about 1991 to 1995 had no detectable effect on populations of

desert tortoises and other animals monitored (DIRS 104593-CRWMS M&O 1999). The U.S. Fish and Wildlife Service issued a Final Biological Opinion that concluded repository construction, operation, and closure would not jeopardize the continued existence of the Mojave population of the desert tortoise (see Appendix O for the Final Opinion).

7.5.4.2 (1847)
Comment - EIS000367 / 0003
The animals, the water in the area, if it does get contaminated, it will affect the pupfish, a very rare species that is in Death Valley, the bighorn sheep that live in the area around that area, and then just the natural people that live in this area, Inyo County, all the way in a big circle, the whole Great Basin.

Response
The flowpath for groundwater beneath Yucca Mountain is described in Section 3.1.4.2.1 of the EIS to be to Jackass Flats, to the Amargosa Desert, and then southward to the primary point of discharge at Alkali Flat southeast of Death Valley Junction. Although the flowpath in the Amargosa Desert is near Ash Meadows and Devils Hole where pupfish occur, these resources would not be effected. However, in this area there is marked decline of 64 meters (210 feet) or more in the water table elevation between Devils Hole and the low axis (Carson Slough) of the Amargosa Desert to the west and south. This elevation decline indicates that the groundwater flow from the carbonate rocks of the Devils Hole Hills is westward across Ash Meadows toward the Amargosa Desert, not the other way around. Therefore, contamination from Yucca Mountain could not discharge to the surface nor contaminate the aquifers at Ash Meadows or Devils Hole.

The calculations in Chapter 5 of the EIS indicate that predicted long-term levels of radionuclide concentration in groundwater and the resulting dose levels at the predicted discharge area in Amargosa Valley, Nevada, would be low. DOE does not expect that the dose rates to plants and animals at that location would cause measurable detrimental effects in populations of any species because the rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992). DOE recognizes in the EIS that some groundwater reaching Alkali Flat may bypass this playa area and continue on into the Death Valley basin which would require first moving through the areas of Tecopa and Shoshone. DOE also recognizes that a small fraction of the groundwater flow beneath the Amargosa Desert might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek Wash area of Death Valley. In either case, any concentrations reaching these areas of Death Valley would be even less than the concentrations presented in Chapter 5 of the EIS for the discharge location at Alkali Flat (Franklin Lake Playa), because concentrations would decline with distance from the proposed repository.

7.5.4.2 (4146)
Comment - EIS001206 / 0001
The discussion of Impacts to Biological Resources and Soils from Performance Confirmation (Section 4.1.4.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity. It is inadequate because it fails to adequately consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity.

The discussion of Impacts to Biological Resources from Construction, Operation, and Monitoring and Closure (Section 4.1.4.2) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity.

The discussion of Impacts to Biological Resources from Retrieval (Section 4.2.1.2.4.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species range. It is inadequate because it fails to properly consider and address the regional and rangewide implications increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity.

The discussion of Consequences to Biological Resources and Soils (Section 4.2.1.2.4.1) is inadequate because it fails to properly consider and address the regional and rangewide implications of the loss of unique desert tortoise (Gopherus agassizii) populations and the genetic potential of these populations at the northern extremes of this species range. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in traffic on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity. It is inadequate because it fails to properly consider and address the regional and rangewide implications of increases in raven populations and their increased levels of predation on unique desert tortoise (Gopherus agassizii) populations at the northern extremes of this species range due to this activity. It is inadequate because it incorrectly asserts that “Desert tortoises are rare or absent on or around playas...” Recent work by Dave McCullough (pers. com.) in the vicinity of Ivanpah Dry Lake has found the desert tortoises are much more common in Atriplex sp. Communities surrounding playas than was previously believed. Therefore, discharge of radioactive and toxic effluent would pose a more significant threat than is currently being considered.

Response
DOE did consider the regional and rangewide implications of the Proposed Action, the loss of genetic potential, and impacts of traffic and ravens on desert tortoises and concluded in Chapter 4 of the EIS that the loss of a small number of tortoises along roads and at the proposed repository site would not affect the genetic potential or the long-term survival of the local or regional population of this species. In addition, the U.S. Fish and Wildlife Service has issued a Final Biological Opinion that repository construction, operation, and closure would not jeopardize the continued existence of the Mojave population of the desert tortoise (see Appendix O of the EIS for the Final Opinion). Research at Yucca Mountain during site characterization confirms that activities similar to those proposed have little effect on tortoises adjacent to disturbances (DIRS 104294-CRWMS M&O 1999). The abundance of ravens at Yucca Mountain was not influenced by construction activities at Yucca Mountain (DIRS 103195-CRWMS M&O 1998) and ravens were not an important predator of young tortoises in this area (DIRS 102236-CRWMS M&O 1998). Section 4.1.4.1 of the Final EIS has been modified to clarify the conclusion that the Proposed Action would not affect desert tortoise populations.

The Atriplex plant community in Ivanpah Valley is substantially different from plant communities near playas in southern Nye County. Information from surveys of desert tortoises in Nye County show that tortoises are rare or absent near playas in this region (DIRS 101914-Rautenstrauch and O’Farrell 1998).

7.5.4.2 (4351)
Comment - EIS001182 / 0004
What consideration had been given to the impact on desert fauna, reptiles, insects and spiders?

Response
Impacts to all desert fauna known to occur at Yucca Mountain were considered in Sections 4.1.4, 5.9, 6.3.1.1, 8.2.4, and 8.4.2.4 of the EIS. Because these species are widespread throughout the region, DOE concluded that the deaths of a few individuals and loss of 3 to 7 square kilometers (800 to 1,700 acres) of habitat would have little impact on the regional populations of those species.

7.5.4.2 (5752)
Comment - EIS001887 / 0356
Page 9-6; Section 9.2.3 - Biological Resources and Soils

In this section, the focus is almost exclusively on the desert tortoise and not on other components of the ecosystem or on the ecosystem itself. Additionally, there is no consideration of risks associated with mitigation. For these and other reasons (Attachments [to this comment document] D, G, M; Clark and Canter, 1997; Ortolano, 1997; Westman, 1985), the section is inadequate.

Response
DOE does not agree that Section 9.2.3 of the EIS is inadequate, as the comment and attachments contend. The primary focus in Sections 9.2.4 and 9.3.4 of the EIS is the desert tortoise because it is the only federally listed threatened species at the site and because there are few other impacts to biological resources or the ecosystem identified in the EIS that require mitigation. The proposed mitigation measures have been developed in consultation with the U.S. Fish and Wildlife Service. The Service has issued a Final Biological Opinion that repository construction, operation and monitoring and closure would not jeopardize the continued existence of the Mojave population of the desert tortoise (see Appendix O of the EIS for the Final Opinion).

7.5.4.2 (6068)
Comment - EIS001898 / 0011
The DEIS may not adequately bound the uncertainty in the predictions of heat generated from radioactive decay during long-term repository performance and the potential effects of this heat generation on fauna.

Basis:

Although most vertebrate species have genetically fixed sex determination, it is now known that chelonians (tortoises and turtles) undergo temperature dependent sex determination (TSD). Spotila (1994) shows that the desert tortoise (*Gopherus agassizii*), a federally listed threatened species of the Mojave Desert, is subject to this effect. Research shows that the temperature that produces a 50:50 sex ratio is 31.8°C. Desert tortoise eggs have good hatching success between 28 and 33°C, but suffer high mortality at temperatures below 26 or above 35.3°C. Temperatures between 26.0 and 30.6°C produce mostly males (temperatures 28°C and below produce 100 percent males) and temperatures between 32.8 and 35.3°C produce mostly females (temperatures above 33°C produce 100 percent females) (Spotila et al., 1998). Lewis-Winokur and Winokur (1995) confirm that the pivotal temperature is between 31 and 32°C and indicated that a lowering of 1.6°C (from 31 to 29.4°C) resulted in all male hatchlings.

The modeling of surface soil temperature for the proposed site produces uncertain results. TRW Environmental Safety Systems, Inc. (1999, page 44) states "...current predictions are somewhat uncertain due to uncertainties in the thermal properties of the soil, particularly thermal conductivity and, hence, thermal diffusivity." This source further states that "analyses based on conventional soil heat-conduction models indicate that the original time scale of the measurements collected at the site (weekly to monthly) could not be used to accurately estimate the soil thermal conductivity for the sampling depths chosen (15, 30 and 45 cm)." However, substantial temperature effects on desert tortoise sex determination have been shown to occur within a range of plus or minus 3°C. Therefore, it is important for the FEIS to clarify the range of soil temperatures associated with the geologic repository and discuss impacts, if any, on protected or endangered species.

Recommendation:

The assessment of the contribution of thermal loading on increased soil temperature should be refined in the FEIS. Soil temperature modeling should take into account the substantial uncertainties in thermal conductivity in Yucca Mountain soils thereby enabling an assessment of the potential impacts to the desert tortoise from increased soil temperatures.

References:

Lewis-Winokur, V., and R.M. Winokur. *Incubation temperature affects sexual differentiation, incubation time, and posthatching survival in desert tortoises [Gopherus agassizi(sic)]. Canadian Journal of Zoology* 73(11):2091-2097. 1955.

Spotilla, J.R., L.C. Zimmerman, C.A. Binckley, J.S. Grumbles, D.C. Rostal, A. List, Jr., E.C. Beyer, K.M. Philips, and S.J. Kemp. *Effects of incubation conditions on sex determination, hatching success, and growth of hatchling desert tortoise, Gopherus agassizii. Herpetological Monographs* 8: 103-116. 1994.

TRW Environmental Safety Systems, Inc. *Impact of Radioactive Waste Heat on Soil Temperatures.* BA0000000=01717-5700-00030. Revision 0. Las Vegas, NV: TRW Environmental Safety Systems, Inc.: 37-44. 1999.

Response
The statement in the Draft EIS on page 5-47, "There is considerable uncertainty in the estimates of soil temperature increases due to uncertainties in the thermal properties of the soil…" is misleading. There are some uncertainties in the thermal properties of the soil but these do not cause "considerable uncertainty" in the estimates of soil temperature increase. DOE has revised the text of the EIS to reflect this. While the Department acknowledges that some uncertainties exist in thermal properties of Yucca Mountain soils, the EIS modeling effort used the best available information for predicting average soil temperature increases. The model did not use the weekly to monthly soil temperatures to which the commenter refers because the time scale "could not be used to accurately estimate the soil thermal conductivity" (DIRS 103618-CRWMS M&O 1999). Rather, it used only hourly soil temperature measurements, which allowed the use of diurnal fluctuations to estimate the thermal diffusivity of the soil and provided a calibration for the thermal diffusivities modeled for wet, dry, and nominal soils. The thermal diffusivity obtained from the hourly soil temperature measurements was similar to that estimated for soils under wet conditions. Therefore, the thermal diffusivity estimated for dry soil represents a conservative value on predicted soil temperature increase, and the "available data suggest very modest temperature rises due to repository heat effects" (DIRS 103618-CRWMS M&O 1999). DOE has revised the EIS to clarify the reasons why dry soil thermal conductivity provides a conservative prediction of soil temperature increase. Temperature changes used to evaluate impacts were based on dry soils, and therefore cover the range of possible effects of soil warming on desert tortoises and other biological resources.

As described in Section 5.9 of the EIS, based on these conservative calculations, the predicted increase in soil temperature at the shallow depth at which tortoises lay eggs would be very small compared to the range of natural variation in soil temperatures at Yucca Mountain (DIRS 105031-CRWMS M&O 1999) and the range of temperatures at which desert tortoise eggs have been successfully incubated. This small change in temperature, therefore, should have no adverse affect on tortoise eggs. Because of this and the small size of the affected area [about 3 square kilometers (740 acres)], DOE believes that impacts to the desert tortoise from heat generated by the proposed repository would be minimal.

7.5.4.2 (6542)
Comment - EIS001632 / 0039
Page 4-33: DOE should plan to construct the evaporation ponds with side slopes or a ramp to facilitate wildlife use.

Response
DOE would consider providing escape ramps from trenches, including ponds and basins, as a mitigation measure (see Section 9.2.3.2 of the EIS).

7.5.4.2 (6543)
Comment - EIS001632 / 0040
Page 4-35: While the impact on the threatened desert tortoise population is unclear (see comment on section 6.3.1.1), EPA [Environmental Protection Agency] questions whether the impact should be rated as low or very low. Some federally listed desert tortoises were killed during site characterization and more will likely be killed during construction, operation and monitoring, and closure. With increased human activity and traffic over the life of the

project, the increases may be significant. EPA notes that DOE is obtaining a Biological Opinion from the Fish and Wildlife Service (page 4-33); any mitigation/conditions for protecting the tortoise should be listed in the final EIS.

Response
The loss of a small number of tortoises along roads and at the repository site would not affect the long-term survival of the local or regional population of desert tortoises. Tortoises are widespread throughout the region and large tracts of undisturbed tortoise habitat surround Yucca Mountain. Research at Yucca Mountain during site characterization confirms that activities similar to those proposed would have little effect on adjacent populations (DIRS 104294-CRWMS M&O 1999). Only five Desert Tortoise deaths have been attributed to site characterization activities. The rate of tortoise mortality would remain comparable to that observed during site characterization because the amount of traffic would be similar. Under the legal-weight truck scenario, the repository would receive about 40 shipments a day of supplies, materials, and equipment (Section J.3.6.1 of the EIS), and up to six shipments of spent nuclear fuel or high-level radioactive waste (Section J.1.2.1 of the EIS). During site characterization, the daily average number of vehicles passing traffic counters in 1993 and 1994 was between 40 and 55 (DIRS 104294-CRWMS M&O 1999). DOE and the U.S. Fish and Wildlife Service have completed consultation on the potential effects of repository construction, operation, and monitoring and closure on threatened and endangered species. In its Biological Opinion, the Fish and Wildlife Service concluded that these actions would not jeopardize the continued existence of the Mojave population of the desert tortoise. That Opinion includes an unlimited take provision of tortoises along roads at Yucca Mountain, in part because deaths due to vehicles are anticipated to be infrequent. (See Appendix O of the EIS for the Biological Opinion.) Section 4.1.4 of the Final EIS has been modified to better explain the conclusion that the Proposed Action would not affect the tortoise population.

7.5.4.2 (7741)
Comment - EIS002016 / 0002
The wildlife will be exposed since you are going to store it in Yucca Mountain.

Response
DOE anticipates that some bats and other animals could use the tunnels as they are excavated; however, after emplacement of materials, the tunnels would be sealed and exposure of wildlife to the emplaced materials would be inconsequential. Releases of radioactive materials, largely noble gases that cannot be incorporated into biological systems, would cause very little exposure to radiation for the plants and animals near the repository (see Section 4.1.4.2 of the EIS). Furthermore, DOE does not expect that the dose rates to plants and animals would cause measurable detrimental effects in populations of any species because the rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992).

7.5.4.2 (7926)
Comment - EIS002004 / 0002
I am concerned about the nuclear waste that is going to be stored at Yucca Mountain, which is located nearby.

The wildlife and water supply could be [severely] damaged by this.

Response
DOE does not anticipate that the dose rates to plants and animals would cause measurable detrimental effects in populations of any species because those rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992). As summarized in Chapter 5 of the EIS, calculations indicate that predicted long-term levels of radionuclide concentrations in groundwater, and the resulting dose levels, would be very low. As stated in Section 3.1.4.2.1 a small amount of groundwater might move beyond the primary groundwater discharge point at Alkali Flat (Franklin Lake Playa) and continue into the Death Valley basin via the areas of Tecopa and Shoshone. It is also recognized in the EIS that a small fraction of the groundwater beneath the Amargosa Desert might flow through fractures in the relatively impermeable Precambrian rocks in the southeastern end of the Funeral Mountains toward spring discharge points in the Furnace Creek Wash area of Death Valley. In either case, any concentrations reaching these areas of Death Valley would be even less than the concentrations presented in Chapter 5 for the discharge

location at Alkali Flat (Franklin Lake Playa), because concentrations would decline with distance from the proposed repository.

7.5.4.2 (9373)
Comment - EIS001888 / 0079
The Clark County Desert Conservation Plan is administered by the Environmental Division of the Department of Comprehensive Planning. The Environmental Division, the scientific community and other stakeholders are deeply concerned about any activity that may threaten the species' survival in the wild and its recoverability. Comments[1] submitted by the Environmental Division reflects the opinions regarding potential impacts on the desert tortoise of conservation and biological experts.

This group pointed out the insufficiency of the DEIS due to the lack of consideration of the well-being of the desert tortoise during various phases of repository construction, operation, monitoring and closure. Potential effects on the desert tortoise due to transportation by rail or highway were also discussed. A copy of this document is included to this report as Attachment A and is incorporated by reference to the present comments.

[1]Cannon Center for Survey Research. Quality of Life in Las Vegas. Report. City of Las Vegas, Nevada, 1999.

Response
DOE did consider the regional and rangewide implications of the Proposed Action, the loss of genetic potential, and impacts of traffic and ravens on desert tortoises. This analysis was based on a large amount of site-specific information on the desert tortoise population at Yucca Mountain. DOE therefore disagrees that the analysis of effects on desert tortoises is insufficient. Sections 4.1.4.1 and 4.1.4.2 of the Final EIS was modified in response to comments by the Clark County Department of Comprehensive Planning to better explain DOE's conclusions about the potential impacts of traffic, habitat loss, and ravens on tortoises at Yucca Mountain and add references to reports summarizing research on desert tortoises. Section 6.1.2.4 of the Final EIS was modified to acknowledge that the Proposed Action would affect some individual desert tortoises but would not negatively affect regional populations of desert tortoises, jeopardize the continued existence of the species, or result in adverse modification of designated critical habitat.

7.5.4.2 (9801)
Comment - EIS001888 / 0387
[Clark County summary of comments it has received from the public.]

Commenters stated that the EIS, based on field surveys prior to further ground disturbance, should thoroughly examine the impacts to biological/natural resources during all phases of repository development. Commenters suggested that the analyses address: (1) critical habitats for threatened, endangered, and sensitive species, including impacts from radiation exposure during accident-free operations and from accidents.

Response
DOE considered impacts to biological resources during all phases of repository development and provides a summary of those impacts in Table 4-13 of the EIS. No critical habitats for threatened, endangered, or other sensitive species would occur at the repository location. Information presented in Section 3.1.4.2.1 indicates that differences in water table elevations show the Amargosa Desert groundwater, which includes flow from beneath the Yucca Mountain area, does not flow toward Ash Meadows and Devils Hole (rather, the flow is in the opposite direction). Therefore, no contamination from Yucca Mountain could flow into these areas and threaten listed species or their critical habitat. As discussed in Section 5.9 of the EIS, DOE does not anticipate that the radiological dose rates to plants and animals would cause measurable detrimental effects in populations of any species because the dose rates would be less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates of less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of even the more radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992).

7.5.4.2 (10717)
Comment - EIS000715 / 0002
Threatened species are defined as plants and animals whose numbers are very low or decreasing rapidly, so it is imperative to the tortoise's survival that it be protected in all proposals concerning Yucca Mountain.

The DEIS notes that from 1989 to 1998, five (5) tortoises were killed by vehicles on roads in the Yucca Mountain region as a result of site characterization activities. However, the DEIS makes light of the fact that several thousand trucks could potentially be travelling on current and new roads in the Yucca Mountain region if the repository is built. If five tortoises were killed in a period of relatively light activity, how many more tortoises will be killed if Yucca Mountain is licensed as a repository, and there are more roads, cars, and trucks? Once again the DEIS has failed to adequately address environmental impacts.

The desert tortoise could also be affected by an increase in soil temperature. Desert tortoises burrow into the soil in order to escape the great heat of the desert. If the temperature of the soil increases (because of the heat generated by the nuclear waste), the tortoise's ability to survive may be compromised. The DEIS also notes that nest temperature determines whether desert tortoise's hatchlings will be male or female. If the temperature of the soil around the repository increases, the sex ratio of the species could be affected, thus compromising the ability of the species to thrive and survive. The DOE admits, "little is known about the effects that minor alterations in habitat would have on desert tortoise population dynamics (p. 5-48)."

The DOE also admits that not much is known about the thermal properties of the soil at Yucca Mountain, particularly thermal conductivity, and so that there is considerable uncertainty in the estimates of soil temperature changes from the repository. The possibility that the repository could cause an unforeseen effect on heating up the desert soil to a dangerous level coupled with the increased risk of death from vehicles could lead to severe consequences for the desert tortoise. Yet, the DEIS does not characterize these potential effects clearly or take them seriously.

Response
In Section 4.1.4.2 of the EIS, DOE concluded that the loss of a small number of desert tortoises along roads and at the repository site would not affect the long-term survival of the local or regional population of this species. In addition, the U.S. Fish and Wildlife Service has issued a Final Biological Opinion stating that repository construction, operation and monitoring, and closure would not jeopardize the continued existence of the Mojave population of the desert tortoise (see Appendix O of the EIS for the Final Opinion). The rate of tortoise mortality would remain comparable to that observed during site characterization because the amount of traffic would be similar. Under the legal-weight truck scenario, the repository would receive about 40 shipments a day of supplies, materials, and equipment (Section J.3.6.1 of the EIS), and six shipments of spent nuclear fuel or high-level radioactive waste (Section J.1.2.1 of the EIS). During site characterization, the daily average number of vehicles passing traffic counters in 1993 and 1994 was between 40 and 55 (DIRS 104294-CRWMS M&O 1999). Section 4.1.4 of the Final EIS has been modified to better explain conclusions about impacts to desert tortoises.

To account for uncertainties in the thermal properties of soil at Yucca Mountain, the predicted temperature changes used to evaluate impacts on biological resources were calculated based on the properties of dry soils, which have a lower thermal conductivity than soil conditions measured at Yucca Mountain (see EIS Section 5.9 of the EIS). These predictions therefore bound the possible effects of soil warming on desert tortoises and other biological resources. Section 5.9 has been modified to clarify the discussion of uncertainty.

As described in Section 5.9 of the EIS, the predicted increase in soil temperature at the shallow depth that tortoises lay eggs would be very small compared to the range of natural variation in soil temperatures at Yucca Mountain (DIRS 105031-CRWMS M&O 1999) and the range of temperatures at which desert tortoise eggs have been successfully incubated. This small change in temperature therefore should have no adverse effects on tortoise eggs. Because of this and the small size of the affected area [about 3 square kilometers (740 acres)], DOE believes that impacts to the desert tortoise from heat generated by the repository would be minimal.

7.5.4.3 Wetlands

7.5.4.3 (6667)
Comment - EIS001878 / 0044
The discussion of the floodplain and wetlands assessment of transportation options (p. 4-24) is in the wrong section of the DEIS.

Response
This comment refers to Section 4.1.3.2 of the EIS, which describes possible alterations of the natural surface-water drainages in the area if the project was to proceed. The floodplain/wetlands assessment mentioned in this section is an appropriate reference to the full assessment in Appendix L.

7.5.4.4 Soils

7.5.4.4 (8884)
Comment - EIS001834 / 0025
The DOE admits that not much is known about the thermal properties of the soil at Yucca Mountain, particularly thermal conductivity, and so that there is considerable uncertainty in the estimates of soil temperature changes from the repository. The possibility that the repository could cause an unforeseen effect of heating up the desert soil to a dangerous level coupled with the increased risk of death from vehicles could lead to severe consequences for the desert tortoise. Yet, the DEIS does not characterize these potential effects clearly or take them seriously.

The desert tortoise and other plants and animals could also be affected by an increase in soil temperature. Desert tortoises burrow into the soil in order to escape the great heat of the desert. If the temperature of the soil increases (because of the heat generated by the nuclear waste), the tortoise's ability to survive may be compromised. The DEIS also notes that nest temperature determines whether desert tortoise hatchlings will be male or female. If the temperature of the soil around the repository increases, the sex ratio of the species could be affected, thus compromising the ability of the species to thrive and survive. The DOE admits, "…little is known about the effects that minor alterations in habitat would have on desert tortoise population dynamics (p. 5-48)." More research needs to be done in order to accurately predict the potential impacts on this threatened species.

Response
To account for uncertainties in the thermal properties of soil at Yucca Mountain, DOE calculated predicted temperature changes used to evaluate impacts on biological resources based on the properties of dry soils, which have a lower thermal conductivity than soil conditions measured at Yucca Mountain (see Section 5.9 of the EIS). These predictions, therefore, cover the range of the possible effects of soil warming on desert tortoises and other biological resources. DOE has modified Section 5.9 to clarify the discussion of uncertainty.

As described in Section 5.9 of the EIS, soil would not heat to dangerous levels. The predicted increase in soil temperature at the shallow depth tortoises lay eggs would very small compared to the range of natural variation in soil temperatures at Yucca Mountain (DIRS 105031-CRWMS M&O 1999) and the range of temperatures at which desert tortoise eggs have been successfully incubated. This small change in temperature, therefore, should have no adverse effects on tortoise eggs or tortoises in burrows. Because of this and the small size of the affected area [about 3 square kilometers (740 acres)], DOE believes that impacts to the desert tortoise from heat generated by the proposed repository would be minimal.

The rate of tortoise mortality due to vehicles would remain comparable to that observed during site characterization because the amount of traffic would be similar. Under the legal-weight truck scenario, the repository would receive about 40 shipments a day of supplies, materials, and equipment (Section J.3.6.1 of the EIS), and six shipments of spent nuclear fuel or high-level radioactive waste (Section J.1.2.1 of the EIS). During site characterization, the daily average number of vehicles passing traffic counters in 1993 and 1994 was between 40 and 55 (DIRS 104294-CRWMS M&O 1999).

7.5.5 CULTURAL RESOURCES

7.5.5 (225)
Comment - 11 comments summarized
A number of commenters noted that the "Programmatic Agreement Between the U.S. Department of Energy and the Advisory Council on Historic Preservation for the Nuclear Waste Deep Geologic Repository, Yucca Mountain, Nevada" is 10 years old. They noted that the existing agreement does not reflect new standards that emphasize public involvement and alternative data recovery as a mitigation measure. Commenters also noted that the existing programmatic agreement does not address linear transportation (rail and heavy-haul truck) routes or intermodal transfer stations.

Response
This comment refers to Section 4.1.3.2 of the EIS, which describes possible alterations of the natural surface-water drainages in the area if the project was to proceed. The floodplain/wetlands assessment mentioned in this section is an appropriate reference to the full assessment in Appendix L.

7.5.4.4 Soils

7.5.4.4 (8884)
Comment - EIS001834 / 0025
The DOE admits that not much is known about the thermal properties of the soil at Yucca Mountain, particularly thermal conductivity, and so that there is considerable uncertainty in the estimates of soil temperature changes from the repository. The possibility that the repository could cause an unforeseen effect of heating up the desert soil to a dangerous level coupled with the increased risk of death from vehicles could lead to severe consequences for the desert tortoise. Yet, the DEIS does not characterize these potential effects clearly or take them seriously.

The desert tortoise and other plants and animals could also be affected by an increase in soil temperature. Desert tortoises burrow into the soil in order to escape the great heat of the desert. If the temperature of the soil increases (because of the heat generated by the nuclear waste), the tortoise's ability to survive may be compromised. The DEIS also notes that nest temperature determines whether desert tortoise hatchlings will be male or female. If the temperature of the soil around the repository increases, the sex ratio of the species could be affected, thus compromising the ability of the species to thrive and survive. The DOE admits, "…little is known about the effects that minor alterations in habitat would have on desert tortoise population dynamics (p. 5-48)." More research needs to be done in order to accurately predict the potential impacts on this threatened species.

Response
To account for uncertainties in the thermal properties of soil at Yucca Mountain, DOE calculated predicted temperature changes used to evaluate impacts on biological resources based on the properties of dry soils, which have a lower thermal conductivity than soil conditions measured at Yucca Mountain (see Section 5.9 of the EIS). These predictions, therefore, cover the range of the possible effects of soil warming on desert tortoises and other biological resources. DOE has modified Section 5.9 to clarify the discussion of uncertainty.

As described in Section 5.9 of the EIS, soil would not heat to dangerous levels. The predicted increase in soil temperature at the shallow depth tortoises lay eggs would very small compared to the range of natural variation in soil temperatures at Yucca Mountain (DIRS 105031-CRWMS M&O 1999) and the range of temperatures at which desert tortoise eggs have been successfully incubated. This small change in temperature, therefore, should have no adverse effects on tortoise eggs or tortoises in burrows. Because of this and the small size of the affected area [about 3 square kilometers (740 acres)], DOE believes that impacts to the desert tortoise from heat generated by the proposed repository would be minimal.

The rate of tortoise mortality due to vehicles would remain comparable to that observed during site characterization because the amount of traffic would be similar. Under the legal-weight truck scenario, the repository would receive about 40 shipments a day of supplies, materials, and equipment (Section J.3.6.1 of the EIS), and six shipments of spent nuclear fuel or high-level radioactive waste (Section J.1.2.1 of the EIS). During site characterization, the daily average number of vehicles passing traffic counters in 1993 and 1994 was between 40 and 55 (DIRS 104294-CRWMS M&O 1999).

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One commenter noted that the text in Section 9.2.4 of the Draft EIS related to the programmatic agreement is incorrect. The commenter noted that DOE states the agreement contains the requirements and general procedures for mitigation of adverse effects at the Yucca Mountain region. The commenter indicates, however, that the agreement deals strictly with identification, evaluation, and treatment of historic properties in advance of characterization activities.

Commenters requested that the existing programmatic agreement be replaced with a new agreement that reflects amendments to the National Historic Preservation Act of 1992 and the revised regulations in 36 CFR Part 800, including provisions for dealing with unavoidable adverse impacts. The State Historic Preservation Officer expressed concerns that the land withdrawal for the repository effectively prevents access to Native American cultural practitioners, as well as to archaeologists for research purposes. Commenters believed a new agreement should be developed in consultation with the State Historic Preservation Officer and the Native American Tribes that consider Yucca Mountain culturally and religiously significant.

One commenter asked that DOE provide a copy of the programmatic agreement and the research design and data recovery plan. The commenter suggested that these documents should appear in an EIS appendix.

Response

The existing Programmatic Agreement between DOE and the Advisory Council on Historic Preservation covers cultural resource preservation requirements for site characterization activities at Yucca Mountain. DOE recognizes that the construction and operation of the proposed repository and transportation corridors would require a new Programmatic Agreement. If a decision was made to develop the Yucca Mountain site as a geologic repository, DOE would interact with the Advisory Council, the Nevada State Historic Preservation Officer, the involved Native American tribes and organizations, and other interested parties, and complete a new Programmatic Agreement pursuant to amended guidelines in 36 CFR Part 800, Section 106. The new agreement would include provisions for dealing with unavoidable adverse impacts pursuant to 36 CFR 800.14(b). DOE has modified the text in Section 9.2.5 of the EIS to reflect the intent of the Programmatic Agreement.

DOE recognizes the importance of preserving the integrity of Native American resources and sites, to the extent possible, during the development and operation of the proposed repository, and in the event of any retrieval actions. Regular interaction with Native American tribes and organizations, as described in Section 3.1.6.2 of the EIS, has occurred and will continue through the Yucca Mountain Native American Interaction Program to ensure the identification and evaluation of issues important to those tribes and organizations. DOE and the Consolidated Group of Tribes and Organizations recognize that restrictions on public access to the area would occur but also recognize that this is generally beneficial and protective of cultural resources. In the case of impacts that cannot be avoided, DOE would consult with Native American tribal representatives to ensure the implementation of the most appropriate mitigation measures to reduce or control any adverse effects.

With regard to existing documentation, a copy of the 1988 Programmatic Agreement (DIRS 104558-DOE 1998) is available in the Yucca Mountain Project Reading Room, as is the 1992 *Environmental Field Activity Plan for Archaeological Resources* (DIRS 103198-YMP 1992). DOE believes that their inclusion in an EIS appendix is not necessary because any new agreements and plans would supersede them, as discussed above.

7.5.5 (1542)

Comment - EIS000357 / 0001

Impacts on American Indian communities are specified in more detail than other communities. There seems to be some bias that the only traditional cultural properties considered are those related to American Indian communities.

This is a misconception. Traditional cultural properties could also be related to pioneer settlements. For example, the original wagon train route used to settle Preston and Lund, or the Keystone and Hiline steam railroad corridor for the Northern Nevada Railroad. There is no assessment of the impacts of the proposed action on cultural tourism. This is a particularly important issue for White Pine County and other areas like Death Valley National Park where the economy is currently being rearranged from traditional extractive industries to tourism.

<u>Response</u>
DOE is committed to ensuring that its analyses include all historic properties that have traditional value to interested parties. The Department agrees that traditional cultural properties are not restricted to those of Native American concern (see DIRS 155897-Parker and King n.d.).

Research to date has identified no cultural properties of interest to groups other than Native American tribes at the Yucca Mountain Repository site itself. If DOE determined a final transportation mode and corridor or route, it would conduct alignment-specific studies in accordance with the requirements of the National Historic Preservation Act and 36 CFR Part 800 to identify cultural resource sites that might exist in or adjacent to the corridor. During these evaluations the Department would interact, as appropriate, with parties who have an interest in cultural resource sites along the route.

7.5.5 (1544)
<u>Comment</u> - EIS000357 / 0003
Costs of cultural resources treatment. The prevailing impression is that significant archeological properties can be bought. Yet the cost of conducting data recovery operations are never specified. It appears that a majority of the significant archeological sites at the Yucca Mountain site have already been treated through data recovery. What have been the costs of this treatment? How do these costs at the sites at Yucca Mountain compare to data recovery costs at locations where highway or rail improvements may be made?

The kind of sites at Yucca Mountain may be less expensive to conduct data recovery operations than sites in valley floors or riparian zones that tend to be more complex and therefore expensive to conduct data recovery operations. What kind of sites might be of such high value that data recovery should not be undertaken, but rather sites should be avoided by direct impacts and preserved in place?

This is a particularly relevant question for a situation like the Five Finger Ridge along I-70 between Richfield and Cove Fort in Utah. This site should have, and could have, been avoided if there had not been a mentality at work in the early 1980s that all archaeological sites could be mitigated by data recovery. Is there any consideration of off-site mitigation along potential tourist corridors that would be alternative routes to avoid heavy-haul nuclear waste shipments?

<u>Response</u>
Previous data recovery efforts at the Yucca Mountain site included limited subsurface testing, National Register evaluations, and data recovery efforts at some archaeological sites to mitigate impacts from project-related field activities (such as exploratory trenches). In general, data recovery methodology includes two methods: subsurface testing/surface analysis and collection of artifacts. Because such efforts have occurred over a long period, beginning in 1982, it is difficult to amass total costs for this work. Because of differences in costs associated with similar data recovery methods over a 20-year period, and the fact that data recovery efforts to mitigate potential impacts from a Yucca Mountain Project transportation corridor would be years away, past data recovery costs have little relevance to future costs.

Because alignment-specific archaeological studies would occur after the final selection of the corridor or route and DOE cannot quantify numbers and importance of sites at this time, it is premature to discuss the possible level of effort required and the associated costs. However, DOE would include avoidance of significant archaeological sites as a mitigative option. Due to cultural value and cost, preservation of archaeological sites in place is the preferred alternative. If avoidance was not possible, a data recovery effort would be necessary to preserve the archaeological data. Section 9.2.5 of the EIS contains additional information regarding proposed mitigative measures.

7.5.5 (1560)
<u>Comment</u> - EIS000357 / 0019
Page 7-48. Section 7.3.2.5. This is inadequate treatment of the known cultural situation where expansion of facilities would be undertaken. If there are existing DOE and commercial facilities, what is known of the cultural resources in these areas, and what would be the specific impacts on known cultural resources? If Scenario 1 is expansion at Yucca Mountain, what would the site-specific surface ground disturbing impacts be?

Response
The EIS does not report the cultural resource baseline situations at other DOE and commercial facilities where expansion of the facilities could occur under Scenario 1 of the No-Action Alternative. In many cases, baseline information can be obtained from the documents cited in Table 7-1 of the EIS. As noted in the EIS (See Section 7.3.2.5), those facilities would adhere to the provisions of relevant State and Federal historic preservation laws and regulations during expansion.

In No-Action Scenario 1, DOE does not propose expansion at Yucca Mountain (see Section 2.2.2.2 of the EIS). The actions taken under No-Action Scenario 1 would be decontamination, decommissioning, and reclamation of previously disturbed areas. Therefore, under Scenario 1, no additional impacts would occur to cultural resources at Yucca Mountain.

7.5.5 (4227)
Comment - EIS001160 / 0043
Although the DEIS acknowledges that there could be impacts to Native American cultural sites along rail spur routes or at Yucca Mountain, the draft document completely ignores wider issues and impacts to Native peoples and communities. The draft includes a discussion of the Native American “perspective” on the project, but then proceeds to discount the viewpoint expressed and goes on to conclude that no significant impacts to Native Americans will occur, even though no substantive impact assessment work has been done in any of the Native communities potentially affected by the facility or by transportation routes.

Impacts on American Indian communities within the DEIS are specified in more detail than other communities. There seems to be some bias that the only “Traditional Cultural Properties” considered are those related to American Indian Communities. This is a misconception. Traditional cultural properties could also be related to Pioneer settlements (for example the original Wagon Train route used to settle Preston and Lund or the Keystone and HiLine steam railroad corridor for the Nevada Northern Railroad). There is no assessment of the impacts of the proposed action on cultural tourism. This is a particularly important issue for White Pine County (and other areas like Death Valley National Park) where the economy is currently being rearranged from traditional extractive industries to tourism.

Response
DOE supported the preparation of an EIS reference document written by the American Indian Writers Subgroup of the Consolidated Group of Tribes and Organizations (DIRS 102043-AIWS 1998). That document presents a Native American point of view about cultural resources management, environmental justice, and the siting of a repository at Yucca Mountain. That point of view does not necessarily require analysis, response, or mitigation. DOE did not ignore the Native American position or concerns made in the document, but agreed to summarize that information in the EIS, as appropriate. Based on the results of the report, DOE acknowledges in the EIS that people from many Native American tribes have used the area proposed for the repository as well as nearby lands; that the lands around the site contain cultural, animal, and plant resources important to those tribes; and that the implementation of the Proposed Action would continue restrictions on access to the repository site environs. Furthermore, the presence of a repository would represent an intrusion into what Native Americans consider an important cultural and spiritual area. Although these viewpoints might suggest that the Yucca Mountain site should not be developed, DOE and the Consolidated Group of Tribes and Organizations recognize that restrictions on public access to the area have been generally beneficial and protective of cultural resources. The Department believes that the summarized information in the EIS is adequate.

With regard to Native American issues associated with transportation routes, the EIS analysis identified no potential impacts to Native American resources along the corridors. However, DOE has not completed systematic studies to identify sites, resources, or areas of cultural significance or traditional value to Native American people or communities. After DOE identified specific transportation modes and routes, it would perform further work addressing tribal issues.

DOE has considered the actual presence or the potential for cultural resource properties along each transportation corridor, including those important to Native Americans or other cultural groups. The examples of other “traditional cultural properties” cited by this comment, such as the original wagon train route to Preston and Lund and Keystone and Hiline railroad corridor, are not traditional cultural properties as typically defined, nor do they occur within the transportation corridors. They are, however, near historic features that could have some level of importance in their own right. Any additional cultural resource assessments along selected transportation corridors would consider all types of cultural resources, including their importance to a given living community, Native American or otherwise. If DOE encountered any such properties during cultural studies for a selected transportation route, it would document and evaluate them against applicable National Register of Historic Places criteria.

DOE evaluated impacts to tourism in general as one of the scopes considered in its Regional Economic Models, Inc. (REMI) computer model simulations for the region of influences. Socioeconomic analyses do not normally use the term "cultural tourism."

7.5.5 (5272)
Comment - EIS001887 / 0026
DOE has already identified archaeological sites potentially eligible for inclusion in the National Register. Additionally, the Consolidated Group of Tribes and Organizations has also indicated an interest in properties around Yucca Mountain, but it is difficult to discern from the Draft EIS whether or not these properties are located within the area of potential effect.

Response
Section 4.1.5.2 of the EIS states that the archaeological sites that are considered potentially eligible for the National Register could be affected by construction of the surface facilities at the repository.

In the same section the EIS states that although Native American representatives have identified several sites, areas, or resources in the vicinity of the repository, construction of the facilities would not have any direct impacts on these important places. However, DOE does recognize that construction and operation of the repository at Yucca Mountain would have continuing adverse impacts for Native Americans who view the past, ongoing, and future repository-related activities as an intrusion on a culturally important and sacred landscape. The Department would continue to interact with Native Americans to ensure that such adverse effects are minimized to the fullest extent possible.

7.5.5 (6064)
Comment - EIS001898 / 0016
Documentation and analyses for the assessment of impacts to cultural resources are incomplete.

Basis:

Some DEIS conclusions regarding cultural resource impacts lack supporting analyses or reference material. Moreover, methods used to conduct the analyses and reach conclusions are not presented. The following are examples:

- Section 3.1.6.1 (Affected Environment-Archeological and Historic Resources) states that a field survey of a 44-km^2 (11,000 acres) parcel was conducted. Clarifying information needs to be provided, including (i) the type of survey (e.g., walk-over); (ii) the percentage of coverage for the 44-km^2 area; (iii) the relationship of the survey area to the entire land withdrawal area; (iv) the relationship of this survey to the "additional archaeological surveys" conducted in Midway Valley, Yucca Wash, and lower Fortymile Canyon; (v) the extent and techniques used for these additional surveys; (vi) specification of the total survey area; and (vii) the extent to which sites have been identified for the complete land withdrawal area.

- Section 3.1.6.1 (Affected Environment-Archeological and Historic Resources) of the DEIS states that "826 archeological sites have been discovered in the analyzed land withdrawal area." This statement requires clarification. It is not clear whether the entire 600 km^2 parcel has been surveyed or whether the number of sites is on a smaller parcel of land. It is difficult to assess site density and cultural resources impacts without knowing the extent of the land area that has been surveyed.

- Section 3.1.6.1 (Affected Environment-Archeological and Historic Resources) states that limited test excavations were conducted at 29 sites. Clarification is required regarding the criteria used to select sites for testing and the representativeness of these sites for the potentially affected area.

The Western Shoshone occupied the Yucca Mountain region into historic times and were engaged in mining, ranching, and other activities. The DEIS is unclear whether any of the historic sites are associated with the Western Shoshone or Paiute peoples or whether these sites are considered to be related only to non-Native American occupation activities.

Recommendation:

The FEIS should provide additional data and descriptions of methods used to assess impacts on cultural resources, including a description of the area of study used in assessing the distribution and types of cultural resources. If the entire land withdrawal area or the entire potential disturbed area was not surveyed for cultural resources, the rationale for not doing so should be presented.

Response

Supporting analyses or references related to issues in this comment are available in the *Environmental Baseline File: Archaeological Resources* (DIRS 104997-CRWMS M&O 1999). That document includes a bibliography of cultural resource reports that contain specific details requested by the commenter. These documents are available from the Yucca Mountain Project Public Reading Room. DOE believes the level of information provided in the EIS is sufficient for decisionmakers to understand the issues and potential for impacts on archaeological and cultural resources.

Archaeological field studies in support of the Yucca Mountain Project have been conducted since 1982 by the staff of the Desert Research Institute. Based on project needs during this period, several methodologies have been employed to characterize and protect archaeological sites and data. These include (1) use of existing archaeological data from previous projects, (2) intensive archaeological field surveys and limited subsurface testing, (3) preactivity surveys at areas ahead of planned ground-disturbing activities for areas lying outside of the acreage surveyed under the previous category, (4) data recovery, (5) random sample unit surveys for larger tracts outside the withdrawal area, and (6) archaeological site monitoring to assess changes to significant sites over time.

Specific field methods and techniques employed at Yucca Mountain are outlined in the following documents:

1. *Programmatic Agreement Among the United States Department of Energy, The Advisory Council on Historic Preservation and the Nevada State Historic Preservation Officer for the First Nuclear Waste Deep Geologic Repository Program, Yucca Mountain, Nevada*. (DIRS 157145-Gertz 1988)

2. *Research Design and Data Recovery Plan for Yucca Mountain Site Characterization Project* (DIRS 103196-DOE 1990)

3. *Environmental Field Activity Plan for Archaeological Resources* (DIRS 103198-YMP 1992)

4. *Branch Technical Procedures: Field Archaeology* (DIRS 157150-DRI 1990)

In addition to these generic documents, several project-specific individual research designs have been prepared for individual field survey, testing, and data recovery efforts undertaken by the Desert Research Institute. Copies of these documents are available from the Desert Research Institute, DOE, and the State Historic Preservation Officer.

DOE used the combined information derived from implementation of the methods noted above to provide the summarization for the EIS. While precise figures (number of acres) have not been compiled for the entire land withdrawal area, all areas associated with the repository site that have either been disturbed by past site characterization activities or that are proposed for disturbance during repository construction and operation have been inventoried for archaeological resources. Archaeological data for other parts of the larger withdrawal area have received varying levels of archaeological study, ranging from random sample unit surveys to intensive coverage associated with preactivity activities away from the repository site. In some instances, known archaeological site data also are derived from surveys conducted by other agencies and/or projects (for example, Bureau of Land Management, Nellis Air Force Base, and the Nevada Test Site) on lands not currently managed by the Yucca Mountain Project.

All of the historic sites discussed in Section 3.1.6 of the EIS are associated with non-Native American occupation and use of the area. Section 3.1.6.2.2 discusses historic-period Native American sites, which are documented in the Native American resource document prepared by the Consolidated Group of Tribes and Organizations' American Indian Writers Subgroup (DIRS 102043-AIWS 1998).

7.5.5 (6740)
Comment - 010152 / 0002
It talks in here about the land right use and ownership. It says on page 3-16 [Section 3.13.13] that the DOE will continue protection of the Native American sacred sites, cultural resources and potential traditional cultural properties and will implement appropriate mitigation measures. I had to look up the word mitigate because I'm not real knowledgeable, but it says to make or become less severe. What I'd like to know is how boring holes into sacred mountains on stolen land and filling it with the deadliest of poisons, how the Department of Energy will, make that theft and that rape less severe?

Response
Under the regulations of the National Environmental Policy Act (40 CFR Part 1508.20), mitigation includes activities that:

- Avoid the impact altogether by not taking a certain action or parts of an action.
- Minimize impacts by limiting the degree or magnitude of the action and its implementation.
- Repair, rehabilitate, or restore the affected environment.
- Reduce or eliminate the impact over time by preservation or maintenance operations during the life of the action.
- Compensate for the impact by replacing substitute resources or environments.

DOE agrees the presence of a repository would represent an intrusion into what Native Americans consider an important cultural and spiritual area. Although this viewpoint might suggest that the Yucca Mountain site should not be developed, DOE and the Consolidated Group of Tribes and Organizations recognize the restrictions on public access to the area have been generally beneficial and protective of cultural resources. In the case of impacts that cannot be avoided, DOE would continue to interact with tribal representatives to ensure the implementation of the most appropriate measures to reduce or control any adverse effects.

7.5.5 (7743)
Comment - EIS001968 / 0008
The Final EIS should include a cultural impact study.

Response
The EIS addresses potential impacts to cultural resources. Pertinent sections of Chapter 4 for the construction, operation and closure of the repository and Chapter 6 for each of the transportation scenarios include impact analyses. With regard to potential impacts related to Nevada transportation, the Final EIS includes cultural resource information based on an expanded baseline for areas crossed by candidate rail corridors or heavy-haul truck routes.

7.5.5 (8857)
Comment - EIS000869 / 0026
The importance of Native American resources and sites being preserved is an important issue. The integrity of archaeological sites and resources has been maintained for hundreds of years without government intervention and would probably continue unscathed without government interference.

Response
DOE recognizes the importance of preserving the integrity of Native American resources and sites, during the development of the repository and its facilities. Regular interactions with tribal representatives as described in Section 3.1.6.2 of the EIS has occurred and would continue through the Yucca Mountain Native American

Interaction Program to ensure the identification and evaluation of issues important to the various tribes, bands, and groups in conjunction with project activities. DOE and the Consolidated Group of Tribes and Organizations recognize that restrictions on public access to the area have been generally beneficial and protective of cultural resources. In the case of impacts that cannot be avoided, DOE would interact with Native American tribes and organizations to ensure the implementation of the most appropriate mitigation measures to reduce or control any adverse effects.

7.5.5 (9348)
Comment - EIS001888 / 0062
DEIS Table 2-7, pg. 2-76, Impacts Associated with the Proposed Action and No-Action Alternatives.

Does DOE intend to fund the protection of cultural resources exposed to risk under the proposed action? DOE should also explain in detail the differing view of the Native Americans as to impacts from nuclear waste transportation. It is insufficient to refer to the concerns of Native Americans as occurring solely with reference to the cultural resource impacts.

Response
The cultural resources management effort has been an integral component of the environmental compliance and field study program of the Yucca Mountain Site Characterization Project since the early 1980s. Since that time, the Project has been in full compliance with applicable cultural resources laws and regulations including the National Historic Preservation Act and the Archaeological Resources Protection Act. In addition, a formal Programmatic Agreement between DOE and the Advisory Council on Historic Preservation has been in place during site characterization. However, DOE recognizes that construction of the repository and of the selected Nevada transportation implementing alternative would require an updated Programmatic Agreement. In conjunction with the Advisory Council, the Nevada State Historic Preservation Office, involved Native American tribes and organizations, and other interested parties, DOE would complete a new Programmatic Agreement following the recently amended guidelines in 36 CFR Part 800, Section 106. A Programmatic Agreement stipulates the compliance and data recovery efforts an agency would undertake. On the Yucca Mountain Project, those efforts would be to protect cultural resources during all phases of the program; the Department would maintain appropriate budgets for such ongoing requirements.

As part of the DOE Native American Interaction Program, tribal representatives have continuously made clear their views about transportation of spent nuclear fuel and high level radioactive waste through their ancestral homelands and near their reservations. Section 3.2.2.1.5 of the EIS discusses those views, and the Native American resource document prepared by tribal representatives for use as a reference in the EIS (DIRS 102043-AIWS 1998) provides more detail. If DOE selected a specific transportation implementing alternative, it would continue to work with tribal representatives to ensure appropriate consideration of their concerns about cultural resources and other issues.

7.5.5 (10651)
Comment - EIS001965 / 0014
According to the DEIS, approximately 826 archaeological sites have been discovered in the analyzed land withdrawal area. (DEIS at 3-66). While none of these sites have been nominated to the National Register, at least 150 are potentially eligible. (Id.). The DEIS goes on to state that "DOE (1988b) describes how the Department meets its responsibilities under Section 106 of the National Historic Preservation Act and the American Indian Religious Freedom Act..." (Id.). Now, is it safe to assume that DOE's responsibilities under current legislation remain unchanged, or have these too been abrogated? Given the bastardized version of NEPA [National Environmental Policy Act] currently being applied to this project, is it still safe to assume that other relevant legislation remains intact?

Response
DOE responsibilities for compliance with the National Historic Preservation Act and the American Indian Religious Freedom Act have not changed (see Chapter 11 of the EIS).

7.5.5 (10652)
Comment - EIS001965 / 0015
We wish to remind the DOE of the three main federal statutes, and implementing regulations, that establish the framework for historic preservation and cultural resource management in Indian country and in areas currently outside of tribal jurisdiction where tribes have religious and cultural interests. The National Historic Preservation Act (NHPA) (16 U.S.C. 470-470w-6), the Archaeological Resources Protection Act (ARPA) (16 U.S.C. 470aa-470ll), and the Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001-3013) may all play a role in the decision-making process. Additionally, DOE must also keep in mind, the various Executive Orders and policy pronouncements concerning tribal-federal interactions.

From the information contained in the DEIS, we urge the DOE to immediately seek eligibility determinations for the 150 sites "potentially eligible for nomination" (DEIS at 3-66). We also urge the DOE to reanalyze the "826 archaeological sites" that have been discovered (Id.). During this process, DOE must remain mindful of the guidance provided in Bulletin 38 published by the National Park Service in 1990. Additionally, DOE must strictly adhere to good faith compliance with section 106 of the NHPA by following the Advisory Council's regulations. These regulations set out the requirements for consultation with Indian tribes and Native Hawaiian organizations, inter alia, undertakings that would affect tribes by affecting traditional cultural properties that are not located within artificial reservation boundaries.

Further, we demand the Department to conduct additional surveys of all lands within the proposed withdrawal. Given the evolving nature of NHPA compliance, we believe that many prior surveys may be tainted by the prejudices and past practices of various federal, state, and local entities. In order to purge these past efforts, as well as to fully and in good faith comply with the requirements of the NHPA, we feel a great deal of work has yet to be done. We remind the DOE to vigilantly adhere to its obligations as articulated in the statutes, policy pronouncements, and case law of this nation. Anything less than full compliance will certainly result in violations of both legal and moral norms.

Response
DOE is fully committed to complying with the cultural resource statutes and regulations that apply to the Yucca Mountain Repository (see Section 11.2.5 of the EIS). All previous cultural resource field surveys have been conducted in a legal and professional manner in accordance with 36 CFR 800.4 and the Guidelines for Federal Agency Responsibilities under Section 110 of the National Historic Preservation Act (53 *FR* 4727). Interactions with the involved Native American tribes and organizations, in accordance with applicable legislation, regulations, and Executive Orders, as well as DOE Native American Policy, is conducted on an ongoing basis through the Yucca Mountain Site Characterization Project Native American Interaction Program (see Section 3.1.6.2.1 of the EIS).

The status of eligibility for the *National Register of Historic Places* for previously recorded archaeological sites in the Yucca Mountain area is handled on a case-by-case basis, depending on each site's relationship to project-driven activities. For purposes of the EIS analysis, development of the repository surface facilities would not directly impact any known archaeological properties, regardless of their National Register status (see Section 4.1.5.2 of the EIS).

7.5.5 (11777)
Comment - 010345 / 0003
We believe there are many native cultural entities that need to be protected, preserved.

Response
DOE would avoid archaeological and cultural resource sites if possible. If avoidance were not possible, DOE would conduct a data recovery program of the sites consistent with applicable regulatory requirements and input from tribal representatives. DOE, through its Cultural Resource Management Program, along with the Native American Interaction Program, has identified a team approach for managing artifacts in place, rather than collecting and curating. DOE is committed to using Native American monitors on field crews when significant data recovery (collection of resources) at a site is necessary. Archaeological contractors are on call to monitor known sites for potential impacts from project activities. In addition, Native Americans can come to the site to monitor locations during Native American Interaction Program field trips, or during special trips, as necessary.

7.5.5 (12157)
Comment - 010115 / 0006
Pages 3-8 and 3-9 says human activities increase the access to land could result in harmful effects intentional to the fragile resources. So both intentional destruction and disturbance by placing the surface aging facility at Midway Valley, which is a known cultural resource site, is irresponsible.

Response
DOE states in the EIS that there are several known archaeological sites in the vicinity of Midway Valley that could be affected by ground-disturbing activities associated with construction of a surface aging facility. One of these sites was partially mitigated during site characterization activities in 1991. The degree to which the aging facility could affect the archaeological sites in the vicinity cannot be determined until precise areas of ground disturbance are identified and the presence or absence of important cultural features or artifacts can be assessed for the disturbed areas.

DOE would avoid archaeological and cultural resource sites if practicable. If avoidance were not practicable, DOE would conduct a data recovery program of the sites consistent with applicable regulatory requirements and input from tribal representatives. DOE, through its Cultural Resource Management Program, along with the Native American Interaction Program, has identified a team approach for managing archaeological sites in place, rather than collecting and curating. DOE is committed to using Native American monitors on field crews when significant data recovery (collection of resources) at a site is necessary. Archaeological contractors are on call to monitor known sites for potential impacts from project activities. In addition, Native Americans can come to the site to monitor locations during Native American Interaction Program field trips, or during special trips, as necessary.

7.5.5 (12414)
Comment - 010279 / 0005
DOE activities which disturb Western Shoshone cultural sites on Yucca Mountain cannot be mitigated.

Response
DOE would include avoidance of significant archaeological sites as a mitigative option. Due to cultural value and cost, preservation of archaeological sites in place is the preferred alternative. If avoidance were not possible, a data recovery effort would be undertaken to preserve the archaeological data. DOE is committed to using Native American monitors on field crews when significant data recovery (collection of resources) at a site is necessary. Archaeological contractors are on-call to monitor known sites for potential impacts from project activities. In addition, Native Americans can come to the site to monitor locations during Native American Interaction Program field trips, or during special trips, as necessary. Section 9.2.5 of the EIS contains additional information regarding proposed mitigative measures.

7.5.5 (12802)
Comment - 010337 / 0004
I would say that based on the material I saw that there should not be such a project in that area, that we need to do whatever we can even if it's flinging our bodies in front of something to protect those rock sites. The area is just amazingly full of culturally significant items.

Response
DOE acknowledges in the EIS that people from many Native American tribes have used the area proposed for the repository as well as nearby lands; that the lands around the site contain cultural, animal, and plant resources important to those tribes; and that the implementation of the Proposed Action would continue restrictions on access to the repository site environs. DOE does recognize that construction and operation of a repository at Yucca Mountain would have continuing adverse impacts for Native Americans who view the past, ongoing, and future repository-related activities as an intrusion on a culturally important and sacred landscape. The Department would continue to interact with Native Americans to ensure that such adverse effects were minimized to the fullest extent possible.

7.5.5 (12879)
<u>**Comment**</u> - 010343 / 0004
And as far as the wind farm goes, I am not in support of the project mainly because as an Indian that from what I heard that there are culturally sensitive areas within this and I think that preservation needs to be looked at.

<u>**Response**</u>
A wind farm is not part of the Proposed Action for the Yucca Mountain Repository. DOE, however, is assessing alternative generation facilities for the Nevada Test Site that include 545 wind turbine generators on three areas of the Test Site. Chapter 8 of the EIS includes this proposed action as part of its cumulative impact assessment. The *Preapproval Draft Environmental Assessment for a Proposed Alternative Energy Generation Facility at the Nevada Test Site* (DIRS 154545-DOE 2001) contains more information. DOE is in the process of preparing an Environmental Impact Statement on the subject.

7.5.5 (13486)
<u>**Comment**</u> - 010260 / 0010
In terms of Environmental Justice, we find it hard to believe that the "DOE will continue its protection of Native American sacred sites, cultural resources, and potential traditional cultural properties" if it is still intent on having Yucca Mountain as the first federal repository since it is considered a sacred site to begin with (Supplement to the Draft Environmental Impact Statement [SDEIS] P. 3-16). Additionally, the SDEIS states, "several known archeological sites could be affected by ground-disturbing activities associated with the construction of the surface aging facility" (P. 3-9). "Reducing adverse effects to the resources" does not mean the same as "continue its protection of Native American sacred sites, cultural resources." How does the DOE determine that a decision made by our society today will not irreversibly negatively impact future generations of Native Americans? They have already been impacted by the Nevada Test Site, so why should they be the host community to an ill-conceived nuclear waste dump that will plague this location for essentially eternity?

<u>**Response**</u>
DOE acknowledges in the EIS that people from many Native American tribes have used the area proposed for the repository as well as nearby lands; that the lands around the site contain cultural, animal, and plant resources important to those tribes; and that the implementation of the Proposed Action would continue restrictions on access to the repository site environs. DOE does recognize that construction and operation of a repository at Yucca Mountain would have continuing adverse impacts for Native Americans who view the past, ongoing, and future repository-related activities as an intrusion on a culturally important and sacred landscape. The Department would continue to interact with Native Americans to ensure that such adverse effects were minimized to the fullest extent possible.

The Yucca Mountain Site Characterization Project has maintained a Native American Interaction Program with 16 tribes and one organization since the mid-1980s (see Section 3.1.6.2.1 of the EIS). Each tribe appoints representatives to sit on a DOE-funded, self-organized committee called the Consolidated Group of Tribes and Organizations. This group meets twice a year and participates in field trips to Yucca Mountain to impart cultural resource protection information and to become more aware of the ongoing studies. While the group does not support the use of Yucca Mountain as a repository, it has agreed to be involved in an honest and participatory process. DOE supported the American Indian Writers Subgroup of the Consolidated Group of Tribes and Organizations in its preparation of *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statements* (DIRS 102043-AIWS 1998). The results of this report were included in the EIS.

With regard to archaeological sites, the Cultural Resource Management Program, along with the Native American Interaction Program, has identified a team approach for managing archaeological sites in place, rather than collecting and curating.

7.5.5.1 Archaeological and Historical Resources

7.5.5.1 (1557)
Comment - EIS000357 / 0016
Page 3-70. Section 3.1.6.2.2. "According to Native American people, the Yucca Mountain area is part of the holy lands of the Western Shoshone, Southern Paiute, and Owens Valley Paiute and Shoshone peoples. Native Americans generally do not concur with the conclusions of archeological [archaeological] investigators that their ancestors were highly mobile groups of aboriginal hunter-gatherers who occupied the Yucca Mountain area before Euroamericans began using the area for prospecting, surveying, and ranching." That was a quote out of the EIS.

This statement is unsubstantiated, unquantified, and unsupportable. What are holy lands? How is it determined that Native Americans generally do not concur? What was the sampling design to determine this opinion? What Native Americans were interviewed or questioned? How were they determined to be representative? What was the specific questions asked to determine that there is a disagreement with archeological scholars.

These statements are outrageous and unsupportable stereotyping based on a sample of unknown representatives.

Response
Representatives of the Consolidated Group of Tribes and Organizations, consisting of members of the Southern Paiute, Western Shoshone, and Owens Valley Paiute/Shoshone tribes, wrote the statement to which the commenter is referring. DOE supported the preparation of an EIS reference document *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement* (DIRS 102043-AIWS 1998), which presents the point of view of Native American peoples on the Yucca Mountain area and the potential siting of a repository there. DOE has no bias toward the views of archaeological scholars or Native Americans; the statement in question is a position of some Native Americans who have been interacting on the Yucca Mountain Site Characterization Project, as well as their general perception of what other Native Americans believe.

7.5.5.1 (4229)
Comment - EIS001160 / 0045
The prevailing impression (including within the DEIS) is that significant archeological properties can be bought. Yet the cost of conducting data recovery operations is not specified within the DEIS. It appears that a majority of the significant archeological sites at the Yucca Mountain site have already been treated through data recovery. What have been the costs of this treatment? How do these costs at the sites at Yucca Mountain compare to data recovery costs at locations where highway or rail improvements may be made? The kinds of sites at Yucca Mountain may be much less expensive to conduct data recovery operations than sites in valley floors or riparian zones that tend to be more complex and therefore expensive to conduct data recovery operations. What kind of sites might be of such high value that data recovery should not be undertaken, but rather sites should be avoided by through rerouting and preserved in place. This is a particularly relevant question for a situation like Five Finger Ridge along 1-70 between Richfield and Cove Fort in Utah. This site should have (and could have) been avoided if there had not been a mentality at work in the early 1980's that all archeological sites could be "mitigated" by data recovery. Why has the DEIS not considered off-site mitigation along potential "tourist corridors" that would be alternative routes to avoid heavy haul nuclear waste shipments?

There is reference to a DOE, Advisory Council on Historic Preservation agreement in each DEIS section on cultural resources. This agreement is now several years old. There are new standards for these agreements that emphasize public involvement and alternatives to data recovery as mitigation measures. Will this agreement be modified to deal with the very different issues in treating cultural properties on linear corridors rather than in large area blocks? Will there be more emphasis on public involvement and public availability of popular and research reports emanating from mitigation?

Response
Previous data recovery efforts at the proposed Yucca Mountain site included limited subsurface testing, *National Register of Historic Places* evaluations, and data recovery efforts at some archaeological sites to mitigate impacts from project-related field activities (such as exploratory trenches). In general, DOE used two data recovery methods: subsurface testing/surface analysis and collection of artifacts. Because such efforts have occurred over a

long period, beginning in 1982, it is difficult to amass total costs for this work. Because of differences in costs associated with similar data recovery methods over a 20-year period, and the fact that data recovery efforts to mitigate potential impacts from a repository-related transportation corridor would be years away, past data recovery costs have little relevance to future costs.

Alignment-specific archaeological studies would occur if the Yucca Mountain site was approved and DOE selected a transportation mode and corridor or route. DOE cannot quantify numbers and importance of sites until these decisions are made. Therefore, it is premature to discuss the possible level of effort required and the associated costs. However, DOE would include avoidance of significant archaeological sites as a mitigative option. Due to cultural value and cost, preservation of archaeological sites in place is the preferred alternative. If avoidance was not possible, a data recovery effort would be necessary to preserve the archaeological data. Section 9.2.5 of the EIS contains more information on proposed mitigation measures.

The Programmatic Agreement between DOE and the Advisory Council on Historic Preservation covers cultural resource requirements for site characterization activities at Yucca Mountain. DOE recognizes that construction of the repository and a Nevada transportation corridor would require a new and updated Programmatic Agreement. In conjunction with the Advisory Council, the Nevada State Historic Preservation Office, involved Native American tribes and organizations, and other interested parties, DOE would complete the new programmatic agreement, following the recently amended guidelines in 36 CFR 800.106.

7.5.5.1 (4287)
Comment - EIS001160 / 0095
Page 3-112. Section 3.2.2.1.5. Analysis of a corridor limited to only 0.2 kilometers is incredibly restrictive for an overview assessment. This results in small sample sizes and an inability to reasonably characterize the affected environment. A wider corridor or sample design based on topographical, geomorphic, and vegetative strata for the corridors would be much more in keeping with current professional practice to predict impacts to cultural resources.

Response
DOE recognizes that the archaeological site file search for the 0.2-kilometer (660-foot)-wide corridor or routes yielded a limited sample of available known data. If DOE selected a final alignment, existing historic preservation laws and regulations require an intensive field survey of the corridor right-of-way to identify all potentially affected cultural resources, recording of these properties, and evaluation of their significance. Potential adverse effects to significant sites and resources would require mitigative attention.

DOE reviewed archaeological site file records at the Bureau of Land Management Battle Mountain and Elko offices to acquire information on known sites along corridors in Lander and Eureka Counties. DOE has revised Section 3.2.2.1.5 of the EIS to include this information. DOE has also incorporated information in the Final EIS from additional site file searches, including relevant Bureau of Land Management District and Resource Area office records, and literature reviews for the areas that the candidate corridors cross to support the comparative analysis of cultural resource issues between corridor alternatives.

7.5.5.1 (12385)
Comment - EIS001160 / 0121
Page 11-14: Executive Order 11593 is now incorporated (since 1986) as Section 110 of the National Historic Preservation Act as an Agency responsibility. References to EO 11593 are no longer appropriate as Section 110 of NHPA clarifies and mandates procedures for conformance with law.

Response
DOE has deleted references to Executive Order 11593 in the EIS.

7.5.5.1 (13085)
Comment - 010227 / 0003
The site of the proposed surface aging facility described in the SDEIS [Supplement to the Draft EIS] is occupied by a known archaeological site, a sacred treasure to the indigenous people of the area. The SDEIS fails to address how many of these sites, potentially eligible for listing on the Nation Register of Historic Places would be protected. DOE says they will develop a plan at some future date, yet gives no timeline for when that will happen, or any

assurance that it will actually take place. These sites, these precious resources of traditional history. In an area where there have already been more than 25,000 cultural artifacts stolen and moved, this threat to the cultural resources is environmental racism.

Response
DOE states in the EIS that there are several known archaeological sites in the vicinity of Midway Valley that could be affected by ground-disturbing activities associated with construction of a surface aging facility. One archaeological site was partially mitigated during site characterization activities in 1991. The degree to which the aging facility could affect the archaeological sites in the vicinity cannot be determined until precise areas of ground disturbance are identified and the presence or absence of important cultural features or artifacts can be assessed for the disturbed areas.

With regard to National Register eligibility, status for previously recorded archaeological sites or sites yet to be discovered in the Yucca Mountain area would be handled on a case-by-case basis, depending on each site's relationship to project-driven activities. DOE would fully comply with its responsibilities under Section 106 of the National Historic Preservation Act and the American Indian Religious Freedom Act.

7.5.5.2 Native American Interests

7.5.5.2 (38)
Comment - 7 comments summarized
Several commenters noted the cultural beliefs of indigenous peoples and the very special status and sacredness of Yucca Mountain to the Western Shoshone. Commenters stated that the EIS does not incorporate Native American beliefs or the American Indian Writer's Subgroup input and concerns. A commenter stated that there is no other group of people that have experienced holy land violations due to cultural affiliation and religious beliefs. Another commenter stated that the use of the term "cultural resources" was "dismissively patronizing." Sacred sites and burial sites are like temples, churches, and cemeteries. Another commenter said that Midway Valley has known cultural resource sites and that DOE's stated goal is to avoid the area as much as possible. Yet, the commenter stated, human activities and increased access could result in harmful effects. Midway Valley and all of Yucca Mountain must be avoided.

Response
DOE supported the preparation of an American Indian Writers Subgroup document (DIRS 102043-AIWS 1998) for use as a primary reference in the EIS. DOE did not ignore the Native American position or concerns, but agreed that applicable information would be summarized in Section 3.1.1.4, 3.1.6.2, 3.1.6.2.2, and 4.1.13.4 of the EIS. DOE has the utmost respect for Native American viewpoints and belief systems. DOE is also aware of the special significance that Yucca Mountain and the surrounding area hold for Native American tribes and bands. DOE will continue to consider the importance of this relationship via an active partnership with Native American tribes and organizations through the established Yucca Mountain Project Native American Interaction Program.

DOE does not intend the term "cultural resources" to be patronizing. The term is one in common use to describe the physical remains of a people's way of life, but can also include such things as cultural uses of the natural environment, spiritual places, religious practices, and community values.

With regard to Midway Valley, DOE states in the EIS that there are several known archaeological sites in the vicinity of Midway Valley that could be affected by ground-disturbing activities associated with the construction of a surface aging facility. One of these sites was partially mitigated in 1991 during site characterization. The degree to which an aging facility could affect the archaeological sites in the vicinity could not be determined until precise areas of ground disturbance were identified and the presence or absence of important cultural features or artifacts could be assessed for the disturbed areas. The final footprint for a surface aging facility has not yet been determined and could ultimately be influenced by a number of factors, including the presence of known or yet-to-be discovered archaeological sites. In the case of impacts that could not be avoided, DOE would interact with Native American tribes and organizations to ensure the implementation of the most appropriate measures to reduce or control any adverse effects.

7.5.5.2 (150)
Comment - 3 comments summarized
Commenters stated that the discussion of Section 3.1.6.2 in the Draft EIS failed to identify the Western Shoshone Nation as it actually exists. Commenters said that for purposes of cultural resource studies at Yucca Mountain, DOE created the Pahrump Paiute Tribe and attributed historic tribal status to the Las Vegas Indian Center, which, out of 100 percent of its service, serves 3 percent of Western Shoshone and 6 percent of Southern Paiute who might have ties to Yucca Mountain. The Western Shoshone National Council was not identified for the purpose of this cultural resource study and the Treaty of Ruby Valley was not included in any review.

A commenter noted that the Director of the Las Vegas Indian Center, who participated in the cultural resource study, became a paid consultant for DOE, and then an employee of the Department. As indicated in the comment, this was a problem relationship because, as a DOE employee, the individual sat in a capacity to make recommendations for the Las Vegas Indian Center, the Pahrump Tribe, the Community Advisory Board for the Nevada Test Site, and the National Indian Nuclear Waste Policy Committee. The commenter stated that this is an unethical relationship.

A commenter also said that the systematic process used in cultural studies is “cultural triage,” the forced-choice situation in which an ethnic group is faced with the decision to rank in importance equally valued cultural resources that could be affected by a proposed development project. The commenter likened this to cultural genocide. Several commenters also indicated that DOE activities would disturb Western Shoshone cultural sites and destroy Western Shoshone culture in ways DOE cannot understand. Ongoing ground disturbing activities disturb wildlife and plants and the whole ecosystem and physical access. Shoshone cultural sites on Yucca Mountain cannot be mitigated.

Response
The Western Shoshone people are represented by Federally recognized tribes. In addition, ethnographic studies and the Native American Interaction Program, which has been in existence since the mid 1980s, identified four Western Shoshone tribes -- Timbisha Shoshone, Yomba Shoshone, Ely Shoshone, and Duckwater Shoshone -- as having cultural ties to the Yucca Mountain area. At this time, representatives of three of these tribes are involved in the interaction program (the Duckwater Shoshone Tribe has chosen not to participate actively). Several members of the Pahrump Paiute Tribe, which is not Federally recognized, actively address Native American issues associated with the repository program. The Las Vegas Indian Center is a nonprofit organization that represents the urban Native American population. The Center is a resource for involvement in the interaction program, and its representatives provide constructive input about Native American issues. DOE will continue to invite the four Federally recognized Western Shoshone tribes to participate in the interaction program.

Because the Western Shoshone National Council does not officially represent all Western Shoshone Tribes, DOE prefers to interact directly with Western Shoshone Tribes that have been identified as having cultural affiliations with the Yucca Mountain area. The Ruby Valley Treaty issue is discussed in Section 3.1.1.4 of the EIS.

Native American involvement in the interaction program is not identified through one individual. The program consists of the active participation of as many as 30 individuals from 16 tribes and one organization, including the Western Shoshone, Southern Paiute, Owens Valley Paiute and Shoshone people from Nevada, California, Arizona, and Utah. DOE compensates Native Americans who attend sanctioned meetings or conduct activities on behalf of the interaction program. DOE receives input and recommendations through a consensus of those involved in the meetings.

With regard to the commenter’s concern about “cultural triage,” the early DOE cultural and ethnographic study effort (1980s) prioritized the significance of resources to help focus study efforts on the cultural resource program.

DOE acknowledges in the EIS that people from many Native American tribes have used the area proposed for the repository, as well as nearby lands; that the lands around the site contain cultural, animal, and plant resources important to those tribes; and that the implementation of the Proposed Action would continue restrictions on access to the repository site environs. DOE does recognize that construction and operation of a repository at Yucca Mountain would have continuing adverse impacts for Native Americans who view the past, ongoing, and future repository-related activities as an intrusion on a culturally important and sacred landscape. The Department would continue to interact with Americans Indians to ensure that such adverse effects were minimized to the fullest extent possible.

DOE would include avoidance of significant archaeological sites as a mitigative option; preservation of archaeological sites is the preferred course of action. DOE is committed to using Native Americans monitors in field crews when data recovery (collection of resources) at a site is necessary. Archaeological contractors are on call to monitor known sites for potential impacts from project activities. In addition, Native Americans are welcome to visit the site to monitor locations during Native American Interaction Program field trips or during special trips, as necessary. Section 9.2.5 of the EIS contains additional information regarding proposed mitigative measures.

7.5.5.2 (237)
Comment - 3 comments summarized
Commenters expressed the concern that adverse effects (damage to the natural state of artifacts) to cultural resources would result from workers and construction activities. One commenter indicated that the statement in Section 9.3.5 of the Draft EIS related to preconstruction surveys should emphasize the avoidance of significant sites. The commenter asked what is the reclamation potential of archaeological sites. Another commenter stated that the Draft EIS failed to reflect that most American Indians see the unwanted disturbance of cultural resources as the inevitable outcome of the Yucca Mountain Project. Most would prefer no disturbances and see mitigation of disturbed archaeological sites as a marginally acceptable alternative.

Response
In Section 4.1.5.1 of the EIS, DOE indicates it would avoid archaeological and cultural resource sites consistent with applicable regulatory requirements and input from tribal representatives. Section 9.3.5 of the EIS further describes mitigation actions that could be taken in those instances where adverse impacts could not be avoided. In addition, DOE has modified the text in Section 9.3.5 of the EIS to reflect the fact that part of the purpose of preconstruction surveys is to determine the research potential of sites, rather than the reclamation potential.

The Cultural Resource Management Program, along with the Native American Interaction Program, has identified a team approach for managing artifacts in place, rather than collecting and curating. DOE would continue to actively consult with Native Americans to ensure that potential adverse effects were minimized to the fullest extent possible.

7.5.5.2 (503)
Comment - EIS000125 / 0004
What about the American native people? What about their ancestors and all their archeological sites and stuff like that?

Response
The Yucca Mountain Site Characterization Project has maintained a Native American Interaction Program with 16 tribes and one organization since the mid-1980s (see Section 3.1.6.2.1 of the EIS). Each tribe appoints representatives to sit on a DOE-funded, self-organized committee called the Consolidated Group of Tribes and Organizations. This group meets twice a year and participates in field trips to Yucca Mountain to impart cultural resource protection information and to become more aware of the ongoing studies. While the group does not support the potential use of Yucca Mountain as a repository, it has agreed to be involved in an honest and participatory process. DOE supported the American Indian Writers Subgroup of the Consolidated Group of Tribes and Organizations in the preparation of *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statements* (DIRS 102043-AIWS 1998), the results of which were included in the EIS.

DOE acknowledges in the EIS that people from many Native American tribes have used the area proposed for the repository as well as nearby lands; that the lands around the site contain cultural, animal, and plant resources important to those tribes; and that the implementation of the Proposed Action would continue restrictions on access to the repository site environs. DOE does recognize that construction and operation of a repository at Yucca Mountain would have continuing adverse impacts for Native Americans who view the past, ongoing, and future repository-related activities as an intrusion on a culturally important and sacred landscape. The Department would continue to interact with Native Americans to ensure that such adverse effects were minimized to the fullest extent possible.

With regard to archaeological sites, the Cultural Resource Management Program, along with the Native American Interaction Program, has identified a team approach for managing artifacts in place, rather than collecting and curating.

DOE understands that all of "Mother Earth" holds sacred, spiritual, cultural, and historic value to Native Americans. It seeks to understand and document those views as part of the Native American Interaction Program.

Cultural resources, which include archaeological and historic resources of interest to Native Americans, are discussed throughout the EIS, including Sections 3.1.6, 3.1.6.2, and 4.1.5.

7.5.5.2 (6545)
Comment - 010485 / 0003
Given DOE's admission that "DOE recognizes that it could not construct and operate a repository at Yucca Mountain without some conflict with Native American concerns," (p. 3-16) it seems an inherent contradiction in the EIS that DOE will respect and protect the sites' cultural resources even as they presume land ownership.

Response
DOE does recognize that construction and operation of a repository at Yucca Mountain could have continuing adverse impacts for individuals who view past, ongoing, and future repository activities as an intrusion on a culturally important and sacred landscape. Although this viewpoint might suggest that the Yucca Mountain should not be developed, DOE and the Consolidated Group of Tribes and Organizations recognize the restrictions on public access to the area have been generally beneficial and protective of cultural resources. Nevertheless, DOE would avoid archaeological and cultural resource sites to the extent possible and consistent with applicable regulatory requirements and input from tribal representatives. The Cultural Resource Management Program, along with the Native American Interaction Program, has identified a team approach for managing artifacts in place, rather than collecting and curating. Rather than a contradiction, this approach provides an active vehicle for DOE, in consultation with Native Americans, to ensure that such adverse effects would be minimized or avoided to the extent possible.

7.5.5.2 (8704)
Comment - EIS001480 / 0009
I'd like to read a short prepared document by the Western Shoshone National Council. The Western Shoshone National Council is the governing body of the Western Shoshone Nation, which is the true stewards of this land of Yucca Mountain. And the Western Shoshone National Council in December of 1995 passed a resolution that said – that created a nuclear free zone in their country, which is called Newe Sogobia. That's the name of their country. And Yucca Mountain is within the boundaries of Newe Sogobia. I'd like to read this. It's just going to take about two minutes, and then we'll be done.

WHEREAS, the people of the Western Shoshone Nation find the presence of radioactive materials, nuclear power facilities and nuclear weapons facilities within the lands, the watershed or airshed of the lands of the Western Shoshone Nation, known in the Shoshone language as Newe Sogobia, as set forth in the Treaty of Ruby Valley of 1863, to be in conflict with the maintenance of the community's economic well being, health and general welfare; and

WHEREAS, Nuclear weapons testing by the United States Government on Western Shoshone lands, in direct conflict with the Western Shoshone National Council law and policy, has left portions of Newe Sogobia scarred and permanently contaminated with radiation; and

WHEREAS, The aforementioned weapons testing by the United States Government on Western Shoshone lands has already caused widespread cancer, bringing illness and death to Western Shoshone, members of other Indian nations, and the non-Indian people of the Great Basin region; and

WHEREAS, The United States Government continues to contaminate Western Shoshone lands at the Nevada Test Site by importing and dumping radioactively [radioactivity].

WHEREAS, The United States Government continues to contaminate Western Shoshone lands at the Nevada Test Site by importing and dumping radioactively and chemically contaminated soil and other waste products; and

WHEREAS, The United States Geological Survey has found that the aquifer under the radioactive waste dump site is about to become contaminated with long-lived radionuclides, endangering drinking water on Western Shoshone lands; and

WHEREAS, The government of the United States, against the expressed wishes of the Western Shoshone National Council, is proposing to store highly-irradiated fuel from commercial nuclear power plants, which will remain deadly for hundreds of thousands of years at Yucca Mountain within Western Shoshone lands; and

WHEREAS, A high volume of truck transportation of radioactive wastes can be expected through the Western Shoshone Nation's lands and the surrounding region, increasing the likelihood of an accident and the rapid dispersal to the environment of deadly, long-lived radioactive wastes; and

WHEREAS, The presence of radioactive waste dumps in the region, and the publicity surrounding it, will severely harm the economy of the Western Shoshone and neighboring peoples; and

WHEREAS, Over 4,500 local communities throughout the world, 25 nations, and the regions of the Antarctic, Latin America and the South Pacific have been declared nuclear free zones; and
WHEREAS, The National Council of the Western Shoshone encourages the development of clean, renewable energy resources in order to create jobs that maintain the traditional Native American values of caretaking and balance with natural creation; and

WHEREAS, The National Council of the Western Shoshone encourages research into radioactive waste neutralization techniques and demands the stabilization and/or cleanup, if possible, of existing radioactive wastes on the lands of the Western Shoshone Nation;

NOW, THEREFORE be it ordained by the Western Shoshone National Council that the following declaration be added to and made a part of the laws of the Western Shoshone Nation:

"Nuclear free zone. For the purposes of this article, the following definitions apply."

I'm going to jump a little bit. The prohibition of storage, use or disposal of radioactive materials; the prohibition of nuclear weapons work; the prohibition of nuclear reactors; the prohibition of uranium and milling; the prohibition of migration of radioactive materials.

"The Western Shoshone National Council shall post and maintain appropriate signs at all recognized entrances to the lands of the Western Shoshone Nation, at entrances to the Yucca Mountain facility and the Nevada Nuclear Test Site, and the National Council office in Cactus Springs, proclaiming the Western Shoshone Nation's status as a nuclear free zone."

Response
Thank you for your comment.

7.5.5.2 (9667)
Comment - EIS002074 / 0011
With respect to an adverse impact to cultural resources, it states in the EIS that impacts may result from workers and from construction activities. Clearly a plan for mitigation has been established to monitor those areas and sites, but the plan does not include or have a provision for any monitors, even though this has been a long-standing relationship and that the tribes have direct cultural ties to the area.

Response
DOE is committed to using Native American monitors on field crews when significant data recovery (collection of resources) at a site is necessary. Archaeological contractors are on call to monitor known sites for potential impacts from project activities. In addition, Native Americans are welcome to visit the site to monitor locations during Native American Interaction Program field trips, or during special trips, as necessary.

7.5.6 SOCIOECONOMICS

7.5.6 (119)
Comment - 2 comments summarized
Commenters expressed concern that Esmeralda County was not adequately addressed in the Draft EIS even though a rail corridor is in or near Esmeralda County. Commenters expressed concern that the EIS discusses the impacts to employment and real disposable income for Clark, Nye, and Lincoln Counties, but does not mention Esmeralda County.

Response
The EIS presents information for counties within the defined region of influence (Clark, Nye, and Lincoln Counties) and the Rest of Nevada. The Rest of Nevada is an aggregate of the 14 remaining Nevada Counties. The socioeconomic simulation model DOE used to estimate potential impacts indicated that the rest of Nevada (including Esmeralda County) would experience some direct economic effects from spending by workers for food and lodging, but incremental changes to the economy would be very small.

7.5.6 (130)
Comment - 43 comments summarized
Several commenters stated that the Draft EIS was inadequate because of reliance on 1990 Census data. Commenters specifically pointed out that the rapid growth of towns and counties in Southern Nevada made 1990 Census population information out of date with regard to both the repository and transportation corridors. These commenters identified alternative sources of population data such as the Nevada State Demographer's Office and Nye County documents that provide data on current and projected population.

Other commenters indicated that the socioeconomic sections of the Draft EIS underestimated county and town populations and projections, most often citing Nye County and Pahrump. These comments included population projections for areas within the 80-kilometer (50-mile) radiological monitoring grid discussed in Section 3.1.8.1 of the EIS

A number of commenters indicated that DOE should project population growth in the region of influence. Several commenters took issue with the long-term population assumptions based on the National Academy of Sciences recommendations that long-term projections would likely be more in error than using present day conditions.

Response
When preparing the Draft EIS, DOE based the Nevada population estimates on the then-most-recent available information (1996 to 1997) from the Bureau of the Census. The Final EIS uses Nevada population data that incorporates data developed by and received from county and State officials.

DOE used the Regional Economic Models, Inc. (REMI) Economic and Demographic Forecasting System (EDFS) 53-sector computer model to project population growth in the regions of influence and to evaluate socioeconomic impacts from the Proposed Action. For the Final EIS, this model incorporates population estimates from 1998 to 1999 provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, DOE used State Demographer estimates as input to the REMI model. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census.

In general, the Bureau of the Census is the preferred source of information for use in DOE socioeconomic analyses because it provides a greater level of consistency across geopolitical boundaries than most other data sources. Bureau information is based on the direct collection of information, while other information sources often rely either on some form of the Bureau information or on proxies such as telephone and electrical connections to households and businesses. The information for a particular variable provided by local and state agencies or private vendors can

Response
DOE is committed to using Native American monitors on field crews when significant data recovery (collection of resources) at a site is necessary. Archaeological contractors are on call to monitor known sites for potential impacts from project activities. In addition, Native Americans are welcome to visit the site to monitor locations during Native American Interaction Program field trips, or during special trips, as necessary.

7.5.6 SOCIOECONOMICS

7.5.6 (119)
Comment - 2 comments summarized
Commenters expressed concern that Esmeralda County was not adequately addressed in the Draft EIS even though a rail corridor is in or near Esmeralda County. Commenters expressed concern that the EIS discusses the impacts to employment and real disposable income for Clark, Nye, and Lincoln Counties, but does not mention Esmeralda County.

Response
The EIS presents information for counties within the defined region of influence (Clark, Nye, and Lincoln Counties) and the Rest of Nevada. The Rest of Nevada is an aggregate of the 14 remaining Nevada Counties. The socioeconomic simulation model DOE used to estimate potential impacts indicated that the rest of Nevada (including Esmeralda County) would experience some direct economic effects from spending by workers for food and lodging, but incremental changes to the economy would be very small.

7.5.6 (130)
Comment - 43 comments summarized
Several commenters stated that the Draft EIS was inadequate because of reliance on 1990 Census data. Commenters specifically pointed out that the rapid growth of towns and counties in Southern Nevada made 1990 Census population information out of date with regard to both the repository and transportation corridors. These commenters identified alternative sources of population data such as the Nevada State Demographer's Office and Nye County documents that provide data on current and projected population.

Other commenters indicated that the socioeconomic sections of the Draft EIS underestimated county and town populations and projections, most often citing Nye County and Pahrump. These comments included population projections for areas within the 80-kilometer (50-mile) radiological monitoring grid discussed in Section 3.1.8.1 of the EIS

A number of commenters indicated that DOE should project population growth in the region of influence. Several commenters took issue with the long-term population assumptions based on the National Academy of Sciences recommendations that long-term projections would likely be more in error than using present day conditions.

Response
When preparing the Draft EIS, DOE based the Nevada population estimates on the then-most-recent available information (1996 to 1997) from the Bureau of the Census. The Final EIS uses Nevada population data that incorporates data developed by and received from county and State officials.

DOE used the Regional Economic Models, Inc. (REMI) Economic and Demographic Forecasting System (EDFS) 53-sector computer model to project population growth in the regions of influence and to evaluate socioeconomic impacts from the Proposed Action. For the Final EIS, this model incorporates population estimates from 1998 to 1999 provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, DOE used State Demographer estimates as input to the REMI model. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census.

In general, the Bureau of the Census is the preferred source of information for use in DOE socioeconomic analyses because it provides a greater level of consistency across geopolitical boundaries than most other data sources. Bureau information is based on the direct collection of information, while other information sources often rely either on some form of the Bureau information or on proxies such as telephone and electrical connections to households and businesses. The information for a particular variable provided by local and state agencies or private vendors can differ, sometimes significantly, from one another because of the use of different methods, source data, level of detail and terminology. In addition, Bureau of the Census information is readily available and population estimates are updated annually.

In response to comments, however, DOE has updated its socioeconomic baseline projections and estimated impacts for the Final EIS to reflect the most recent data available from the State of Nevada and local communities, as well as the 2000 Census population summary data for Nevada.

In March 2001, the Bureau of the Census released its county-level population data for the State of Nevada based on 2000 Census. DOE then updated the baseline projection to 2000 Census data for the State of Nevada. The 2000 Census data baseline was then compared to baseline projections utilizing State and local data. Sensitivity analyses of the two data sets indicated that the differences between the two baselines were small. DOE's population projections and impact estimates in the Final EIS are based on the most recent available information from State and local sources.

Similarly, DOE's population projections to 2035 within 80 kilometers (50 miles) of the repository use the most recent available information from State and local sources. DOE determined the number of individuals within a particular sector within the 80-kilometer area based on surveys conducted in 2000. Figure 3-25 of the EIS provides the projected population distribution for 2035.

The Final EIS baseline uses REMI computer model projections of population totals for each county to 2035. The Clark County projections correspond to those used by the University of Nevada, Las Vegas (DIRS 136698–Riddel and Schwer 1999), which are also based on the REMI EDFS 53-sector model. The Nye County population projections for the Final EIS are based on data supplied by Nye County (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998) that are based, in part, on a REMI 14-sector model. For Lincoln County and the rest of Nevada, population projections by the Nevada State Demographer's Office (Nevada Statistical Abstract) through 2018 were used as inputs to population projections for these areas. DOE used data from these sources to project the population distribution within the 80-kilometer radiological monitoring grid. For Inyo County, DOE used the California Department of Finance projections (DIRS 105294-State of California 1998) to project population distributions.

To update the health and safety analyses associated with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 census. For example, if a county's population was estimated to double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double; radiological impacts were then doubled accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance information from a report prepared for the City of North Las Vegas).

As discussed in Section 5.2.4.1 of the EIS, DOE accepts the position of the National Academy of Sciences that it is not possible to accurately predict future human behavior. DOE used a default position of today's conditions. For the Final EIS, DOE has projected baseline population and other economic measures to 2035.

7.5.6 (231)

Comment - 6 comments summarized

Several commenters said that the EIS needs to address a number of direct impacts to Lander County. The listing of issues include real estate property values, socioeconomic impacts, revenue sources for southern Lander County (fishing, hunting, and recreation), tourism, shortage of law enforcement officers, mining, ranching, and grazing allotments.

Response

DOE developed a list of assumptions to determine projected economic and demographic changes in Nevada from the construction and operation of the proposed repository. The Regional Economic Models, Inc. (REMI) computer model used in these determinations incorporates four regions. Three of the regions are Clark, Nye, and Lincoln Counties. The fourth region is the Rest of Nevada, comprising the other 14 counties in the state (including Lander County).

DOE assumed for railroad construction that workers would be nominally assigned to base camps according to an even split by the number of camps. All railroad construction workers would commute weekly from Clark County to the trailer camps outside Clark County. The base camps would subcontract to provide mess facilities for its workers. For purposes of the economic analysis, it was assumed that monies expended on eating and drinking would enter the economy through retail establishments, although most meals would be eaten at the base camps. Operations workers would live in the county where the route branches off the main line, except for the Carlin routes, for which they would live in Elko.

Given these assumptions, the total estimated incremental population increases for the 14 counties in the Rest of Nevada attributed to the Carlin Corridor would be about 170 individuals in the peak year. Total employment associated with the Carlin Corridor for the 14 counties for the peak year would be about 90. DOE does not believe there would be discernible direct or indirect impacts to the infrastructure or revenue sources (such as public safety or recreation) for any of these counties, including Lander, because 90 individuals is a small percentage of the current and projected population of the Rest of Nevada.

DOE did not address potential changes in property values because of the dynamic nature of real estate and the uncontrollable factors that can influence property values. Similarly, definitive information is not available on specific tracts of land (grazing allotments, mining claims, or otherwise) that could be required for a given transportation alternative. For any land that would be required or otherwise affected, the Department would compensate landowners fairly under the Federal acquisition procedures, as applicable. If the Department had to exercise its rights of eminent domain, it would follow applicable laws and regulations.

7.5.6 (255)
Comment - 3 comments summarized
Several commenters indicated that the Supplement to the Draft EIS did not address the socioeconomic impacts associated with the aging facility.

Response
Section 3.1.8 of the Supplement to the Draft EIS includes a discussion of the potential socioeconomic impacts associated with the surface aging of spent nuclear fuel. Because about half of the operational period for an aging facility would occur after 2035, beyond the credible limits of the REMI computer model utilized to estimate socioeconomic impacts, DOE did not quantity impacts beyond 2035.

7.5.6 (338)
Comment - EIS000055 / 0002
Provide a version of Fig 3-21, pg 3-80 with Nye town boundaries and 1997 population distribution.

Response
Figure 3-25 of the EIS depicts 2035 (not 1997) population distribution within 80 kilometers (50 miles) of the proposed repository. The distribution in the Final EIS is based upon 2000 population estimates incorporating housing counts estimated through windshield surveys and electric utility data. While it would be possible to overlay existing town boundaries on the radiological monitoring grid, DOE has not done so for the EIS because the focus of the assessment is to establish the relative number of residents in a given direction and distance from the repository. Potential health and safety impacts to individuals or populations groups are a function of direction and distance and independent of municipal boundaries or governmental jurisdictions.

7.5.6 (420)
Comment - EIS000071 / 0018
With the cessation of nuclear weapons testing in 1992, Nye County has made substantial efforts to plan for its economic future in the US 95 corridor.

The DEIS does not recognize these plans and does not reflect the DOE obligation to ensure that the Yucca Mountain project will not thwart those plans.

Response
Consistent with Council on Environmental Quality regulations (40 CFR Parts 1500 to 1508), DOE considered past, present, and reasonably foreseeable actions in its assessment of cumulative impacts and has reviewed a number of actions, both current and proposed, to determine relevance. The expression "reasonably foreseeable" refers to future actions where there is some reasonable expectation that the action will occur.

Cumulative impacts are discussed in Chapter 8 of the EIS. DOE developed these analyses by identifying other actions whose effects could coincide in time and space with the effects from the repository (examples include the underground testing at the Nevada Test Site, the proposed Desert Space Museum, and low-level radioactive waste disposal at the Nevada Test Site and in Beatty, Nevada). The identification of these past, present, and reasonably foreseeable actions (including past, current and future actions at the Nevada Test Site) was based on a review of resource plans prepared by Federal agencies, other EISs and environmental assessments, tribal meeting records, and other documents developed by federal, state, local and private organizations including those submitted by Nye County. DOE has followed the Nye County economic development activities, particularly the development of the Desert Space Museum and adjacent business park. Other activities that have been followed include the possible siting of Kistler Aerospace and the VentureStar® Program. Thus far, these actions remain in the very early idea or planning. DOE would continue to have dialogue with and continue to monitor planning activities. The Final EIS includes factual changes and clarifications, and DOE believes that the EIS adequately characterizes the cumulative impacts associated with the proposed repository.

The documents cited in Section 3.2.2.1.1 of the EIS are source documents used by DOE for land use features and possible future actions taking place within the transportation corridors. The more notable land use features and influences that exist or could exist on lands within the transportation corridors are presented in Chapter 6 of the EIS. The potential impacts of each transportation alternative in Nevada are described in Section 6.3 of the EIS. Included are estimates of impacts to health and safety in Nevada from incident-free waste transport to Yucca Mountain and from transportation accidents, as well as regional socioeconomic impacts to potentially affected counties (see Table 6-4 of the EIS). Section 6.3 and Appendix J.3 of the EIS reflect planning/zoning designations in completed land use planning documents prepared by public entities with jurisdiction over transportation routes in Nevada. Section 6.3 of the EIS establishes the scope of land use information deemed useful for assessing potential impacts of transportation implementing alternatives in Nevada.

7.5.6 (464)
Comment - EIS000113 / 0003
I know demographically we don't -- we're not even a pimple on a gnat's ass, and I say that because we will be the only place within fifty miles of a major DOE thing that is under 400,000 people.

So if this is saying we don't count.

This is a moral question and should be answered.
We're just as important as any place else in the nation, we think, and we hope.

Response
DOE agrees that small communities are just as important as large communities with regard to potential effects to individuals. As a consequence, the Department has estimated potential health and safety impacts by population sector and to the hypothetical maximally exposed individual.

7.5.6 (479)
Comment - EIS000084 / 0001
One of the criteria used in selecting Yucca Mountain was according to your EIS the sparsely populated area around Yucca Mountain. Well, this sparsely populated area of land around Yucca Mountain grows crops and feeds 5,000 milk cows which produces twenty percent of Nevada's milk production. This dairy [Ponderosa Dairy in Amargosa Valley] ships out 128 million pounds of milk annually to 30 million people throughout California and the West Coast. In the future event of juvenile nuclear contamination, this dairy would be a direct conduit of that contamination to 30 million people. Yet this large dairy industry is not even mentioned in your report. Now, how could a comprehensive and well researched and documented EIS miss this? I don't know. We have also invested

over 1 million dollars in producing and marketing the first organic milk in Nevada. Who is going to want to drink organic milk produced next to the largest nuclear dump in the world? I want to know that.

Response
Section 3.1.1.1 of the EIS acknowledges there are farming and dairy operations about 30 kilometers (19 miles) south of the proposed repository in the Amargosa Valley. The concerns the commenter raises relate ultimately to the marketability of milk produced in the vicinity of Yucca Mountain. While DOE has not addressed marketing issues, it has assessed the potential health and safety issues for all applicable environmental pathways associated with the repository in Chapter 4 of the EIS. In addition, the Department has programs in place that includes testing to ensure the safety of milk produced near its sites. In Nevada, DOE has established a milk surveillance network to monitor the potential uptake of radioisotopes in milk near the Nevada Test Site. The network includes commercial dairies and family-owned milk cows and goats representing the major milksheds within 300 kilometers (186 miles) of the Test Site. In southern Nye County, this includes the Pahrump Dairy and Ponderosa Dairy. The program specifically identifies the use of farmland and dairies in Amargosa Valley and other areas within 80 kilometers (50 miles) of the proposed repository.

7.5.6 (480)
Comment - EIS000084 / 0002
In your EIS draft, page 3-75, it states that 110 people are employed in agriculture, forestry and fisheries in all of Nye County. We [Ponderosa Dairy in Amargosa Valley) alone employ over a hundred people directly. We alone. Here is yet another serious error in just simple basic facts. 27 million dollars and they can't figure out how many farm workers there are in Nye County? I'm really having some serious doubts now.

Response
Page 3-75 of the Draft EIS reported 110 employees in the agriculture, forestry, and fisheries sector for 1995. The Draft EIS, however, also reported 210 employees in the farming sector for 1995. These data and job sector classifications are from the U.S. Department of Commerce, Bureau of Economic Analyses, Regional Economic Information System. This is the same data source Nye County used in its socioeconomic reports prepared by the Planning Information Corporation. The information for 2000 reported in the Final EIS shows levels of employment in the farming and agricultural services sectors. The agricultural sector is 110 (the same as in 1995), while farming is 260 (about 50 employees higher).

7.5.6 (529)
Comment - EIS000118 / 0001
Our basic preliminary comments on the socioeconomics are that the EIS does not sufficiently deal with -- sort of reflect ground truth in Nye County communities as they have evolved in the last few years in the 1990s.

It doesn't include [an] adequate reflection of what Nye County communities, especially southern Nye communities, are -- could become over the long period of time of this project, and it does not address some of the actions of the Commission and other agencies regarding land development and activities of Nye County.

A few quick examples. On page -- I think it's 3-17 [3-73] of the [Draft] EIS, it says that Nye County had a population of 26,000 in 1997, and it also says that no community level population estimates were available for 1991 or 1995.

Nye County has prepared community level population estimates since before the 1990 census on a quarterly basis using a consistent method with methods fully explained and with results fully distributed since or before the 1990 census and people in Pahrump think our estimates are conservative.

But our estimate for 1997 is 31,000, not 26,000, and our estimates for today are in the 37,000 area. The point is that the EIS assumes that Yucca Mountain is going to be imposed on basically a static community, not one that is changed as much as this one has.

Another quick example is that all the radiation exposure estimates in the EIS assume that there will be 28,000 people within fifty miles of the repository. That includes all of Pahrump.

Nye County has published population projections that say that by 2010, which is when this project is scheduled to go operational, there will be at least 47,100 population within fifty miles and in Nye County.

That doesn't include California, that doesn't include Indian Springs, within fifty miles, and that estimate it says in the projection doesn't include some of the economic development matters. It doesn't include some of the extraordinary subdivision developments in Pahrump.

Since 1992, when nuclear weapons testing was stopped at the Nevada Test Site, the DOE Nevada has sought out to think through new kinds of missions for the test site, and Nye County has made a considerable effort sort of reflecting that to develop ideas of economic development for the US 95 corridor, Indian Springs all the way up to Tonopah.

These are ambitious, they are innovative and they reflect a vision for Nye County's future that should not just be done for nuclear weapons testing, low-level radioactive test and high-level radioactive waste.

And so the use of the 28,000 estimate reflects a notion that this is being imposed on a community that is static at a level that was passed back in 1995.

Response
In the area of socioeconomic impacts, the primary uncertainties that could be analyzed are those associated with projections of population and economic growth. The Final EIS incorporates Nevada population data developed by and received from county and state officials. In response to comments, DOE has updated its population estimates in the regions of influence to reflect the most recent state and local information. For the repository- and transportation-related regions of influence, DOE performed Regional Economic Models, Inc. (REMI) computer model simulations to establish an updated population baseline by accounting for population estimates and projections provided by county governments. In the absence of county information, population estimates and projections from the Nevada State Demographer's Office were used. The updated population baselines were then used to estimate populations for Clark, Nye, and Lincoln Counties and the Rest of Nevada through 2035. In addition, DOE prepared estimates based on the actual 2000 Census data for that year and projections of growth rates provided by local and state agencies. A sensitivity analysis revealed only small differences in the two projections.

The Final EIS baseline used REMI model projections of population totals for each Nevada county in the region of influence and the rest of Nevada until 2035. DOE based inputs to Nye County projections for the Final EIS on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the comment response period are based in part on a REMI 14-sector model. Nye County projections and source documents were used to project population distributions within the 80-kilometer (50-mile) radiological monitoring grid.

Consistent with Council on Environmental Quality regulations (40 CFR Parts 1500 to 1508), DOE considered past, present, and reasonably foreseeable actions in its assessment of cumulative impacts and has reviewed a number of actions both current and proposed to determine relevance. The expression "reasonably foreseeable" refers to future actions where there is some reasonable expectation that the action could occur.

Such as a Proposed Action under analysis, a project that has already started, or a future action that has obligated funding.

Cumulative impacts are discussed in Chapter 8 of the EIS. DOE developed these analyses by identifying other actions whose effects could coincide in time and space with the effects from the repository (examples include the underground testing at the Nevada Test Site, the proposed Desert Space Museum, and low-level radioactive waste disposal at the Nevada Test Site and in Beatty, Nevada). The identification of these past, present, and reasonably foreseeable actions (including past, current and future actions at the Nevada Test Site) was based on a review of resource plans prepared by Federal agencies, other EISs and environmental assessments, tribal meeting records, and other documents developed by Federal, state, local, and private organizations. The Final EIS includes factual changes and clarifications, and DOE believes that the EIS adequately characterizes the cumulative impacts associated with the proposed repository.

DOE has followed the Nye County economic development activities, particularly the development of the Desert Space Museum and adjacent business park. Other activities that have been followed include the possible siting of Kistler Aerospace and the VentureStar® program. Thus far, these actions remain in the very early idea or planning stage. DOE would continue to have dialogue with, and continue to monitor the planning activities of the affected units of local government to ensure they are taken into account in the decision-making process for the proposed repository.

7.5.6 (558)
Comment - EIS000227 / 0006
The draft EIS completely ignores the potential for major and widespread socioeconomic impacts from the project, both in Nevada and in cities and communities throughout the nation.

Response
DOE has assessed the potential socioeconomic impacts associated with development of a repository at the Yucca Mountain. The Department estimated the incremental impacts at the county level for Clark, Lincoln, and Nye Counties, and the rest of the 14 Nevada Counties aggregately. It used the REMI EDFS-53 Forecasting and Simulation Model. The model segments age, ethnicity, and gender based on 600 cohorts to predict population. The model also calculates births, deaths, and aging. Employment and fiscal changes to the economy are derived from inter-industry relationships, labor markets, and national/worldwide economic variables. Based on the results of the model outputs, DOE does not believe the incremental increases in socioeconomic parameters represents large or widespread economic impacts.

From the national perspective, DOE did not analyze the potential socioeconomic impacts of transportation because all spent nuclear fuel and high-level radioactive waste shipments would be over existing highways and railroads. The shipments would represent a very small fraction of total national highway and railroad traffic (0.008 percent of truck kilometers and 0.007 percent of railcar kilometers).

With regard to suggestions that major or widespread socioeconomic impacts would arise through perceptions of the repository or transportation of spent nuclear fuel and high-level radioactive waste, DOE has determined that it could not measure any potential impacts in a meaningful way. This is discussed in Section 2.5.4 of the Final EIS and Appendix N.

7.5.6 (603)
Comment - EIS000127 / 0020
It says in here that Pahrump has all the services we need to take care of the problem. We don't even have a hospital.

Response
Section 3.1.7.5 of the EIS notes that there are no hospitals in Southern Nye County. Section 4.1.6.2.5 states that the Proposed Action would increase demand for public services in pathway and other portions of Southern Nye County. After a decision was made on the proposed repository, and transportation modes and routes, local jurisdictions would be better able to identify the likely economic, social, public health and safety, and environmental impacts that would be the basis for a request for economic assistance, which might include assistance in providing additional medical and emergency response facilities, under Section 116(c) of the NWPA.

In the Final EIS, DOE has expanded its socioeconomic discussions in Chapter 3 to provide a clarified basis for understanding the potential impacts described in Chapter 4. This discussion includes a projection of baseline parameters through 2035 based on the most recently available information and assumptions. Section 116(c)(2)(A)(i) of the NWPA states that "the Secretary shall provide financial and technical assistance to the State of Nevada and any affected unit of local government to mitigate the impact on such [an affected unit of local government or the State of Nevada] of the development of [a] repository and the characterization of [the Yucca Mountain] site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

Under the NWPA, the Section 116 impact assistance review process and this EIS process are distinct from one another, and the implementation of one is not dependent on the implementation of the other. Thus, the provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 would be based on an evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 to document likely economic, social, public health and safety, and environmental impacts. If the proposed repository was to become operational, DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

7.5.6 (606)
Comment - EIS000127 / 0024
There's one thing left I'd like to say. You talk about worst case scenarios. What about the socioeconomic impacts of a worst case scenario that nobody in the State of Nevada wants Yucca Mountain; not the government, not the people.

If they try to ram it down Nevada's throat, what if Nevada tries to secede from the union? That's a socioeconomic impact that could be very real.

You got a lot of militias out here who don't like the Federal Government, anyway. So that is something that really should be considered. What about if we just say, "No go."

Response
DOE recognizes that there is considerable opposition to the proposed Yucca Mountain Repository. The decision as to whether or not the repository would be implemented as proposed lies with the President, the State of Nevada, the United States Congress, and the Nuclear Regulatory Commission.

7.5.6 (1130)
Comment - EIS000270 / 0013
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Adoption of arbitrarily limited, unrealistic scenarios, cultural and economic systems and characteristics, to describe future conditions and situations affecting future populations.

Response
DOE has assessed the potential socioeconomic impacts associated with the proposed Yucca Mountain Project. The Department estimated the incremental impacts at the county level for Clark, Lincoln, and Nye Counties, and the rest of the 14 Nevada Counties aggregately. It used the REMI EDFS-53 Forecasting and Simulation Model. The model segments age, ethnicity, and gender based on 600 cohorts to predict population. The model also calculates births, deaths, and aging. Employment and fiscal changes to the economy are derived from inter-industry relationships, labor markets, and national and worldwide economic variables. Based on the results of the model outputs, DOE does not believe the incremental increases in socioeconomic parameters represent large or widespread economic impacts.

From the national perspective, DOE did not analyze the potential socioeconomic impacts of transportation because all spent nuclear fuel and high-level radioactive waste shipments would be over existing highways and railroads. The shipments would represent a very small fraction of total national highway and railroad traffic (0.008 percent of truck kilometers and 0.007 percent of railcar kilometers).

7.5.6 (1184)
Comment - EIS000114 / 0005
If you read the Environmental Impact Statement, they estimate our population in Pahrump to be 16,800 in the year 2000. We're now double that.

If you look at the baseline population estimates and you draw the graph, it comes from his office -- we're going to be guaranteed 45,000 people in the year 2005 before they'll even start construction up on the railway.

What was amazing to me about the summary or in the impact statement was the bomb that went off. This is a radius of fifty miles. Pahrump's in it.

It shows population 16,800, and they don't want to address sabotage.

Isn't it amazing that Mr. Reagan allowed us to take in ten percent of outside nuclear storage to include high-level plutonium, and in our impact statement, they say that sabotage is very unlikely, yet we're going to be out here in the middle of nowhere on a railway and all it's going to take is a couple tons of dynamite to blow it up and to get to that plutonium.

Response
The Final EIS uses Nevada population estimates that incorporate data developed by and received from county and State officials. In the case of Nye County population estimates, DOE incorporated the latest population estimates received from Nye County.

Sabotage is discussed in Sections 4.1.8.3, 6.2.4.2.3, 7.2.1.15, and 7.2.2.9 of the EIS. The commenter is correct in that portions of Pahrump are within 80 kilometers (50 miles) of the proposed repository. Figure 3-20 of the EIS shows the areas that DOE regularly monitors for radiological releases to the environment.

7.5.6 (1187)
Comment - EIS000114 / 0008
The population studies suck. You're wrong. You're wrong.

Response
The Final EIS uses Nevada population estimates that incorporate data developed by and received from County and State officials.

7.5.6 (2652)
Comment - EIS000409 / 0009
Socio & Economic hardships. Under Executive Order 12866 (58 *FR* 7735, Oct. 4, 1993) and other OMB reviewed Presidential Orders will affect the economies of many places in the nation. YM could potentially materially alter, as well as adverse economic impacts on a city like Chicago or a town like Pahrump ($100 million or more impact).

Response
Executive Order 12866, "Regulatory Planning and Review," sets forth guidance for a more efficient regulatory process.

DOE agrees that Yucca Mountain activities could affect small and large communities. As a consequence, the Department has estimated the potential socioeconomic impacts to areas that could receive the most impacts. The concern is not with the size of the community, but with the distribution of people in the potentially affected areas and with the incremental change in a given parameter.

7.5.6 (4388)
Comment - EIS001399 / 0003
This city is the fastest growing city in the United States with a growth rate of over 400%. It is estimated that we will have a population of influence within the next 10 years of approximately 80,000. The draft statement has not addressed the fiscal impact to the city or its businesses. We suggest that the Environmental Draft Statement be rejected on the basis of incomplete or outdated data and assumptions that do not include the City of Mesquite.

Response
DOE has evaluated socioeconomic impacts of its actions on Clark County, based on the historic residential patterns of its employees who live in Clark County; the majority of new employees associated with the Yucca Mountain Project would reside in the Las Vegas urban area. Potential fiscal impacts on the county level were captured through estimation of real disposable income and state and local spending.

7.5.6 (5037)
<u>Comment</u> - EIS001520 / 0005
Population data used in the EIS should be updated from the 1990 census figures and should be extrapolated to estimate continued population growth for a reasonable time in the future.

The draft EIS uses 1990 census data for those analyses that require estimates of population sizes. Because of rapid growth in the Las Vegas Valley area, the 1990 census data are out of date. More recent population estimates and twenty-year projections of future growth are available from the Nevada State Demographer's Office at the University of Nevada, Reno. The Board recommends that the State Demographer's population projections be used when preparing impact estimates for the final EIS.

<u>Response</u>
The Final EIS incorporates Nevada population data developed by and received from county and State officials.

After DOE issued the Draft EIS and the Supplement to the Draft EIS and reviewed public comments on these documents, it started revising its socioeconomic baseline projections and estimated impacts for the Final EIS utilizing population data from the State of Nevada and local communities. The revisions include an estimated baseline projection to 2035 for the socioeconomic parameters considered in the EIS.

In March 2001, while DOE was preparing the Final EIS, the Bureau of the Census released its county-level population data for the State of Nevada based on the 2000 Census. DOE prepared an additional baseline projection anchored to the 2000 Census data for the State of Nevada.

DOE compared the 2000 Census baseline to the baseline projections incorporating State and local data. Sensitivity analyses revealed that the incremental differences between the two baselines were generally small.

DOE elected to incorporate the most recently available information from state and local sources as a basis for impact assessment in the Final EIS in consideration of the critiques received from commenters for the following reasons:

- Analyses showed that the differences or potential socioeconomic impacts associated with Yucca Mountain Repository activities are basically insensitive to which baseline is used.

- There is some uncertainty involving what the final totals will be for the Census data at the county level.

- The State of Nevada and local communities have not yet made available their independent estimates based on the 2000 Census data.

Similarly, DOE based its estimated population distribution within 80 kilometers (50 miles) of the repository on projections to 2035, utilizing the information available from State and local sources. DOE based the allocation of individuals to a particular sector within the 80-kilometer area on surveys conducted in 2000. Figure 3-25 of the EIS provides the population distribution for 2035.

The Final EIS baseline uses REMI model projections of population totals for each county until 2035. DOE's Clark County projections correspond to those used by the University of Nevada-Las Vegas (DIRS 136698-Riddel and Schwer 1999), which also uses the REMI Economic and Demographic Forecasting System (EDFS) 53-sector model. DOE used inputs to the Nye County projections for the Final EIS on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the Draft EIS public comment period are based in part on a REMI 14-sector model. DOE used Lincoln County and Rest of Nevada projections through 2018 from the Nevada State Demographer's Office (DIRS 155350-State of Nevada 1999) as inputs to population projections for these areas. DOE used the county projections and Nye County source documents to project population distribution within the 80-kilometer (50-mile) radiological monitoring grid. DOE used California Department of Finance projections (DIRS 150294-State of California 1998) for Inyo County, California, as the basis for projecting population distributions for Inyo County sections of the radiological monitoring grid.

To update the health and safety analyses with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 Census. For example, if a county's estimated population would double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double, and doubled the radiological impacts accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance, information from a report prepared for the City of Las Vegas).

For other Nevada counties, Nevada State Demographer projections (DIRS 155350-State of Nevada 1999) are used as the basis for population projections used in analyses of accidents near transportation corridors and for health effects modeling. Estimates of historic populations of towns and cities in Nevada are obtained from the Nevada State Demographer's Office or from county documents, as appropriate.

7.5.6 (5208)
Comment - EIS001443 / 0032
Socioeconomic impact analysis in the DEIS is limited to regional impacts on employment, housing and other standard economic indicators. There is no analysis of potential socioeconomic disturbances due to repository operation and transportation under both normal and accident conditions. Conversely, the DEIS lacks discussion of the impact of socioeconomic changes on the operation of the repository. Growth rates and development expectations along transportation corridors, and the implications of same for the evolution of new transportation risks during the 30-year span of repository operations are not considered.

Response
The EIS does assess potential socioeconomic impacts of each repository and transportation scenario. Section 4.1.6.2 contains impact estimates for each phase of repository construction and operations for the three counties most likely to be affected (Clark, Nye, and Lincoln) and for the remaining 14 counties in Nevada together. Sections 6.3.2.2 and 6.3.3 contain socioeconomic impact estimates for each rail corridor and Nevada heavy-haul truck route, respectively.

The analyses for each scenario estimate the projected change in a number of socioeconomic parameters through 2035. The changes are based on baseline projected growth trends and economic activity for each potentially affected county and the Rest of Nevada, with Yucca Mountain-associated influences factored in as potential activities are scheduled to occur.

The EIS does not present quantitative socioeconomic analysis for areas outside Nevada since no effects from repository construction, operating and monitoring, and closure are expected and since all transportation outside Nevada would occur on existing corridors and would constitute only a small portion of overall traffic on those corridors.

While the socioeconomic analyses focus on normal operations, the EIS also analyzes a range of accident scenarios. These scenarios are based on probabilities, with no definitive knowledge of when or where an accident could occur. Therefore, an attempt to assess potential socioeconomic impacts of an accident to a specific local economy would be highly speculative.

7.5.6 (5285)
Comment - EIS000968 / 0006
Population figures used in the DEIS to describe the population along the routes is from 1990 census. Clark County has been the fastest growing area of the country for the past 10 years. This would then effect the numbers in the exposure figures that are calculated.

The study should identify special populations along proposed routes as well. The Local Emergency Planning Committee identified 37 schools, 23 hotels (6,000+ rooms), 1 major health care facility and 1 special event facility within 1/2 mile of the proposed routes.

<u>Response</u>
The Final EIS uses Nevada population data that reflect data developed by and received from county and state officials.

The REMI Economic and Demographic Forecasting System (EDFS) 53-sector computer model incorporates population estimates from recent years (1998 to 1999) provided by officials from Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model uses State Demographer estimates for the period.

The Final EIS baseline uses REMI model projections of population totals for each county until 2035. DOE's Clark County projections correspond to those used by the University of Nevada, Las Vegas (DIRS 136698-Riddel and Schwer 1999), which also uses the REMI EDFS 53-sector model.

To update the health and safety analyses with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 census. For example, if a county's estimated population would double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double, and doubled the radiological impacts accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance, information from a report prepared for the City of North Las Vegas).

For other Nevada counties, Nevada State Demographer projections (Budget and Planning Division 1999) are used for population projections used in analyses of accidents near transportation corridors and for health effects modeling. Estimates of historical populations of towns and cities in Nevada are obtained from the Nevada State Demographer's Office or from county documents, as appropriate.

The Yucca Mountain Draft EIS used U.S. Census data to estimate the number of people in the general population who would live near the highway and rail routes that were selected for analysis. However, it was not possible or practical to identify each special or transient population that would be in each of the thousands of Census blocks crossed by the routes analyzed. However, the use of Census data for populations along real routes selected for the analysis ensured that estimated impacts would be calculated for the health and safety of real people -- not generic populations along generic routes. Because resident-in-care facilities for the elderly are included in Census data, the analysis included the impacts to these populations. Furthermore, impacts to temporary occupants of schools and hospitals that would be near routes and whose temporary occupancy is not included in Census data were included in the analysis, because the analysis assumed that adults, children, and hospital patients should be present in their homes when every shipment passes. Thus, while it is certain that the approach of using Census data to estimate the number of people who would be exposed to passing shipments leaves some uncounted, it is also certain that the analysis counts some who would not be affected. For the purpose of estimating health and safety risks to populations along routes, the approach provides reasonable estimates and does not exclude special populations.

7.5.6 (5548)
<u>Comment</u> - EIS001887 / 0187
Page 3-76; Section 3.1.7.3 - Payments Equal to Taxes

The Draft EIS briefly discusses the Payments Equal to Taxes (PETT) paid to State and local governments under Section 116 of the Nuclear Waste Policy Act. It is unclear what purpose this discussion serves since it is not part of a larger description of State and local revenues. The Draft EIS should have described the status of State and local government revenue systems (of which PETT is a very small element) as a basis for examining the potential impacts of the Proposed Action on State and local government finances. As noted in comments on Section 4 of the Draft EIS, the proposed Yucca Mountain project has the potential to result in significant impacts to Nevada's tourism-based economy, leading to fewer tourist visits and to reduced gaming, sales, room, and related taxes. Because of the State's unique revenue system and the way sales and gaming taxes are collected and distributed to local governments, even a relatively small decline in tourism can have significant impacts to State and local government revenues. An understanding and explication of Nevada's unique revenue system is a prerequisite for carrying out any meaningful socioeconomic impacts assessment.

<u>Response</u>
DOE believes that the EIS description of socioeconomic components at the State level is appropriate. The analysis considered the entire State of Nevada. DOE structured the information in the EIS into four regions – Clark County, Nye County, Lincoln County, and the Rest of Nevada, which is a compilation of the 14 remaining counties. DOE used the same economic parameters to estimate the potential impacts of each alternative on each region. DOE believes the analyses provide a reasonable representation of impact. Furthermore, attempts to assess fiscal changes at the agency level would not provide discriminating information for the decisionmaker.

Regarding potential impacts to "Nevada's tourism-based economy," over the past several years DOE has received other comments that it should analyze the socioeconomic effects of perception-based impacts on business, tourism, property values, and other economic and quality-of-life issues. While DOE agrees stigmatization could result in adverse impacts under some scenarios, it is not inevitable or measurable, and such stigmatization would likely be an after-effect of unpredictable future events. As a consequence, DOE addressed but did not attempt to quantify potential impacts from risk perception or stigma in the Final EIS. This is discussed in Section 2.5.4 and Appendix N of the Final EIS.

Regarding impact mitigation measures and "Nevada's unique revenue system," DOE will not speculate on what local governments or agencies feel that they might need to do to serve their citizenry, nor will it comment on the State's preferred fiscal structure. The Department would, however, enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

Section 116 (c) of the NWPA provides a process by which DOE and the State of Nevada or local governments can negotiate for compensation outside the National Environmental Protection Agency framework.

7.5.6 (5574)
<u>Comment</u> - EIS001887 / 0200
Page 3-114; Section 3.2.2.1.6 - Socioeconomics

The Draft EIS is deficient in its description of the socioeconomic component of the affected environment. The Draft EIS fails to include any description of socioeconomic conditions/factors at the State level that stand to be impacted by the Proposed Action. State-level revenues and expenditures, such as costs and other impacts to State agencies affected by the project (such as the State Department of Transportation, Department of Motor Vehicles and Public Safety, the State Health Division, and other agencies) and impacts to the State's major economic sector are all missing from the Draft EIS -- either in Section 3 or in subsequent sections on impact assessment.

Please refer to previous comments regarding the inappropriateness of limiting the socioeconomic scope of the Draft EIS to just three counties in DOE's truncated "region of influence."

See detailed comments regarding the inadequacy of DOE treatment of socioeconomic conditions and impacts in comments on Section 4 of the Draft EIS.

<u>Response</u>
DOE believes that the description of socioeconomic components at the State level is adequate. The economic and demographic simulations that DOE performed using the REMI EDFS-53 Forecasting and Simulation Model derived fiscal changes to the economy from interindustry relationships (including the Eating and Drinking Places and Hotel Sectors of the Standard Industrial Code), labor markets, and national and worldwide economic variables.

The analyses considered the entire State of Nevada. DOE structured the information presented in the EIS into four regions – Clark County, Nye County, Lincoln County, and the Rest of Nevada, which is an aggregate of the 14 remaining Nevada counties. DOE estimated the potential impacts of each alternative on the same economic parameters for each region. One of the parameters was change in State and local spending. DOE believes the analytical structure provides a reasonable representation of impacts. Further, attempts to assess fiscal changes at the agency level would not provide discriminating information.

7.5.6 (5638)
Comment - EIS001887 / 0261
Page 4-105; Section 4.2.1.2.6 - Impacts to Socioeconomics from Retrieval

The Draft EIS treatment of socioeconomic impacts of retrieval (limiting them to merely the effects of employment during the retrieval period) is entirely inadequate and grossly understates the real impacts associated with such a dramatic and far reaching event.

The Draft EIS should comprehensively examine the impacts of the retrieval scenario on the State of Nevada and on the State's principal economic sector. (See comments on Socioeconomics for Section 4.1.6 above and contained in Appendix I of these comments.) The decision to remove waste from a Yucca Mountain facility will undoubtedly be accompanied by considerable national and international media attention. The decision will have been made amidst major public and political controversy and concern regarding the safety of the facility. Such a situation will have considerable stigmatizing potential that could easily spill over to the State and the State's tourism industries. In many ways, the need to retrieve waste would be a worst case situation for generating broad and potentially substantial economic impacts statewide, since it would mean that the repository's waste isolation systems had failed and that such failure was receiving major media attention.

Response
DOE is required to maintain the ability to retrieve emplaced waste for at least 50 years after the start of emplacement and may preserve the retrieval option for up to 300 years after the completion of emplacement. Because potential retrieval actions are not part of the Proposed Action, and are assumed to be needed only far in the future, DOE did not quantify potential socioeconomic impacts beyond its current modeling capabilities. However, DOE assumes that socioeconomic impacts of retrieval would be of a magnitude similar to those of emplacement.

Assessing the perceived impact of the retrieval on quality-of-life variables or the impact of "stigma" is generally problematic because it does not necessarily depend on the actual physical effects or risks of the proposed action, but the negative perception of those effects or risks by the public. While DOE agrees stigmatization could result in adverse impacts under some scenarios, it is not inevitable or measurable, and such stigmatization would likely be an after-effect of unpredictable future events. As a consequence, DOE addressed but did not attempt to quantify potential impacts from risk perception or stigma in the Final EIS. This issue is discussed in Section 2.5.4 and Appendix N of the Final EIS.

7.5.6 (5993)
Comment - EIS001879 / 0019
The Draft EIS estimates Nye County's population at 18,000 in 1990, 24,000 in 1995 and 26,000 in 2000 (pg. 3-78). It elsewhere estimates the 1997 population of Nye County at 26,000, and the 1997 population of the community of Pahrump at 19,000 (pg. 3-73). The Draft EIS estimates the year 2000 population within a 50-mile radius of the proposed repository at about 28,000 of which 25,600 are residents of Nye County (pg. 3-79, 80).

The Draft EIS ignores state and local population monitoring and projection information, and ignores locally approved economic development plans. The Draft EIS characterizes Nye County as a community that has been relatively static in the 1990s, and which can be expected to remain static through the first decade of the 21st century and throughout the emplacement period. It seriously underestimates the current and potential population within a 50-mile radius of Yucca Mountain -- the population that is the most at risk of exposure to radiological contamination from emplacement of highly radioactive wastes at the geologic repository.

Nye County Conditions During the 1990s

As noted above, the Draft EIS estimates the population of the site county at 18,000 in 1990 and 26,000 in the year 2000, suggesting an average annual population growth rate of 3.75 percent in the 1990s. Nye County has monitored community population, using accepted estimation data and procedures, on a quarterly basis since the 1990 census. These estimates show that Nye County's population has grown at over twice the average annual rate assumed in the Draft EIS. This growth rate (8.1 percent) is more rapid that [then] that of the State of Nevada (7.0 percent), the Mountain West Region (2.5 percent) or the nation as a whole (1.0 percent). The Nye County community of Pahrump has grown at a 14.5 percent average annual rate during the 1990s.[1]

Economic and demographic conditions in the site county have been dynamic, not static, during the 1990s. They should not be expected to become static in future decades. There is no valid basis to assume that the Yucca Mountain site is in a community that can be expected to remain sparsely populated and static over the next decades and centuries.

If the communities affected by the Yucca Mountain Project can reasonably be expected to be dynamic, not static, during the construction and operation periods at Yucca Mountain, and if the dynamic elements are aspects that have been promoted and advocated by Nye County's elected commission, then it becomes an obligation of the proponent to ensure that its project does not, directly or indirectly, thwart Nye County's desired economic future.

Comparison of State and Local Population Monitoring Methods

Nye County's population estimates have been consistently above those of the State of Nevada, especially since 1994.[2] In 1998, the county's estimate was 4,300 persons (14.4 percent) above that of the State Demographer.

The State Demographer's estimates have used housing vacancy rates, which in 1999 were demonstrated to be about twice the actual rate. By contrast, Nye County's estimate uses active residential utility accounts, thus avoiding the vacancy factor. Also, the State Demographer averages an estimate based on the housing unit method with an estimate based on employment. Since a very large number of DOE employees are in-commuters to Nye County worksites, employment-based estimates are unreliable in Nye County. By contrast, Nye County's estimate uses a housing unit method only.

Nye County Growth

The Draft EIS presents no projections of socioeconomic conditions in the county and communities most affected by the Yucca Mountain Project. By not addressing other economic potentials for the site county, the EIS avoids the question whether the repository program, by raising concerns about the potential radiological contamination beyond the site boundary, could thwart other desired economic development that has been supported and advocated by the Nye County community and its elected officials.

Nye County population is projected to reach 54,000 by 2010, the State Demographer's "Middle" Projection, and could reach 62,000, which is the State Demographer's "High" Projection. Either projection reflects a higher average annual growth rate than that projected for the State (3.2 percent) or the nation (0.8 percent).[3] Consistent with these projections, in the community of Pahrump can be projected to grow at a 6.4 percent average annual rate. While the percentage growth rate in Pahrump is expected to decline, the population increase could be almost 2,500 persons annually over the coming decade, up from about 2,100 persons annually in the 1990s.

Using a respected economic model, Nye County has prepared a "baseline" projection in which the County's population increases to 54,000 in 2010. This projection, which is consistent with the State Demographer's "middle" projection for the County, does not reflect special economic events, some of which the County has addressed in separate assessments.[4] Thus, not only have economic and demographic conditions in the site county been dynamic in the last decade of the 20th century, they are projected, by both the State and the County, to be dynamic in the first decade of the 21st century. Nye County does not offer Yucca Mountain a site community that will remain sparsely populated and static over the life of the project.

Nye County Population and Current Baseline Projections

Nye County has examined the economic impacts of several potential economic events not reflected in its baseline projections. One of these alone, the development of two subdivision communities in Pahrump that are proposed for build-out over the next decade, could add 30,000 persons to Nye County's population, thus exceeding the State's "high" projection for Nye County in the year 2020.[5]

Since the end of the Cold War in 1992, Nye County has made special efforts to devise a new economic future for the US-95 corridor in which development historically has been complicated by the proximity of nuclear weapons testing conducted at the NTS. These efforts are taking shape, and are being advanced in a project referred to as the "Science and Technology Corridor." Nye County communities and the Nye County Board of Commissioners have supported the economic proposals, and do not wish them to be jeopardized by the development of a Yucca Mountain repository.

Economic Contribution of Yucca Mountain Project

The Draft EIS does not address changes in the traditional management of the DOE's activity in Nevada, changes that have long been advocated by Nye County. Nor does it address the consequence of a continuation of current management practices. This consequence is that the Yucca Mountain Project makes a minor contribution to Nye County economy, while posing potential threats to other desirable development within the US-95 corridor and the 50-mile radius for radiological exposure calculation. The repository depicted in the Draft EIS poses a potential threat to the site county's desired post-Cold War economic future, without providing a guarantee that the project will not threaten that future, or even an economic basis for Nye County to accept the additional risk imposed by the transfer of the nation's entire inventory of highly radioactive commercial and defense wastes.

Nye County's economic impact analyses show that the Yucca Mountain Project made a very limited contribution to the economy of the site county in 1999. Of about $112 million in Gross Regional Product attributed to the Yucca Mountain Project in the State of Nevada, only $8.1 million (7.3 percent) occurred in the site county. The estimates reflect traditional DOE management of its activities in Nevada, patterns that the Draft EIS suggests DOE expects to continue in the future.[6]

The current contribution of the YMP to Nye County's economy is much smaller than that of DOE/NV ($47.8 million), or of two dairies operating in Nye County ($12.4 million), or of the proposed Desert Space Station Science Museum and its visitors ($13.1 million).[7]

Nye County is concerned that the repository project, a project that makes little contribution to County's economy, will jeopardize other desired economic efforts that the County has worked hard to identify and promote. The EIS must address what measures the DOE will adopt if the proposed repository results in a loss of economic opportunity. Nye County believes that it should not be required to accept the risk associated with the repository without the benefit of appropriate mitigation.

Population Within the Radiologic Risk Zone

The Draft EIS estimates the 1997 population within a 50-mile radius of Yucca Mountain at 19,340, of which 16,700 is in Nye County.[8] Nye County's population monitoring program estimates the Nye County population within the radius used for calculations of radiological risk at 24,700 persons; this estimate is 4.1 percent above the Draft EIS estimate for Beatty, 7.7 percent above Draft EIS estimate for Amargosa Valley, and 57.5 percent above Draft EIS estimate for Pahrump.[9]

The Draft EIS estimates year 2000 population within a 50-mile radius of Yucca Mountain at about 28,000 persons, of which 25,600 are in Nye County (pg. 3-80). Nye County's baseline population projections estimate the County population within the radius used for calculations of radiological risk at 32,500 persons; this estimate is 26.4 percent above the Draft EIS estimate for Beatty, 11.8 percent above the Draft EIS estimate for Amargosa Valley, and 28.1 percent above the Draft EIS estimate for Pahrump.[10]

Nye County's baseline projections for 2010 place 47,900 persons within the 50-mile radius used in calculation of radiological risk, a figure 85 percent greater than the Draft EIS year 2000 estimate. Other special economic events could easily increase this figure to three times the Draft EIS year 2000 estimate.

Baseline Projections For Nye County

It is apparent that baseline model runs were conducted in preparing estimates of the Draft EIS estimates of the economic impacts of the Yucca Mountain Project from 2010 through 2035 (pg. 4-44). However, these baseline projections are not presented or discussed in the Draft EIS projection. Thus, the Draft EIS presents no information about the context of the socioeconomic conditions affected by the Yucca Mountain Project in Nye County, nor does it recognize the ongoing local economic development efforts aimed at improving the post-Cold War economic conditions. There is no recognition by the DOE of any intent to avoid harm to this locally planned economic future.

[1] See Figure 1: Estimates for the U.S. and the Mountain West Region (AZ, CO, ID, MT, NV, NM, UT, WY) are based on data from the U.S. Census (State Population Estimates: Annual Time Series: ST-99-3). Estimates for the State of Nevada are based on data from the NV Department of Taxation & NV State Demographer. Estimates for Nye County and Pahrump are based on data from the Nye County Population Monitoring Program.

[2] See Figure 2: The State Demographer's estimates include the initial revision of the estimate for 1999. The Nye County estimates are from the County's Population Monitoring Program. Note: The State's 1998 estimates are 6.2 percent above those of the Census for the State of Nevada, and 3.2 percent above those of the Census for Nye County (See U.S. Census: CO-98-2).

[3] See Figure 3: U.S. forecast from U.S. Census "Resident Population Series (March 1996, Middle Series). Nevada and Nye County forecasts from Nevada State Demographer's Office: "Population Estimates (1997) and Forecasts (1998-2018)". Pahrump forecast based on the State Demographer's forecast for Nye County, and applies Nye County estimates of the percentage of county population growth in Pahrump.

[4] See "Baseline Economic and Demographic Projections for Nye County, Nevada", Nye County Repository Program, January 1998.

[5] See "Nye County Economic-Demographic Reports: #10", Nye County Department of Natural Resources and Federal Facilities, December 1999.

[6] See: Nye County Economic-Demographic Reports: #1, Nye County Department of Natural Resources and Federal Facilities, December 1999.

[7] See Figures 4 & 5: Based on Nye County Economic-Demographic Reports #1, #6, #7, #3. Nye County Department of Natural Resources and Federal Facilities, December 1999.

[8] Based on DOE estimates of population within 50-miles of the repository site: 1997 (Quarter 1-4) and 1998 (Quarter 1), as requested from DOE.

[9] See Figures 6a-c: Nye County Population Monitoring Program.

[10] See Figures 7a-c: "Baseline Economic and Demographic Projections for Nye County, Nevada," Nye County Department of Natural Resources and Federal Facilities, January 1998, and Nye County Economic-Demographic Reports.

Response

DOE appreciates the breadth of this comment and the information provided. The final EIS reflects some of the issues raised and this response provides a capsule of how DOE has taken steps to incorporate Nye County's opinions into its assessments.

Nye County Conditions During the 1990s and Nye County Growth

DOE acknowledges Southern Nevada, including Nye County, has been and continues to be one of the fastest growing areas in the country. As noted in Section 3.1.7.1 of the EIS, Nye County and Pahrump are experiencing growth caused primarily by in-migrating retirees and the development of master planned communities. Nye County has about 32,500 residents in 2000, having experienced an 82.7-percent growth in the 1990s. DOE agrees that although the annual growth rate experienced in the 1990s is likely to slow, the population should continue to grow at a rate of 2 to 4 percent a year in this decade. Clark County is expected to continue to lead the population growth in Southern Nevada for the foreseeable future.

Population Monitoring Methods and Baseline Projections

The REMI Economic and Demographic Forecasting System 53-sector computer model incorporates population estimates from recent years provided by officials from Nye County for the socioeconomic baseline projected through 2035. DOE compared the locally derived estimates to the 2000 data provided by the U.S. Bureau of the Census.

Inputs to the Nye County projections for the Final EIS are based on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the comment response period are based in part on a REMI 14-sector model. The county projections and Nye County source documents were used to project population distribution within the 80-kilometer (50-mile) radiological monitoring grid.

Economic Contribution of the Yucca Mountain Project

DOE agrees with the Nye County assessment that, as currently configured, the Yucca Mountain Project economic impact in Nye County is relatively minor, although the Payments-Equal-to-Taxes monies in accordance with Section 116(c)(3)(A) of the NWPA are provided (see Appendix M of the EIS). However, should the construction and operation of a repository be authorized, there would be an increased impact in Nye County, as discussed in Chapter 4 of the EIS. DOE does not believe these impacts would be large.

DOE has followed with interest the Nye County economic development activities, particularly the development of the Desert Space Museum and adjacent business park. Other activities that have been followed include the possible siting of Kistler Aerospace and the VentureStar® program. Thus far, these remain in the early idea or planning stage. Should they come to fruition, DOE does not believe that the proposed repository would have any impact on their development. Chapter 8 of the EIS discusses these and other potential cumulative impacts of the proposed repository.

Suggested management changes by DOE that would require or provide incentives to firms or employees to locate in Nye County are not analyzed within the scope of the EIS and are not contemplated under the National Environmental Policy Act.

With regard to mitigation under Council on Environmental Quality regulations implementing the National Environmental Policy Act (40 CFR 1508.20), mitigation includes activities that (1) avoid the impact altogether by not taking a certain action or parts of an action; (2) minimize impacts by limiting the degree or magnitude of the action and its implementation; (3) repair, rehabilitate, or restore the affected environment; (4) reduce or eliminate impacts over time by preservation or maintenance operations during the life of the action; or (5) compensate for the impact by replacing or substituting resources or environments.

Section 116(c) of the NWPA states that "the Secretary [of Energy] shall provide financial and technical assistance to [an affected unit of local government or the State of Nevada] … to mitigate the impact on such [an affected unit of local government or the State of Nevada] of the development of [a] repository and the characterization of [the Yucca Mountain] site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the Act limits the potential scope of impacts that are appropriate for consideration under Section 116 to the environmental impacts considered in this EIS. Any decision to provide assistance under Section 116 would be based in part on an evaluation a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116(c)(2) to document likely economic, social, public health and safety, and environmental impacts.

Population Within the Radiological Risk Zone

Figure 3-25 of the EIS depicts population distribution within 80 kilometers (50 miles) of the proposed repository. The total population within the 80-kilometers grid incorporates Nye County population estimates. The distribution of population in the Final EIS is based upon 2000 estimates incorporating housing counts obtained through windshield surveys and electric utility data. The focus of this information is to establish the relative number of residents in a given direction and distance from the repository.

7.5.6 (6049)
<u>Comment</u> - EIS001898 / 0013
Additional documentation or analysis should be provided in the FEIS to support the characterization of impacts and the description of environmental parameters in some areas of the FEIS.

Section 4.1.6.2.1 (Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure-Impacts to Employment), page 4-41 states "[i]f the present economic growth continued in the region of influence, it could absorb declines in the repository workforce." To assess the adequacy of this statement, the assumptions used to generate the Regional Economic Models, Inc. (REMI) (Treyz et al., 1992) baseline results should be provided. The conclusion appears to require the assumption that the skills of displaced workers are compatible with the employment growth and needs of other sectors.

Reference:

Treyz, G.I., D.S. Rickman, and G. Shao. The REMI economic-demographic forecasting and simulation model. *International Regional Science Review* 14(3): 221-253. 1992.

<u>Response</u>
The Final EIS presents the baseline information for economic measures to 2035. The intent of the cited statement in Section 4.1.6.2.1 is that there would not be a significant decline in the economy due to the closure of the repository. It does not indicate that individual workers might not be absorbed into the local economy fully using their "repository skills." This would be no different than the closure of any workplace, such as a manufacturing facility, where displaced employees might have to change occupations or move, although the impacts to the local economy might be small.

7.5.6 (6120)
<u>Comment</u> - EIS001654 / 0046
Page 3-73. Socioeconomic Analysis Needs Revision.

NARUC ES-11 gave our opinion that the socioeconomic analysis is flawed by choosing an overlarge region of influence that includes metropolitan Las Vegas. We think a segmented or two-tier approach might be more appropriate:

Primary Impact: Portions of Nye County and other areas with adjoining boundaries to the repository using some criterion like a 25 mile zone

Secondary Impact: Balance of Nye County and other areas (including Clark County/Las Vegas) with socioeconomic resources related to or affected by the repository

Nye County is relatively fast growing. We understand Nye County residents have complained that county population has grown far greater than the 26,000 level shown in the DEIS. More current data should be included in the FEIS and used for refined localized socioeconomic analysis.

<u>Response</u>
DOE believes its approach to socioeconomic analysis is appropriate. The comment's suggestion of using two tiers with the first tier of approximately 40 kilometers (25 miles) would include only the unincorporated areas of Amargosa Valley and Beatty. This approach would ignore the fact that the economic driver for southern Nevada is the metropolitan area of Clark County. The analysis assumed that construction and operation of the repository would rely heavily on the resources available only in the greater Las Vegas area. Yucca Mountain Project workers currently live primarily in Clark County. DOE assumes that workers needed to construct and operate a repository at Yucca Mountain would also live primarily in Clark County. Of those who would live in Nye County (which is estimated to be approximately 20 percent of the employees at the Yucca Mountain site), the most common residence would likely be Pahrump, based on current trends. Pahrump is 64 to 80 kilometers (40 to 50 miles) from the Yucca Mountain site.

The Final EIS incorporates Nevada population data developed by and received from county and state officials.

The REMI Economic and Demographic Forecasting System (EDFS) 53-sector computer model incorporates population estimates from recent years (1998 and 1999) provided by officials from Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model uses State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census.

The Final EIS baseline uses REMI model projections of population totals for each county until 2035. DOE's Clark County projections correspond to those used by the University of Nevada, Las Vegas (DIRS 136698-Riddel and Schwer 1999), which also uses the REMI EDFS 53-sector model. Inputs to the Nye County projections for the Final EIS are based on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the comment response period are based in part on a REMI 14-sector model. Lincoln County and the Rest of Nevada projections through 2018 by the Nevada State Demographer's Office (DIRS 155350-State of Nevada 1999 [Nevada Statistical Abstract]) were used as inputs to population projections for these areas. The county projections and Nye County source documents are used to project population distribution within the 80-kilometer (50-mile) radiological monitoring grid. California Department of Finance projections (DIRS 150294-State of California 1998) for Inyo County, California, is used as the basis for projecting population distributions for Inyo County sections of the radiological monitoring grid.

To update the health and safety analyses with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 Census. For example, if a county's estimated population would double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double, and doubled the radiological impacts accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance, information from a report prepared for the City of North Las Vegas).

For other Nevada counties, Nevada State Demographer projections (DIRS 155350-State of Nevada 1999) were used as the basis for population projections used in analyses of accidents near transportation corridors and for health effects modeling. Estimates of historic populations of towns and cities in Nevada were obtained from the Nevada State Demographer's Office or from county documents, as appropriate.

7.5.6 (6471)
Comment - EIS001632 / 0030
Page 3-79, Section 3.1.8: The assessments of impacts to the local populations appropriately focus on the current demographics of the area. However, there should also be some consideration given to short-term (approximately 20 years) projections of population and land use, particularly in the area directly south of the repository where potential receptors are located. While the National Academy of Science (NAS) recommends against long term (thousands of years) projections of population characteristics, the changing demographics in the greater region around the site argue for considering a reasonable compromise between long term projections and a static situation, such as extending local planning projections for a decade or two. For example, projections of growth at the 20-kilometer location indicate modest population increases.

Response
DOE revised its socioeconomic baseline projections and estimated impacts for the Final EIS incorporating population data available from the State of Nevada and local communities. The revisions include an estimated baseline projection to 2035 for the socioeconomic parameters considered in the EIS. In the Final EIS, the estimated population distribution within 80-kilometers (50-miles) of the repository is also based on projections to 2035 utilizing information available from State and local sources. The allocation of individuals to a particular sector within the 80-kilometer area was based upon surveys conducted in 2000. Figure 3-25 of the EIS provides the population distribution for 2035.

7.5.6 (6646)
Comment - EIS001878 / 0035
The socio-economic descriptions for the environment that would be affected by rail corridors in Nevada are equally inadequate. The DEIS does not contain a complete or accurate description of baseline socioeconomic information for the affected counties. Although more recent population data are available from Nevada's State Demographer

(Exhibit E), the DEIS uses out-of-date population data. Furthermore, the socio-economic description of Eureka County discloses only: the average unemployment rate, per capita income, population, and population density for a single year, projected population for the year 2000, and the total and occupied numbers of housing units. (pp. 3-114, -115) The DEIS should discuss Eureka County's demographic data, economic drivers and trends, local fiscal conditions, cost of living, work force issues, and economic development plans. An example of a more adequate socio-economic description can be found in the South Pipeline Project Draft Environmental Impact Statement (U.S. Department of the Interior, Bureau of Land Management, August 1999), at pp. 4-181 to 4-211.

Since the DOE says that the DEIS is adequate to support a decision on transportation modes, routes, and corridors, the concerns of Eureka County are especially great. The DEIS implies that the affected environment is sparsely populated, lightly used, and not important. To the contrary, the resource-based economy of Eureka County and other Nevada counties depends almost entirely on the land and its mineral and biological resources.

The DEIS should cite the underlying data source for the population statistics in Table 3-22 (p. 3-73) and compare the statistics to current population estimates available from Nevada's state demographer.

<u>Response</u>
Table 3-22 in the EIS lists information from the Nevada State Demographer's Office, rounded to two significant figures. The Final EIS incorporates Nevada population data developed by and received from county and State officials. These are discussed in the following paragraphs.

The REMI Economic and Demographic Forecasting System 53-sector computer model incorporated population estimates from recent years provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model used State Demographer estimates for the period. DOE compared these basically derived estimates to the 2000 data provided by the Bureau of the Census. Eureka County is part of the Rest of Nevada.

DOE has chosen economic and demographic measures that are representative of the economy and potential impacts from the repository. These include population, employment, Gross Regional Product, and state and local government spending. The National Environmental Policy Act requires an analysis detailed enough to understand the effects of the action. It is not necessary to consider each impact, no matter how inconsequential. The Final EIS baseline uses REMI model projections of population totals and other economic measures for each county and the Rest of Nevada until 2035.

To update the health and safety analyses with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 census. For example, if a county's estimated population would double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double, and doubled the radiological impacts accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance, information from a report prepared for the City of North Las Vegas).

As discussed in Section 5.2.4.1 of the Draft EIS, DOE accepts the position of the National Academy of Sciences that it is not possible to make accurate predictions of future human behavior. As stated in Section 5.2.4.1 of the Draft EIS, DOE used a default position of today's conditions. For the Final EIS, DOE has projected baseline population and other economic measures to 2035. Projections for periods farther in the future would be substantially less credible.

7.5.6 (6662)
<u>Comment</u> - EIS001878 / 0040
Impacts on land use not adequately addressed. Largely due to arbitrary limits on the region of influence, the DEIS does not adequately address land use impacts within Clark, Nye, and Lincoln Counties. (pp. 4-4, -5) The DEIS does not discuss whether the repository would accelerate land development by stimulating the economy or, alternatively, reduce the rate of development due to perceived risk and stigmatization.

Response
It is not clear what the commenter means by "arbitrary limits on the region of influence." DOE based the region of influence on historic residential patterns of Yucca Mountain Project and Nevada Test Site workers and included land in each alternative transportation corridor. (See Chapter 6 of the EIS.) DOE does not expect a "boom or bust" situation because sustained marginal increases in population would occur over a long period, and because of the repository's relative proximity to a large metropolitan area. In general, if population growth associated with a Proposed Action is less than 5 percent of the study area's total population, potential impacts are considered to be small and notable land use changes because of changes in population are unlikely.

7.5.6 (6664)
Comment - EIS001878 / 0042
DEIS assumes public service impacts evenly distributed. The analysis of public service impacts of the repository (p. 4-44) is unsupported. The DEIS assumes that population growth and, therefore, demands for public services would be evenly distributed throughout Clark County and southern Nye County. Realistically, impacts will be concentrated in those areas within close commuting distance of Yucca Mountain, creating larger public service impacts with their associated costs.

Response
The DOE analysis concluded that potential impacts to the public services of Nye and Clark Counties would not be discernible because increases in employment and population associated with the Yucca Mountain Project Yucca Mountain Project would occur over a long period. DOE agrees that incremental population increases in Nye County would be more evident than it would for Clark County. However, the Department has no basis to conclude that commuting patterns would vary from what has historically occurred for the Yucca Mountain Project and Nevada Test Site workforces.

7.5.6 (6670)
Comment - EIS001878 / 0045
The information on land exchanges in Clark County (p. 4-43) is incorrect, and it fails to consider that land supply is only one of the factors affecting housing conditions.

Response
While the commenter did not elaborate on exactly what he considers to be incorrect about the information on page 4-43 of the Draft EIS, DOE does agree that land supply is a factor that could affect housing. Land or housing availability, however, is a direct indicator of whether an action could affect existing housing stock. Housing impacts are likely to be small for workforces located in medium or high population areas and in areas where vacancy rates are high and land and housing stock is available. DOE has clarified this in Section 4.1.6.2.4 of the Final EIS.

7.5.6 (7143)
Comment - EIS001337 / 0040
Lincoln County and the City of Caliente recommended that the DEIS include a comprehensive assessment of desirable and undesirable economic and fiscal consequences of repository system activities in the County and City. The County and City noted in their EIS scoping comments that a credible assessment of socioeconomic impacts would only be possible by DOE if the agency had at its disposal an accurate understanding of existing socioeconomic conditions within the County and among its communities. The County and City further suggested that such a baseline assessment of "without repository system" socioeconomic conditions should include the following factors: economy, demographics, social conditions, Native Americans, public perceptions and attitudes, community services, community infrastructure, local government finances, government structure, local politics, telecommunications, emergency management, transportation infrastructure, land use, traffic, military operations, and public health. The County and City noted that the DEIS must present a comprehensive appraisal of current and without repository future socioeconomic conditions. According to the County and City, this baseline of information could then be used to compare against projected with repository conditions to extract resultant system impacts upon the County and its communities. Section 3, Affected Environment of the DEIS provides only a limited description of socioeconomic conditions in Lincoln County and the City of Caliente. The only desegregated description of socioeconomic conditions for Caliente concerns population. The DEIS provides no baseline description for many potentially impacted parameters including: age distribution; projected population growth without repository activities through at least 2035; baseline projected employment and incomes by economic sector through at least

2035; baseline projections of school enrollments by age distribution through at least 2035; baseline projections of supply and demand for public infrastructure (including water, wastewater, solid waste, electricity, recreation facilities, educational facilities, emergency first response equipment and facilities; emergency medical facilities and equipment) through at least 2035; baseline social conditions including crime, substance abuse, and demand for social programs; community cohesion; baseline projections of local government revenues and expenditures at least through 2035; baseline projections of housing availability, condition and cost through at least 2035; and baseline projections of land use through at least 2035 among other possible parameters. All of these descriptions of baseline and without repository projections of conditions should be at the Lincoln County and at the community level (i.e. Caliente, Alamo, Panaca, Pioche, Hiko, Rachel). For example, baseline projections of wastewater treatment facility demand and capacity is key in Caliente as the proposed location of the intermodal facility is the current City wastewater treatment facility which would require that the City's existing wastewater treatment facilities be relocated. In addition, a recent DOE study has identified U.S. 93 (which is immediately adjacent to Pioche) as a potential corridor for legal weight truck shipments of radioactive waste.[6] The social tapestries, which characterize each community in Lincoln County, vary greatly. Religious and occupational variation contribute greatly to community social delineation. Age clusters define important social characteristics within each community. Previous studies by the State of Nevada have detailed differences in social conditions among Lincoln County communities.[7,8] Growth within Lincoln County's small communities may induce significant changes in social conditions. Ethnographic research sponsored by Lincoln County and the City of Caliente have illustrated the unique cultural dimension which characterizes the County and City. The County and City continue to believe that the EIS must a thorough description of social indicators for Lincoln County communities. Such information is not contained within the DEIS.

[6] TRW Environmental Safety Systems, Inc., Nevada Potential Repository Preliminary Transportation Strategy Study 1 Prepared for U.S. Department of Energy, Office of Civilian Radioactive Waste Management, April 1995.

[7] Krannich, R. and R. Little, Baseline Community Social Profiles for Communities in Nye, Esmeralda, Lincoln and Clark Counties (3 volume), prepared for the State of Nevada, Nuclear Waste Projects Office, 1987. See also, Krannich, R. and R. Little, Ethnographic Summary Report: Eastern Lincoln County, prepared for the State of Nevada, Nuclear Waste Projects Office, 1988. See also, Krannich, R. and R. Little, Ethnographic Summary Report: Pahranagat Valley, prepared for the State of Nevada, Nuclear Waste Projects Office, 1988. See also, Krannich, R. and R. Little, 1988 Rural Community Surveys: updated Background Report, prepared for the State of Nevada, Nuclear Waste Projects Office, 1989. See also, Krannich, R. and R. Little, Analysis of Key Sociocultural Relationships in Seven Southern Nevada Rural Communities, prepared for the State of Nevada, Nuclear Waste Projects Office, 1989.

[8] McCracken, B. Lincoln County Oral History Series oral histories of various County residents prepared for the Lincoln County Nuclear Waste Project Office, 1990 through 1993.

Response

The Final EIS presents a baseline of economic measures, chosen as representative of the economy, to 2035. The measures were projected through the use of the REMI Economic and Demographic Forecasting System 53-sector computer model, and incorporated population estimates from recent years (1998 and 1999). For Lincoln County the REMI model used State Demographer estimates for the period. DOE compared these locally State-derived estimates to the 2000 data provided by the Bureau of the Census. The model projections directly reflect economic and population data developed by and received from State officials. Impacts were measured against this baseline by identifying the changes in the economy as a result of implementation of the alternatives. Section 3.1.7 of the Final EIS addresses the projected baseline conditions through 2035 for Lincoln County. Sections 6.3.2 and 6.3.3 provide an estimate of the change in population and other economic measures for each relevant implementing alternative. The transportation analysis in the Final EIS includes a sensitivity analysis that assigns all potential impacts to Caliente. The analysis conservatively estimates the potential transportation actions on a community level for what could be the most effected community in the State of Nevada.

In the Final EIS, DOE has expanded the socioeconomic discussion in Chapter 3 to provide a clarified basis for understanding the magnitude of potential impacts described in Chapters 4 and 6. This discussion includes a projection of baseline parameters through 2035 based on the most recently available information and assumptions.

The Final EIS provides a quantified estimate, to the extent possible, of potential school enrollment and changes in law enforcement and public service personnel requirements caused by the Proposed Action.

7.5.6 (7145)
Comment - EIS001337 / 0042
During scoping of the EIS, Lincoln County and the City of Caliente made clear the difficulty that small rural counties and communities have in developing and maintaining public services and facilities. Any change in population, related demands for public services and facilities and induced changes in local revenues and expenditures can pose a significant hardship on the area and its residents. The County and City urged the DOE to include in the DEIS the repository EIS and assessment of existing and future "without repository" community service and infrastructure characteristics within Lincoln County and among its various communities. The County and City noted that when included in the affected environment section of the EIS, this information will be useful for comparison with "with repository" service and facility demands to determine net impacts. The DEIS does not provide a sufficient assessment of existing and without repository future community service and facility needs within Lincoln County and the City of Caliente. As a consequence, subsequent impact analyses are wholly inadequate as a means to discern how the repository system (including transportation) may effect the County and City.

Response
The Final EIS presents a baseline of economic measures, chosen as representative of the economy, to 2035. DOE projected the measures through the use of the REMI Economic and Demographic Forecasting System 53-sector computer model, which incorporates population estimates from recent years (1998 and 1999) provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model used State Demographer estimates for the period. The model projections directly reflect economic and population data developed by and received from county and state officials. The model measured impacts against this baseline by identifying changes in the economy resulting from implementation of the alternatives.

In addition, DOE has expanded its socioeconomic discussions in Chapter 3 of the EIS to provide a clarified basis for understanding the magnitude of potential impacts described in Chapters 4 and 6. These discussions include a projection of baseline parameters through 2035 based on the most recently available information and assumptions. The Final EIS provides a quantified estimate, to the extent possible, of school enrollment and changes in law enforcement and public service personnel requirements caused by the Proposed Action.

7.5.6 (7151)
Comment - EIS001337 / 0048
Lincoln County and the City of Caliente encouraged DOE to consider population growth resulting from location of repository system support industries in the County and demands for public services and infrastructure by dependents of DOE or contractor employees within the County and City. The DEIS does not consider the potential nor attempt to quantify population growth resulting from location of repository support industries in the County or related demands for public services and facilities.

Response
Section 3.1.7 of the EIS addresses projected baseline conditions for Lincoln County through 2035. Sections 6.3.2 and 6.3.3 of the EIS discuss quantification of changes in population and other economic measures for each relevant implementing alternative. The transportation analysis included a sensitivity analysis that assigned potential impacts to Caliente. This analysis showed the conservative impacts of transportation actions on a community level for what could be the most affected community in Nevada.

7.5.6 (7154)
Comment - EIS001337 / 0050
In comments to the scope of the EIS, Lincoln County and the City of Caliente substantiated the propensity for Clark County and the metropolitan Las Vegas area to garner a disequitable share of economic benefits associated with activities at the Nevada Test Site. The County and City pointed out that unlike many other projects, the construction and operation of the repository system is characterized by clearly discernable risks and benefits. The County and City further noted that unlike many other industrial activities, the spatial and temporal distribution of these risks and benefits has the potential to be disequitable between places and periods of time. The County and City concluded

that the distribution of risks and benefits associated with DOE activities in Nevada during the past 30 years has not been fair.

In their comments, Lincoln County and the City of Caliente worried that development and operation of the repository system within Nevada has the potential for extending and perhaps exacerbating this disequitable distribution of risks and benefits. They suggested examples of practices which DOE might adopt which can widen the risk/benefit gap including: use of union workers, most of whom reside in urban areas, provision of subsidized bussing of repository workers electing to reside in Clark County, and purchase of goods and services from vendors located in urban areas, among other possibilities. Lincoln County and the City of Caliente suggested that the repository EIS should evaluate the distributional equity implications of various options for system development and operation. The County and City recommended that the evaluation should consider the cumulative aspects of risks and benefits associated with other DOE activities likely to occur within Nevada (i.e. LLRW management). They concluded that this information should be used to inform identification and analysis of alternatives for mitigating the disequitable distribution of repository system risks and benefits. The DEIS does not consider the potential for disequitable distribution of repository system economic benefits, fiscal impacts and risk to public health and the environment among Nevada's geographic areas. As a consequence no measures to mitigate disequitable distribution of benefits and costs are identified or presented within the DEIS.

Response
The EIS does not directly address the "distributional equity implications of various options for system development and operation." The EIS does include an extensive discussion of cumulative impacts in Chapter 8, which states that "An evaluation of cumulative impacts is necessary to an understanding of the environmental implications of implementing the Proposed Action and is essential to the development of appropriate mitigation measures and the monitoring of their effectiveness." In addition, consistent with the National Environmental Policy Act, the discussion of potential mitigation measures in Chapter 9 of the EIS is focused on the "...adverse impacts to the environment that could occur if the Department implemented the Proposed Action..." While DOE has evaluated cumulative impacts and considered them in the context of the overall assessment of environmental impacts that could result from the Proposed Action, the discussion of mitigation measures focused appropriately is on the potential impacts of the Proposed Action rather than mitigation of cumulative effects.

Apart from the considerations required under the National Environmental Policy Act, Section 116(c)(2)(A)(i) of the NWPA states that "the Secretary shall provide financial and technical assistance to (State of Nevada or affected unit of local government)…to mitigate the impact on such (State of Nevada or affected unit of local government) of the development of (a) repository and the characterization of (the Yucca Mountain) site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

Under the NWPA, the Section 116 impact assistance review process and the EIS process are distinct from one another, and the implementation of one is not dependent on the implementation of the other. Thus, the provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 would be based on an evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 to document likely economic, social, public health and safety, and environmental impacts. DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

Examination of the practices suggested by the commenter (for example, use of union workers, provision of subsidized bussing of repository workers, and procurement practices for goods and services) is beyond the scope of the EIS or their consideration is premature.

7.5.6 (7155)
Comment - EIS001337 / 0051
In comments to the scope of the EIS, Lincoln County and the City of Caliente concluded that DOE must consider the positive implications of DOE and contractor spending in Lincoln County. In addition, the County and City felt

that the EIS must include a thorough analysis of the fiscal consequences of repository system development and operation upon Lincoln County, City of Caliente, and the Lincoln County School District.

Response
Historically, very few workers associated with DOE operations in Nevada have resided in Lincoln County. In the Draft EIS, DOE estimated that no operational workers and only five construction workers on the Yucca Mountain Repository project would live in Lincoln County. Either rail or heavy-haul truck traffic could traverse Lincoln County. The largest potential increase in county population would be associated with operation of the Caliente/Chalk Mountain heavy-haul truck corridor. About 241 new residents would be likely during the peak year. Assuming approximately 32 of these individuals would be of school age, the increase in school enrollment would be about 3 percent based on current enrollment estimates. Incremental increases in the Gross Regional Product for Lincoln County would be extremely small.

7.5.6 (7240)
Comment - EIS001337 / 0111
Page 6-57 Socioeconomic Section - In the discussion of the socioeconomic impacts associated with construction of the branch line in the Caliente corridor, the Draft EIS identifies that the annual average number of construction workers to be 500 to 560 and that there would be 5 construction camps. It would seem that some of the camps will be in the vicinity of the rural communities in Nevada and could have a significant economic impact on the community, in terms of setting up the camps, during construction and when the construction work is, completed. We feel that this impact needs to be addressed in the socioeconomic section and how these impacts could be mitigated needs to be included. Some of the measures taken would be to provide temporary living facilities and classrooms, if many of the workers plan to stay in the community for the construction period and have school age children.

Response
The EIS presents information on the counties in the designated region of influence (Clark, Nye, and Lincoln) and on the Rest of Nevada, which comprises the 14 remaining counties. The socioeconomic simulation model that DOE used to estimate potential impacts indicated that the Rest of Nevada would experience direct economic effects from construction worker spending for food and lodging. The economic simulations assumed that DOE would contract construction camp development and water drilling to firms in the counties in which the camps would be located. They also assumed that all railroad construction workers would commute weekly from Clark County to camps outside Clark County and eat in local restaurants 5 days a week, 50 weeks a year.

The simulations accounted for workforce expenditures through the Eating and Drinking Places Sector and the Construction Sector of the Standard Industrial Code. No impacts to the Rest of Nevada were identified by the simulation.

The transportation analysis in the Final EIS includes a sensitivity assessment that assigns potential impacts to Caliente. This assessment showed conservative impacts of transportation on a community level for what could be the most affected community in Nevada.

With regard to mitigation actions, DOE would conduct discussions with potentially affected units of local government and consider appropriate support and mitigation measures.

7.5.6 (7534)
Comment - EIS001912 / 0057
Pg. 3-114 Section 3.2.2.1.6. Those areas generally have low unemployment.

Response
The information presented in Section 3.2.2.1.6 of the Draft EIS was reevaluated to ensure that the Final EIS accurately portrayed unemployment levels in the referenced areas.

7.5.6 (7875)
Comment - EIS001653 / 0042
The DEIS needs to consider future water demands for diary cattle in the Amargosa Valley. Milking cows require about 150 gallons per day (consumptive and non-consumptive use). Also there appears to be little information about livestock water consumption (10 gallons per day per milking cow) and the distribution of milk product produced in the Amargosa Valley. With the increasing populations of the southwest, it is possible for more diaries to move to the Amargosa area.

Response
DOE has revised Chapter 8.2.3.2.2 of the EIS to include a more detailed discussion of groundwater use in the area and potential cumulative impacts of the various activities in the region that require the use of groundwater. In addition, DOE has updated the EIS to include the new or expanded information where necessary. Groundwater use includes use by livestock. DOE has an active program that surveys and identifies the use of farmland in Amargosa Valley and other areas within 80 kilometers (50 miles) of the proposed repository. This includes the Ponderosa Dairy and other farms in the Amargosa Valley, although the EIS does not name them specifically.

7.5.6 (7910)
Comment - EIS001653 / 0053
Pg. 3-114 Section 3.2.2.1.6 These areas [Eureka, Esmeralda, and Lander Counties] generally have low unemployment.

Response
The Final EIS contains up-to-date unemployment rates (See Section 3.2.2.1.6 of the Final EIS). The unemployment rates in Eureka, Esmeralda, and Lander Counties were 2.6. 10.0, and 7.7 percent, respectively, in 2000.

7.5.6 (7984)
Comment - EIS001577 / 0004
Section 7.3.2.7 claims that the employment of personnel involved with construction and maintenance of 77 facilities is the only contributing factor in socioeconomic impacts due to on site storage. I would comment that the potential of collective responsibility for the safe guarding of these wastes for the time period considered would allow the creation of much greater socioeconomic impact. Participation in the activity of oversight, construction and maintenance of the storage facilities beyond the previously mentioned 100 year planned obsolescence. The possibility of tourism and pilgrimages and educational and interpretational opportunities to understand and contemplate the profoundly deep social and economic commitment that human ancestors made to nuclear technology and the ongoing efforts of current generations to keep its waste products from contaminating the planet, could have enormous social, economic and political impacts, which are not even alluded to in the DEIS.

Response
As noted by the commenter, DOE estimated the workforce impacts associated with the No Action Alternative. This estimate included construction, oversight, and maintenance activities. On the other hand, DOE cannot speculate on the possible role of generator sites as tourism and educational destinations. Commercial utilities, as nuclear plant operators under Nuclear Regulatory Commission regulations, determine the scope of public outreach and interpretative programs provided at their nuclear facilities. DOE does not believe that this level of activity provides discriminating information for the decisionmakers.

7.5.6 (8364)
Comment - EIS001873 / 0048
P. 4-60. Accident impacts would involve more than radiation exposure to humans. Socioeconomic impacts of accidents are one example of other impacts that must be included.

Response
Risks to health and safety would be small because the risks of releases of radioactive materials in accidents would be small. Because the risks of releasing radioactive materials in transportation accidents would be small, the risk of detrimental environmental or economic consequences would also be small, although risks would be different for each location and community along the routes used. For example, the National Marine Fisheries Service concluded

that while there would be risk to marine fisheries from accidents in transporting spent nuclear fuel and high-level radioactive waste from 77 generator sites to Yucca Mountain, this risk would be so small that it can be discounted. Economic consequences of releases of radioactive materials in transportation accidents would be compensated under provisions of the Price-Anderson Act (see Section M.8 of the EIS). In response to public comments, Appendix J now contains a review of analyses of potential environmental and economic impacts from releases of radioactive materials.

7.5.6 (8621)
Comment - EIS001256 / 0014
Population assumptions and radiation dose limits are based on additional assumptions that lack appropriate conservatism to protect all individuals either today or in the future. Our original comments pointed out weaknesses in the population data for Clark County, Nevada. In general, the assumptions for the population figures and the dose limits are not stringent and they underestimate risk and exposure.

Response
Thank you for your comments. DOE believes its assessment of dose to both individuals and the population, as a whole is conservative. Regarding population estimates, however, the Department has revised the population data for the Final EIS to incorporate population estimates and projections from Nye County, the Nevada State Demographer's Office, and Clark County and University of Nevada, Las Vegas information. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census.

7.5.6 (8856)
Comment - EIS000869 / 0025
S.5.1 addresses the no-action alternative and the resultant loss of approximately 4,700 jobs. Those jobs would be lost at the end of the construction and storage period and would only be terminated at a sooner period with the no-action alternative.
Response
The 4,700 jobs that could be lost under the No-Action Alternative include indirect jobs that would have been created in the region of influence. Approximately 3,200 project-related jobs would be lost after a 1-year decommissioning and reclamation period. Section 7.1.6 of the EIS contains additional information.

7.5.6 (9202)
Comment - EIS002111 / 0003
When you have risk assessment, you have to talk about environmental impact, economical impact. I don't know what would be the economical impact and the consequences of Madam Butterfly. Are we going to have more trucker or less customer? It was not addressed in the EIS.

Response
DOE analyzed the socioeconomic and employment impact of the repository and transportation at the county level and determined there would be small increases to population in the region of influence. DOE did not attempt to analyze the impacts or a particular business establishment.

7.5.6 (9206)
Comment - EIS002140 / 0004
People keep on talking about jobs. Every time Steve Wynn opens a new hotel, he talks about jobs. Most of them are -- you know, most of them are making beds and so forth. But that's fine. I'm glad those people have jobs and it's great. The jobs out at Yucca Mountain pay at least 1,000 a week.

Response
DOE and its contractors pay competitive wages for the required jobs and associated skill levels.

7.5.6 (9339)
Comment - EIS001888 / 0055
DEIS Statement (p. 9-5) 9.2.2.2 - The DEIS asserts that the Yucca Mountain vicinity is isolated from concentrations of human population and human activity and is likely to remain so.

This statement is not supportable given the rate of growth in the Amargosa Valley area and the rapidly expanding growth of northern Clark County. Expansion in the Amargosa Valley (and indeed southern Nevada) would most likely be limited by the availability of ground water. Therefore, any reduction in the water available for farming and/or other development is an important impact to that area. Considering the hydrologic basin that receives water from the Yucca Mountain area as "sparsely populated" may be true today, but considering the rapid growth in this area this statement cannot "hold water" for the period of repository construction and operation. NEPA Regulation: Sec. 1502.16 Environmental consequences.

Response
The EIS incorporates Nevada population data developed by and received from county and State officials. DOE used this information in its determination of potential environmental impacts on these revised estimates. The following paragraphs describe the EIS methodology.

The REMI Economic and Demographic Forecasting System (EDFS) 53-sector computer model incorporated population estimates from recent years provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model used State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census.

The Final EIS baseline used REMI model projections of population totals for each county until 2035. The DOE Clark County projections correspond to those used by the University of Nevada, Las Vegas (DIRS 136698-Riddel and Schwer 1999), which also uses the REMI EDFS 53-sector model. DOE based inputs to the Nye County projections for the Final EIS on data identified in County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the Draft EIS public comment period were based in part on a REMI 14-sector model. DOE used Lincoln County and Rest of Nevada projections through 2018 from the State Demographer's Office (DIRS 155350-State of Nevada 1999) as inputs to population projections for those areas. The Department used county projections and Nye County source documents to project population distribution within the 80-kilometer (50-mile) radiological monitoring grid. California Department of Finance projections (DIRS 150294-State of California 1998) were used as the basis for projecting population distributions for Inyo County sections of the grid.

For other Nevada counties, DOE used State Demographer projections (DIRS 155350-State of Nevada 1999) as the basis for population projections in analyses of accidents near transportation corridors and for health effects modeling. Estimates of historic populations of towns and cities in Nevada came from the State Demographer's Office or from county documents, as appropriate.

DOE has revised Chapter 8 to include a more detailed discussion of groundwater use in the area and the potential cumulative impacts of activities in the region that require the use of groundwater. The Department has updated the EIS to include new or expanded information where necessary.

7.5.6 (9364)
Comment - EIS001373 / 0004
A second comment regarding population considerations is as follows. The *Federal Register*/Vol. 64, No. 229/Tuesday, November 30, 1999, page 67056, Section II A, subsection 2, paragraph 4, states: "....Except for population density, the specific content of the qualifying or disqualifying factors was left to DOE's informed discretion...." This describes the guidelines used during the preliminary site screening process associated with Section 112(a) of NWPA that was completed in the mid-1980's. Given the population growth that occurred in southern Nevada since the original site identification, and the projected growth of the area in the immediate future, would the Yucca Mountain site meet the population density guidelines that were employed in the mid-1980's assessment that originally identified the Yucca site?

Response
The economic and demographic projections in the Final EIS directly reflect data developed by and received from county and State officials. Even with the updated population projections and recognition of the population growth that has occurred in southern Nevada during the last 20 years, it is unlikely that the Yucca Mountain site would be disqualified as a result of the population density guidelines.

The 1986 *Environmental Assessment for Yucca Mountain* (DIRS 100136-DOE 1986) evaluated the site against two favorable conditions and two potentially adverse conditions for population density and distribution. The first favorable condition was “a low population density in the general region of the site.” The assessment said the site is in a county with a population density of 0.5 person per square mile and that the density in nearby areas “was well below the continental U.S. average.” The other favorable condition was “remoteness from highly populated areas” and the assessment noted that the site is 137 kilometers (85 miles) from the nearest highly populated area in the Las Vegas Valley. Although the distance to a highly populated area is somewhat less today, the distance is still great enough to conclude that the site is remote.

Similarly, DOE has concluded that the absence of potentially adverse conditions has not changed. Adverse conditions include high residential, seasonal, or day-time population within the projected site boundaries, and proximity to highly populated areas (defined as areas with at least 1,000 persons per square mile). There was and is no population within the site boundaries except for a relatively small workforce and the nearest highly populated area is still the Las Vegas Valley.

7.5.6 (9498)
Comment - EIS001888 / 0157
[Summary of comments noted by Clark County Nuclear Waste Division staff at various citizens’ meetings.]

One person felt that there weren’t great risks from the waste coming through and that it would add jobs to the economy. Other citizens responded that the jobs would be technical or high risk and not really be available to the people living here.

Response
DOE’s assumption is that repository construction and operations jobs would be filled from the existing workforce and the regional pool of workers. DOE does not anticipate the need to import large numbers of specialized employees. With regard to construction of the transportation corridors, DOE assumed most of the workers would reside in Clark County and commute to temporary work camps. Much of the incremental change in employment in the region of influence over the long term would be from secondary or repository-induced jobs.

7.5.6 (9499)
Comment - EIS001888 / 0158
[Summary of comments noted by Clark County Nuclear Waste Division staff at various citizens’ meetings.]

Don’t believe that DOE is really looking at the potential impacts to the citizens and economy.

Response
DOE has extensively evaluated potential impacts to the citizens and the economy. In fact, the Final EIS presents a baseline of economic measures chosen as representative of the economy to 2035. These measures were projected through the use of the REMI Economic and Demographic Forecasting System 53-sector computer model, and incorporate population estimates from recent years provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model used State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census. The model projections directly reflect economic and population data developed by and received from county and State officials. Impacts were measured against this baseline by identifying the changes in the economy as a result of implementation of the alternatives. It is not necessary to consider or identify each impact.

DOE has expanded the socioeconomic discussions in Chapter 3 of the Final EIS to provide a clarified basis for understanding the magnitude of the potential impacts described in Chapters 4 and 6. This discussion includes a projection of baseline parameters through 2035 based on the most recently available information and assumptions. The EIS provides quantified estimates, to the extent possible, of school enrollment and changes in law enforcement and public service personnel requirements caused by the Proposed Action.

7.5.6 (9853)
Comment - EIS001888 / 0418
[Clark County summary of a comment it received from a member of the public.]

One commenter believed that the EIS should consider the extent to which communities near the repository would grow rapidly and the resulting impacts from increased demands on the use of limited private lands for residential, commercial, and industrial development.

Response
The Draft EIS provides an assessment of growth by each county within the region of influence associated with the repository and each transportation alternative. The incremental increase in total population is not expected to result in any discernible increased demands on the use of private lands. Similar to environmental assessments conducted by the Nuclear Regulatory Commission, DOE believes that for action-related population growth of less than 5 percent of the study area's total population, off site land use changes would be small.

In the siting of transportation corridors, DOE has attempted to avoid, to the extent practicable, private lands. At this time definitive information is not available on specific tracts of land that could be required for a given transportation alternative.

7.5.6 (9935)
Comment - EIS001888 / 0464
[Clark County summary of comments it has received from the public.]

37% of Yucca Mountain employees live in 4 zip codes in the most rapidly growing area in Las Vegas. This is accelerating the rate of expansion of needed services.

Response
It is true that many employees live in the rapidly growing areas of Las Vegas and that contributes to requirements for services. However, the number of employees (and their families) who have moved to the Las Vegas area since the beginning of site characterization in 1986 has been a very small component of the overall growth of the area. Many of the employees already were residents of the Las Vegas area when they were hired.

7.5.6 (9941)
Comment - EIS001888 / 0469
[Clark County summary of comments it has received from the public.]

Tourism currently underwrites many of the services provided to DOE employees.

Response
DOE acknowledges that taxes collected by the tourism industry underwrite many of the services provided to residents of Clark County and the State of Nevada. This would be true no matter who the employer was, whether DOE or a small business service provider. DOE does not believe it is appropriate to comment on the State's (and Clark County's) preferred fiscal structure.

7.5.6 (9950)
Comment - EIS001888 / 0476
[Clark County summary of comments it has received from the public.]

Three commenters stated that the EIS should use socioeconomic models that consider local projections and not rely on national or regional projections. The models should consider economic and population growth driven by retirement and "lifestyle" migration, and should operate at a sub-county level. All assumptions used in the analysis should be made explicit and justified by reference to social science theory and/or experience in analogous cases. And, the methods by which impacts are estimated should be specified so that they can be reviewed and validated. Conclusions and findings should account for the applicable data and present the logic for any professional judgments, including specification of probabilities and ranges of uncertainty when appropriate. Conditions for which there are insufficient data or theory to make a finding should be identified, the current level of knowledge should be explained, and the implications for drawing conclusions should be presented. The EIS should then make recommendations for resolving significant issues that cannot be properly evaluated due to data or theory limitations.

Response
The Final EIS presents a baseline of economic measures chosen as representative of the economy to 2035. The measures, projected through the use of the REMI Economic and Demographic Forecasting System 53-sector computer model, incorporate population estimates provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the rest of Nevada, the REMI model used State Demographer estimates. The model projections directly reflect economic and population data developed by and received from county and State officials. DOE measured impacts against this baseline by identifying the incremental changes in the economy as a result of implementation of the alternatives. For the Final EIS, DOE compared these locally derived population estimates to the 2000 data provided by the U.S. Bureau of Census.

The National Environmental Policy Act requires that an analysis be detailed enough to understand the effects of the action. It is not necessary to analyze in detail each impact, no matter how inconsequential. Further, it is not necessary for the EIS to provide exhaustive information on the nature of the economic demographic projections.

7.5.6 (9954)
Comment - EIS001888 / 0479
[Clark County summary of comments it has received from the public.]

Commenters stated that the EIS analysis of potential socioeconomic impacts should be evaluated against a baseline affected environment. Some commenters viewed the baseline as existing without Yucca Mountain site characterization activities. Commenters provided detailed lists of parameters to be described in the baseline, including: economic (employment and income by SIC sector), demographic, social, and public finance conditions (including growth trends); conditions in the State of Nevada, southern Nevada counties and sub-county jurisdictions, communities, and impact areas (including government structures and finances, military operations, telecommunication capabilities, community services, emergency management, public health, land use, and transportation infrastructure and traffic); economic base in the State of Nevada, southern Nevada counties, and key sub-county communities -- key interregional linkages for each major component of the economic base at each of the above levels; current demographic and social character, public perceptions, and political landscape; local government service systems and expenditures at each of the above levels (including state shared revenues); Nevada's state/local revenue structure, and the revenues generated for public funds at each of the above levels; and community social conditions. One commenter suggested the EIS should attempt to incorporate the trend toward increased per capita local government service costs.

Response
The EIS presents a baseline of economic measures, chosen as representative of the economy, to 2035. DOE used the REMI Economic and Demographic Forecasting System 53-sector computer model to project the measures, and incorporated population estimates from recent years provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model used Nevada State Demographer estimates for the period. The projections directly reflect economic and population data developed by and received from county and state officials. The analysis measured impacts against this baseline by identifying the incremental changes in the economy as a result of implementation of the alternatives. For the Final EIS, DOE compared the locally derived population estimates to the 2000 data provided by the Bureau of the Census.

7.5.6 (9992)
Comment - EIS001888 / 0497
[Clark County summary of comments it has received from the public.]

Commenters stated that the EIS analyses of potential socioeconomic impacts should be conducted on specific populations, including Yucca Mountain area populations (unincorporated areas, cities and towns, counties, and Native American Reservations proximity to Yucca Mountain), the State of Nevada, all areas affected by regional and national transportation of waste to the repository, and areas where waste might be stored. Other commenters preferred that the analyses be conducted at the community or neighborhood level, or by rural/suburban/urban areas. Commenters also recommended that the EIS provide a detailed evaluation of direct and indirect impacts on public services, state and local services, and state governments that occur as a result of the project, whether as fees, taxes, or other payments. The services to be assessed include all state and local government services that contribute to the program, and state and local public services to the direct, indirect, and induced population and households resulting from the program. The estimates of costs for these services should include expenses for all services, facilities, equipment, infrastructure, and staff. Revenues should be calculated for the project and these revenues should be compared to the costs of services. Services by jurisdiction and type of service should be analyzed and the analysis should be allocated to the proper jurisdictions consistent with the state and local fiscal structure. Lastly, commenters called for the EIS to estimate those impacts that are due to intergovernmental conflict, including costs of legal adjudication, law enforcement and criminal justice services, political activities, and restrictions on state/local/federal relations.

Response
The EIS presents a baseline of economic measures chosen as representative of the economy to 2035. DOE projected the measures through the use of the REMI Economic and Demographic Forecasting System 53-sector computer model, and incorporated population estimates from recent years provided by Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the rest of Nevada, the REMI model used State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census. In addition, the model projections directly reflect economic and population data developed by and received from county and state officials. Impacts were measured against this baseline by identifying changes in the economy as a result of implementation of the alternatives.

7.5.6 (9995)
Comment - EIS001888 / 0499
[Clark County summary of comments it has received from the public.]

Commenters requested the EIS to present sufficiently detailed descriptions, for each alternative, in terms useful for socioeconomic analysis and comparison between alternatives. The descriptions should include detailed data on: annual expenditures, employment, and procurement; annual waste and material transportation shipments; management policies (busing, housing, per diem, food service, etc.); and any community development programs or intergovernmental agreements for the provision of service to project.

Response
DOE has assessed the potential socioeconomic impacts associated with the Yucca Mountain Repository and each rail and heavy-haul truck alternative. The Department estimated the impacts at the county level for Clark, Lincoln, and Nye Counties, and the rest of the 14 Nevada counties aggregately, using the REMI Economic and Demographic Forecasting System-53 Forecasting and Simulation Model. The model segments age, ethnicity, and gender based on 600 cohorts to predict population, and calculates births, deaths, and aging. Employment and fiscal changes to the economy are derived from interindustry relationships, labor markets, and national/worldwide economic variables. The analyses quantified the potential impacts for employment, population, personal income, Gross Regional Product, and state and local government spending.

Some of the general assumptions used to generate REMI estimates included basing lodging expenses on the standard General Services Administration rate of $50 per day; meal expenses based on the General Services Administration rate of $30 per day; and wages based on the REMI personal consumption expenditures index. Other input variables included number of waste shipments, commuter patterns, fuel cost, and construction cost.

7.5.6 (9996)
Comment - EIS001888 / 0500
[Clark County summary of a comment it received from a member of the public.]

One commenter stated that the EIS should evaluate the feasibility of taxing each shipment of SNF or HLW at the county or state level.

Response
In the NWPA, Congress directed DOE to evaluate the suitability of a repository at Yucca Mountain. Questions pertaining to the potential for local and state governments to tax individual waste shipments are not within the scope

of the Congressional directive. Constitutional issues pertaining to separation of powers and interstate commerce would likely foreclose a possibility of such taxation.

7.5.6 (10115)

<u>Comment</u> - EIS002155 / 0004

We are the fastest growing community, if not the fastest in the nation. Why would we put this a stone's throw away from that kind of population growth? That's crazy.

<u>Response</u>

DOE acknowledges the fast growth rate of Clark County and southern Nevada. The economic and demographic projections in the Final EIS incorporate data developed by county and State officials. Even with the updated population estimates, it is unlikely that the Yucca Mountain site would pose a substantial risk to members of the public.

7.5.6 (10229)

<u>Comment</u> - EIS002115 / 0004

The statistics for the population and growth in Nevada is outdated. The population of places like Las Vegas, Reno, Carson City and Pahrump have significantly increased. With the population increase has come an increase in Nevada's transportation system. Along with its increase has come an increase in accidents all over Nevada.

What precautions are being taken or safe havens being used, updated or built to ensure the safe transportation of the high-level radioactive waste? The EIS should contain this information using current data.

<u>Response</u>

The Final EIS uses Nevada population data that incorporate data developed by and received from county and State officials.

The REMI Economic and Demographic Forecasting System (EDFS) 53-sector computer model incorporates population estimates from recent years (1998 to 1999) provided by officials from Nye and Clark counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model uses State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the Bureau of the Census.

The Final EIS baseline uses REMI model projections of population totals for each county until 2035. The DOE Clark County projections correspond to those used by the University of Nevada, Las Vegas (DIRS 136698-Riddel and Schwer 1999), which also uses the REMI EDFS 53-sector model. Inputs to the Nye County projections for the Final EIS are based on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the comment response period are based in part on a REMI 14-sector model. Lincoln County and rest of Nevada projections through 2018 by the Nevada State Demographer's Office (DIRS 153928-NDA 2000) are used as inputs to population projections for these areas. The county projections and Nye County source documents are used to project population distribution within the 80-kilometer (50-mile) radiological monitoring grid. Projections for Inyo County, California (DIRS 150294-California Department of Finance 1998), are used as the basis for projecting population distributions for Inyo County sections of the radiological monitoring grid.

To update the health and safety analyses with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 Census. For example, if a county's estimated population would double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double, and doubled the radiological impacts accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance, information from a report prepared for the City of North Las Vegas).

For other Nevada counties, Nevada State Demographer projections (DIRS 155350-State of Nevada 1999) were used as the basis for population projections used in analyses of accidents near transportation corridors and for health effects modeling. Estimates of historic populations of towns and cities in Nevada were obtained from the Nevada State Demographer's Office or from county documents, as appropriate.

Finally, as discussed in Section 5.2.4.1, DOE accepts the position of the National Academy of Sciences that it is not possible to predict future human behavior accurately. As stated in Section 5.2.4.1 of the Draft EIS, DOE used a default position of today's conditions. For the Final EIS, DOE has projected baseline population and other economic measures to 2035. Projections for periods further in the future would be substantially less credible.

In response to public comments, DOE has included additional information in a new appendix to the EIS (Appendix M) regarding operational protocols that are planned for DOE's transportation operations. These operational protocols include instructions to prospective waste acceptance and transportation services contractors regarding use of safe parking areas in the event that shipments to the repository were delayed in transit. Additional details on safe parking areas would be forthcoming when specific routes and modes of transportation were determined. For additional information see 49 CFR 397.5(d)(3)).

7.5.6 (10239)
<u>Comment</u> - EIS001888 / 0588
We have reviewed the Environmental Impact Draft Study (EIDS) [Draft Environmental Impact Statement (Draft EIS)], and have found many areas have been completely over looked.

There were no studies or surveys done in the following areas:

Economic Effects-

Special Taxing Districts & Special Taxes - that are collected from Auto Rental, Trucking, Airport user fees, just to name a few.

Tax Base - over 50% of our tax base comes from gaming revenues.
Visitor Volume -- the reduction of a world wide visitor volume based on a by country by region or state.

Property Taxes and Property Values

<u>Response</u>
The potential environmental impacts on the socioeconomics of the region are discussed in Section 4.1.6 of the EIS for each of the alternative transportation corridor and routes throughout Chapter 6. The analyses are based on a projection of pertinent parameters through 2035. The analyses were conducted at a county and regional level including estimates of changes to state and local spending. Various industrial sectors were an inherent part of the analysis, including the farming and tourism sectors. Property tax and property values were not specifically analyzed because of the dynamics of the real estate market and the fact that definitive information is not yet available on specific tracts of land that could be affected.

7.5.6 (10433)
<u>Comment</u> - EIS002194 / 0008
The only thing I saw in here that said anything about possible disqualifier is human impacts. Now, how come socioeconomic impact was not counted in the DEIS?

<u>Response</u>
Potential socioeconomic impacts were addressed extensively in the Draft EIS (see Sections 3.1.7 and 4.1.6). Furthermore, the Final EIS presents a baseline of economic measures, chosen as representative of the economy, to 2035. The measures are projected through use of the REMI Economic and Demographic Forecasting System 53-sector computer model, and incorporates population estimates from recent years provided by officials from Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the Rest of Nevada, the REMI model uses State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the U.S. Bureau of the Census. The model projections directly reflect economic and population data developed by and received from county and state officials. Impacts are measured against this baseline by identifying the incremental changes in the economy as a result of implementation of the alternatives.

In addition, in the Final EIS DOE has expanded its socioeconomic discussions in Chapter 3 to provide a clarified basis for understanding the magnitude of potential impacts described in Chapter 4. This discussion includes a projection of baseline parameters through 2035 based on the most recently available information and assumptions. In the Final EIS, DOE provides a quantified estimate, to the extent possible, of school enrollment and changes in law enforcement and public service personnel requirements.

7.5.6 (10698)
Comment - EIS002146 / 0003
They wanted all of the facts and figures and they got them, believe me, and as far as the economy goes, I think a lot of the people fail to realize here the economy that that place is going to have. When that test site starts, if that is anything close to what it's supposed to be, we're talking about 2,800 people that it's probably going to employ. We're not talking about minimum wage jobs. We're talking about jobs of people making a thousand dollars a week plus. That's going to really put some real money into the economy in the state for tax purposes and everything else.

Response
DOE and its contractors pay competitive wages for the required jobs and associated skill levels.

7.5.6 (10699)
Comment - EIS002146 / 0004
A lot of these people don't realize that what it's going to contribute to the infrastructure as far as what's going to be donated by the government to the school districts, to the surrounding counties. We're talking about a lot of money that people aren't addressing here as far as schools, infrastructure, fare roads. What's that going to do? That's going to create jobs for people, also.

Response
Section 116(c) of the NWPA states that "the Secretary shall provide financial and technical assistance to (an affected unit of local government or the State of Nevada)…to mitigate the impact on such (an affected unit of local government or the State of Nevada) of the development of (a) repository and the characterization of (the Yucca Mountain) site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

Under the NWPA, the Section 116 impact assistance review process and the EIS process are distinct from one another, and the implementation of one is not dependent on the implementation of the other. Thus, the provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 would be based on an evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 to document likely economic, social, public health and safety, and environmental impacts. If the proposed repository was to become operational, DOE would enter into discussions with the State of Nevada and affected units of local government and consider appropriate support and mitigation measures.

After a decision was made regarding the proposed repository and transportation modes and routes, local jurisdictions would be better able to identify the likely economic, social, public health and safety, and environmental impacts that would be the basis for a request for economic assistance, which could include assistance in providing additional medical and emergency response facilities, under Section 116(c) of the Act.

7.5.6 (11014)
Comment - EIS001896 / 0012
Section 3.1.7

There could be direct and indirect impacts on the City of Henderson in terms of employment, housing, schools, and parks from the construction of the Yucca Mountain project.

<u>Response</u>
DOE assessed the potential socioeconomic impacts associated with Yucca Mountain Repository activities on a countywide level for Clark, Lincoln, and Nye Counties. The Department expects that there would be some nominal direct and indirect impacts to the City of Henderson proportional to the historic residential patterns of the Yucca Mountain Project and Nevada Test Site workforces.

7.5.6 (11022)
<u>Comment</u> - EIS001896 / 0019
Section 4.1.6.2.2

The construction and operation of Yucca Mountain facility could impact Clark County with population increase, increased demand for housing, and schools.

<u>Response</u>
Section 4.1.6.2.2 of the Draft EIS indicates that the peak population increase associated with the repository is expected to be about 5,062 people (in 2030). This represents an extremely small component of the overall population growth in Clark County, which is projected to be more than 850,000 persons between 2005 and 2030. Nevertheless, in the Final EIS, DOE has expanded its socioeconomic discussions in Chapter 3 to provide a clarified basis for understanding the magnitude of potential impacts described in Chapter 4. This discussion includes a projection of baseline parameters through 2035 based on the most recently available information and assumptions. In the Final EIS, DOE provides a quantified estimate, to the extent possible, of school enrollment and changes in law enforcement and public service personnel requirements.

7.5.6 (11128)
<u>Comment</u> - EIS000207 / 0002
The nearly 750,000 members of the IBEW [International Brotherhood of Electrical Workers] include many workers at nuclear facilities. Overall, over 70,000 union employees work in long-term, good-paying jobs at the 103 operating nuclear power plants. Without a proper storage facility for their used nuclear fuel, these nuclear plants face the possibility of having to shut down.

If plants start closing down due to a lack of spent fuel storage space, many union jobs will disappear, and consumers, for no compelling reason, lose a real contender for lower-cost electricity in the newly competitive electric supply industry.

In addition to the 70,000 permanent jobs, thousands of additional union employees are hired during each refueling outage at the plants around the country. In order for these jobs to continue, it is obviously necessary for the nuclear plants to continued operating. If even one plant is forced to shut down because of a lack of storage space, hundreds, possibly thousands, of jobs will be irretrievably lost.

<u>Response</u>
The EIS considers the incremental impacts of the Proposed Action and No-Action Alternatives. Section 113(c)(F) of the NWPA requires that if the Yucca Mountain Site would be determined to be unsuitable, the Secretary of Energy shall "report to Congress not later than 6 months after such determination, the Secretary's recommendation for further action to assure the safe, permanent disposal of spent nuclear fuel and high-level radioactive waste."

7.5.6 (11307)
<u>Comment</u> - EIS001814 / 0036
DEIS Page 3-134
Section 3.1.7 contains socioeconomic background information on the three counties (Clark, Lincoln, and Nye) most involved in the heavy-haul routes.

<u>Comment</u>: The section referenced contains very little information on the expected future population of these areas during the period of operations. To accurately predict the impact of heavy-haul operations, future population projections are necessary. These projections are required in order to forecast traffic volumes on the affected highways. Without these projections, the impact of operations on the level-of-service for the affected highways cannot be assessed. In the Las Vegas urban area, the area where growth is expected to occur given the proposed construction of urban area bypasses should also be projected. Highway improvements are known to effect growth patterns in urban areas. Without projecting the change in growth patterns associated with the urban bypasses, the projected traffic volumes on these roads cannot be predicted.

Response
The Final EIS incorporates Nevada population data developed by and received from county and state officials.

The REMI Economic and Demographic Forecasting System (EDFS) 53-sector computer model incorporates population estimates from recent years provided by officials from Nye and Clark Counties for the socioeconomic baseline. For Lincoln County and the rest of Nevada, the REMI model uses State Demographer estimates for the period. DOE compared these locally derived estimates to the 2000 data provided by the U.S. Bureau of the Census.

The Final EIS baseline uses REMI model projections of population totals for each county until 2035. DOE's Clark County projections correspond to those used by the University of Nevada, Las Vegas (DIRS 136698-Riddel and Schwer 1999), which also uses the REMI EDFS 53-sector model. Inputs to the Nye County projections for the Final EIS are based on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the comment response period are based in part on a REMI 14-sector model. Lincoln County and Rest of Nevada projections through 2018 by the Nevada State Demographer's Office (DIRS 155350-State of Nevada 1999) were used as inputs to population projections for these areas. The county projections and Nye County source documents were used to project population distribution within the 80-kilometer (50-mile) radiological monitoring grid.

To update the health and safety analyses with transportation in Nevada, DOE used the baseline population for each county in the region of influence and forecast to 2035 to scale impacts from results based on the 1990 Census. For example, if a county's estimated population would double from 1990 to 2035, DOE assumed that the population along the associated rail corridor also would double, and doubled the radiological impacts accordingly. In certain locales, however, such as around the planned Las Vegas Beltway, DOE used local sources of population information to better reflect population growth trends (in this instance, information from a report prepared for the City of North Las Vegas).

As discussed in the EIS (Section 6.2), legal-weight truck shipments of spent nuclear fuel and high-level radioactive waste to Yucca Mountain would present only a small increase in truck traffic on regional highways and would not affect level of service conditions. DOE expects operations requirements for heavy-haul trucks, if this mode of transportation was used, would be selected to limit impacts to traffic flow on highways. Thus, DOE does not anticipate level-of-service impacts for highways where heavy-haul trucks could be used.

7.5.6 (11523)
Comment - EIS002252 / 0009
The DEIS failed to address the socioeconomic impact to not only Southern Nevada, as the fastest growing region in the country, but every region that the nuclear waste will be traveling through.

Response
DOE recognizes the rapid growth in southern Nevada. Chapter 6 of the EIS contains estimates of potential socioeconomic impacts from the construction and operation of alternative transportation scenarios. The economic and demographic simulations that DOE performed using the REMI EDF-53 Forecasting and Simulation Models derived changes to the economy from interindustry relationships, labor markets, and national and worldwide economic variables.

The analysis considered the entire State of Nevada. DOE structured the information in the EIS into four regions – Clark County, Nye County, Lincoln County, and the Rest of Nevada, which comprises the 14 remaining counties in the State. The Department estimated the potential impact of each alternative on the same economic parameters for each region. DOE believes this analytical structure provides a reasonable representation of impacts.

From the national perspective, DOE did not analyze the potential socioeconomic impacts of transportation because all spent nuclear fuel and high-level radioactive waste shipments would use existing routes. The shipments would represent a very small fraction of total national highway and railroad traffic (0.008 percent of truck kilometers and 0.007 percent of railcar kilometers).

7.5.6 (12416)
Comment - EIS001888 / 0491
[Clark County summary of comments it has received from the public.]

Commenters believed that the socioeconomic analysis should be conducted at a level which reveals rather than obscures potential impacts, and which supports evaluation at the community level. Key dimensions included: annual estimates of transportation shipments, employment, and procurement effects, analysis at community-specific geographic levels (worksite locations, community ZIP code, place of residence, or procurement destination of payment), and shipments by Nevada transportation route segment; cause and effect links between expenditure, management policy, work activity, and estimated Nevada employment and procurement; cause and effect links between the current and projected inventory, the acceptance schedule, and the characteristics of shipment campaigns; cause and effect links between projected shipments, surface facility capacities, and permanent disposal capacity. One commenter suggested the EIS should discuss socioeconomic impacts in cause and effect terms to allow reviewers to understand and trace the estimation of potential impacts.

Response
The Final EIS presents a baseline of economic measures representative of the economy to 2035. The measures, which were projected through the use of the REMI and Demographic Forecasting System 53-sector computer model, incorporate population estimates provided by Nye and Clark Counties. For Lincoln County and the Rest of Nevada, the model used State Demographer estimates. DOE compared these locally derived estimates to the 2000 data provided by the U.S. Bureau of the Census. The model projections directly reflect economic and population data developed by county and State officials. The model measured impacts against this baseline by identifying incremental changes in the economy as a result of the implementation of different implementing alternatives. Inherent within these analyses are employment levels based on assumptions such as labor required for transportation of spent nuclear fuel and high-level radioactive waste shipments and operation of intermodal transfer facilities.

Much of the information requested by this commenter, such as “analysis at community-specific geographic levels (worksite locations, community ZIP code, place of residence, or procurement destination of payment),” is not available because definitive information on specific transportation routes has not yet been developed. Further identification of the locations of business that could sell products or services to DOE, or the future residential patterns of its employees, would be speculative.

7.5.6 (12423)
Comment - 010375 / 0009
Nye County, Pahrump high rate growth not taken into consideration.

Response
The REMI Economic and Demographic Forecasting System 53-sector computer model incorporates population estimates from recent years (1998 to 1999) provided by officials from Nye County, including the town of Pahrump. DOE compared these locally derived estimates to the 2000 data provided by the U.S. Census Bureau.

The Final EIS baseline uses REMI model projections of population totals for each county until 2035 in the region of influence and the rest of Nevada. Inputs to the Nye County projections for the Final EIS are based on data identified in Nye County documents (DIRS 150996-Williams 2000; DIRS 148140-PIC 1998). The Nye County projections provided during the comment response period are based in part on a REMI 14-sector model. The Nye County source documents are used to project population growth rate within the 80-kilometer (50-mile) radiological monitoring grid.

7.5.6 (12588)
Comment - EIS001654 / 0021
Page S-43. Socioeconomic Impact Analysis Flaws

We have heard complaints that the socioeconomic analysis is inaccurate because the census data that was used is not current because of the rapid growth in Clark County and Southern Nevada.

We have a more basic concern that the analysis of socioeconomic impacts examines the wrong region of influence. Elsewhere in the document (Page 3-71) DOE states that the region of influence was defined based on distribution of residences of current DOE employees and contractors who work on the project. Since 79 percent of those employees live in Clark County (metropolitan Las Vegas,) that county is included in the analysis of impacts from the development and operation of the repository. There can be little dispute that current employees have chosen those living patterns, for a variety of reasons, but does it necessarily follow that a future workforce associated with the repository construction and operation would also follow that pattern?

One of the consequences of using the larger region of influence than might normally have been defined for a similar project elsewhere, is that the effects of the project that might be a large proportion of, say, Nye County, with a population of 30,000 people but those same effects would have a much smaller impact as a proportion of Clark County (more than 700,000 people) when analyzed with Nye and Lincoln County.

In simple terms, the socioeconomic impacts of the project are diluted by having such a large region of influence. There may, in reality, be some aspects of the project that may overwhelm the resources of the immediate vicinity of the repository, yet the regional analysis would indicate there would be no problem for the large region. As example, we understand that the emergency health care services in Nye County are limited, as is often the case in rural locations. Yet, if an accident were to occur on or close to the repository site it is little comfort to know that metropolitan Las Vegas-90 miles away-has ample medical treatment capacity. We challenge the statement (Page S-45) that “impacts to ... public services from population changes in the region resulting from repository activities would be small.” They may be small in proportion to the large regional study area but the more localized impacts in the area most proximate to Yucca Mountain will be more dramatic and potentially overwhelming in some categories.

We will return to this point with a suggestion for handling future socioeconomic impacts that is less centered on Clark County.

Response
DOE recognizes the rapid growth of population in southern Nevada and has modified the population information in this EIS to approximate the estimates developed by Nye County, the Nevada State Demographer and the University of Nevada Las Vegas, the latter working with Clark County. Table 3-23 of this EIS shows approximately 79 percent of Nevada Test Site and Yucca Mountain Project workers live in Clark County; 19 percent in Nye County; and about 2 percent outside the region of influence.

While DOE agrees the historic commuting patterns of the Yucca Mountain Project and Nevada Test Site employees is no guarantee that future residential distribution would be the same, DOE believes this is a valid assumption for analytical purposes and has no basis for assuming otherwise.

DOE estimated impacts at the county level for the three potentially most affected counties (Clark, Nye, and Lincoln). As a consequence, the Department does not believe the impacts are diluted. For all reported socioeconomic parameters, information is provided for all three counties.

Section 3.1.7.5 of the EIS describes health care services in the region of influence for 2000. The EIS discusses that the residents of southern Nye County rely on clinics or go to hospitals in Las Vegas. DOE makes no judgment on the adequacy of existing medical care in the potentially affected communities. The Department does believe, however, that because the increase in population, based on the assumed residential distribution and migration patterns, would occur steadily over a long period, population increases would not result in a degradation of the level of services historically provided to those communities.

7.5.6 (13079)
Comment - 010230 / 0005
The SDEIS should consider locating required off-site manufacturing plants for drip shields, waste packages, and emplacement pallets in Esmeralda County.

Response
DOE has made no decisions with regard to the procurement or manufacture of waste shipping casks, emplacement pallets, or drip shields. Final determinations would be subject to Federal procurement regulations, total need, timing, manufacturing capabilities, and availability of raw materials. DOE assumes for purposes of analysis that existing vendors in Massachusetts, North Carolina, Ohio, Pennsylvania, and Tennessee would supply waste shipping casks and emplacements pallets. However, DOE would not categorically exclude any location as a possible site for repository support functions.

7.5.6 (13081)
Comment - 010230 / 0007
In Section 3.1.6, “Socioeconomics,” the SDEIS does not adequately address negative impacts to local economies if workers are drawn away from small communities to work at the Test Site. The tax base and real estate values in a small mining community such as Goldfield could suffer.

Response
DOE evaluated the potential socioeconomic impacts of its actions in Nevada based on the historic residential and commuting patterns of its employees, over 90 percent of whom reside in and commute from Clark County. While DOE acknowledges the historic commuting patterns of the Yucca Mountain Project and Nevada Test Site employees is no guarantee that future residential distributions would be the same, DOE believes this is a valid assumption for analytical purposes and has no basis for assuming otherwise. DOE does not anticipate that a large number of Goldfield residents, or residents of other smaller communities located relatively long distances from Yucca Mountain and the Nevada Test Site, would relocate in the future to work at DOE facilities because historical information shows they have not done so to date. As a consequence, direct impacts to factors such as the tax base due to the out-migration of residents are not anticipated.

7.5.6 (13173)
Comment - 010243 / 0020
Employment at the [fuel blending] facility is expected to reach 2000 persons. Approximately ninety percent of the 2000 persons expected to be employed at the fuel handling facility will live in Clark County. Based on traditional planning calculations the following impacts on municipal services are likely to be experienced.

$1,972,125 Park Cost
$375,000 Fire Station Costs
$155,000 Police Station Costs
$68,400 Traffic Signal Costs
$12,236,574 Elementary School Cost
$5,760,000 Middle School Cost
$7,860,262 High School Cost
$28,427,361 Total Direct Costs to Clark County

Figure 1 Direct Costs to Governments in Clark County due to Fuel Blending

Response
DOE appreciates the input provided by Clark County with regard to estimates of potential impacts to municipal services. The Department anticipates that about 1,800 workers of the 2,000 workers associated with functions in support of the repository could result in up to a $166-million-per-year increase in Gross Regional Product and a $110-million-per-year increase in real disposable income. As noted by Clark County, a large percentage of the workers are likely to reside in Clark County and Las Vegas. As a consequence, not only would most of the services used by the workers be in Clark County, but most of the positive regional effects would also be centered in the metropolitan area, where the workers would pay property, sales, vehicle, and all other taxes and fees collected by Clark County and the State of Nevada.

In addition to the estimated contribution to the regional economy associated with repository workers, DOE is responsible for Payments-Equal-To-Taxes (PETT) pursuant to Section 116(c)(3)(A) of the NWPA, which requires the Secretary of Energy to "…grant to the State of Nevada and any affected unit of government, an amount each fiscal year equal to the amount such State or affected unit of government, respectively, would receive if authorized to tax site characterization activities…." Clark County has been eligible to receive PETT since the enactment of the amendments Nuclear Waste Policy Amendments Act of 1987 (Public Law 100-203, 101 Statute 1330).

DOE acquires data from the Yucca Mountain Site project organizations that purchase or acquire property for use in Nevada, have employees in Nevada, or use property in Nevada. These organizations include Federal agencies, national laboratories, and private firms. Not all of these organizations have Federal exemption status so they pay the appropriate taxes. The purchases (sales and use tax), employees (business tax), and property (property or possessory use taxes) of the Yucca Mountain Project organizations that exercise a Federal exemption are subject to the PETT Program (DIRS 103412-NLCB 1996).

The actual sales and use taxes, property taxes, and Nevada business taxes paid by Yucca Mountain Project organizations that were not exempted from tax payment obligations for the period from May 1986 through June 2000 have been calculated. These organizations paid sales and use taxes of $2.5 million for purchases made in Clark County; paid property or possessory taxes of about $90,000 in Clark County; and paid the State of Nevada about $810,000 in business taxes (DIRS 156763-YMSCO 2001). The PETT for sales or use taxes from May 1986 through June 2000 was about $4.4 million for purchases in Clark County. For property taxes, it was about $940,000 in Clark County; about $130,000 was paid to the State of Nevada in business taxes.

7.5.7 HUMAN HEALTH AND SAFETY

7.5.7 (66)
Comment - 15 comments summarized
Commenters were both for and against DOE's methods for estimating radiation health impacts from low-level exposure to radiation, methods that are based on the linear no-threshold hypothesis. Several commenters thought use of the linear no-threshold hypothesis was too conservative, noting the extrapolation of observed high dose and effect relationships to low doses, where no effects have been observed, and the possibility of positive effects (radiation hormesis). One commenter noted the opposing "supralinearity" hypothesis, which theorizes higher effects at low doses. Other commenters noted the general acceptance of the linear no-threshold hypothesis and its implication that all radiation exposure carries with it some degree of risk. Some commenters suggested DOE needed to reconsider models used for the dose-health effect relationship.

Response
DOE recognizes there are uncertainties regarding the relationship of radiation dose and health effects at low doses and low dose rates. Scientific advisory groups, including the National Academy of Sciences, National Council on Radiation Protection and Measurements, and the International Commission on Radiological Protection have reviewed the research and population exposure data and recommended methods for calculating dose and estimating exposure effects. These organizations recognize that the use of dose-to-risk conversion factors based on the linear no-threshold hypothesis to estimate stochastic effects (latent cancer fatalities, nonfatal cancer incidence, and hereditary effects) from very low exposures to ionizing radiation may overestimate the actual risk. DOE also recognizes that experts in the scientific community are reviewing the merits of the linear no-threshold hypothesis. However, because of uncertainties in the low dose/low dose rate region of the dose-health effect curve, the dose-to-risk conversion factors recommended by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) for estimating the risk from exposure to ionizing radiation are based on the linear no-threshold hypothesis. These organizations have been careful to point out over the years that the use of the linear no-threshold-derived risk factors will provide reasonable assurance that the actual effect will not be underestimated. For these reasons, the linear no-threshold hypothesis has been accepted for use by federal agencies—including DOE, the Environmental Protection Agency, and the Nuclear Regulatory Commission—for radiation protection and for estimating risk from exposure to ionizing radiation.

Although human response to radiation exposure has been extensively studied for over 75 years, there is still much that is unknown about effects of chronic exposure to low level radiation. This is why, in 1998, the Environmental

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7.5.7 (66)
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Although human response to radiation exposure has been extensively studied for over 75 years, there is still much that is unknown about effects of chronic exposure to low level radiation. This is why, in 1998, the Environmental

Protection Agency and DOE called on the National Academy of Sciences-National Research Council to reconvene the Committee on Health Risks from Exposure to Low Levels of Ionizing Radiation to analyze the large amount of published data since the last Committee report (DIRS 100473-National Research Council 1990) was published. The committee will consider relevant data derived from molecular, cellular, animal, and epidemiologic studies in its comprehensive reassessment of the health risks resulting from exposures to low-level ionizing radiation.

In 1995, the National Academy of Science/National Research Council Committee on and Assessment of CDC Radiation Studies stated the following (DIRS 100018-National Research Council 1995):

"From the beginning of time, humans have lived in a "sea of radiation," namely that which results from natural background (cosmic and terrestrial radiation, and naturally occurring radionuclides in out air, water, and food). The accompanying dose rates are estimated (NCRP, Report 93) to be three times the current dose rate limit for members of the public. If exposures to these sources have led to any significant health effects, humans would never have been successful in reaching their current stage of development."

The report went on to say (DIRS 100018-National Research Council 1995):

"Traditionally, radiation protection guidelines are predicated on a linear dose response, which assumes that the harmful effects of radiation are linearly related to the dose and that there is no threshold dose. Most experts believe this assumption is conservative; that is, it overestimates the effects of ionizing radiation at low doses because it ignores the potentially beneficial effects of the body's repair mechanisms [radiation hormesis]."

For these reasons the Committee on Health Risks has been charged with, among other things, assessing the current status and relevance to risk models of biological data and models of carcinogenesis, including critically assessing all data that might affect the shape of the response curve at low doses, in particular, evidence of thresholds or the lack thereof in dose-response relationships and the influence of adaptive responses and radiation hormesis.

DOE joins the charge to the Committee, namely that there is a need for a critical assessment of all biological data that could affect the shape of the dose/response curve at low doses. The outcome of this review might (1) confirm the linear no-threshold hypothesis; (2) confirm the evidence that there is a threshold below which no harmful effects occur; or (3) show that there are beneficial effects in the low dose regime. Because of the need to ensure that our radiation protection standards are adequate, and that we are not spending money on nonexistent problems, DOE believes that that such a review is timely. Although beneficial effects of low-level radiation could be one of the outcomes of the study, any such effects will not be known to exist until the committee completes its studies and issues its report in 2003.

7.5.7 (93)
Comment - 39 comments summarized
Commenters expressed concern about the potential for cancer and other health effects caused by exposure to ionizing radiation from the repository.

Response
DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (40 CFR Part 197), and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15 millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual dose to the reasonably maximally exposed individual would be thousands of times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to

15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peak doses would be even smaller at greater distances.

The EIS provides estimates of lifetime doses and potential additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation, which could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). Similar estimates have been made for impacts to populations exposed over 10,000 years (see Table 5-7).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (98)

Comment - 35 comments summarized

Commenters noted that the Draft EIS presented only estimates of latent cancer fatalities and no estimates of other health effects. A number of other diseases and effects were listed as concerns, including death, birth defects, genetic damage, nonfatal cancers, immune system depression, visual impairment, mental retardation, spina bifida, female reproductive impairment, premature aging or life shortening, tumors, teratogenic effects, Alzheimer’s disease, Parkinson’s disease, pulmonary fibrosis, emphysema, and others. Other commenters requested that Appendix F of the EIS (the “radiation primer”) provide additional information. Commenters stated that individual members of the population, specifically those with increased sensitivity to radiation such as children or an embryo-fetus, should be evaluated as the hypothetical maximally exposed individual member of the public.

Response

Health effects of radiation exposure can be placed in two categories: stochastic (random) and nonstochastic (deterministic). Stochastic effects are those that have a probability (not a certainty) of occurrence and include somatic effects such as latent fatal and nonfatal cancers, and genetic effects such as hereditary disorders that could occur in the progeny of exposed individuals (that is, future generations). The probability of the occurrence of such effects, not their severity, is affected by the amount of radiation exposure an individual receives. To estimate the probability of occurrence of these effects, DOE used the linear no-threshold hypothesis, which conservatively assumes that every dose, no matter how small, carries some increased risk of fatal cancer.

On the other hand, nonstochastic or deterministic effects occur only after a certain amount of radiation exposure has occurred. These occurrences and the severity of the effects (not the probability of occurrence), which are affected by the amount of radiation exposure an individual receives, include somatic effects such as cataracts, premature aging, infertility, emphysema, and pulmonary fibrosis as well as teratogenic effects in children exposed in-utero such as microcephaly (smallness of the head) and mental retardation. Most of the health effects noted by commenters are nonstochastic and would be unlikely to occur even at doses thousands of times higher than those resulting from the Proposed Action.

DOE recognizes that the risk of cancer and other health effects attributed to radiation exposure are of concern to many citizens. However, for chronic low doses such as those estimated in the EIS to result from the Proposed Action, the National Research Council Committee on the Biological Effects of Ionizing Radiation stated that cancer induction is the most important somatic effect (DIRS 153007-National Research Council 1980). The Committee went on to say that among the somatic effects of radiation other than cancer, developmental effects on the unborn child are of greatest concern (DIRS 153007-National Research Council 1980). In addition, the Committee said that for somatic effects other than cancer and developmental changes (for example, cataracts, aging, and infertility), the available data do not suggest an increased risk with low-dose, low-linear-energy-transfer exposure of human populations (DIRS 153007-National Research Council 1980).

In addition to fatal cancers, as the commenters have suggested, experts generally recognize that other health effects could result from exposure to radiation. Therefore, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) suggested the use of detriment weighting factors that consider the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancers and heredity effects. However, as discussed in Section F.1.1.5 of the EIS, because both of these life detriment factors, taken together, amount to less than half the fatal cancer risk, DOE has chosen to estimate only latent cancer fatalities as the most important health effect from exposure to radiation.

For these reasons, DOE used dose-to-risk conversion factors recommended by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) for estimating the risk of latent cancer fatality from exposure to ionizing radiation. These factors were developed based on the linear no-threshold hypothesis, which assumes that adverse health effects could occur from exposure to ionizing radiation regardless of how small the dose.

However, all types of individuals are included in the radiation risk factor of 1 latent cancer fatality per 2,000 rem of ionizing radiation received by an exposed population (0.0005 latent cancer fatality per rem). Children comprise a relatively large part of the population and are more sensitive to the effects of radiation (cancer induction) than adults. Children are the principal reason the risk factor for the whole population is 25 percent higher than the factor for workers (1 latent cancer fatality per 2,500 rem, or 0.0004 latent cancer fatality per rem).

Other types of individuals, such as pregnant women, the aged, and those with impaired health, are not unduly radiosensitive, especially to the low levels of radiation expected from the proposed activities at the Yucca Mountain site. The embryo-fetus is more radiosensitive than the general population and the radiosensitivity varies with the stage of development. However, the embryo-fetus is not suitable as the hypothetical reasonably maximally exposed individual because:

- The embryo-fetus is exposed for at most 9 months, compared to 70 years of exposure for an individual.
- The body of the mother protects the embryo-fetus. Many radionuclides are either excreted or would first migrate to the organs of the mother. Many particulate radionuclides do not cross the placental barrier.
- There is not an extensive database of scientific information on placental transfer of radionuclides and their concentrations and dosimetry in the human embryo-fetus, and there are a number of unknowns and uncertainties about this information (DIRS 157140-NCRP 1998).

For comparison, the National Council on Radiation Protection and Measurements recommends a dose limit of 50 millirem per month to protect the embryo-fetus of occupationally exposed women (DIRS 101856-NCRP 1993).

DOE has revised the radiation health primer in Section F.1 of the EIS to include an expanded discussion of ionizing radiation and radiation-related health effects. Section 6.3 evaluates the health impacts of transporting waste by truck or rail in Nevada, including accidents.

7.5.7 (105)
Comment - 11 comments summarized
Commenters suggested that DOE should conduct a baseline health assessment in the 10 affected counties. This assessment would determine what types and frequencies of health effects are currently occurring in affected counties. Commenters stated that by showing the present health situation, a case might be made for not adding to a potential number of latent cancer fatalities, and for documenting current health conditions before an occurrence of a radioactive waste accident. Other commenters were concerned about compensation in a timely manner in the event of an accident.

Response
DOE believes that a baseline health assessment is unnecessary for the Yucca Mountain Repository because adverse health impacts from the Proposed Action would be highly unlikely. For example, in the vicinity of the repository [the area within 80 kilometers (50 miles)], DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual dose to the reasonably maximally exposed individual would be thousands of times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peak doses would be even smaller at greater distances.

The EIS provides estimates of lifetime doses and potential additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation, which could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). In all cases, these risks have been shown to be very low and, considering the conservatisms used in these estimates, probably nonexistent. DOE believes that even if large-scale health studies were conducted, the identification of adverse health impacts resulting from the Proposed Action would not be discernible.

In the event of actions that compromised the integrity of the repository, mitigation activities would be funded under either the Nuclear Waste Fund or the Price-Anderson Act. The Price-Anderson Act provides liability coverage for commercial activities operating under a license from the Nuclear Regulatory Commission and DOE activities. It establishes a system of private insurance and Federal indemnification that generally ensures that up to $9.43 billion is available to compensate for damages suffered by the public from a “nuclear incident,” regardless of who causes the damage. Payment would be from government funds or, if public liability arose out of nuclear waste activities funded by the Nuclear Waste Fund (for example, activities at a geologic repository), from that fund. The liability of all responsible parties is limited to the amount of coverage provided by the Price-Anderson system. State and local governments cannot be required to provide any additional compensation. The EIS has been revised to include more details about indemnification under the Price-Anderson Act (see discussion in Section M.8).

Price-Anderson indemnification would apply to the operators of a nuclear waste repository at Yucca Mountain (which would also be licensed by the Nuclear Regulatory Commission pursuant to the NWPA) and to transporters of nuclear waste from commercial nuclear utilities and from DOE sites to the repository. Thus, Price-Anderson liability coverage extends to DOE contractors that manage and conduct nuclear activities in the DOE complex. In a general sense, the Federal Government acts as an insurer for these contractors against any findings of liability arising from the nuclear activities of the contractor within the scope of the contract.

7.5.7 (235)
Comment - 11 comments summarized
Several commenters were concerned about the magnitude of the radon release from the repository in ventilation air, and about the potential for radiation dose to workers – especially during construction – and members of the public. The use of a 20 km distance for the maximally exposed member of the public was questioned. Other commenters noted that the SDEIS should provide an assessment of the impacts associated with increased ventilation from the repository under the flexible design operating modes.

Response
Radon-222 is a ubiquitous, naturally occurring noble gas. It accounts for greater than 99 percent of the radiation dose to the public from repository activities, because only very small quantities of manmade, noble gas radionuclides would be released from spent nuclear fuel handling activities (Section G.2.3.2). Radon itself has very little dose potential because it is a noble gas and does not deposit or bind to other substances or tissue. Nearly all of the potential for radiation dose comes from its decay products. Most of the concern for radon exposure comes from

the buildup of radon and its decay products in enclosed spaces where there is little ventilation to remove these radionuclides to the outside air and people can inhale them. That is why the Environmental Protection Agency has established guidelines for radon in indoor air and particularly applicable to living spaces such as basements. It is estimated that the average annual dose from inhalation of radon and its decay products is 200 millirem in the United States (Section 3.1.8).

DOE recognizes the potential for radon exposure to workers in the underground facilities and also recognizes the need for good ventilation conditions to minimize this exposure. The potential dose from radon and radon decay products to both surface and subsurface workers is discussed in Appendix F of the EIS and included in results shown in Section 4.1.7. Except during construction, when there would be no spent nuclear fuel in the repository, exposure to radon is a very minor component of the worker radiation dose. Radiation doses to workers during the construction phase would be very low, with potential impacts expected to be small (see Section 4.1.7.2). The dose from radon and radon decay products to a subsurface worker is estimated to be about 50 millirem per year for 2,000 working hours underground. As 2,000 hours is about 22 percent of the 8,760 hours in a year, workers would probably receive about 45 millirem from naturally occurring radon if they were not working underground. However, the EIS conservatively assumes that all of this 50 millirem dose as part of the occupational dose. The additional dose from radon to surface workers very small (see Section 4.1.2).

The ventilation conditions in the repository to remove heat from the waste packages under the flexible design operating modes also provide good ventilation conditions for workers. These ventilation conditions also provide the potential for more radon to be released from the repository and potential for exposure to members of the public. The EIS analyses examined all ventilation pathways releasing radon from the repository during all project phases. The maximally exposed individual located 20 kilometers (12 miles) south of the repository would receive a total dose of about 30 millirem over a 70-year lifetime from Yucca Mountain activities. The maximum annual dose would be less than 2 millirem, which would be less than 1 percent of the average annual 200 millirem dose in the United States from exposure to naturally occurring radon. Members of the public would not be able to continuously reside closer than this to the repository because DOE would withdraw the area around the repository from public use and access (see Chapter 3). The potential dose to members of the public visiting the repository would be very small. Even if they spent 2,000 hours a year at the repository their maximum annual dose would only be about 2 millirem, the same as that for the maximally exposed noninvolved worker.

Discussion of radon exposure of workers is provided in Appendix F.1.1, and radon exposure to members of the public is discussed in Appendix G.2.

7.5.7 (236)
Comment - 3 comments summarized
Several comments were made about the potential for pinon pine nuts to accumulate radionuclides and expressed concern that their consumption could represent a potentially unevaluated exposure pathway to humans. One comment also noted the commercial growth of pistachio nuts in the Amargosa Valley and their consumption as well.

Response
Pinon pine trees occupy over 50 million acres in the western United States, primarily in Nevada, Utah, Arizona, Colorado, and New Mexico. They are the dominant overstory tree species around Las Alamos National Laboratory, where researchers have examined the concentration of radionuclides in pinon pine nuts (DIRS 156058-Fresquez et al. 2000). Pinon pine nuts are produced irregularly in nonannual cycles about every seven to ten years. Nonedible portions of plants (roots, stems, and leaves) generally contain higher radionuclide concentrations than the edible tissues (fruiting bodies) of the same plant species. The Los Alamos researchers found this to be true of pinon pines as well, finding radionuclide concentrations higher in pinon pine shoots than in pinon pine nuts. Soil-to-nut concentration ratios (the concentration in nuts divided by the concentration in soil) for most radionuclides were within the range of default values found in the literature for common fruits and vegetables. For potential radionuclide releases from the Yucca Mountain repository to groundwater, only those pinion pines and other nut-bearing trees located down-gradient from the repository and that are irrigated or at a location where groundwater is naturally near the surface could be affected by repository releases. Atmospheric releases of noble gases during repository operations would be minor sources of radionuclides. While the Los Alamos researchers did not examine all of the radionuclides of interest for the Yucca Mountain project, their findings are consistent with the current Project understanding that concentrations of radionuclides in pinon pine nuts -- and other types of locally grown nuts

including pistachios -- represent a relatively minor source of radiation exposure to the public. When the relative quantities consumed are compared for nuts and other more commonly consumed fruits and vegetables, nuts would likely be a minor contributor to the ingestion dose pathway and the overall dose received. The limited areas of potential exposure and multiyear cycling of pinon pine nut production would also reduce the contribution to Native American traditional diets, which could include larger quantities of pinon pine nuts.

7.5.7 (384)
Comment - EIS000048 / 0004
The surrounding areas have no protection from spills and accidents on [the repository] site.

Response
Before beginning repository operations, DOE must have systems in place to prevent and mitigate spills/releases. Because the spent nuclear fuel and high-level radioactive waste would be solid material, the potential for spills would be very small, with the risk of spills mainly associated with liquids and fluids such as those used in any industrial operation.

The following sections of the EIS discuss the measures and plans DOE would use to protect onsite and offsite areas from spills or accidents at the repository site:

- Section 4.1.3.1 discusses the approaches DOE would follow during preconstruction testing and performance confirmation activities to minimize the effects on groundwater of potential releases of hazardous materials.

- Sections 4.1.3.2 and 4.1.3.3 contain discussions on potential contaminant spread to surface water and groundwater, respectively from construction, operation, monitoring and closure of the repository. The discussions include hazardous liquid materials that DOE would store or use on the site, the potential for release of the materials as a result of a spill, and the measures that DOE would institute to prevent their spread during construction, operation and monitoring, and closure.

- Section 4.1.4.4 contains a discussion on "Contamination" that describes how DOE would clean up and dispose of soils contaminated by radiological or nonradiological hazardous materials.

- Section 4.1.8.1 discusses onsite radiological accidents. It notes that impact calculations show that the quantities of radioactivity released to the environment and the quantities of material deposited on the ground would be very low and below the Environmental Protection Agency Protective Action Guidelines, so interdiction would not be necessary.

- Section 4.1.8.2 discusses the control of releases of nonradiological hazardous materials in the event of an accident.

- Sections 9.3.3.1 and 9.3.3.2 discuss the mitigative measures that DOE would institute in the event of an onsite spill/release or accident to minimize the spread of the released contaminant (radiological and nonradiological) to or by surface water and groundwater, respectively.

7.5.7 (564)
Comment - EIS000106 / 0003
The EIS also assumes in all its radiation exposure estimates that there's 28,000 -- there will be 28,000 people within a fifty mile radius of Yucca Mountain. You know, Nye County has published population estimates which showed that the county population in fifty miles, which includes Pahrump, will be at least 47,100 in 2010 when this project starts, and this doesn't include the population that's in California or down in Indian Springs. So in the assumption of the 28,000 within a fifty mile radius, the EIS is assuming that the Yucca Mountain project will be imposed on its static -- on a community that's static at a level that the county passed way back in the mid-1990s.

Response
DOE has revised the population baseline for population dose estimates in the EIS. The Final EIS uses the estimated population in 2035 rather than 2000 as in the Draft EIS. Impact estimates for the Final EIS assume that

the 80-kilometer (50-mile) population would be 76,000 individuals. However, Nye County is one of four counties within the 80-kilometer area around Yucca Mountain. Lincoln and Clark Counties in Nevada and Inyo County, California, are the other three. The bulk of the population in this 80-kilometer area would live in Nye County, but the area does not include all of the County. Therefore, the 80-kilometer population and the county population numbers do not match.

7.5.7 (604)
Comment - EIS000127 / 0021
They're talking about pumping a whole lot water out of Jackass Flats to put a lot of concrete linings in and all of these things, but that they're not taking into consideration is that all the water they pump out of Jackass Flats is already radioactive, so they're going to be building the repository out of radioactive concrete.

And they're not addressing that in the impacts; not for the workers; not for us.

What are the effects of making concrete with radioactive water and then expecting it to last for 10,000 years?

Response
DOE would pump water from groundwater wells at the Yucca Mountain Repository site for use in concrete at the repository. The aquifer supplying those wells is part of the Jackass Flats hydrographic basin. Results of the 1997 groundwater sampling and analysis for radioactivity are shown in Table 3-19 of the EIS. Groundwater monitoring at Yucca Mountain has not detected any radionuclides related to human activities.

7.5.7 (663)
Comment - EIS000167 / 0004
There is an obvious parallel between radiation exposure and incidence of cancer. How can we trust DOE when standards of exposure are set so low. When standards are changed to make Yucca Mountain "OK" and those same standards are set to 1 death related to cancer (i.e., radiation exposure) in 1,000 as opposed to the previous 1 in a million. That one human being in a thousand has lost the most precious inalienable right of all, the right to his or her life. Can you as [a] DOE employee help to replace that trust? Not with propaganda but with changes in how you set the standards? You can. You can set the standards at 1 in a million or at 0.

Response
With regard to radiation exposure and the incidence of cancer, as discussed in Sections K.4.3.2 and Section F.1.1.5, the dose-to-risk conversion factors typically used to estimate adverse human health impacts resulting from radiation exposures contain considerable uncertainty. The risk conversion factor of 0.0005 latent cancer fatality per person-rem (or, one latent cancer per 2,000 rem of exposure) of collective dose for the general public typically used in DOE National Environmental Policy Act documents is based on recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993). The factor is based on health effects observed in the high dose and high dose rate region (20 to 50 rem per year). Because health effects in humans have not been observed below acute 10 rem (10,000 millirem) exposures, potential health effects were extrapolated to the low-dose region (less than 10 rem per year) using the linear no-threshold model. This model is generally recommended by the International Commission on Radiological Protection and the National Council of Radiation Protection and Measurements, and some radiation protection professionals believe this model produces a conservative estimate (that is, an overestimate) of health effects in the low-dose region, which is the exposure region associated with continued storage of spent nuclear fuel and high-level radioactive waste. This EIS summarizes estimates of the impacts associated with very small chronic population doses to enable comparison of alternatives in this EIS. Therefore, impact estimates should be viewed as conservatively high.

The Environmental Protection Agency has responsibility for setting applicable standards for Yucca Mountain. The Nuclear Regulatory Commission has responsibility for modifying technical standards for the repository to be consistent with the Environmental Protection Agency standards. The Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective dose of 15 millirem per year for Yucca Mountain. This level of exposure would, using the recommended risk factors discussed above (0.0005 latent cancer fatality per rem or 1,000 millirem), would represent a risk of contracting a fatal cancer of 8 chances in a million for one year of exposure or about 5 chances in 10,000 for a lifetime (70 years) of exposure. For comparison, based on the most recent statistics, individuals living in the United States have about a 1 in 4 chance of dying of cancer from all causes (DIRS 153066-Murphy 2000).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than 1 chance in 100 million (see Table 5-6). This level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes.

7.5.7 (677)
Comment - EIS000205 / 0002
The DEIS does not note that waste repository release limits at Yucca Mountain would be much higher than the accepted standards set by the EPA [Environmental Protection Agency]. If the EPA had remained as the standard setter in this agreement, the Yucca Mountain site would indeed be disqualified. The plans for Yucca Mountain have been allowed to proceed only because Congress has agreed to more and more relaxed health and safety standards. We believe that the EPA should set the standards for radiation releases, and that groundwater at this site should be subjected to safe drinking water standards established by the EPA.

Response
The Energy Policy Act of 1992 requires the Environmental Protection Agency to set applicable standards for Yucca Mountain. The Act also requires the Nuclear Regulatory Commission to modify technical standards for the repository (10 CFR Part 63) to be consistent with the standards set by Environmental Protection Agency. DOE notes that the Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective does of 15 millirem per year for Yucca Mountain, and a groundwater protection standard of 4 millirem per year. The groundwater protection standards are consistent with the Environmental Protection Agency's safe drinking water regulations.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

With respect to groundwater protection standards set forth in 40 CFR 197.30, estimated groundwater concentration during the 10,000-year regulatory are thousands of times lower than the regulatory limits (see Table 5-13).

7.5.7 (678)
Comment - EIS000205 / 0003
We [Physicians for Social Responsibility (PSR)] also note the inconsistencies that appear when you compare health and safety standards for the Yucca Mountain site with those outlined for the Waste Isolation Pilot Project. The NRC [Nuclear Regulatory Commission] proposes radiation release rates of 25 millirem/year for Yucca Mountain as compared to a slightly better EPA [Environmental Protection Agency] standard of 15 millirem/year for WIPP [Waste Isolation Pilot Plant]. At WIPP, groundwater samples are to be taken 5 kms [kilometers] outside the site, while the Yucca Mountain measurements would be gathered from 20 kms away. The WIPP site currently has a groundwater standard of 4 millirems, while Yucca has none. PSR believes that Nevada residents deserve the same level of protection granted to residents of New Mexico and that everyone has the right to clean air and safe drinking water.

Response
As the commenter notes, the Environmental Protection Agency and the Nuclear Regulatory Commission are responsible for setting the radiation dose standards for two DOE repository facilities, the Waste Isolation Pilot Plant in Carlsbad, New Mexico, and the proposed repository at Yucca Mountain. Although compliance methods prescribed by their respective protection standards may be different, DOE believes both regulations provide essentially the same level of protection (to both individuals and groundwater) and that this level of protection is adequate to ensure that health impacts would be highly unlikely to occur.

The Energy Policy Act of 1992 requires the Environmental Protection Agency to set applicable standards for Yucca Mountain. The Act also requires the Nuclear Regulatory Commission to modify technical standards for the repository (10 CFR Part 63) to be consistent with the standards set by the Environmental Protection Agency. DOE notes that the Environmental Protection Agency has established new regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual receive no more than an annual committed effective does of 15 millirem per year for Yucca Mountain, and a groundwater protection standard of 4 millirem per year. The groundwater protection standards are consistent with the Environmental Protection Agency's safe drinking water regulations. The final Agency regulations specify that the point of compliance is at about 18 kilometers (11 miles). The Nuclear Regulatory Commission has issued final rules that are consistent with the Environmental Protection Agency rules (10 CFR Part 63).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

7.5.7 (688)
Comment - EIS000270 / 0015
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Failure in dose calculations to account for the additive, multiplicative, and synergistic relationships of radiological and other biologically hazardous pollutants, factors, and conditions ultimately affecting recipients.

Response
The EIS presents the risks of exposure to ionizing radiation and hazardous chemicals separately, where the potential for these exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues were the same, because exposure pathways and cellular and molecular mechanisms of cancer induction could differ. The low levels of exposure to radiation and hazardous substances likely to occur from repository operations (Sections 4.1.2 and 4.1.7) and long-term performance (Sections 5.4 and 5.6) would be such that there would likely be no impacts, even though the linear, no-threshold application of risk factors generates fractional impact estimates, such as fractional latent cancer fatalities. Section F.1 of the EIS contains more information.

7.5.7 (838)
Comment - EIS000173 / 0004
Dairy cows graze fairly close to Yucca Mountain. Would you like your children to drink milk that may well have been contaminated with radioactive substances? Many people in this country have died from bone cancer caused by the milk they drank as children that contained strontium-90 from our atmospheric nuclear tests. Let's not make the same mistake of allowing radioactive isotopes in our milk again!

Response
The EIS evaluation of potential human health impacts of the Yucca Mountain Repository considered all exposure pathways, including the vegetation-to-cow-to-milk pathway. Sections G.2.4.1, I.2.9, and I.4.4.6 of the EIS include these pathways in the descriptions of dose factors for operations and long-term performance, respectively. The updated analysis presented in the Final EIS projects that the Proposed Action would likely result in extremely small

releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem, including milk pathways, which is more than 100,000 times less than the individual protection standard set by 40 CFR Part 197.

7.5.7 (846)
Comment - EIS000173 / 0012
Some of your studies have projected that there will be one extra cancer death per 1,000 in the population from the plan to transport spent fuel to Yucca Mountain. Some, however, have questioned your statistics which seem to average in radioactivity for the whole population of the United States and sometimes use the radiation level considered safe for adults without acknowledging that it is much lower for children and fetuses. However, even if we accept your estimate of one new death per 1,000 people, for the 50 million who live within half a mile of a transportation route, would this mean that 50,000 people would get cancer as a result of this plan? That is not acceptable to me. Who are these people who would die prematurely as a result of this plan? Many would be the Native Americans who live near Yucca Mountain and claim it as their own sacred property.

Response
DOE is unaware of studies that predict one death per 1,000 persons for transporting spent nuclear fuel to Yucca Mountain. The Department estimates three latent cancer fatalities could occur nationally as a consequence of transporting spent nuclear fuel using mostly legal-weight trucks and one latent cancer fatalities could occur from using mostly rail over the 24 years of the Proposed Action. These estimates are based on a large number of people each receiving a small radiation dose and assuming there is a risk of health effect without threshold (the linear no-threshold hypothesis). The dose and risk to individuals would be very small. For example, Section 6.2.3.1 of the EIS discusses that the maximally exposed resident along a legal-weight truck route would receive about six millirem over 24 years of transport, with a 0.000003 risk of latent cancer fatality (about 1 chance in 300,000). A small number of individuals (for example, a service station attendant where trucks stopped) could receive larger doses. Section J.1.3.2 describes the methods and assumptions DOE used to estimate such impacts.

DOE believes that adverse health impacts resulting from the Proposed Action are highly unlikely. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. In addition, for the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6).

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). In all cases, these risks have been shown to be very low and, considering the conservatisms used in these estimates, likely nonexistent. As such, DOE believes that even if large-scale health studies were conducted, the identification of adverse health impacts resulting from the Proposed Action would not be discernible.

7.5.7 (848)
Comment - EIS002247 / 0005
I want to know if you took the Petkau effect into account when you figured out the health effects of this project. I know this is kind of a double-edged sword for you guys, because I know health effects in the DEIS means deaths, latent cancer fatalities; but as we all know, there are a lot other health effects from nuclear material, including birth defects, leukemia, childhood cancers, other cancers which are not necessarily fatal. And I want to whether or not the

Petkau effect which was discovered in 1972 by Canadian scientist Petkau, and basically says that low-level exposure -- constant low-level exposure has a much more detrimental effect on the human body than a single dose of this high level -- a single high-level dosage.

In fact, it's something like 5,000 times more -- it has more -- 5,000 times more effect on your body than if you are getting a constant low-level dose. That means the people in these corridors, the people here in San Bernardino County, will be getting these low-level doses, and I want to know if the Petkau effect was taken into consideration when dealing with the transportation, when dealing with the health effects. And I would like to hear more about that.

Response

The National Research Council (DIRS 153007-National Research Council 1980) evaluated the research of Dr. A. Petkau, which hypothesizes an alternative or conjoined damage mechanism for ionizing radiation in addition to effects on DNA. Effects on DNA are generally accepted as the primary modes of damage in biologic systems. Dr. Petkau suggested radiation damage to cellular and intracellular membranes is manifested by alterations in permeability, which lead to altered distribution of various intracellular molecules and ions and disruption of membrane-associated biochemical processes. Although it is well recognized that membrane integrity is essential for normal cell function, at the time of the BEIR III report there was inadequate basic understanding of membrane structure and function on which to base a detailed theory of radiation-induced damage mechanisms. Also, available data were not adequate to assess the role of radiation damage of membranes in the induction of pathologic states in living systems. Subsequent BEIR reports and National Council on Radiation and Protection and Measurement and International Commission on Radiological Protection recommendations have not considered non-nucleonic damage mechanisms (Petkau effects), presumably because of the lack of additional or supporting scientific research. Because DOE uses the recommendations of the Council and the Commission in making estimates of risk from exposure to ionizing radiation, Dr. Petkau's research was not considered.

7.5.7 (916)

Comment - EIS000089 / 0005

And then we're looking at the situation that they say twelve miles from there, which I just found out tonight is in this town. You're going to be getting one x-ray a year if you live at the twelve-mile parameter line they're coming up with.

That's what the EPA [Environmental Protection Agency] wants. The NRC [Nuclear Regulatory Commission] wants you to have a little bit more.

Well, how do they know that?

And then what happens at six miles into the animal life or what happens to animal life that spends a lot of time up there and then come out here? What happens a thousand years from now? They say in a million years.

They use all these big numbers that I don't understand. I'm only going to be getting 89 millirems a year at the twelve-mile line.

I want [to] know who thinks they could predict anything that's going to happen in a million years. These guys can't even tell us what's going to happen in ten years.

I do -- work for a lot of different companies because I'm one of those folks who come out here as a protester and found myself being here, so I do groundwater remediation work.

I worked at the Federal Building down there. I'm the guy that goes out and lays the hoses and the PVC pipe and making systems go that clean the groundwater under Las Vegas, and I see how they're supposed to have us trained to deal with this stuff, and when they dump it into the wash, that water is barely cleaner than when we pulled it out.

It's contaminated from the leaking gasoline tanks, from the diesel fuel, from the chemical plants, and all that stuff's happening in the last twenty years, and now you folks want us to believe that you can tell us what's going to happen 10,000 years from now?

Response

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 100,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency (40 CFR Part 197).

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed in accordance with 40 CFR Part 197 to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than those resulting from natural background radiation (see Table 5-11 of the EIS for details).

With regard to differences between the Environmental Protection Agency and Nuclear Regulatory Commission protection standards, Section 801 of the Energy Policy Act of 1992 requires the Agency to set standards for the protection of public health and safety from releases from radioactive materials stored or disposed of at Yucca Mountain. The Agency issued a proposed rule (64 *FR* 46976) on August 27, 1999. The final rule, 40 CFR Part 197, was issued on June 13, 2001.

The Energy Policy Act of 1992 requires the Nuclear Regulatory Commission to publish final criteria for licensing consistent with the radiation protection standards set by the Environmental Protection Agency no more than 1 year after the Agency publishes its final rule. The Commission published a proposed rule (64 *FR* 8640, February 22, 1999) before the Agency published its proposed rule. As noted by this comment, the Commission rule was less stringent in some ways than that proposed by the Agency. However, in conformance with the Energy Policy Act of 1992, the Commission has issued a final rule (10 CFR Part 63) that establishes licensing criteria for the proposed geologic repository at Yucca Mountain, including a radiation protection standard, that are consistent with the radiation protection standards in the final Agency rule (40 CFR Part 197).

With regard to potential impacts of the Proposed Action on animal life, as discussed in Section 10.1.1.4 of the EIS, adverse impacts on regional populations of animals, including the desert tortoise, would be minimal and largely undetectable in part because the impacts would be restricted to a small area and the animal species found at Yucca Mountain are widespread throughout the region. Traffic and other site characterization activities during about 1991 to 1995 had no detectable effect on populations of desert tortoises and other animals monitored (DIRS 104593-CRWMS M&O 1999). Five desert tortoise deaths have been attributed to site characterization activities. The U.S. Fish and Wildlife Service issued a Biological Opinion (DIRS 104618-Buchanan 1997) that site characterization activities, which were similar in type and scope to the Proposed Action, would not jeopardize the continued existence of the Mojave population of the desert tortoise. The Final Biological Opinion for repository activities was issued in 2001 (see Appendix O of the EIS).

DOE acknowledges that it is not possible to predict with certainty what will occur hundreds or thousands of years in the future. However, DOE's confidence in the disposal techniques is based on defense-in-depth that, for example, placing drip shields over waste packages to account for uncertainties. DOE has adopted an assessment approach that explicitly considers the spatial and temporal variability and inherent uncertainties in geologic and biological components. The bases of the approach are summarized as follows:

1. The site description is based on extensive underground exploratory studies and investigations of the surface environment.

2. The reference design is based on laboratory investigations and conceptual engineering studies.

3. Features, events, and processes that could effect the long-term safety of the repository are identified.

4. Evaluation of a wide range of exposure scenarios, including the normal evolution of the disposal system under the expected thermal, hydrologic, chemical, and mechanical conditions; altered conditions due to natural processes such as changes in climate; human intrusion or actions such as use of water supply wells, irrigation of

crops, and exploratory drilling; and low-probability events such as volcanoes, earthquakes, and nuclear criticality.

5. Development of alternative conceptual and numerical models to represent the features, events, and processes of a particular scenario and to simulate system performance for that scenario.

6. Parameter distributions to represent the possible change of the system over the long term and use of conservative assessments that lead to over estimation of impacts when there is insufficient information for use of a probability distribution.

7. Performance of sensitivity analyses.

8. Extensive peer review and oversight.

DOE believes this process results in a representative estimation of impacts and is sufficient for comparing the relative merits of the various repository scenarios.

DOE continues to evaluate the sufficiency of its approach of dealing with uncertainty at the process level (scientific) as well as the system level (modeling). A task force is reviewing and outlining further work to be completed on uncertainties before the time of License Application, should the repository be recommended and approved as a suitable site.

7.5.7 (926)
Comment - EIS000122 / 0001
The gentleman that spoke earlier up here at the table, I believe he said one rem 1,000 would kill people with cancer, might get in 1,000. I beg to differ with him.

One rem exposure, you will get cancer one person in 250. If ten rems of exposure, one in 25 would get lethal cancer.

Response
As explained in Section 3.1.8 of the EIS, National and international advisory organizations such as the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection have established estimates of the risk of latent cancer fatality from exposure to ionizing radiation. The Federal agencies responsible for dealing with exposures to radiation, including the Nuclear Regulatory Commission and DOE, have accepted the Council and Commission estimates and use them in their calculations of risk. For members of the general public the accepted dose-to-risk conversion factor is 1 latent cancer fatality per 2,000 rem of ionizing radiation received by an exposed population (0.0005 latent cancer fatality per rem). For workers the dose-to-risk conversion factor is 1 latent cancer fatality per 2,500 rem of ionizing radiation received by an exposed population. DOE used these factors in the EIS to estimate human health impacts from exposure to ionizing radiation.

7.5.7 (965)
Comment - EIS000268 / 0003
The DEIS fails to explicitly acknowledge the deadly nature of spent nuclear fuel (SNF) and high-level radioactive waste (HLW). Nevada's 1995 scoping comments recommended: "The radiological consequences of exposure and contamination and associated with each reference fuel type should be presented in terms understandable to the general public, and these consequences should be presented in the Executive Summary as well as in the body of the draft EIS." DOE has chosen to ignore Nevada's recommendation.

The DEIS barely discusses the radiological hazards of SNF. The Executive Summary states that spent nuclear fuel "consists mostly of uranium, and is usually intensely radioactive because it also contains a high level of radioactive nuclear fission products." [p. S-4] Volume 1 states that spent nuclear fuel "is intensely radioactive in comparison to nonirradiated fuel." [p. 1-6] Except for identifying cesium-137 as a major source of SNF preclosure impacts and shielding requirements. [p. A-9] Appendices A, F, and J provide little specific information on the hazards of SNF.

How dangerous is spent nuclear fuel? Specifically, how dangerous to human health is DOE's designated "typical fuel type," [p. A-14] a 26 year-old PWR spent fuel assembly with 39,560 MWd/MTHM burnup and 3.69 percent

U-235 initial enrichment? The DEIS fails to provide a technically accurate answer in language understandable to members of the affected public along the transportation corridors to Yucca Mountain.

Nevada's final comments will provide a detailed assessment of the full range of SNF and HLW irradiation and contamination consequences, expressed in the language of the health physics profession, complete with outputs from the ORIGEN2, RADTRAN, and RISKIND computer codes. Today we attempt to speak plainly, and conclude our preliminary analysis with the following observations.

The DEIS should have taken a conservative approach to radiological health effects by basing its evaluation on transportation 5 or 10 year-old SNF. DOE chose instead to evaluate 26 year-old SNF, which is considerably less dangerous. But even 26 year-old SNF is extremely dangerous. A person standing or sitting next to a single, unshielded 26 year-old SNF assembly for the amount of time that I have spoken this morning would receive a radiation exposure sufficient to cause death in 50 percent of the population. Extend the time to ten minutes, and death from classic radiation sickness replaces concern about latent cancer fatalities.

It works like this. Even after 26 years of cooling, the typical PWR assembly described in the DEIS contains 31,000 curies of cesium-137 and 21,000 curies of strontium-90, and is a powerful source of penetrating gamma and neutron radiation. Based on other DOE references, we estimate the surface dose rate to be at least 10,000 rem per hour, or about 166 rem per minute. A person standing or sitting next to an unshielded PWR assembly would receive at least 100 rem per minute.

How does the human body respond to such acute exposures? After one minute, mild symptoms of radiation sickness might appear, including vomiting and blood chemistry changes. After two minutes, vomiting and blood changes would definitely be expected, and cancer risk would approximately double. After six minutes, one could expect vomiting within three hours, followed by hair loss, and 50 percent probability of death within two months from hemorrhage or infection. After 10 minutes or more, vomiting would be expected within one hour, followed by severe blood changes, hemorrhage, infection, loss of hair, damage to bone marrow, and 80 to 90 percent probability of death within two months. The lucky few survivors would look forward to many months or even years of convalescence.

Response

DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A.2.1.5. The revised fuel now used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel that could be received at the repository (5 years old) would produce impacts about three times higher than the representative fuel selected for the analysis. It should also be noted that accidents involving transportation casks and waste packages would not involve only the hottest fuel since licensing limitations preclude loading these containers with only the hottest fuel.

Appendix A of the EIS reports the expected radionuclide inventory in curies for contributing radionuclides for both "average" fuel used to estimate total repository inventory and "representative" fuel used for transportation and repository preclosure accident analysis. Tables A-9, A-10, A-12, and A-13 list these values on a per assembly basis, and Table A-11 lists the total projected number of curies by isotope for the Proposed Action and the additional inventory modules. The EIS analysis did not require surface dose rates for irradiated fuel, so Appendix A does not provide them. For transportation impacts, the EIS conservatively uses the U.S. Department of Transportation surface dose rate limit for all transportation casks when calculating incident-free risk impacts to the public. In addition, none of the severe accidents evaluated in a recent Nuclear Regulatory Commission report

(DIRS 152476-Sprung et al. 2000) would result in a release of spent nuclear fuel assemblies from their shipping casks or a direct exposure to the public. For repository operations, DOE estimated personnel exposures for various activities from shielded elements based on the representative fuel assemblies during normal operations and postulated accidents. In summary, the EIS analysis included all appropriate information required to assess impacts from the spent nuclear fuel and high-level radioactive waste.

7.5.7 (1132)
Comment - EIS000270 / 0016
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Inadequate consideration of the traditional basis of risk acceptance: that, for any additional dose above naturally-occurring background radiation, the individual recipient shall obtain a benefit greater than or commensurate with the added risk incurred and shall have the option of refusing the additional dose.

Response
The Environmental Protection Agency has responsibility for setting applicable standards for Yucca Mountain. The Nuclear Regulatory Commission has responsibility for modifying technical standards for the repository to be consistent with the Environmental Protection Agency standards. The Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective dose of 15 millirem per year for Yucca Mountain. This level of exposure would, using the recommended risk factors discussed above (0.0005 latent cancer fatality per rem or 1,000 millirem), would represent a risk of contracting a fatal cancer of 8 chances in a million for 1 year of exposure or about 5 chances in 10,000 for a lifetime (70 years) of exposure. For comparison, based on the most recent statistics, individuals living in the United Stated have about a 1 in 4 chance of dying of cancer from all causes (DIRS 153066-Murphy 2000).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than one chance in 100 million (see Table 5-6). This incremental level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes and far below that which people consider important to their everyday decisionmaking process (see Section F.1.1.5 for a discussion on risk perspectives). DOE believes that the benefits of safely isolating spent nuclear fuel and high-level radioactive waste from the accessible environment far out weigh the very small levels of additional risk associated with the long-term performance of the Proposed Repository.

7.5.7 (1133)
Comment - EIS000270 / 0018
Factors that give rise to public concerns about and opposition to approval of the Yucca Mountain site include:

Use of high costs to the generators of nuclear waste as a justification for relaxations of health and safety requirements.

Response
DOE has not proposed to amend its general guidelines (10 CFR Part 960) to mitigate the high costs to generators. Rather, the purpose of the new Yucca Mountain-specific guidelines (proposed 10 CFR Part 963) is to implement the NWPA, consistent with the current regulatory framework and technical basis for assessing the ability (or performance) of a geologic repository to isolate spent nuclear fuel and high-level radioactive waste from the environment.

Section 112(a) of the NWPA directs the Secretary of Energy (and by extension, DOE) to issue general guidelines for the recommendation of sites for characterization, in consultation with certain Federal agencies and interested

Governors, and with the concurrence of the Nuclear Regulatory Commission. These guidelines (issued in 1984 at 10 CFR Part 960) were to include factors related to the comparative advantages among candidate sites located in various geologic media, and other considerations such as the proximity to storage locations of spent nuclear fuel and high-level radioactive waste, and population density and distribution.

In 1987, amendments to the Nuclear Waste Policy Act specified Yucca Mountain as the only site DOE was to characterize. For this reason and given advancements in site characterization, DOE proposed in 1996 to clarify and focus its 10 CFR Part 960 guidelines to apply only to the Yucca Mountain site (proposed 10 CFR Part 963), but never issued these guidelines as final. In 1999, DOE proposed further revisions to the Part 963 guidelines for three primary reasons:

1. To address comments that criticized the omission of essential details of the criteria and methodology for evaluating the suitability of the Yucca Mountain site

2. To update the criteria and methodology for assessing site suitability based on the most current technical and scientific understanding of the performance of a potential repository at the Yucca Mountain site, as reflected in the DOE report, *Viability Assessment of a Repository at Yucca Mountain* (DIRS 101779-DOE 1998)

3. To be consistent with the then-proposed site-specific licensing criteria for the Yucca Mountain site issued by the Nuclear Regulatory Commission (the Commission has since finalized these criteria at 10 CFR Part 63), and the then-proposed site-specific radiation protection standards issued by the Environmental Protection Agency (the EPA has since finalized these standards at 40 CFR Part 197)

In 2001, after the Agency's 40 CFR Part 197 and the Commissions 10 CFR Part 63 were finalized, DOE finalized its 10 CFR Part 963 guidelines.

DOE has modified Chapter 11 of the EIS to reflect the current status and content of the Department's site suitability guidelines.

7.5.7 (1139)
Comment - EIS000270 / 0026
To remedy DOE's misguided nuclear waste disposal policy, and to achieve the safest management and isolation of all radioactive materials and wastes, the Sierra Club strongly urges adoption of the Precautionary Principle by the Department of Energy.[1] This Principle is variously defined but in essence states: "Until a practice or substance is proven safe, it should be treated as though it is unsafe."

Unquestionably, ionizing radiation is not safe for living beings; the Linear Hypothesis of Dose and Response remains basic to radiation Standards. The Precautionary Principle helps us to avoid potentially dangerous impacts of substances that are persistent, toxic, and liable to bioaccumulate even when there is little scientific evidence to prove the strength of the causal link between release and effects.

The Precautionary Principle also implies that decision-makers should act in advance of scientific certainty to prevent harm to humans and the environment. In Canada, this principle has been expanded to cover all government policies with the potential to degrade the environment. The Bergen Declaration states, in part:

.....[P]olicies must be based on the Precautionary Principle. Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

This reasoning underscores the necessity of halting the accumulation of nuclear waste. It then follows:

- the task of the Department is to halt its relentless drive for approval of the inadequate Yucca Mountain site;

- explain to the Congress why it should not proceed;

- and give serious reconsideration to finding the least dangerous, most equitable methods of retaining control of all the radioactive wastes required to be disposed of in a regulated facility, in a manner that will best assure that future populations will have an opportunity equal with our own to be able to continue to maintain control for the duration of its hazardous lifetime.

[1] Wingspread Statement on the Precautionary Statement http://www.wajones.org/wajones/wingcons.html; Also see *Protecting Health & the Environment: Implementing the Precautionary Principle* edited by Carolyn Raffensperger and Joel Tickner, Island Press, 1999).

Response
DOE believes that precautionary measures should be taken especially where cause and effect relationships are not fully understood. For example, DOE uses the linear no-threshold hypothesis for estimating effects of exposure to low levels of ionizing radiation, where there is no definitive scientific evidence that ionizing radiation has an adverse effect. Note that exposure to natural background radiation is in the range of 300 millirem per year. The linear no-threshold hypothesis states the stochastic (that is, effects having a probability of occurrence rather than a threshold) cause and effect relationship of radiation noted at high doses and dose rates, namely cancer, are also presumed to occur at low doses and/or low dose rates. For purposes of radiation protection, national and international advisory groups, including the National Academy of Sciences, National Council on Radiation Protection and Measurements, and International Commission on Radiological Protection have recommended that it is both prudent and conservative to apply high dose or dose rate evidence to those situations where low doses or low dose rates may be received. DOE and other Federal agencies, including the Environmental Protection Agency and the Nuclear Regulatory Commission, have accepted the recommendations of these advisory groups for purposes of radiation protection and for making estimates of the risk from ionizing radiation exposure, adopting the linear, no-threshold hypothesis for estimating health effects from exposure to low levels of ionizing radiation.

With regard to this comment's suggestion that "...lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation," the National Academy of Sciences concluded that: "...[the] better safe than sorry... philosophy holds true only when unlimited resources are available to protect the public health and the environment. Once resources are acknowledged to be limited, overestimates of a particular risk are ultimately harmful to the public health because funds are diverted from larger risks to protect society from smaller risks. This diversion of funds ultimately will result in greater mortality than would have occurred if resources were spent in proportion to the amount of health benefit that would be achieved" (DIRS 154539-National Research Council 1995). The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the maximally exposed individual of less than 0.0001 millirem (see Table 5-6), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than one chance in 100,000,000 (see Table 5-6). This incremental level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes and far below that which people consider important to their everyday decisionmaking process (see Section F.1.1.5 for a discussion on risk perspectives). DOE believes that the benefits of safely isolating spent nuclear fuel and high-level radioactive waste from the accessible environment far outweigh the small levels of additional risk associated with the long-term performance of the proposed repository.

With regard to the commenter's suggestion that DOE stop efforts to gain approval for a repository at Yucca Mountain, Congress specifically directed the Secretary of Energy to characterize and evaluate the Yucca Mountain site for suitability as a geologic repository. Through the NWPA, Congress established a process that will lead to a decision by the Secretary of Energy on whether to recommend to the President approval of the Yucca Mountain site for the development of a repository.

7.5.7 (1392)
Comment - EIS000418 / 0002
Considering that the half-life decay period of U-235 is 5,000 years, a 1 in 7,000 chance over 10,000 years would mean that those odds would hold BEFORE half of a given volume of Uranium would decay to lead. That presents a 1 in 7,000 risk of exposure at unsafe levels of radioactivity to the environment.

Response
The half-life of uranium-235 is about 700 million years (the half-life of uranium-238 is about 5 billion years). Over 10,000 years the probability that a given atom of uranium-235 will decay is about 1 in 100,000. DOE considered the contribution of the uranium isotopes (mainly uranium-234, -235, and -238) to the radiation doses that workers and members of the public could receive. In all cases, uranium isotopes (mainly because of their long half-lives and low radioactive decay rates) would be minor dose contributors in comparison to other radionuclides.

7.5.7 (1707)
Comment - EIS000640 / 0001
You know those animals that come from near Yucca Mountain, near the Nevada Test Site, those are animals we [Western Shoshone] eat. I mean, they might sound repugnant to you, but we eat squirrels and deer and gophers, and way back when we might have eaten snakes and whatever. But those are animals that do not know the boundaries of the little easement that you are going to put alongside the railroad. Those are animals that we're going to consume. And no one has put a study together to tell us about the long risk that we are going to have to take when we consume those animals. Those animals are part of our heritage. And no one has bothered to study what is happening to us because of our traditional foods.

Response
During the period of construction, operation and monitoring, and closure at the proposed Yucca Mountain Repository, the only radionuclides that expected to be released would be naturally occurring radon and radon decay products, and noble gases. Of these, only radon decay products have the potential to accumulate in the environment in the edible portions of animals that might live in the land withdrawal area. The consumption of meat accounts for about 5 percent of the dose from radon and radon decay products [using the dose screening factors described in Section G.2 of the EIS (see DIRS 101882-NCRP 1996)], assuming that the animals are at the same location as the person being exposed. If these animals roamed in the land withdrawal area closer to the repository, the concentration in meat could increase by as much as a factor of 5. The overall dose to a person living at the land withdrawal boundary could increase by about 20 percent. For the year of highest exposure this would represent an increase in dose from 1.3 millirem per year to about 1.6 millirem per year. No adverse radiation-related health impacts would be likely at these levels of exposure. DOE based this estimated increase on the consumption of 100 kilograms (220 pounds) of meat per year and the assumption that the radionuclide uptake in wild animals can be represented by domestic animal uptake.

In addition, the updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197. These dose estimates considered the food consumption habits of the potentially exposed population in Amargosa Valley including those of the Native Americans.

7.5.7 (2217)
Comment - EIS000621 / 0007
Will the radiation levels in our area be monitored?

Response
Routine monitoring of transportation routes would not likely be performed. A release of radioactive material would be unlikely to occur during transportation activities. In the unlikely event that contamination was discovered on the external surface of a shipping cask, DOE would evaluate the potential for spread of contamination and, if necessary, monitor and contain contamination along the transportation route as part of the response plan. In the unlikely event of an accident involving the transportation of spent nuclear fuel or high-level radioactive waste, the response plan would include environmental monitoring in the vicinity.

7.5.7 (2603)
Comment - EIS001257 / 0003
The risks to health and life are unacceptable due to the possible contamination of the groundwater and our environment. Your own evaluation states transportation of this material will result in approx. 18 latent deaths a year. Any number of deaths per year related to this disposal of nuclear waste is completely unacceptable.

Response
DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency's environmental protection standards (40 CFR Part 197) and Nuclear Regulatory Commission's licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-34 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 10 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the exposed populations over a 340-year period. Similar estimates have been made for impacts to populations potentially exposed over 10,000 years (see Table 5-7).

With regard to health impacts associated with transportation, the analysis presented in the EIS estimates that 3 additional latent cancer fatalities could occur under the most hazardous transportation scenario (mostly truck).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (2653)
Comment - EIS000409 / 0010
The health effects as well as the stress is incalculable. What $ figure can be placed on the genetic changes, mental retardation etc. to our future generations? How many billions of dollars is spent on cancer treatments? We'd like to see estimated costs on the cancers that will occur. (numbers anticipated from YM project from all 43 state[s])

Response
DOE agrees that the potential public health impacts associated with the repository are important and thus has estimated a range of impacts to potentially exposed individuals and populations from both operational and accident scenarios. The health impacts caused by psychological stress rather than physical effects, however, are too attenuated to establish a clear causal relationship and cannot be calculated.

As pointed out in this comment, it is generally recognized that, in addition to fatal cancers, other health effects could result from exposure to radiation. Therefore, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) suggested use of detriment weighting factor which take into consideration the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancer and heredity effect. However, as discussed in Section F.1.1.5, since both of these life-detriment factors, when taken together, are less than half of the fatal cancer risk, DOE has chosen to estimate total cancer fatalities as the major potential health effect from exposure to radiation.

With regard to estimating the cost of treating cancers that may result from activities discussed in the Final EIS, it should be pointed out that even under the most hazardous transportation scenario (mostly truck) the estimated incremental increase in cancer fatalities (about 3 deaths over the 24-year shipping campaign) represents an increase over the natural occurrence of cancer fatalities from all causes of less than 0.0002 percent in the exposed population of 7.2 million. In addition, as discussed in Section K.4, the large uncertainties associated with predicting adverse health impacts from very low dose cannot preclude the possibility that no additional cancer deaths may occur. Further, the cost associated with treating this small number of additional cancers would be very small in comparison to the health care cost for the 7.2 million potentially exposed individuals and therefore would not provide useful information for the decisionmakers.

7.5.7 (2867)
<u>Comment</u> - 010096 / 0024
Pages 3-4, 3-10, and 3-11 – The SDEIS indicates that S&ER Design fatalities from air quality, occupational health and safety and accidents will increase from a low of 1.82 to 3.8 deaths. It is not clear that the long-term performance benefits from a latent cancer fatality standpoint are greater than the increase in short-term deaths. In fact, Table 3-14 does not even address latent cancer fatalities. As a consequence, it is not possible within the SDEIS to conclude whether the S&ER flexible design is better from a fatality perspective. This is a critical shortcoming of the SDEIS.

<u>Response</u>
As noted on page 3-1 of the Supplement to the Draft EIS, the intent of presenting the "...primary impact indicators enables a comparison between the impacts of the flexible design and those [impacts] presented in the Draft EIS." The flexible design presented in the Supplement to the Draft EIS was carried forward to the Final EIS. The overall increase in the number of fatalities for the flexible design as noted in the comment is due mainly to the increase in the length of the project and the corresponding increase in the total number of workers needed to complete the project over the longer time period. The potential radiation dose or risk to any individual member of the public or of the workforce does not increase under the flexible design, shown in Section 4.1.7.5 of the Final EIS.

A similar comparison is made for long-term performance. Table 3-14 of the Supplement to the Draft EIS lists long-term performance impact indicators that show impacts from the flexible design to be lower than those of the Draft EIS thermal load scenarios. Individual doses are used in the Supplement to the Draft EIS to allow comparison between the thermal load scenarios of the Draft EIS and the flexible design. Table 3-14 shows the individual doses under the flexible design to be lower in every case. By extension, the number of potential latent cancer fatalities—although very low in every case—from the flexible design would also be lower than for the Draft EIS thermal load scenarios. Population impact estimates for long-term performance under the flexible design are provided in Chapter 5 of the Final EIS, similar to those shown in Chapter 5 of the Draft EIS.

DOE believes that information provided in the Final EIS on short-term and long-term health impacts and latent cancer fatality risks are sufficient for current decisionmaking.

7.5.7 (3038)
<u>Comment</u> - EIS000539 / 0003
The DEIS does not acknowledge the lethal nature of the waste and fails to provide sufficient information on the radiological characteristics of highly irradiated nuclear fuel. An adequate environmental review of the proposed repository program must absolutely address the deadly nature of the waste to be shipped and buried. Yet DOE barely touches on the radiological risks imposed by highly irradiated nuclear fuel.

Information on the total activity and curies and the surface dose rate in rems per hour of the assemblies of irradiated fuel is essential for the assessment of risk proposed by the transportation and burial of radioactive waste. Yet DOE does not provide such data.

For example, one unshielded assembly of the sort to be buried at Yucca Mountain would have enough radiation to give a person standing next to it a dose of at least 100 rem per minute, meaning that with 10 minutes' exposure, the person would almost certainly be doomed to death within two months. This would be a rather quick but certainly not painless death.

<u>Response</u>
DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and potentially deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

Appendix A of the EIS reports the expected radionuclide inventory in curies for contributing radionuclides for both "average" fuel used to estimate total repository inventory and "representative" fuel used for transportation and repository preclosure accident analysis. Tables A-9, A-10, A-12, and A-13 list these values on a per assembly basis, and Table A-11 lists the total projected number of curies by isotope for the Proposed Action and the additional inventory modules. The EIS analysis did not require surface dose rates for irradiated fuel, so Appendix A does not provide them. For transportation impacts, the EIS conservatively uses the U.S. Department of Transportation surface dose rate limit for all transportation casks when calculating incident-free risk impacts to the public. In addition, none of the severe accidents evaluated in a recent Nuclear Regulatory Commission report (DIRS 152476-Sprung et al. 2000) would result in a release of spent nuclear fuel assemblies from their shipping casks or a direct exposure to the public. For repository operations, DOE estimated personnel exposures for various activities from shielded elements based on the representative fuel assemblies during normal operations and postulated accidents. In summary, the EIS analysis included all appropriate information required to assess impacts from the spent nuclear fuel and high-level radioactive waste.

7.5.7 (3130)
<u>Comment</u> - EIS000726 / 0022
There is no mention of the impacts to the dairy at Amargosa Valley, nor of the impacts caused by or to the electronic battlefield that Fallon NAS operates along one of the transportation routes. I question the safety of nuclear waste shipments made through an electronic battlefield.

<u>Response</u>
Section 3.1.1.1 of the EIS acknowledges there is farming and dairy operations about 30 kilometers south of the proposed repository in the Amargosa Valley. DOE has assessed the potential health and safety issues, for all applicable environmental pathways for the repository, in Chapter 4 of the EIS.

With regard to the potential impacts caused by or to the electronic battlefield operated by the Fallon Naval Air Station, DOE does not consider the possibility of an aircraft crash, commercial or military, on a truck or train carrying spent nuclear fuel or high-level radioactive waste to be credible except at an intermodal transfer facility. Such an event (discussed in Section J.3.3.1) of the EIS would not result in a release of radioactive materials.

For a description of operations at the Naval Station Fallon, the reader is referred to the Final Impact Statement, Withdrawal of Lands for Range Safety and Training Purposes Naval Air Station Fallon, Nevada, Department of the Navy, May 1998.

7.5.7 (3312)
Comment - EIS001085 / 0002
The DEIS lacks some very basic radiological information of the site. For the purpose of future reference and comparison, the DEIS should be revised to include the following baseline background information:

1. The average and ranges of natural occurring radionuclide concentrations (U-238/Ra-226 [uranium-2381/ radium-226]) of the repository rocks.

2. The average and ranges of background external radiation levels inside and outside the ESF.

Response
Section 3.1.8 of the EIS has been revised to incorporate the requested information.

7.5.7 (3319)
Comment - EIS001000 / 0007
High-level radioactive waste contains tritium [radioactive hydrogen]. Radioactive and nonradioactive hydrogen is like Houdini. It can and does escape easily.

Scientists and health physicists and doctors have not yet learned everything they need to know about the hundreds of different man-made isotopes that are being created in nuclear power plants.

Response
Table A-11 of the EIS lists the estimated quantities of tritium in spent nuclear fuel at the time of emplacement. Those estimates indicate an overall tritium content of about 15 million curies. Releases of tritium during the period of repository operation would be limited to the number of commercial fuel rods with intact cladding that fails during this period which would be expected to be a very small number if not zero. As the commenter points out, other fuel types (for example, DOE spent nuclear fuel and a small amount of commercial spent nuclear fuel) would not be a source because of the tritium in these fuel type would have escaped at the time of cladding failure.

In addition, most of the tritium released during handling would remain in the water of the spent nuclear fuel handling basins (DIRS 104508-CRWMS M&O 1999).

For postclosure releases of radionuclides, DOE estimates that no radioactive material would reach the affected environment for many thousands of years. Since tritium has a 12.3-year half-life, its radioactivity would be reduced by about a million times every 250 years, so it would have decayed to insignificant levels before it could reach the accessible environment. Thus, it would not be a significant contributor to postclosure dose.

There is an extensive body of knowledge about the physiological effects of fission products and other radionuclides generated in spent nuclear fuel during reactor operations. DOE applied that knowledge to estimate health effects for a proposed repository at the Yucca Mountain site. The Department used the best available information and accepted methodologies to produce conservative best estimates (not underestimates) of health effects associated with a repository at Yucca Mountain.

7.5.7 (3596)
Comment - EIS000715 / 0006
It is vital that the DOE honestly characterize the potential impacts of groundwater contamination. The residents of the Amargosa Valley rely on the groundwater that runs beneath Yucca Mountain for drinking, washing, and irrigation. The cumulative effect of contaminated groundwater on these residents would be great. The DOE fails to adequately identify those who would be most severely affected by radiological contamination of groundwater. The DEIS identifies the “critical group reference person” as an adult who lives year round in Amargosa Valley, uses a well as a primary water source, and lives in a manner similar to a typical inhabitant of Amargosa Valley (p. 5-14). The DEIS should instead identify the maximally exposed individual (MEI) person as a fetus in the womb of a subsistence farmer in the Amargosa Valley region because this fetus would more accurately represent the individual whose health will be most at risk from groundwater contamination.

Response
Environmental Protection Agency rules (40 CFR Part 197) and Nuclear Regulatory Commission rules (10 CFR Part 63) specify protection of the individual as the standard of safety for the proposed Yucca Mountain Repository.

The Final EIS does not use the "critical group reference person." Rather, DOE uses the definition of the reasonably maximally exposed individual (RMEI) given at 40 CFR 197.21, which defines the individual as a hypothetical person who could meet the following criteria:

"(a) Has a diet and living style representative of the people who are now residing in the Town of Amargosa Valley, Nevada. DOE must use the most accurate projections, which might be based upon surveys of the people residing in the Town of Amargosa Valley, Nevada, to determine their current diets and living styles and use the mean values in the assessments conducted for Sections 197.20 and 197.25."

"(b) Drinks 2 liters (0.5 gallon) of water per day from wells drilled into the groundwater at the location where the RMEI lives. "

The location of the reasonably maximally exposed individual described in 40 CFR Part 197 would be where the predominant groundwater flow path crosses the southern boundary of the Nevada Test Site which coincides with the southern boundary of the controlled area as defined in the regulation. This point is approximately 18 kilometers (11 miles) from the proposed repository. DOE has concluded that it is not necessary to analyze in the Final EIS a hypothetical individual at locations closer than approximately 18 kilometers (11 miles) to the repository because it is unreasonable to assume that anyone would reside in this area, for these reasons:

- An individual would need to install and operate a water well in volcanic rock at more than 360 meters (1,200 feet) deep to reach the water table at costs significantly above (and likely prohibitive) those that would be incurred several kilometers farther south of the repository where the water tables lies less than 60 meters (200 feet) beneath the surface through sand and gravel

- Locations closer than about 18 kilometers (11 miles) are within the controlled area defined in the Environmental Protection Agency standard for a Yucca Mountain repository and therefore not in the postclosure accessible environment defined by the Agency.

The updated analysis in the Final EIS estimates potential groundwater impacts reported for the compliance point prescribed in 40 CFR Part 197 [about 18 kilometers (11 miles) from the proposed repository]. As part of a comprehensive presentation of impacts, this EIS is charged with providing groundwater impacts for two other important down gradient locations. These are 30 kilometers (18 miles), where most of the current population in the groundwater path is located, and 60 kilometers (37 miles) where the aquifer discharges to the surface (this location is known as Franklin Lake Playa). This analysis indicates that for the first 10,000 years there would be only very limited releases, attributable to a small number of early waste package failures (zero to three, and possibly as many as five) due to waste package manufacturing defects, with very small radiological consequences (see Table 5-6). For the first 10,000 years after repository closure, the mean peak annual receptor would be thousands of times less than the Environmental Protection Agency individual protection standard (40 CFR 197.20), which allows up to 15-millirem-per-year dose rates during the first 10,000 years. The peaks would be even smaller at greater distances.

A fundamental objective of radiation protection is the limitation of lifetime risk to an individual in the exposed population. As noted in Section F.1.1.5 of the EIS, cancer is the principal potential risk from exposure to low or chronic levels of radiation. The EIS provides estimates of latent cancer fatalities for the general population and for workers based on risk coefficients adopted by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993). The risk coefficients depend on age. The risk factor for the general population is higher than that for workers due to the inclusion of children in the population group, while the worker group includes only people older than 18.

Section II.B of the preamble to the Environmental Protection Agency's regulations at 40 CFR Part 197 addresses health risks to sensitive subgroups of the potentially exposed population, including the embryo-fetus and children. The Agency notes that the fetus is more sensitive to radiation than adults and that the sensitivity is greatest from 8 to

15 weeks following conception. Article II.B provides the following lifetime risk factors for cancer and hereditary effects:

- 0.000575 per rem for fatal cancers for the general population
- 0.0003 per rem for fatal childhood cancers, from exposure in the fetal stage
- 0.0001 per rem for severe hereditary effects in offspring

The risk factors for childhood cancers and hereditary effects are smaller because the period of increased sensitivity is much shorter. Hence, at a constant exposure rate, fatal cancer in the general population remains the dominant factor.

There are a number of reasons why the embryo-fetus is not suitable as the hypothetical reasonably maximally exposed individual:

- The embryo-fetus is exposed for at most 9 months, compared to 70 years of exposure for an individual.

- The body of the mother protects the embryo-fetus. Many radionuclides are excreted or go first to the organs of the mother. Many particulate radionuclides do not cross the placental barrier.

- 40 CFR Part 197 and 10 CFR Part 63 do not include attributes of the embryo-fetus in the radiation protection rules.

- The database of scientific information on placental transfer of radionuclides and their concentrations and dosimetry in the human embryo-fetus is not extensive, and there are a number of unknowns and uncertainties about this information (DIRS 157140-NCRP 1998). As a basis for comparison, the National Council on Radiation Protection and Measurements recommends a dose limit of 50 millirem per month to protect the embryo-fetus of occupationally exposed women (DIRS 101856-NCRP 1993).

7.5.7 (4111)
Comment - EIS001476 / 0004
I also want to mention that it's not an isolated area. It's not desolate. Within a 20-mile radius there are about 50,000 people. If there was, like the DOE scientists themselves in 1995 reported that high-level radioactive waste in the repository could reach -- well, there goes all these people. And then what about the rest of the people downwind, and what about you and what about your children?

Response
Section 3.1.8 of the Draft EIS estimates the population within 80 kilometers (50 miles) of the repository to be about 28,000 people in the year 2000. Revised population estimates have increased this number, but only to about 34,000. The Final EIS was revised to project an estimated population of about 76,000 in the year 2035, the year considered to be representative of the total population over the time period representing repository construction, operation and monitoring, and closure. Sections 4.1.2, 4.1.7, 4.1.8, and 5.4 of the EIS consider the estimated health impacts of routine operations, accidents at the repository, and long-term repository performance, respectively.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

Very low probability accidents could have higher potential consequences than these very low radiation exposures, but DOE believes that adverse radiation-related health impacts would be highly unlikely in any situation.

7.5.7 (4149)
Comment - EIS001411 / 0001
As an undergraduate student pursuing a career in medicine, I feel that this document poses serious health risks to everyone involved. The Yucca Mountain Nuclear Waste facility should not be built when the DEIS blatantly ignores addressing the public safety threats this facility would impose if it were built.

The conclusion that the US Department of Energy (DOE) reached that supports the construction of the facility lacks substantial rationale. Surely it is preposterous to take the Draft Environmental Impact Statement (DEIS) seriously when it avoided confronting the public safety issues at hand.

As a concerned citizen of the United States of America, I see the construction of such a facility as a massive accident waiting to happen with profound health-related repercussions. I hope that you think not only about the problems that will be incurred a few years down the line, but take into account the threat a facility of this magnitude would impose on America a million years down the line.

Response
The EIS evaluated potential impacts to the environment and to the public resulting from normal operation and from accidents during construction, operation and monitoring, and closure of the proposed repository (see Chapter 4 and Appendixes F and H); from long-term (including 1 million years) repository performance (see Chapter 5 and Appendix I); from incident free transportation and from accidents during transportation of spent nuclear fuel and high-level radioactive waste (see Chapter 6 and Appendix J; from implementing the No-Action Alternative (see Chapter 7 and Appendix K); and considering the cumulative impacts of past, present, and reasonably foreseeable future actions (see Chapter 8).

The EIS evaluated potential exposures to naturally occurring radiological and nonradiological hazardous materials (for example, radon, cristobalite, and erionite) and toxic chemical (chromium) and radiological impacts associated with storage, transportation, handling, emplacement, and disposal of spent nuclear fuel and high-level radioactive waste. Quantitative estimates of these exposures and potential resultant impacts have been presented throughout Chapters 4, 5, 6, 7, and 8. For all cases evaluated in the EIS, the estimated impacts from the release of and exposure to toxic materials have been shown to likely be very small or nonexistent.

7.5.7 (4288)
Comment - EIS001160 / 0096
Page 4-45, Section 4.1.7, does not appear to consider exposure beyond 80 kilometers. The DEIS should indicate whether exposure beyond 80 kilometers is possible and if so, to what extent.

Response
The commenter is correct. The EIS does not consider exposures beyond 80 kilometers (50 miles). Exposures beyond that distance would be possible, but very small. Eighty kilometers is the established precedent for calculating the potential population (collective) dose around a nuclear facility. The National Council on Radiation Protection and Measurements report, *Principles and Application of Collective Dose in Radiation Protection* (DIRS 101858-NCRP 1995), contains a brief history of the development of the 80-kilometer application. The dose to the offsite maximally exposed individual at the southern boundary of the land withdrawal area [about 18 kilometers (11 miles) from the repository] would be no more than 2.5 millirem during the 5-year initial construction period. This dose would be about 3 percent of the 15-millirem-per year regulatory limit at 40 CFR 197.4 and 10 CFR 63.204. At 80 kilometers (50 miles) from the repository, the potential for exposure would be even less.

7.5.7 (4603)
Comment - EIS001202 / 0003
The DEIS expected annual dose to an average individual living 20 km from repository shall not exceed 25 mrem [millirem] from all pathways is still in excess of the 15 mrem that the EPA [Environmental Protection Agency] says is safe. The idea that 25 mrem is expected is totally unacceptable.

Response
At the time the Draft EIS was issued, neither the Environmental Protection Agency (EPA) nor the Nuclear Regulatory Commission (NRC) had finalized their respective Yucca Mountain regulations. At that time, the EPA

was proposing an individual protection standard of 15 millirem per year while the Commission was proposing 25 millirem. However, the Energy Policy Act of 1992 requires the NRC to publish final criteria for licensing consistent with the radiation protection standards set by EPA no more than 1 year after EPA publishes its final rule. The NRC published a proposed rule (64 *FR* 8640, February 22, 1999) before EPA published its proposed rule. As noted by this comment, the NRC rule was less stringent in some ways than that proposed by EPA. However, in conformance with the Energy Policy Act of 1992, the NRC has issued a final rule at 10 CFR Part 63 that establishes licensing criteria for the proposed geologic repository at Yucca Mountain, including a radiation protection standard, that is consistent with the radiation protection standards in the final EPA rule.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by EPA at 40 CFR Part 197.

7.5.7 (4627)
Comment - EIS001433 / 0009
The predicted long-term health consequences of the construction, operation, monitoring and closure of the geological repository are arguably incorrect about yearly predicted cancer fatalities because the figures are based upon data for male subjects, and the more sensitive parts of the population, such as children and pregnant women, are not taken into account. (DEIS F.2.1)

Response
The radiation risk factor for the whole population, which is 1 latent cancer fatality per 2,000 rem of ionizing radiation received by an exposed population (5×10^{-4} per rem), includes all segments of the population, including the more sensitive individuals noted in the comment. Children, who are more sensitive than adults to the effects of radiation (cancer induction), comprise a relatively large part of the population. As a consequence, children are the principal reason the risk factor for the whole population is 25 percent higher than the factor for workers. Although the embryo-fetus is more radiosensitive (with a radiation risk factor about twice that for the whole population), it is protected by the body of the mother and comprises a small part of the whole population. The National Council on Radiation Protection and Measurements recommends a dose limit of 50 millirem per month to protect the embryo-fetus (see DIRS 101856-NCRP 1993). Other types of individuals (pregnant women, the aged, and those with impaired health) are not unduly radiosensitive, especially to low levels of radiation. Impacts to human health from exposure to radiation are discussed in Section F.1.1.5 of the EIS.

7.5.7 (4876)
Comment - EIS000337 / 0016
Pg. 3-79, Section 3.1.8, Occupational and Public Health and Safety: This section is a play on numbers. Public health officials are always trading off for example, the amount of people who will die from a flu shot vs. how many will die if there is no flu shot available. All these calculations are irrelevant if there was a method to keep the flu out of the state. I don’t believe it is the number who will die that is important but the number whose quality of life will be diminished because of the proposed project. This is very difficult, if not impossible, to quantify especially when children and pregnant women are factored into the equation. I saw no data on how the radiation exposure is increased by the concentration of the radiation when cows digest grass that is radiated, drink water and then the milk sold to citizens. Root plants also will concentrate the radiation. I did not find any mention of this in the report.

Response
The purpose of Chapter 3 of the EIS is to describe the affected environment in the vicinity of Yucca Mountain to establish a baseline against which the analyses described in later chapters can measure potential environmental impacts. It does not present analyses of potential impacts from Yucca Mountain activities. Sections 4.1.2, 4.1.7, 5.4, 8.2.2 and 8.2.7 of the EIS describe these analyses.

Radiation-related health effects and a decrease in quality of life would be unlikely from radiation exposures resulting from the Proposed Action. Latent cancer fatality is the principal risk from exposure to ionizing radiation. DOE recognizes the potential for other types of health effects, namely nonfatal cancer and hereditary disorders. Section F.1.1.5 of the EIS discusses the potential for other effects.

Radiation risk factors include potential impacts to children and pregnant women. Pregnant women are no more sensitive to ionizing radiation than other adults. Although the embryo-fetus is more radiosensitive, the body of the mother protects it, so environmental radiation exposures are usually of little concern. The analyses considered the exposure pathways noted by the commenter—vegetation to grass to milk and uptake by plants. The EIS discusses these pathways in Section G.2.4 for repository operations and Section I.4.5.6 for long-term performance assessment.

7.5.7 (4877)
Comment - EIS000337 / 0017
Pg. 2-84 [3-84], Section 3.1.8.3: The discussion focuses on the workers in the tunnel. There is no mention of the workers who are not in the tunnel but will be exposed to the dust from the material removed from the drilling. What is the impact of strong winds moving the material to the public? DOE's position is that they will "use the experience gained during Experimental Studies Facility activities to design engineering controls to minimize future exposures." What does the statement mean? How many will have a reduced quality of life and how many will die? Are these people working for a company who come under SISS?

Response
Chapter 3 of the EIS describes the affected environment in the vicinity of Yucca Mountain to establish a baseline against which DOE can measure potential environmental impacts. The excerpt referred to by the commenter specifically refers to the use of engineering controls to reduce future exposures to dust. These controls are preferable to the use of personal respirators and could include such dust suppression methods as water sprays and ventilation filtration.

Sections 4.1.2 and 4.1.7 describe the potential impacts discussed in this comment. DOE would use engineering and practical experience gained during excavations in the Exploratory Studies Facility to ensure that exposures to workers to during repository operations would be within regulatory limits and as low as reasonably achievable. Sections 4.1.2 and G.1 evaluate surface exposures from excavated material to workers and the public. Overall, worker and public exposure to excavated material would be small fractions of regulatory limits. No deaths or reduction in quality of life would be expected among workers or members of the public from these exposures.

7.5.7 (4967)
Comment - EIS001326 / 0001
My question for you is how can you be sure that we won't all be exposed to radiation and the young engineers in fifty years will have cancer?

I have learned that you will never be positive on the amount of radiation that we might be exposed to. Before even beginning to create such large amounts of nuclear power and storage of radiation you first must be sure that there is no glitches.

Response
Potential health impacts to the workers identified in the comment have been examined in the EIS, except the impacts to workers at the nuclear powerplants. These actions have been evaluated in separate National Environmental Policy Act documents prepared by the Nuclear Regulatory Commission as part of the licensing process for nuclear powerplants. The EIS considered the potential impacts to nuclear plant workers who would load the casks onto trucks or trains for transportation to Yucca Mountain, activities which are related to the repository and therefore within the scope of the EIS. However, occupational radiation exposure at Commission-licensed facilities is monitored and reported in strict accordance with regulations codified at 10 CFR Part 20.

Potential impacts to workers at the repository are discussed in Section 4.1.7 of the EIS while impacts to workers involved in the various aspects of transporting commercial spent nuclear fuel are discussed throughout the health and safety sections in Chapter 6. Workers at Yucca Mountain may be exposed during the period of construction, operation and monitoring, and closure, which could total up to more than 300 years. For purposes of analysis, individual workers were assumed to be occupationally exposed for up to 50 years. Transportation activities for the proposed action were estimated to last 24 years.

The main source of radiation exposure to workers is the penetrating electromagnetic external radiation (gamma rays), not radioactive emissions or contamination from the spent nuclear fuel assemblies. The potential for exposure to radioactive emissions or contamination is very low at Yucca Mountain. If the repository was approved for development, the approval of a license to operate would require strict compliance with occupational radiation protection standards similar to those at 10 CFR Part 20, thus ensuring the health and safety of the radiation workers at the repository.

7.5.7 (5617)
Comment - EIS001887 / 0244
Page 4-58; Table 4-32 - Estimated impacts to workers from industrial hazards for all phases

The statistics shown in this table are based on a DOE worker data base that is not consistent with national labor statistics. The national labor statistics data base should be used because repository construction and operation will best resemble an industrial work environment with an emphasis on daily work production and efficiency, rather than a DOE work environment where meeting production goals is not so closely linked to a profit motive. This approach would be consistent with the analysis approach used in Section 4.1.15, Impacts From Manufacturing Disposal Containers and Shipping Casks.

Response
Table 4-25 of the Final EIS lists values for impacts from industrial hazards for preclosure operations at the proposed repository. DOE used industrial hazard statistics developed from its experience in similar kinds of operations to calculate these values. Tables F-2 and F-3 list the values. Section F.2.2.2 explains that industrial loss statistics were based on DOE rather than industrial experience since there have been no reported fatalities as a result of workplace activities for the Yucca Mountain Site Characterization Project nor are there fatalities listed in the Mine Safety and Health Administration data base for stone mining workers. Because fatalities in industrial operations sometimes occur, the more extensive overall DOE database was used to estimate a fatality rate for the activities at the Yucca Mountain site. DOE would perform preclosure activities at Yucca Mountain under DOE Orders and Directives rather than the approaches followed in industrial construction and mining operations. The loss statistics listed in Table F-3 for site characterization activities at the Yucca Mountain site, which were performed under DOE Orders and Directives, generally agree with the values in Table F-2, which are used to make industrial safety impact estimates.

With respect to operations involved in manufacturing disposal canisters cited by the commenter, DOE would contract the fabrication of canisters to a commercial manufacturer, which would not use the DOE Order system. Therefore, Section 4.1.1.5 of the EIS presents a different set of statistics (based on industrial experience) for the industrial safety impact estimates for the manufacture of shipping casks.

7.5.7 (5618)
Comment - EIS001887 / 0243
Pages 4-44 through 4-60; Section 4.1.7 - Occupational and Public Health and Safety Impacts

Based on the Draft EIS, health impacts to workers and the public from initial construction through continuing construction, operation and monitoring, and eventual closure of the repository are expected to be relatively non-existent. A critical review of this apparent lack of danger to workers and the public reveals a disregard for analytical consistency on the part of the Department of Energy, the application of different measurement standards for workers and the public, and the use of a large number of unverifiable assumptions. The resulting analysis is confusing, at best, to both technicians and the public and provides virtually no basis for a scientifically valid decision making process. For example:

Section 4.1.7.5.1 indicates that only 1.5 to 2.0 worker fatalities related to industrial hazards will occur during the entire 110-120 years of construction, operation, and closure. This is inconsistent with other information in the Draft EIS.

Section 4.1.7.5.2 states that, based on a 50-year work life, impacts to workers in all phases of the repository activities will result in only 2.5-4.0 Latent Cancer Fatalities over 110-120 years. The highest collective dose is estimated to occur in relation to the uncanistered, low thermal load scenario and is calculated at 10,700 person-rem over the 110-120 years of operation. (NOTE: Section 7.1.7, "Short-Term Impacts in the Yucca Mountain Vicinity" indicates a collective dose to workers of 77 person-rem, which is inconsistent with Table 4-33 referenced in this section.)

Section 4.1.7.5.3 summarizes public health impacts in all phases of repository development as resulting in only 0.14-0.41 Latent Cancer Fatalities and indicates that "additional LCFs from short-term activities" will equal less than 0.4 or an increase of 0.01% over the existing average occurrence. Over the full range of construction and operation of the repository, the highest annual dose to the public is identified as 1.5 mrem "or less."

Section 4.1.8.1 informs the reader that, in the event of a catastrophic earthquake, the worst case population exposure would cause only 0.0072 Latent Cancer Fatalities. A summary of exposure statistics for all potential environmental accidents shows that less than 0.02 additional LCFs would occur in the general population.

Section 4.1.15.5.2 illustrates that there will be absolutely no deterioration of worker safety or resulting increase in accidents during the manufacture of disposal containers and shipping casks because there would be no unusual demands on existing facilities.

Section 4.2.1.2.7 states that no health and safety impacts (other than industrial hazards) will occur during the construction sub-period related to retrieval. However, during the 11-year operations sub-period, while industrial hazards will remain about the same for all thermal load scenarios and the LCF for the Maximum Exposed Worker with a total exposure of 6950 millirem will be 0.015, the "calculated LCF" for all workers during retrieval is given as 0.19. During this same period, the Maximum Exposed Individual (MEI) in the public will receive 5.5 mrems, and the LCF is estimated to be 2.8×10^{6}. The "total population" collective dose is listed as 28 "person-rems," with LCFs equaling 0.014. "Exposure to the public for operations only" is noted as 0.1 Latent Cancer Fatalities. Surface and subsurface workers end up with a low 0.003 LCF probability and 0.19 LCFs during the retrieval period.

Section 8.2.7 informs the reviewer that the cumulative impacts of the Nevada Test Site activities and historic dose scenario, combined with whatever impacts will or will not occur as a result of Yucca Mountain activities, will result in "less than 1 additional LCF." Whether this number was calculated in addition to already identified LCFs related to Yucca Mountain and indicates only the increase occurring from NTS is unclear.

Reciting dose numbers and LCF estimates only serve to reinforce the fact that, based on information provided by DOE, it is virtually impossible to determine whether there will, or could be, any measurable worker or public health and safety impacts as a result of the proposed construction and operation of a Yucca Mountain repository. Based on these inadequacies, the State specifically requests a re-draft of the Occupational and Public Health and Safety analysis contained in the Draft EIS.

Existing sections on health and public safety are written in confusing jargon and conflicting technical terminology and do not provide opportunity for the public or decision makers to distinguish between routine radiological risk and radiological exposure risk related to the Proposed Action. The Draft EIS suffers from extensive shortcomings in analytical and statistical methods and serves to overstate DOE's ability to analyze potential radiation effects related to the Proposed Action.

Response
DOE believes that the analysis is internally consistent. Responses to specific comments are presented below.

As discussed in Section 4.1.7.5.1 of the Draft EIS, industrial hazards are those common to any industrial setting. They do not include potential fatalities from radiological or nonradiological, or hazardous substance exposure. The value of 1.5 to 2 is consistent throughout the Draft EIS.

The estimate of 2.5 to 4 radiation-related latent cancer fatalities presented in Section 4.1.7.5.2 is correct and consistent throughout the Draft EIS. The estimate presented in Section 7.1.7, is part of the No-Action Alternative, where repository activities would be completely different than those discussed in Chapter 4.

The estimate of 0.14 to 0.41 latent cancer fatalities in Section 4.1.7.5.3 of the Draft EIS is for the entire project duration. The characterization of "less than 0.4" is a one significant figure reference to this range of impacts. This value, compared to the normal Nevada cancer incidence noted (more than 5,000 over the life of the project), would result in the stated increase of less than 0.01 percent. This section of the EIS has been clarified per the reviewer's comment.

The commenter refers to information in Section 4.1.8.1 on page 4-64 of the Draft EIS. The Draft EIS notes that a "summation [not 'summary'] of all potential accidents in Table 4-36 would result in less than 0.02 additional latent cancer fatality for the exposed population." That is, if all the postulated accidents occurred, only an additional 0.02 latent cancer fatality would occur.

Normal industrial accidents and no fatalities would be expected, as presented in Section 4.1.15.5.2.

In Table 4-56 of the Draft EIS, the probability of a latent cancer fatality for the maximally exposed subsurface facility worker from hypothetical retrieval operations, an individual who receives a dose of 6,950 millirem would be 0.003. A value of 0.015, as noted in this comment, is in error. The latent cancer fatality incidence, that is, the number of latent cancer fatalities, in the total exposed population of surface and subsurface workers, would be 0.19. For the maximally exposed member of the public, the probability of a latent cancer fatality in this individual is 2.8 × 10-6. The number of latent cancer fatalities that could occur in the exposed public population is 0.014.

The entire paragraph in 4.2.1.2.7 of the Draft EIS where the value of 0.1 latent cancer fatality for "exposure to the public for operations only" is a typographical error and incorrectly duplicates the information in the previous paragraph. This paragraph has been deleted from the EIS.

The total potential radiological impacts to workers and the public from the three thermal load scenarios of the Proposed Action are clearly noted in Section 4.1.7.5 of the Draft EIS. They are the same values discussed earlier in this comment, namely 2.5 to 4.0 Latent cancer fatalities for workers and 0.14 to 0.41 latent cancer fatality for the public. More detailed breakout of information is presented in other sections of Chapter 4. These same values are also presented in the Tables S-1 and 2-7. The retrieval period is not considered part of the Proposed Action, and so potential impacts are presented separately.

Section 8.2.7 of the EIS presents a discussion of the cumulative impacts to the environment if the decision were made to construct a repository at the Yucca Mountain site. In the introduction to Chapter 8 of the EIS, a cumulative impact as defined by the National Environmental Policy Act is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions" (40 CFR 1508.7). Therefore, consistent with the National Environmental Policy Act, the impacts would be in addition to those latent cancer fatalities calculated for Yucca Mountain activities.

In response to public comments, DOE has revised the Draft EIS to provide additional clarification on potential health and safety impacts. In particular, Section F.1.1 now includes explanations of the impact parameters used, namely the probability of latent cancer fatality in an exposed individual and the number of latent cancer fatalities in an exposed population. The potential for nonfatal radiation effects is also included.

7.5.7 (5639)
Comment - EIS001887 / 0262
Page 4-107; Section 4.2.1.2.7 - Table 4-56: Radiological health impacts from retrieval operations

The uncertainty in these calculated doses and risks should be provided. The operational procedures are conceptual, at best; therefore, the uncertainties associated with various operations scenarios should be provided as part of this evaluation.

Response
Table 4-56 of the EIS lists the estimates of radiological consequences (dose) and health impacts (latent cancer fatalities) for retrieval operations. The dose values are based on the best available data as is required under National Environmental Policy Act guidance issued by the Council on Environmental Quality. DOE recognizes that there are uncertainties in both the full time equivalent worker year estimates; and in the estimates of the worker doses that would be received from inhalation of radon from background radiation from the drift walls and from radiation

emanating from the waste packages during work in the subsurface environment. However, these data are not available upon which to base meaningful uncertainty estimates.

With regard to radiation exposure and the incidence of cancer, as discussed in Sections K.4.3.2 and F.1.1.5, the dose-to-risk conversion factors typically used to estimate adverse human health impacts resulting from radiation exposures contain considerable uncertainty. The risk conversion factor of 0.0005 latent cancer fatality per person-rem (or, one latent cancer per 2,000 rem of exposure) of collective dose for the general public typically used in DOE National Environmental Policy Act documents is based on recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993). The factor is based on health effects observed in the high dose and high dose rate region (20 to 50 rem per year). Because health effects in humans have not been observed below acute 10-rem exposures, potential health effects were extrapolated to the low-dose region (less than 10 rem per year) using the linear no-threshold model. This model is generally recommended by the International Commission on Radiological Protection and the National Council of Radiation Protection and Measurements, and some radiation protection professionals believe this model produces a conservative estimate (that is, an overestimate) of health effects in the low-dose region, which is the exposure region associated with continued storage of spent nuclear fuel and high-level radioactive waste. This EIS summarizes estimates of the impacts associated with very small chronic population doses to enable comparison of alternatives in this EIS. Detailed discussions of other uncertainties associated with impact estimated are provided in Sections K.4.3.2 and F.1.1.5 of the EIS.

7.5.7 (6071)
Comment - EIS001898 / 0018
Inconsistencies concerning the appropriate range for 222Rn concentration should be remedied and impacts of thermal loading on radon release and worker safety should be explained in the FEIS.

Basis:

The median and range of 222Rn concentrations used for radiological impact calculations are not consistent throughout the DEIS. Sections 3.1.8.2 (Affected Environment-Radiation Environment in the Yucca Mountain region) and F.1.1.6 (Human Health Impacts Primer and Details for Estimating Health Impacts to Workers from Yucca Mountain Repository Operations-Exposures from Naturally Occurring Radionuclides in the Subsurface Environment) of the DEIS report that radon concentrations in the Exploratory Studies Facility (ESF) during working hours (with active ventilation) range from 0.22 to 72 pCi/L, with a median concentration of 6.5 pCi/L. Sections 4.1.2.2.2 (Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure-Radiological Impacts to Air quality from Construction) and G.2.3.1 (Air Quality-Release of Radon-222 and Radon Decay Products from the Subsurface Facility) of the DEIS report that radon concentrations in the ESF during working hours with the ventilation system on range from 0.65 to 163 pCi/L, with a median concentration of 24 pCi/L. The difference is a factor of 2-3 in the range and a factor of approximately 4 for the median.

Section 4.1.7.3.1 [Environmental Consequences of Repository Construction, Operation and Monitoring, and Closure-Occupational Impacts (Involved and Non-involved Workers)] of the DEIS states that "radiological health impacts to surface workers would be independent of the thermal load scenarios." However, it is not apparent whether there was any consideration of higher heat loadings increasing the radon release rate from the wall surfaces. Table G-48 of the DEIS reports that the annual average radon releases during the 24-yr operation period are expected to be 880 Ci, 1000 Ci, and 1900 Ci for the high, intermediate, and low thermal loads. It also appears that these source terms did not take into account the relative volume of the repository under each heat loading alternative.

Recommendation:

The FEIS should explain or address inconsistencies related to the appropriate range for 222Rn concentration. The FEIS should also discuss the effects of the various heat loading scenarios on total radon release and provide a technical basis for the conclusion that radiological health impacts are independent of thermal load scenarios.

Response
These sections differed because some addressed exposure of workers during working hours, while others addressed the continuous exposure of members of the public. Sections 3.1.8.2 and F.1.1.6 are specifically concerned with the potential exposure of workers. Radon concentrations at points of exposure within the repository and several kilometers from repository ventilation exhaust are considerably different. The use in the Draft EIS was consistent and appropriate.

The Final EIS uses more recent repository radon flux information that has become available since the Draft EIS was published. This new information has replaced much of the information used as the basis of estimates in the Draft EIS. Dose estimates to subsurface workers from radon decay products now use Working Level estimates made for the flexible design (DIRS 154176-CRWMS M&O 2000). Section F.1.1.6 of the Final EIS describes these dose estimates. Working Level estimates can be converted to estimates of dose using a published conversion factor (DIRS 103279-ICRP 1994). Dose estimates for members of the public are also based on new estimates of radon release from the repository, which take advantage of new analyses of ventilation and radon flux from the repository walls (DIRS 150246-CRWMS M&O 2000; DIRS 154176-CRWMS M&O 2000). Section 4.1.2 reports revised dose estimates for the public from radon.

Information was not available for the Draft EIS to take into account the effect of heating of the emplacement drift walls by the waste packages. The analyses noted above have addressed the effect of heating (DIRS 154176-CRWMS M&O 2000), and the Final EIS takes this factor into account. All analysis scenarios for the Draft and Final EIS account for the effects of different repository sizes or volumes. A larger repository has a correspondingly larger radon release. However, the radon flux from repository walls and total radon release is not directly proportional to the total repository volume. Radon flux and release depend on the specific characteristics of the repository, including the relative quantity of larger-diameter excavations such as access mains, 5.5-meter (18-foot)-diameter excavations such as emplacement drifts, and smaller excavations such as ventilation raises. Radon release also depends upon the project phase, and whether or not a specific excavation would have a concrete liner (which would reduce radon flux).

The statement in Section 4.1.7.3.1 of the Draft EIS that radiological health impacts in the “surface” facilities are independent of thermal load scenarios is unrelated to subsurface radon release. The bulk of dose to surface workers is due to handling of spent nuclear fuel, which depends on the facility throughput, (that is, 63,000 metric tons of heavy metal for the Proposed Action). The dose contribution from radon released from the subsurface is negligible. These statements remain correct for the Flexible Design evaluated in the Final EIS. Additional clarification on the contribution of subsurface radon to workers doses has been added.

Sections G.2 and F.1.1.6 have been extensively revised in the Final EIS to present the new information noted above, as have the corresponding impacts in Sections 4.1.2 and 4.1.7.

7.5.7 (6082)
Comment - EIS001469 / 0005
We would think that it would be important for public process that the document be made as easy to read and as clear to find information as possible, and this doesn’t seem to really be the case.

I want to give an example. Page 277 [2-77] of Volume 1 gives a table. This same table is duplicated in the summary document as well. And so this table is, in my opinion, an important part of what people will look at first in looking at the document. I want to point out something, some inconsistencies here.

First of all, there’s a section in the table which indicates accidents. Doesn’t say transportation, but it seems like that’s the intent here. And there’s categories under accidents. I’m going to focus on the category called Public, and there is Public Radiological, and bracketed it says LCF, which is latent cancer fatalities. So that should mean the number of fatalities in my reading of this document.

Under that category there are two sections, one called MEI, which is the maximally exposed individual, and the other is called Population. Okay. So if we go to the proposed action and we look under transportation, transportation column, I notice that the LCF number is lower for the maximally exposed individual than it is to the general population on the average. There’s a range there, but the average number would definitely be lower. This doesn't really make any sense to me. I don't understand why the maximally exposed individual would be less likely to receive cancer than the general population.

Further, I attempted to find out why this might be the case in the document, and I noticed something else rather interesting. Under the maximally exposed individual, if you go back on page 67, the number is reported in the document as the -- under the mostly legal truck scenario, there's a range there. And it does report in this document 31 latent cancer fatalities to the exposed population. The number that's reported in the document and on the table here under maximally exposed individuals is .002 to .013. And in the document it appears as though that represents the probability and not an actual latent cancer fatality number. Above it appears as though the actual latent cancer fatality number is more in the range of 31. So what are we reporting in this table? It's not really clear to me.

Further, it's interesting to me that in other places in this table actual whole numbers are recorded, and they seem to be consistent with the LCF described in the document and not a probability. So I find it odd that it may have been reported as a probability in this particular spot in the table.

One other thing that leaves me a little bit suspicious is, if you go over to the column under the no-action scenarios, of course there's no impact under transportation. So it almost appears to me as though there was an attempt to minimize the appearance of fatalities under transportation by using a figure which is a probability and not an actual latent cancer fatality number. So I'm kind of concerned about that, that we're not really communicating on a first glance what's there.

How is the MEI, the maximally exposed individual calculation done? Well, here again, on this table on page 277 [2-77], I tried to find the figure for the LCF under the population, the .02 to .07. I tried to find that in the document. I had a lot of trouble with it. I've looked in the Appendix J under that section. I've looked in the section where it talks about transportation impacts for accidents. I'm not really finding any. But actually there is a number here that looks like it might be pertaining to it, and then I try to find a calculation for this.

And I want to point something out right here. I teach chemistry, I teach science myself, and in my 101 class I tell the students, whenever you report a number in a table, you need to show clearly how you calculate that number. And this is the idea of communicating information. This is always a very important aspect of science. In my opinion, this is not clearly communicating what's happening. It took me in the past 45 minutes [to] an hour trying to find this figure and where it came from. Not too easy. I know eventually I'd be able to figure it out.

But I'm thinking in terms of the average public that maybe has a little less experience working with figures. It should be a lot more clear. There should be a simple calculation so people can see exactly where the number came from. That is not communicated to the public. That's frustrating to the public. If I were not someone who is more into numbers, I would probably give up on it. And to me, that fails in what the charge of this document is supposed to do.

This is only one example of this. There are many examples which will be in the written comments on this. But this is where I feel the document really fails. As an instructor, it's insulting. I tell my students, you've got to report your numbers. You've got to show your calculations. It should be clear to a man on the street. And yet here it is here. It's like my teachings are being countermanded publicly.

So in a way I'm kind of insulted by that. I wish it were better communicated. And I think that's a very important principle. Everybody needs to understand the basics of this document, and that table is really significant because it's in the summary. A lot of people only look at the summary. It's very important. I think we need to address that.

Response

Table 2-7, on page 2-77 of the Draft EIS, summarized impacts at and around the repository (and the No-Action Alternative); including transportation impacts for the State of Nevada. National transportation impacts were included in Table 2-8.

The explanation of latent cancer fatalities in this and other summary tables has been clarified so the impacts to the reasonably maximally exposed individual are explained as the "probability of a latent cancer fatality" while impacts to an exposed population are the "number of latent cancer fatalities" in that population.

DOE agrees that misunderstandings of this type are frustrating. The summary tables in the EIS have been revised so it is clearer that this table is for repository and no-action impacts and the following table is for impacts from transportation.

7.5.7 (6088)

Comment - EIS001469 / 0007

I think that what has happened over the years is that radiation standards have been lower and lower and lower over the years. My interpretation of that is, as the body of knowledge increases we're beginning to see more and more ways that radiation impacts us. This document does not address that part of it, either. Over time I think it will become more and more important.

Response

Over the years, the levels of occupational radiation exposure considered acceptable have been reduced significantly. Except in the very early years, these reductions occurred not because of observed health effects but rather because of improved control technology and better understanding of the risks associated with radiation exposure (DIRS 155764-Moeller 1997). Occupational radiation protection standards have remained at about 5 rem per year since about 1965, when the potential for somatic effects (cancer) became the basis for radiation protection standards. Before that, the basis was for possible hereditary effects in humans, based on a 1927 report on experiments with *drosophila* flies. Earlier than that, following the discovery of X-rays in 1895, the basis for standards was prevention of acute exposure effects. Moeller (DIRS 155764-1997) discusses the evolution of radiation protection standards.

Recommendations for limiting dose to the public were developed much later than occupational limits (mainly because the potential for public exposure did not exist until use of radioactive material became more widespread after development of nuclear energy) and have remained in the range of 100 to 500 millirem per year. The current Nuclear Regulatory Commission dose limit for a member of the public is 100 millirem per year, set in 1991. As a point of reference, the Environmental Protection Agency and Nuclear Regulatory Commission individual radiation protection standard for long-term performance of the proposed repository is 15 millirem per year.

7.5.7 (6145)

Comment - EIS001654 / 0022

Page S-45. Occupational and Public Health and Safety

Much has been said at public hearings and many comments are likely to be submitted regarding radiological impacts. It often seemed to us that opponents have made statements objecting to either building a repository in Nevada or anywhere or transporting nuclear waste at any time by any means. Often the statements were made without factual support and served to add to the fear that many seem to have of radioactive materials of any kind under any conditions. DOE has provided a helpful presentation of knowledge on this difficult to understand subject. While much of the data that is provided in the DEIS throughout the document is extensive, it may be studied by few and understood by even less. We encourage DOE and EPA to continue the public education on the subject of radiological safety so that more will understand the subject matter and become better able to tell the difference between fact and myth.

This section refers to radiological impacts to workers and the public for various thermal load levels in the repository. Those risks are summarized in the summary in terms of latent cancer fatality increases to various populations. However, we found no discussion and linkage to dose-based standards that have been the subject of different positions by the U.S. Environmental Protection Agency (EPA) and the NRC [Nuclear Regulatory Commission]. The applicable standard for dose limits has not been established for the Yucca Mountain repository. If and when a standard is set it should be explicitly addressed in this section and in other sections of the FEIS.

While there has been much public speculation and expressions of alarm over radionuclide transport during the 10,000 year performance period and beyond, such concerns are based on levels of uncertainty that are difficult to prove or disprove. Likewise, there has been much concern and comment on radiation exposure during transportation to the repository even though the dose estimates provided are very small. Yet, there may be more direct exposure risks that have not drawn as much public notice. The latent cancer risks to repository workers during pre-closure period are given (page S-46) as 3-4 fatalities depending on thermal loads. This compares with one latent cancer fatality forecast (page S-48) among the general public during the 9,900 years following closure. If the comparison is correctly made, great care needs to be taken to protect worker safety during the pre-closure period. We would expect that the burden would be with DOE to demonstrate a sound radiological worker safety program in the operating license application with the goal of minimizing worker radiological risks.

Response
In the Nuclear Waste Policy Act of 1982, Congress found that State and public participation in the planning and development of repositories is essential to promote public confidence in the safety of disposal. DOE believes that its approach to the public involvement process is consistent with the National Environmental Policy Act, the Council on Environmental Quality, DOE regulations, and the intent of the Nuclear Waste Policy Act. A major element of the Yucca Mountain Project has been to ensure stakeholders, the media, and the public have an opportunity to participate in and acquire the information about the project that they need to make informed decisions. This effort is focused on building and maintaining relationships with stakeholders, the public, and media through regular interaction and provision of project information and educational opportunities. The program develops public information products, including permanent and portable field exhibits, information materials, models, audiovisuals, electronic media, publications and public outreach announcements. These public information sources are available at science centers in Las Vegas, Pahrump, and Beatty, Nevada; on the Yucca Mountain and DOE Office of Civilian Radioactive Waste Management Web internet sites at *http://www.ymp.gov* and *http://www.rw.doe.gov*; through public meetings and hearings on Yucca Mountain-related topics and during public tours of the Yucca Mountain site, as well by specific inquiries and requests for information and models, audiovisuals, electronic media, publications and public outreach announcements. Additional information on Yucca Mountain public outreach activities can be obtained by calling 1-702-295-1312 or 1-800-225-6972.

In addition, Appendix F of the Final EIS has been revised and expanded to include, in addition to human health impacts resulting from exposure from radioactive and toxic materials, a discussion of natural and manmade risks that are experienced in everyday life and a comparison with potential risks associated with storage, transportation, handling and disposal of spent nuclear fuel and high-level radioactive wastes. DOE expects to continue its public education programs related to health risks from exposure to ionizing radiation.

The Environmental Protection Agency had not finalized its environmental radiation protection standards for Yucca Mountain (released in draft at 64 *FR* 46976, August 27, 1999) when DOE published the Draft EIS. The results described in the Final EIS address the final Agency standards (40 CFR Part 197) promulgated in 2001 and include other information that might be of interest to the public and to the decisionmakers.

Radiological and industrial safety are high priorities within the DOE complex. The Department's goal is to promote safety of workers as well as the public and the environment. Chapter 11 of the EIS identifies the major requirements that could be applicable to the Proposed Action. With regard to protection of workers and members of the public and the environment against undue risk from radiation, the tables in Section 11.3 and Section 11.4 list the applicable DOE Orders and Federal regulations, including Orders 5400.1, 5400.5, and 10 CFR Part 835. The Department expects applicable portions of these regulations to be incorporated into the Nuclear Regulatory Commission license that must be issued prior to construction, operation and monitoring, and closure of a monitored geological repository.

7.5.7 (6318)
Comment - EIS001083 / 0006
As proposals are considered, whether they be for expansion of on-site storage, the creation of private central storage facilities, establishment of a federal interim storage or the emplacement of a permanent nuclear waste repository at Yucca Mountain, we must continue to utilize sound scientific and technical methods to ensure the safety of all Americans. The protection of our citizens and neighborhoods must be our foremost consideration when reviewing any proposal.

Response
Thank you for your comment.

7.5.7 (6359)
Comment - EIS001586 / 0002
One of the things that we are very concerned about with the nuclear waste, is that it is biocumulative and people get it in small amounts in products and they don't realize it's dangerous. And, as I say, I have got this whole thing, what I am talking about and other things I have published policies, Too Hot to Handle, Radioactive Waste Policy is Dangerous. They've put in – you've put in something saying below regulatory concern. Well, that cumulative, and some of the things that are below regulatory concern are dangerous.

Response
The calculation of potential radiation doses considered bioaccumulation, or environmental accumulation of radionuclides, regardless of the level of radionuclide released. This potential is included in the dose factors and methods described in Section G.2.4.1 of the EIS for repository operations and in Sections I.2.9 and I.4.4.6 for long-term performance. DOE estimates that the most likely outcome from potential exposure to ionizing radiation from the Yucca Mountain Repository during operations and the 10,000-year postclosure period would be no adverse health effects in the surrounding population.

The Environmental Protection Agency has responsibility for setting generally applicable standards for Yucca Mountain. The Nuclear Regulatory Commission has responsibility for modifying technical standards for the repository to be consistent with the Environmental Protection Agency standards. The Environmental Protection Agency has established final regulations at 40 CFR Part 197. This regulation establishes individual protection and human intrusion standards requiring that DOE demonstrate that there is a reasonable expectation that for 10,000 years after disposal, the reasonably maximally exposed individual would receive no more than an annual committed effective dose of 15 millirem per year for Yucca Mountain. This level of exposure would, using the recommended risk factors discussed above (0.0005 latent cancer fatality per rem or 1,000 millirem), would represent a risk of contracting a fatal cancer of 8 chances in 1 million for one year of exposure or about 5 chances in 10,000 for a lifetime (70 years) of exposure. For comparison, based on the most recent statistics, individuals living in the United Stated have about a 1 in 4 of dying of cancer from all causes (DIRS 153006-Murphy 2000).

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than 1 chance in 100 million (see Table 5-6). This level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes.

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (6473)
Comment - EIS001632 / 0031
Page 3-82, second full paragraph: The DOE's value of 0.0005 latent cancer fatalities per person-rem is lower than the Federal Guidance level of 0.000575 latent cancer fatalities per person-rem (Table 7.3, page 174, Federal Guidance Report 13, "Cancer Risk Coefficients for Environmental Exposure to radionuclides," EPA 402-R-99-001, September 1999). Since DOE was one of the funding, reviewing, and approving agencies for this study, EPA recommends that the Federal guidance level be used.

Response

The Environmental Protection Agency recently published an age-specific risk factor of 5.75 chances in 10 million per millirem for fatal cancer (DIRS 153733-EPA 2000). However, DOE currently uses the value of 5.0 and 4.0 chances in 10 million per millirem for fatal cancer for members of the public and workers, respectively, as recommended by the International Commission on Radiological Protection (DIRS 101836-ICRP 1991). When recommending these risk factors, the International Commission on Radiological Protection also expressed the desirability, for purposes of radiation protection, to use the same nominal risk factors for both men and women and for a representative population with wide ranges in age. The Commission stated that although there are differences between the sexes and populations of different age-specific mortality rates, these differences are not so large as to necessitate the use of different nominal risk factors. However, the higher risk factor for members of the public compared to that recommended for workers accounts for the fact that children comprise a relatively large part of the population and are more sensitive to the effects of radiation (cancer induction) than adults. Although the embryo-fetus is more radiosensitive (with a radiation risk factor about two times that for the whole population) it is protected by the body of the mother and comprises a small part of the overall population. Pregnant women are not unduly radiosensitive, especially to low levels of radiation.

Both the Agency and DOE recognize that there are large uncertainties associated with these risk factors, as expressed by the National Council on Radiation Protection and Measurements comment on the result of their uncertainty analysis in the risk coefficients that " … show a range (90 percent confidence intervals) of uncertainty values for the lifetime risk for both a population of all ages and an adult worker population from about a factor of 2.5 to 3 below and above the 50th percentile value" (DIRS 101884-NCRP 1997). The Department believes that the 15-percent difference in these risk factors is well within other uncertainties and would provide little additional information to the decisionmaking process that this document informs. For these reasons, DOE will continue to use risk factors recommended by the International Commission on Radiological Protection in their National Environmental Policy Act documents.

7.5.7 (6577)

Comment - EIS001380 / 0009

Page F-11. The worker dosage analysis at Yucca Mountain makes the incorrect implicit assumption that workers are only exposed during the Yucca Mountain project. However, most of the permanent workers spend their full working lifetimes at nuclear sites and thus their probable lifetime exposures, including the intervals of their lives before and after being employed at Yucca Mountain, need to be factored into the risk estimates. The "double hit" hypothesis of cancerogenesis is now conclusively established. Thus, a worker could have suffered the initial hit at another nuclear site, and then get the critical second hit that leads to cancer formation at Yucca Mountain. Exposure and employment data should be readily available on Yucca Mountain workers. My guess would be that many have large cumulative radiation exposures that already increase their risk for cancers and other subthreshold radiation injuries.

Response

The EIS makes no assumption about worker's radiation exposures at other nuclear facilities either before construction or after closure but focuses on incremental exposures resulting from the Proposed Action and No-Action Alternative. However, it should be noted that like their counterparts who work in commercial nuclear facilities licensed by the Nuclear Regulator Commission, DOE worker occupational exposures are closely monitored and reported. Also, like their commercial counterparts, worker annual and lifetime occupational exposures are carefully tracked to ensure compliance with annual exposure limits codified at 10 CFR 835.202 (annual limits for commercial workers are codified at 10 CFR 20.1201). Lifetime exposure limits are strictly controlled and regulatory limits are codified for both commercial and DOE workers at 10 CFR 1206(e)(2) and 10 CFR 835.204(c)(2), respectively. These regulations require new employees to submit detailed annual and lifetime exposure histories provided by the appropriate Federal agency (DOE and the Commission) prior to receiving additional radiation exposure. Therefore, it is highly unlikely that any radiation worker at either DOE or Commission facilities would be allowed to continue working in a radiation environment if previous exposures had been determined to be above the regulatory limits.

In 1999, DOE and the Nuclear Regulatory Commission published reports that detailed occupational radiation exposure at DOE and commercial facilities. These reports show that in 1998, the average annual worker exposures at DOE facilities and NRC nuclear fuel cycle facilities were about 74 millirem and 230 millirem, respectively. For perspective, these occupational doses represent a fraction of the average dose received from natural background radiation in the United States (see Table 3-30 of the EIS).

7.5.7 (6582)
Comment - EIS001380 / 0010
Page F-12. How was the factor of 0.0004 latent cancer fatality per rem validated and derived? A source is given, but a brief rationale should be stated explicitly in the draft EIS. The secondary documents cannot be obtained in time to comment by Feb. 9. The statements are made that consideration of other “non-fatal cancers and severe genetic effects” of radiation exposure that “increases the total change by a factor of 1.5 to 5 compared to the change for latent cancer fatalities” is data that “as is the general practice for any DOE EIS, estimates of the total change were not included in the Yucca Mountain EIS.” This policy should be reconsidered; it is absurd. Why this policy is justifiable scientifically needs to be stated explicitly. To this physician, the policy misleads the public as to the actual danger of radiation exposure -- does DOE believe death is the only legitimate concern of the public? I think not.

Response
As discussed in Section F.1.1.5, the risk conversion factors of 0.0005 latent cancer fatality per person-rem of collective dose for the general public and 0.0004 latent cancer fatality per person-rem of collective dose for workers, which DOE typically uses in its National Environmental Policy Act documents, are based on recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993). However, because adverse health effects have never been observed statistically in humans exposed to low doses of radiation, validation of these factors has not been possible in the classical sense. Rather, the factors are based on health effects observed in the high dose and high dose rate region (20 to 50 rem per year). Health effects were linearly extrapolated to the low dose region (less than 10 rem per year) using the linear no-threshold model. In general, the International Commission on Radiological Protection and the National Council of Radiation Protection and Measurements recommend this model, and some radiation protection professionals believe the model produces a conservative estimate (that is, an overestimate) of health effects in the low-dose region, which is the exposure region associated with the activities evaluated in the EIS.

Because validation of the risk factors has not been possible, estimates of impacts contain considerable uncertainty. According to the National Council on Radiation Protection and Measurements, the results of an analysis of the uncertainties in the risk coefficients “show a range (90-percent confidence intervals) of uncertainty values for the lifetime risk for both a population of all ages and an adult worker population from about a factor of 2.5 to 3 below and above the 50th percentile value” (DIRS 101884-NCRP 1997).

However, the National Academy of Science National Research Council stated that: “epidemiological data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero” (DIRS 100473-National Research Council 1990). In the United States, natural background radiation ranges from about 300 millirem per year.

Many adverse health effects have been attributed to exposure to ionizing radiation but have been observed in humans only at high doses or dose rates. However, for chronic low doses such as those predicted in the EIS resulting from the Proposed Action, the National Research Council Committee on the Biological Effects of Ionizing Radiation (BEIR III) has stated that cancer induction is considered to be the most important somatic effect (DIRS 153007-National Research Council 1980). The Committee went on to say that among the somatic effects of radiation other than cancer, developmental effects on the unborn child are of greatest concern (DIRS 153007-National Research Council 1980). The Committee also said that for somatic effects other than cancer and developmental changes (for example, cataracts, aging, and infertility), the available data do not suggest an increased risk with low-dose, low-energy-transfer exposure of human populations (DIRS 153007-National Research Council 1980).

However, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection suggested use of detriment weighting factors that consider the cure rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancers and heredity effects (DIRS 101836-ICRP 1991). As discussed in Section F.1.1.5 of the EIS, because both of these life-detriment factors together would be less than half of the fatal cancer risk, DOE has chosen to estimate total cancer fatalities as the major potential health effect from exposure to radiation.

7.5.7 (6584)
Comment - EIS001380 / 0011
The CAIRS [Computerized Accident Incident Reporting System] database datasets are mentioned on pages F-15 and F-16 but the draft EIS does not state how or if the public has access to these data in a similar manner to its access to the EPA's [Environmental Protection Agency's] Internet-access CEDR database. This information should be footnoted in the EIS.

Response
The reference list at the end of Appendix F in the Draft EIS contains the information on the Computerized Accident Incident Reporting System (CAIRS) database. The information is available to the public through the DOE Office of Environment, Safety and Health Information Portal at http://tis.eh.doe.gov.

7.5.7 (6594)
Comment - EIS001380 / 0016
I found the elementary primer on radiation to be perfunctory and simplistic (although the facts were true in general) and missed the point. The primer and the analysis could and should have addressed all of the many proven adverse effects of radiation on human cells and tissues, not just cancer alone which is the tip of the medical iceberg. In the case of inhalation exposure, for example, pulmonary fibrosis and emphysema as well as cancer should have been addressed. Radiation biology is far more advanced than the draft EIS would indicate. No where is mentioned, as another example, that radiation can damage and kill cells by apoptosis without damaging nucleic acids. Whole sections of current radiation biology scientific journals are devoted to this topic alone. I got the impression that physicians knowledgeable about human radiation pathologic effects probably had no part in writing this document. I find this to be a very disappointing oversight if one's intent were to accurately analyze possible adverse scenarios of an accident while transporting high-level and spent nuclear fuels.

Response
DOE agrees that the information provided in Appendix F related to radiation effects is simplistic. Space limitations and the intended lay audience preclude a detailed review of the health effects of ionizing radiation or details of cellular radiobiology.

DOE agrees that many adverse health effects have been attributed to exposure to ionizing radiation. However, for chronic low doses such as those predicted in the EIS resulting from the Proposed Action, the National Research Council Committee on the Biological Effects of Ionizing stated in the BEIR III report that cancer induction is considered to be the most important somatic effect (DIRS 153007-National Research Council 1980). The Committee went on to say that among the somatic effects of radiation other than cancer, developmental effects on the unborn child are of greatest concern (DIRS 153007-National Research Council 1980). In addition, the Committee said that for somatic effects other than cancer and developmental changes (e.g., cataracts, aging, and infertility), the available data do not suggest an increased risk with low-dose, low linear energy transfer (LET) exposure of human populations (DIRS 153007-National Research Council 1980).

For these reasons, DOE has selected, for use in the EIS, dose-to-risk factors recommended by the National Council on Radiation Protection and Measurements (DIRS 101856-NCRP 1993) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) for estimating the risk of latent cancer fatality from exposure to ionizing radiation. These factors were developed based on the linear no-threshold hypothesis, which assumes that adverse health effects could occur from exposure to ionizing radiation regardless of how small the dose.

In addition to fatal cancers, as the commenter has pointed out, experts generally recognize that other health effects could result from exposure to radiation. Therefore, to enable comparisons with fatal cancer risk, the International Commission on Radiological Protection (DIRS 101836-ICRP 1991) suggested use of detriment weighting factors which take into consideration the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancer and heredity effect. However, as discussed in Section F.1.1.5, since both of these life-detriment factors, when taken together, are less than half of the fatal cancer risk, DOE has chosen to estimate total cancer fatalities as the major potential health effect from exposure to radiation.

With regard to noncarcinogenic diseases of the lung, according to Dr. John B. Little, M. D., Simmons Professor of Radiology and Director of Radiobiology, School of Public Health, Harvard University (DIRS 157321-Rollins 2000), "Pulmonary fibrosis [and emphysema] is observed only at high radiation doses, such as are experienced in radiation therapy. Pulmonary fibrosis is not observed at low or chronic levels of radiation dose."

DOE believes that the studies of apoptosis (as were the studies of the mechanisms of radiation interactions in human cells and tissues) are designed to provide a better understanding of the sequence of events that lead to the development of cancer. However, knowledge of the details of the interactions of radiation in human cells and tissues would be of little value in developing scenarios for evaluating the potential impacts from, for example, transportation accidents on human populations. What is important is the amount and form of the radioactive material that might be released, the pathways through which it might cause exposures to nearby population groups, and the doses that might occur that could result in adverse health effects.

7.5.7 (6684)
Comment - EIS001632 / 0084
Page 14-22, definition of "maximally exposed individual": The last sentence of this definition equates the maximally exposed individual (MEI) with the "reasonably maximally exposed individual (RMEI)," a term used in the recently proposed 40 CFR Part 197 (see 64 *FR* 46988 and 47014/47015, August 27, 1999). These two terms are very different. The dose incurred by the MEI is calculated by using the most conservative values (i.e., producing the highest dose) for all parameters needed to calculate the dose to an individual. The dose incurred by the RMEI, on the other hand, assumes that one or a few parameters are at their maximum or most conservative values while the others are at their average values.

Page 14-29, definition of "reasonably maximally exposed individual"

Response
DOE has revised these definitions in the Final EIS. Chapters 4, 6, and 7 now use the term "maximally exposed individual," and Chapter 5 uses "receptor." The receptor is equivalent to both the "reasonably maximally exposed individual" defined in the Environmental Protection Agency's regulations at 40 CFR Part 197. This change reflects the regulatory definitions and requirements for long-term performance recently promulgated by both agencies.

7.5.7 (6870)
Comment - EIS001466 / 0013
We could see Amargosa Valley in the distance, the farming community downstream of Yucca Mountain where the highest doses will be coming out into the water. People will be drinking that water, using it to irrigate their crops.

And the biomagnification of radioactivity is something that I've experienced in Chernobyl. My wife and I have spent some time over there. We have a lot of friends over there. And to hear them talk about if they only had a Geiger counter they could take it to the marketplace with them, but of course it would be a year's salary to buy that anyway. But that will be the main source of contamination to people downstream Yucca Mountain is the food that they eat will be contaminated with radionuclides.

Response
DOE is aware of the environmental accumulation or "biomagnification" of radionuclides or other substances that could occur. The calculation of potential radiation doses for individuals and the population of Amargosa Valley considered the potential for environmental accumulation, for example, in uptake of radionuclides by plants and animal products that residents could consume. This potential is included in the dose factors and methods described in Section G.2.4.1 of the EIS for repository operations and Section I.4.4.6 for long-term performance. The experience at Chernobyl is considerably different from anything that would reasonably be expected to occur around Yucca Mountain and in the Amargosa Valley, both in the type of release and levels and pathways of exposure. DOE recognizes that people living in the Amargosa Valley have concerns about the potential for low levels of radioactivity in groundwater from radioactive material disposed of at Yucca Mountain. The analysis in the EIS

shows that releases of this type would be well below regulatory standards. DOE expects no adverse radiation-related health impacts to individuals in Amargosa Valley or elsewhere around Yucca Mountain.

7.5.7 (6894)
Comment - EIS001608 / 0001
I thought I heard someone earlier refer to low dose, the effect of low dose, which brought to mind the work of John Golfman. I am a little surprised his name hasn't been brought up. He's the renowned scientist, doctor in California who has shown that low doses can be more harmful than higher doses.

His work impacts particularly this notion of the chest X-ray, and that's precisely what Dr. Golfman has been addressing in terms of breast cancer, which is one of the big problems. So I wouldn't dismiss a chest X-ray. The problem is these doses usually aren't measured.

Response
The views of Dr. John Gofman on the effects of exposure to low levels of ionizing radiation are unsupported by independent scientific research and have not been accepted by the scientific community at large. His theories have also been generally repudiated in the courts. DOE cannot accept these views until they have received independent scientific peer review and been accepted into the mainstream body of scientific literature.

7.5.7 (6899)
Comment - EIS001608 / 0003
I know someone whose grandchildren went to school in Colorado, one of those school buildings, the foundation of which was built with uranium mine tailings. I know the story of Colorado's use of mine tailings for concrete, house foundations, Grand Junction Shopping Mall, and I worry. I mean, there's nothing I've heard today that says when you talk about using concrete as part of, say, a repository, how do I know you aren't going to use some of those mine tailings? It doesn't sound like a good idea, but when you are desperate to get rid of some of this stuff, who knows, it might happen.

Now, we have been accused of having an irrational fear of radiation, and that is totally unacceptable. It's abnormal not to be more than extremely respectful of nuclear radiation.

Response
In some locations such as Grand Junction, uranium mill tailings were used as fill around the foundations of buildings and for other purposes. Although most of the uranium had been removed, the uranium decay products including radium-226 remained in the tailings. Radium-226 decays to the noble gas radon-222, which diffused through the foundations and led to elevated radiation exposures of the residents to radioactive radon decay products. This problem resulted from the use of this radioactive material in near-proximity to residences and buildings, where people could be readily exposed. Disposal of this same material in the isolated environment of the geologic repository would be considerably different. However, uranium mill tailings would not be disposed of at Yucca Mountain. These mill tailings are already being successfully remediated near the locations where they were originally generated.

DOE agrees that the potential for ionizing radiation exposure and health effects should be treated in a respectful manner. Decisions need to be made with a clear understanding of the potential risks and benefits. DOE is committed to meeting the regulations regarding dose from ionizing radiation, and keeping radiation exposures resulting from preclosure activities at the proposed repository as low as reasonably achievable.

7.5.7 (7267)
Comment - EIS001832 / 0015
Appendix K of the DEIS states that the impacts of the radiological population doses estimated in the DEIS "should be viewed as conservatively high; in fact, the uncertainties are such that **the actual level of impact could be zero**." [emphasis added] This fact should be included in the Summary and Volume I of the DEIS. Further, this conservatism in the estimates of the radiological impact should be more clearly identified and explained in plain language.

The following statement from Appendix K is one example of such a clarification, that needs to be brought forward and integrated into the conclusion of the DEIS to establish appropriate context, is:

"The dose-to-risk conversion factors typically used to estimate adverse human health impacts resulting from radiation exposure contain considerable uncertainty. The risk conversion factor of 0.0005 latent cancer fatality per person-rem of collective dose for the general public is based ... on health effects observed in the high dose and high dose rate region. Health effects were extrapolated to the low-dose region (less than 10 rem per year) using the linear no-threshold model. This model is generally recommended by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements, and most radiation protection professionals believe this model produces a conservative estimate (that is, an overestimate) of health effects in the low dose region..."

In clarifying this statement, DOE should recognize that the use of the linear no-threshold dose response model is conservative and, thus, DOE used that assumption in assessing human health effects associated with the proposed action. The view that the dose response model assumed results in a conservative estimate of the human health impacts is an important factor in explaining the radiological consequences of the proposed action to members of the public. This conservatism in the calculated effects should be clearly stated in the Summary and in Volume 1 of the EIS and not only in an appendix.

Response
DOE agrees that this information is important and deserves expanded explanation in the EIS. Therefore, the Department has revised the "Radiation Primer" in Appendix F and included a discussion of uncertainties in impact estimates. In addition, DOE has revised the information in Chapter 4, where the EIS first discusses radiation-related health impacts. The Summary and Chapters 5, 6, and 7 now include a more limited discussion.

7.5.7 (7451)
Comment - EIS001969 / 0008
If we are interpreting Table 4-34 (page 4-59) correctly, over a 70 year life span a person living within 12 miles of the repository would receive a life time radiation dose of between 38 to 100 millirems from the repository depending on the thermal load scenario used. Is this correct? If so, it is significantly lower than the NRC's [Nuclear Regulatory Commission's] standard of 100 millirems per year at abandoned mines after reclamation. We believe that it is unusual that a person residing near this repository would receive less radiation than would one who lived near many other areas containing less radiation, such as abandoned mine sites. If our interpretation is incorrect, and the correct dose rate is between 38 and 100 millirems; per year, then the low thermal load matches the NRC standard. Perhaps this figure needs to be reevaluated in the final EIS to clear up this ambiguity.

Response
The interpretation is correct. In the Draft EIS, the maximally exposed individual would receive an estimated dose of 38 to 100 millirem over 70 years. Table 4-35 (Footnote c) and Section 4.1.7.5.3 of the Draft EIS explain this dose. Section 4.1.2 of the EIS discusses the highest potential annual dose would be less than 2 millirem per year.

Exposure scenarios at reclaimed uranium mines or mills are much different from the potential exposure near the proposed repository at the Yucca Mountain site. The key differences at Yucca Mountain would be the lack of high uranium and uranium decay product source material, lack of tailings with enhanced concentrations of uranium decay chain radionuclides, and the location of the potential public dose receptor at the boundary of the controlled area (15 millirem per 40 CFR Part 197). Further, potential public exposures at Yucca Mountain would be held to a much more rigorous standard than 100 millirem per year. The discussions in Sections 4.1.2 and 4.1.7, along with the supporting information in Section G.2, explain potential public radiation doses.

7.5.7 (7584)
Comment - EIS001969 / 0036
Page 3-79, Section 3.1.8 Occupational and Public Health and Safety.

The radiological hazards and their consequences were discussed in a concise way such that the average citizen can draw conclusions about the risks of the proposed and alternative actions. The background information that was provided to develop an understanding of ionizing radiation and the hazards/risks was especially helpful.

Response

Thank you for your comment.

7.5.7 (7652)

Comment - EIS001928 / 0010

Pg. S-48 – 3rd and 4th para. – This section on health impacts is very confusing. In the 9,900-year analysis (3rd para) the maximally exposed individual (MEI) would be expected to receive only 1.3 mr/yr. [millirem per year] at a distance of three miles. Then, the million-year analysis (4th para.) predicts an MEI peak dose rate of 9,100 millirem at a three-mile distance occurring 320,000 years after closure. 1.3 mr vs 9,100 mr! Is the 9,100 value per year? Or spread out over the 320,000 years? If the latter is the case, then what is the relevance? An MEI will live only a tiny fraction of 320,000 years whether he contracts a radiation-induced cancer or not.

Furthermore, after 9,900 years (and even much sooner), all the relatively short-lived fission products will have decayed away. And in 320,000 years, even that widely-feared and misunderstood bugbear, plutonium, in its common guises of Pu 239, 240 and 241 will have disappeared.

So, really, what is one to make of this section on health impacts. What does it all mean in a practical sense?

Response

Dose rates in the EIS are in millirem per year. DOE has revised the summary so it is clear these are annual doses. Section 5.4 contains additional information on the radionuclides that would contribute to the dose. Since publication of the Draft EIS, the Environmental Protection Agency has finalized their regulations at 10 CFR 40.197 applicable to a Yucca Mountain repository. These regulations require DOE to make estimates of the annual dose to the reasonably maximally exposed individual for 10,000 years following closure of the repository. In addition to the 10,000-year regulatory period, the regulations require estimates of peak dose through the period of geologic stability, which is assumed to be 1,000,000 years for the Yucca Mountain site.

The Environmental Protection Agency, in promulgating the Yucca Mountain environmental protection standards (40 CFR Part 197), recognized that with the current state of technology it is impossible to provide a reasonable expectation that there would be “zero” releases over 10,000 years or longer. Therefore, standards have been established that the Environmental Protection Agency believes provide comparable protections to those of other regulated activities related to nonradioactive wastes. These standards do not require complete isolation of the wastes over the 10,000-year compliance period. The goal of a performance assessment for Yucca Mountain supporting the Site Recommendation decision and later licensing (if the site was recommended), is to evaluate whether the repository would be likely to meet these standards. The goal of performance analysis in the EIS is to project possible impacts using modeling technology similar to that used for the long-term performance assessment.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed, in accordance with 40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than those resulting from natural background radiation (see Table 5-8 for details).

With respect to groundwater protection standards set forth in 40 CFR Part 197.30, estimated groundwater concentration during the 10,000-year regulatory are hundreds of thousands of times lower than the regulatory limits (see Table 5-9).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (8085)

Comment - EIS001653 / 0064

Table 4-35 what does the information in this table [radiological consequences of the repository operations] mean? Are the results adverse?

Response

As discussed in Section 4.1.8.1 of the EIS, Table 4-35 lists radiological consequences of repository operations accident scenarios for median (50th-percentile) meteorological conditions The results in Table 4-35 indicate the highest probability of a latent cancer fatality to the maximally exposed offsite individual who receives the calculated dose would be 0.000016. The number of latent cancer fatalities in the exposed population would be 0.46. The fact that these values are far below 1 indicates that the increased risk of contracting a fatal cancer is very small.

In addition, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Appendix K, Section K.4.3.2 and Appendix F, Section F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (8260)

Comment - EIS001950 / 0003

Nevadans and persons living in the path of the aquifer downstream of Yucca Mountain should be exposed to a dose of zero additional radiation.

Response

The goal of geologic disposal is to concentrate and isolate spent nuclear fuel and high-level radioactive waste in a relatively small area for a very long time. DOE intends to achieve isolation of the wastes in the proposed repository by using a system of engineered barriers and by locating the repository in the geologic setting of Yucca Mountain. However, it is always possible to conceive of circumstances (both manmade and natural) that, given the inherent uncertainties associated with long-term projections, could result in the release of radioactive materials to the accessible environment. It is also likely that eventual release of some material is inevitable because all systems will degrade given sufficient time.

The Environmental Protection Agency standards (40 CFR Part 197) recognize that, with the current state of technology, it is impossible to provide a reasonable expectation that there would be no releases over a 10,000-year or longer time frame. Therefore, the Agency has established public health protection standards it believes provide comparable protections to those of other activities related to radioactive and nonradioactive wastes. These standards do not require complete isolation of the wastes over the compliance period (that is, 10,000 years) or the period of geologic stability (1 million years). The goal of a performance assessment for Yucca Mountain is to evaluate whether the repository would be likely to meet these standards and thus provide adequate protection of human safety and the environment.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). This evaluation was performed, in accordance with

40 CFR Part 197, to gain insight into the very long-term performance of the repository and thus provide information for the decisionmakers in making both design and licensing decisions. These results show a mean peak dose rate that is much lower than those resulting from natural background radiation (See Table 5-8 for details).

7.5.7 (8363)
Comment - EIS001873 / 0047
P. 4-47. It should be noted that death is one adverse non cancer effect of silicosis.

Response
There have been historical instances where acute exposures of workers to extremely high concentrations of crystalline silica dust have resulted in fatalities. Current standards for crystalline silica have been established to prevent silicosis in workers. The Federal Occupational Safety and Health Administration has established Permissible Exposure Limits and the American Conference of Governmental Industrial Hygienists have established Threshold Limit Values for these forms of silica. Because of these established limits on exposure of workers to crystalline silica, such an effect at Yucca Mountain would be highly unlikely.

7.5.7 (8456)
Comment - EIS000817 / 0136
I guess I don't like a hypothetical person and use of averages, etc. To me, no amount of added radiation to a person is acceptable, and why people in Nevada should be targeted, is unfair. Will people in that area be given pills to counteract any unexpected releases? Will those pills to protect [the] thyroid from iodine-129, etc. be stockpiled in the area and distribution plans be public? They should be. If not, why not? I'm going to skip over a lot of this on doses, for I don't think you actually can predict them at all. The VSC-24 [Ventilated Storage Cask, Model 24] cask for example was touted as having such low doses. Well, with all the problems -- UT [ultrasonic] testing, etc., and now they want to reduce shielding on the transfer cask to lower the weight in order to put in BPRAs [burnable poison rod assemblies]. What happened to ALARA [as low as reasonably achievable] anyway? Promises were broken on dose rates. I don't believe predictions of this sort -- they don't see reality and they expect a perfect world with no human error. Expect the unexpected. Murphy's Law is in effect. "What can go wrong, will go wrong," as Mr. Haughney of NRC [Nuclear Regulatory Commission] said after the VSC-24 explosion. And it continued to do so.

Response
DOE used a hypothetical reasonably maximally exposed individual in estimating doses to an individual. This hypothetical individual was assumed to have lifestyle characteristics that tend to maximize potential radiation dose. Average values were not used. The actual dose received by an individual probably would be lower than the DOE estimates. The pills noted in this comment are stable iodine pills, sometimes taken so that stable iodine goes into the thyroid rather than radioactive iodine. Releases of radioactive iodine would be highly unlikely and would be extremely small, even in accident cases (see Section 4.1.8) during repository operations. Some very small releases of iodine-129 could occur long term and enter the groundwater. The potential radiation dose from radioactive iodine would be very small and unlikely to result in adverse health impacts.

On May 28, 1996, a hydrogen gas ignition occurred during the welding of the shield lid on a ventilated storage cask (VSC-24) multiassembly sealed basket at the Point Beach Nuclear Plant. The gas ignition displaced the shield lid, leaving one edge about 7.6 centimeters (3 inches) higher than normal. The source of the hydrogen was oxidation of zinc in a coating designed to prevent corrosion when in contact with borated water in the spent nuclear fuel pool. The gas ignition caused no injuries, no radiological releases, and no apparent damage to the spent nuclear fuel, storage cask, or the reactor facility itself (NRC Bulletin 96-04 – Spent Fuel Casks, *http://www.nrc.gov/OPA/reports/bl9604.htm*). While it is not possible to predict in advance any particular sequence of events constituting an accident, the DOE performs extensive safety analyses of transportation, operation, and postclosure conditions to identify accident scenarios and resultant consequences. Adherence to the as low as reasonably achievable principle is an integral part of DOE radiation safety programs.

7.5.7 (8613)
Comment - EIS001256 / 0009
Dose calculations do not account for the additive, multiplicative and synergistic relationships of radiological and other biologically hazardous pollutants, factors and conditions that ultimately will affect recipients.

Response

The EIS discusses the risks of exposure to ionizing radiation and hazardous chemicals separately where such exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues might be the same, because exposure pathways and cellular and molecular mechanisms of cancer induction can differ.

DOE expects no adverse radiation-related health effects from Yucca Mountain activities. The levels of radiation exposure estimated to occur from Yucca Mountain operations are very low, less than 2 millirem per year for the highest annual exposure (see Sections 4.1.2 and 4.1.7). No hazardous substance exposure is expected during operations. Low levels of exposure to criteria pollutants (Section 4.1.2) are expected to have no health impacts.

Radiation exposure would be even less during the first 10,000 years of the postclosure period (see Section 5.4). There is some potential for exposure to hazardous substances during this period (see Section 5.6) but it is similarly very low. Again, no health impacts would be expected.

7.5.7 (8637)

Comment - EIS001256 / 0019

The Precautionary Principle must be the over-riding principle within this decision making process. This Precautionary Principle says that where there are threats of serious or irreversible damage, a practice or substance should be treated as though it is unsafe, until it is proven to be safe. The potential damage to people and to the environment here is immense. The threat stretches from the point of origin of the nuclear waste, across the entire continent, along several rail and highway routes. There is no way that anyone could ever prove that any of the practices involved in this plan are safe. Therefore, according to the Precautionary Principle, this group of practices must be considered inherently unsafe and should not be pursued.

There is too much at stake here – millions of people, thousands of tons of high level waste, thousands of miles of highways and rail, millions of acres of land where intricate suites of plants, animals, and people live. Radioactive contamination and its effects are persistent, toxic, and liable to bioaccumulative even when there is little scientific evidence to prove the strength of the causal link between release and effects. In the absence of scientific certainty, the Precautionary Principle implies that actions must be taken that will protect people and the environment from that which must be assumed to be unsafe. Certainly we have here the threat of serious and irreversible damage. It then follows that the DOE must:

Halt our relentless drive for approval of the inadequate Yucca Mountain site;

Explain to the Congress why we should not proceed.

Give serious reconsideration to finding the least dangerous, most equitable methods of retaining control of all radioactive wastes in a manner that will best assure that future populations will have an opportunity equal with our own to be able to continue to maintain control for the duration of its hazardous lifetime.

The DOE must take these actions to protect the nation's people and our natural heritage from the hazards of high level nuclear waste, for our environment, for our families, and for our future.

Response

DOE also believes that precautionary measures should be taken especially where cause and effect relationships are not fully understood. For example, DOE uses the linear no-threshold hypothesis for estimating effects of exposure to low levels of ionizing radiation, where there is no definitive scientific evidence that ionizing radiation has an adverse effect. The linear no-threshold hypothesis states the stochastic (that is, effects having a probability of occurrence rather than a threshold) cause and effect relationship of radiation noted at high doses and dose rates, namely cancer, are also presumed to occur at low doses and/or low dose rates. For purposes of radiation protection, national and international advisory groups, including the National Academy of Sciences, National Council on Radiation Protection and Measurements, and International Commission on Radiological Protection have recommended that it is both prudent and conservative to apply high dose or dose rate evidence to those situations where low doses or low dose rates might be received. DOE and other federal agencies, including the Environmental Protection Agency and the Nuclear Regulatory Commission, have accepted the recommendations of these advisory groups for purposes of radiation protection and for making estimates of the risk from ionizing radiation exposure, adopting the linear, no-threshold hypothesis for estimating health effects from exposure to low levels of ionizing radiation.

With regard to the comments about proving safety and considering actions inherently unsafe and not taking them until proven, and also using lack of full scientific certainty as a basis for taking no action, the National Academy of Sciences concluded that: " … [the] better safe than sorry … philosophy holds true only when unlimited resources are available to protect the public health and the environment. Once resources are acknowledged to be limited, overestimates of a particular risk are ultimately harmful to the public health because funds are diverted from larger risks to protect society from smaller risks. This diversion of funds ultimately will result in greater mortality than would have occurred if resources were spent in proportion to the amount of health benefit that would be achieved" (DIRS 154539-National Research Council 1995). The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197 and represents an incremental lifetime risk of contracting a fatal cancer of less than one chance in 100 million (see Section 5.4.2 of the EIS). This incremental level of risk is about 25 million times lower than the current risk of contracting a fatal cancer in the United States from all other causes and far below that which people consider important to their everyday decisionmaking process (see Section F.1.1.5 for a discussion on risk perspectives). DOE believes that the benefits of safely isolating spent nuclear fuel and high-level radioactive waste from the accessible environment far out weigh the small levels of additional risk associated with the long-term performance of the Proposed Repository.

With regard to the statement that DOE should stop efforts to gain approval for a repository at Yucca Mountain, Congress specifically directed the Secretary of Energy to characterize and evaluate the Yucca Mountain site for suitability as a geologic repository. Through the NWPA, Congress established a process that will lead to a decision by the Secretary of Energy on whether to recommend to the President approval of the Yucca Mountain site for the development of a repository. Therefore, consistent with the NWPA, DOE continues to characterize and evaluate the suitability of the Yucca Mountain site.

DOE believes that the information provided in the EIS on safely handling, transporting, and disposing of high-level radioactive materials and the protection of individuals and populations is consistent with the National Environmental Policy Act and sufficient to support the Secretary of Energy's determination whether to recommend the Yucca Mountain site for development of a repository.

7.5.7 (8797)
Comment - EIS001907 / 0025
Only 12 miles from Yucca Mt. lies numerous dairy and agricultural (including several organic dairies and farms) industries. One of these dairy's ships 30,000 gallons of milk per day to Los Angeles, was this taken into consideration in this document? I don't think that it was, and this is another reason to start the DEIS process over.

Response
In evaluating potential human health impacts of the Yucca Mountain Repository, DOE considered all exposure pathways, including agricultural and animal products such as milk, for residents of Amargosa Valley. The dose factors described in Section G.2.4.1 of the EIS for operations and Section I.4.4.6 for long-term performance include these pathways. DOE estimates that the most likely outcome from potential exposure to ionizing radiation from the Yucca Mountain Repository during operations and the 10,000-year postclosure period would be no latent cancer fatalities in the surrounding population. Chapter 5 addresses potential impacts to individuals outside the Yucca Mountain region from transported agricultural products, specifically from consumption of milk products produced by the dairies noted by the commenter. The dose to these individuals would be less than the estimated dose to the "reference individual" described in the EIS sections mentioned above.

7.5.7 (8833)
Comment - EIS000869 / 0010
Regarding S.3.1.2, paragraph seven, there is no recommendation as to which thermal load scenario is planned. I appreciate the attempts made to protect workers by creating a negative pressure gradient on the emplacement side thus venting radon and any other exposures away from workers, on the development side, and into the nuclear waste emplacement area. My concern is that these contaminants will be vented from the emplacement areas, with the heat from the thermal load, whichever scenario is utilized, via the exhaust ventilation into the air to drift with the winds. Any radiation leak, in any canister, would also be vented away reminiscent of the above ground bomb testing, at the Nevada Test Site, to affect the down-winders.

Response
Air from both the development and emplacement sides of the proposed repository would be exhausted from the repository to the atmosphere. The only radionuclides normally exhausted from the repository would be naturally occurring radon and radon decay products, as discussed in Section 4.1.2 of the EIS. The presence of these materials would be indistinguishable from natural background radiation in the environment around Yucca Mountain. Table 4-4 of the EIS shows that the potential dose to the maximally exposed individual during the year of highest exposure would be 1.3 millirem per year for expected conditions under the lower-temperature repository operating mode (the scenario which could result in the highest dose). Section 4.1.8 of the EIS discusses the potential for accidental radiation release from the repository, which would be very small. DOE expects no adverse radiation-related health effects to members of the public from either routine operations or hypothetical repository accidents.

7.5.7 (8916)
Comment - EIS001027 / 0002
I am concerned on behalf of those who will be put in harm's way as a result of DOE's proposed shipments, including both the public at large – that is, anyone who breathes the air, drinks or bathes in the water, or lives on the land in this region -- and also the workers involved with these shipments. This latter group includes the following:

- Workers at the nuclear power plants who have to remove the spent nuclear fuel from spent-fuel pools in order to put the spent nuclear fuel into casks. Even with the use remote equipment, these workers will be exposed to contaminated water in the pools and contaminated air in the buildings housing these pools.

- Truck drivers and railroad locomotive engineers who are in the vicinity of these casks during shipment and storage.

- Crews who monitor and maintain the vehicles that are used in these shipments.

- Workers at Yucca Mountain who unload casks and then empty shipping casks to put the spent fuel rods into disposal casks, during which time an known amount of radioactive gases and particulate matter is likely to be released. One reason for the likelihood of such releases is that the spent fuel rods that arrive at Yucca Mountain are all different. They have different histories, including their age, their years of use, the extent of their exposures to heat, water and radiation, and the condition of the welding of their metal tube cladding.

- Finally, the workers who move the disposal casks into the underground tunnels of Yucca Mountain both immediately and over the next 10,000 years will undoubtedly be exposed to radioactive emissions.

Response
Potential health impacts to the workers identified in the comment have been examined in the EIS, except the impacts to workers at the nuclear powerplants. These actions have been evaluated in separate National Environmental Policy Act documents prepared by the Nuclear Regulatory Commission as part of the licensing process for nuclear powerplants. The EIS considered the potential impacts to nuclear plant workers who would load the casks onto trucks or trains for transportation to Yucca Mountain, activities which are related to the repository and therefore within the scope of the EIS. However, occupational radiation exposure at Commission-licensed facilities is monitored and reported in strict accordance with regulations codified at 10 CFR Part 20.

Potential impacts to workers at the repository are discussed in Section 4.1.7 of the EIS while impacts to workers involved in the various aspects of transporting commercial spent nuclear fuel are discussed throughout the health and safety sections in Chapter 6. Workers at Yucca Mountain may be exposed during the period of construction, operation and monitoring, and closure, which could total up to more than 300 years. For purposes of analysis, individual workers were assumed to be occupationally exposed for up to 50 years. Transportation activities for the proposed action were estimated to last 24 years.

The main source of radiation exposure to workers is the penetrating electromagnetic external radiation (gamma rays), not radioactive emissions or contamination from the spent nuclear fuel assemblies. The potential for exposure to radioactive emissions or contamination is very low at Yucca Mountain. If the repository was approved for development, the approval of a license to operate would require strict compliance with occupational radiation protection standards similar to those at 10 CFR Part 20, thus ensuring the health and safety of the radiation workers at the repository.

7.5.7 (9211)
Comment - EIS000489 / 0005
The harshest thing I have to say today is that the Department of Energy just doesn't want to admit how deadly spent nuclear fuel is. I don't make a point about talking about this, but I was put on the spot by a citizen activist in my state, why don't you talk about how dangerous it is? Everyone who works on this knows. Let me try to.

How do we determine how dangerous spent nuclear fuel is? There are a number of different ways to approach this technically in the language of the health physics profession where we quote outputs from the origin to risk by computer codes. We'll try to speak plainly today.

DOE should have taken a conservative approach to radiological health by basing its evaluation on transportation of fuel that was only five or ten years out of the reactor. They choose, instead, 26-year-old fuel, which is considerably less dangerous. But even the fuel they have chosen is extremely dangerous.

My best example for you is one that I'm never comfortable using, but I think it's technically correct, and I think it should give us all a reason to pause and ask about why we have all the safety requirements, ask about why so many people die in the No Action alternative. It's because spent fuel is very dangerous.

Like this: In the time I've spoken already, if I had a spent nuclear fuel assembly here, to reference one from the EIS, I would have already gotten what in the business is known as an LD50 dose, a dose that gives either a cancer or radiation death to 50 percent of the exposed population. You have a lot of cesium and strontium that generates a gamma radiation field. There are other contributors to the dose as well.

If you were to stand next to, immediately next to the spent fuel assembly, which we believe has a surface dose rate of about 10,000 rem per hour – and we're trying to be conservative. We'll bottle it down to a 100 rem per minute exposure – how does your body react to that?

After a minute, mild symptoms of radiation sickness. After two minutes, vomiting, blood changes that wouldn't be immediately apparent, nor the doubling of the cancer risk.

After six minutes, you'd expect vomiting within three hours, hair loss, 50 percent probability of death in two months, and after 10 minutes or more, you'd be at the point where you'd expect an 80 to 90 percent probability of death within two months, and the survivors would have a hard time.

It's harsh to say these things. That's why it's important that the Department of Energy be challenged not to fall into the easy business of thinking that they have made this process of transporting waste safe.

I think the single greatest problem is what we used to call arrogance, and what social scientists now call, in highfalutin terms, the organizational atrophy of vigilance. We need to remind ourselves just how dangerous spent nuclear fuel is to make sure that whatever is done in its handling, storage, and disposal is done is recognition of just how dangerous the materials are.

Response
DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and potentially deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A.2.1.5. The revised fuel now used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses ("representative" fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel to be received at the repository (5 years old) would produce impacts about 3 times higher than the representative fuel selected for the analysis. It should also be noted that accidents involving transportation casks and waste packages would not involve only the hottest fuel since licensing limitations preclude loading these containers with only the hottest fuel.

7.5.7 (9518)
Comment - EIS001888 / 0179
[Summary of comments noted by Clark County Nuclear Waste Division staff at various citizens' meetings.]

Concerns over effects of the radiation in the area where it would be stored because of problems they observed when they lived in the Tri-Cities area near Hanford. Effects, on animals and plants, etc.

Response
DOE studied the potential impacts of radiation exposure to biota in the vicinity of the Yucca Mountain site and found the effects would be negligible. As discussed in Section 4.1.4.2, current international guidance is that chronic dose rates of 100 millirad-per-day or less are unlikely to harm even the more radiosensitive species. Potential doses to biota at Yucca Mountain would be well below these rates. A comprehensive environmental surveillance program has been established at the Hanford Site to monitor radiation effects on biota; however no radiation effects have been observed. Additional information is available in the Hanford Site Annual Environmental Report (DIRS 156931-DOE 2000).

7.5.7 (9921)
Comment - 010235 / 0001
The SDEIS evolving design puts workers at greater risk. The low temperature design increases worker's exposure to radioactive waste during the fuel blending and repackaging process, a procedure that has never been done before (p. 3-10). The effects of this prolonged exposure on workers, their offspring, and succeeding generations of offspring, are not documented.

Response
Selecting a lower-temperature operating mode could require that the repository be open longer, possibly up to 336 years (24 years of emplacement, 300 years of natural ventilation, and 12 years of closure activity), so the total number of workers involved with the work is increased, as noted in Section 3.1.7 of the Supplement to the Draft EIS (refer to Figure 2-9 in the Final EIS). Many of these additional workers would be radiation workers and exposed to radiation, so the overall worker population risk would be somewhat higher. However, the radiation dose to any individual radiation (involved) worker is estimated to be about the same as the thermal load scenarios, and to be lower for noninvolved workers, as shown in Section 4.1.7.5 of the Final EIS. The individual risk in all cases remains low, as discussed in Section 4.1.7 of the EIS. The potential impacts to workers for nonfatal cancers and to their succeeding generations from hereditary disorders would be even smaller, about 20 and 26 percent, respectively, of the fatal cancer risk. The potential for these effects is discussed in Section F.1.1. The Final EIS describes the potential risk of latent cancer fatality to workers in Section 4.1.7. The risk of the other nonfatal stochastic effects noted above can be estimated using the percentages presented, and is discussed in Section F.1.1 of the Final EIS.

7.5.7 (10372)

Comment - EIS001927 / 0012

One would be hard pressed to find in the DEIS many citations that refer to the dangers of irradiated fuel rods and high-level nuclear waste. Where is it described in there that just a few minutes exposure to fuel rods that have cooled down for years is still enough to cause a lethal exposure? Where is it mentioned that a lethal exposure to fuel rods just coming out of a reactor core after three years irradiation could occur in less than a minute? Where are the particular hazards of different radioactive poisons – alpha particles, beta particles, gamma rays, neutrons – described in simple enough terms that ordinary citizens can understand?

This DEIS retains that same “conspiracy of silence” about the health dangers of radioactivity that I encountered in the Yucca Mountain Project information center. But really, it’s healthier for all of us to openly discuss that 800 pound gorilla sitting in the middle of the room.

Response

DOE is well aware of the high external radiation fields associated with commercial spent nuclear fuel and the potential for very serious and potentially deadly health effects from exposure to an unshielded fuel assembly. This is one reason the NWPA specifies isolation of this material in a deep geologic repository for thousands of years. However, with appropriate institutional controls an exposure to a member of the public or to nuclear facility workers due to an unshielded fuel assembly and high external radiation fields is not considered to be a credible scenario (an annual probability of less than 1 chance in 10 million).

DOE has reevaluated the fuel characteristics used for the base case accident analyses based on a hazard index approach as described in Section A.2.1.5. The revised fuel now used for the analyses in the Final EIS is younger than the fuel used in the Draft EIS. For example, the pressurized-water reactor fuel now used in the accident analyses (“representative” fuel) is 15 years old rather than 26 years old as assumed in the Draft EIS. DOE has also performed sensitivity analyses to determine the relationship between accident impacts and fuel characteristics. These studies indicate that the hottest fuel to be received at the repository (5 years old) would produce impacts about 3 times higher than the representative fuel selected for the analysis. It should also be noted that accidents involving transportation casks and waste packages would not involve only the hottest fuel since licensing limitations preclude loading these containers with only the hottest fuel.

Appendix A of the EIS reports the expected radionuclide inventory in curies for contributing radionuclides for both “average” fuel used to estimate total repository inventory and “representative” fuel used for transportation and repository preclosure accident analysis. Tables A-9, A-10, A-12, and A-13 list these values on a per assembly basis, and Table A-11 lists the total projected number of curies by isotope for the Proposed Action and the additional inventory modules. The EIS analysis did not require surface dose rates for irradiated fuel, so Appendix A does not provide them. For transportation impacts, the EIS conservatively uses the U.S. Department of Transportation surface dose rate limit for all transportation casks when calculating incident-free risk impacts to the public. In addition, none of the severe accidents evaluated in a recent Nuclear Regulatory Commission report (DIRS 152476-Sprung et al. 2000, Section 5.1.4) would result in a release of spent nuclear fuel assemblies from their shipping casks or a direct exposure to the public. For repository operations, DOE estimated personnel exposures for various activities from shielded elements based on the representative fuel assemblies during normal operations and postulated accidents. In summary, the EIS analysis included all appropriate information required to assess impacts from the spent nuclear fuel and high-level radioactive waste.

Section F.1 of the EIS contains a brief primer that includes discussion of the different types of radiation and potential human health effects. More detailed information is available in public libraries and on the Internet at web sites such as the Environmental Protection Agency’s site (*http://www.epa.gov/radiation/*) and the Health Physics Society’s site (*http://www.hps.org/publicinformation/*). DOE is committed to open discussions of the potential risks of radiation and of Yucca Mountain activities.

7.5.7 (10390)

Comment - EIS002192 / 0002

But what bothers me the most -- and I have stated it many times publicly -- is that the workers are allowed 5,000 millirems, and as the reports come out with Richardson stating that we have killed our people, this is very serious.

Response
Federal regulations (10 CFR Part 835) limit the current annual radiation dose to DOE workers to 5,000 millirem. DOE implements lower administrative limits (for example, 1,000 or 2,000 millirem per year at many facilities) as well as a philosophy of achieving the standards that are as low as reasonably achievable to help keep worker doses as far below the dose limits as possible. DOE is designing the proposed repository and surface facilities to keep worker radiation doses as low as reasonably achievable. In today's working environment at DOE facilities, very few workers come close to the 5,000-millirem-per-year limit.

7.5.7 (10395)
Comment - EIS002217 / 0001
Firstly what is radiation? No one in the DOE or the Nuclear Regulatory Agency -- either they don't know what it is or they know it is and they won't say, and this I feel should be brought up.

Nuclear radiation is basically alpha, beta, gamma and delta waves accompanied by electromagnetic waves, as well.

All of these waves are negative energy. They are in a distorted condition. Their affect on the human mind and human existence is awesome. This issue has not been addressed.

Now, alpha, beta and gamma and delta waves are mental energy waves. They are the same waves that constitute our minds.

Brain waves are lower harmonics of these waves, so out from this refined uranium and other radioactive elements come -- comes a flood of distorted mental energy waves creating a distortion in our minds.

This is why radiation is bad, why we're seeing the intellectual collapse of many American citizens.

This issue, as I say, has not been addressed and the public should be made aware of this basic fact before we talk about what we're going to do with radioactive waste in -- in a populated area.

Now in addition to these negative mental energy waves that come out from radioactive elements, refined uranium and so forth, we have negative electromagnetic waves, energy waves in an extremely distorted and anti-life condition.

In effect, negative life energy, negative electronic energy, negative magnetic energy, and these are also affecting the human aura tremendously, and this is not being addressed by the scientists of these agencies.
Now, if this level of understanding isn't even attained by officials of the DOE, what about higher levels of understanding about what we're doing?

Response
Thank you for your comment. DOE is unaware of any peer-reviewed scientific literature that supports the opinions expressed by this commenter. Appendix F of the EIS contains a primer on the types of ionizing radiation and exposure pathways important to the impact evaluations.

7.5.7 (10396)
Comment - EIS002217 / 0002
The fact, like it or not, the earth is a living being with energy flows and energy centers that are scientific facts.

If the reality of nuclear fallout is not understood by members of government agencies, and obviously the next level of understanding is not understood what these elements do to the planet when we place them in certain areas that we could define as sacred areas.

Now that might sound mystical, not scientific, but when we talk about sacred areas in a scientific sense, we're talking about places such as Yucca Mountain where the planet interphases with the energy fields of the universe and where -- where certain kinds of energies come into earth in order to revitalize us.

If we place radioactive elements, a tremendous source of awesome negative energy in the sites we're in effect doing a horrible damage to the planet and committing harmful acts to all of humanity, and I feel these issues should be addressed, and since other people know more about the Yucca Mountain matter in particular.

Response
Thank you for your comment. DOE is unaware of any peer-reviewed scientific literature that supports the opinions expressed in this comment.

7.5.7 (10495)
Comment - 010115 / 0003
These designs increase worker exposure to radioactivity and further challenges their health. We know that a potential for fatality from cancer increases the longer you're around radiation. And a low-level facility increases the number of workers and the amount of time they're exposed to radiation leaks. So the question isn't directly addressed of how many people will develop cancer potentially and how many people will be exposed, how this will affect larger populations, their relatives, their children for generations to come.

So the SDEIS did not detail the long-term cumulative health impact of workers and civilians.

Response
The potential cumulative health impact to members of the public and workers over the project duration prior to closure are presented in the Supplement to the Draft EIS, where these impacts are also compared to the health impacts estimated for the Draft EIS. Potentially exposed individuals and populations would be the same as those described in the Draft EIS, namely the maximally exposed individual member of the public and worker, general population within 80 kilometers of the repository, and the exposed repository workforce. The text of Section 3.1.2.1 of the Supplement to the Draft EIS describes the estimates of latent cancer fatalities to the public from exposure to radiation from the flexible design operating modes. Section 3.1.7 of the Supplement describes the estimates of fatalities from industrial hazards and latent cancer fatalities from radiation exposure under the flexible design. In general, the lower-temperature repository operating mode would result in higher potential impacts to members of the public and workers than the thermal load scenarios because of the longer duration of the project. Overall, the exposures to individual members of the public and individual workers are not higher, as shown in section 4.1.7.5 of the Final EIS. The Final EIS fully describes the potential human health impacts of the flexible design operating modes in Section 4.1.7 for all project phases and in Section 4.1.7.5 for total project impacts.

DOE believes that adverse health impacts resulting from the Proposed Action are highly unlikely. For, example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 1.3 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. Also, for the updated flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). In all cases, these risks have been shown to be very low and, considering the conservatisms used in these estimates, likely nonexistent. As such, DOE believes that even if large-scale health studies were conducted, the identification of adverse health impacts resulting from the Proposed Action would not be discernible.

7.5.7 (10501)
Comment - EIS002138 / 0008
Volume 2, page[s] 1[I]-9 through 1[I]-12, what is the conclusion of impact on the nuclides on public health posed in the repository and during transportation to the site?

Response
The referenced section of the Draft EIS describes the radioactive material inventories consisting of both DOE and commercial spent nuclear fuel and high-level radioactive waste. The results of the analysis in the Draft EIS show that the mean peak dose rate would be 0.22 millirem per year, with a 0.000011 probability of a latent cancer fatality at the repository location as described in Section 5.4 of the Draft EIS (Table 5-4). There would be an even lower probability of other radiation-related health effects. Iodine-129 and technetium-99 would be the major dose contributors.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197.

Chapter 6 of the Final EIS discusses potential health impacts of the transportation of spent nuclear fuel and high-level radioactive waste, with supporting information in Appendix J. DOE estimates three latent cancer fatalities could occur nationally as a consequence of transporting spent nuclear fuel using mostly legal-weight trucks and one latent cancer fatalities could occur from using mostly rail over the 24 years of the Proposed Action. These estimates are based on a large number of people each receiving a small radiation dose and assuming there is a risk of health effect without threshold (the linear no-threshold hypothesis). The dose and risk to individuals would be very small. For example, Section 6.2.3.1 of the EIS discusses that the maximally exposed resident along a legal-weight truck route would receive about 6 millirem over 24 years of transport, with a 0.000003 risk of latent cancer fatality (about 1 chance in 300,000). A small number of individuals (for example, a service station attendant where trucks stopped) could receive larger doses. Section J.1.3.2 describes the methods and assumptions DOE used to estimate such impacts.

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Appendix K, Section K.4.3.2 and Appendix F, Section F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (10722)
Comment - EIS000112 / 0002
There are two more examples that I wanted to bring up of the technical problems that are associated with this project.

And one of them is right here, right outside the door here is a dust detector, and it's supposed to be able to detect radiation in the dust.

Well, UNLV [University of Nevada, Las Vegas] finally informed us the other day that the dust worldwide has half a picocurie of plutonium per gram. That's not anything too serious. The EPA [Environmental Protection Agency] requires five times that amount to be remediated immediately.

This dust detector out here has never detected anything according to the guy that runs it, so it's not detecting what's here to begin with.

The other thing that UNLV pointed out is that the dust in Plutonium Valley, which is disappearing by the way, going up into the air contains 500 picocuries per gram, so the Test Site is in violation of EPA laws by not remediating that.

So when the wind blows from that area to here, this dust detector has never detected that, either, so we have this stuff inundated on us. We know that now from the UNLV studies, and we have a detector out here that says that it isn't happening.

That's typical of the technical problems with these kind of projects.

Response
DOE routinely monitors levels of plutonium on the Nevada Test Site and reports the results of this monitoring in the annual site environmental report. The report for 1997 states that the highest detected level of plutonium onsite was less than 0.00000000008 picocuries per liter of air (DIRS 146591-Black and Townsend 1996). The level of plutonium from this source in offsite air would be much smaller, due to redeposition on the ground and atmospheric dispersion.

7.5.7 (10749)
Comment - EIS001886 / 0005
The DOE's analysis that the primary radiological impacts would occur from the water pathway is not correct for collective population doses. The EPA [Environmental Protection Agency] Science Advisory Board report on carbon-14 emissions from Yucca Mountain showed that, while the individual doses from carbon-14 emissions would be tiny, the collective global doses would be immense. Based on the linear no-threshold hypothesis, which is the basis for current radiation protection standards, and which is also the modeling approach recommended in the BEIR V committee report,[3] carbon-14 collective doses would be estimated to cause thousands of cancer fatalities.[4] These estimates cannot be ignored in the Draft EIS.

[3]National Research Council, Commission on Life Sciences, Board on Radiation Effects Research, Committee on the Biological Effects of Ionizing Radiations, *Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V*. Washington, D.C.: National Academy Press, 1990.

[4]*United States Environmental Protection Agency, Science Advisory Board, An SAB Report: Review of Gaseous Release of Carbon-14: Review, by the Radiation Advisory Committee, of the Release of Carbon-14 in Gaseous Form from High-Level Waste Disposal,* EPA-SAB-RAC-93-010. Washington, DC, April 1993.

Response
The EIS did not report potential global impacts to environmental "commons" such as surface waters because, in the case of Yucca Mountain, there would be no release of radioactive material to major rivers, and thus no releases to the oceans. As stated in *Technical Bases for Yucca Mountain Standards*, " … the most likely pathway for global distribution are gaseous releases of carbon dioxide containing the radioactive isotope of carbon-14, that eventually will escape from the waste containers, or by widespread distribution of foodstuffs grown with contaminated water" (DIRS 100018-National Research Council 1995). However, the National Research Council stated that "In general, the risks of radiation produced by such wide dispersion are likely to be several orders of magnitude below those to a critical group" (DIRS 100018-National Research Council 1995). For example, the report estimated that the average dose to members of the global population, based upon the release of 91,000 curies of carbon-14, to be 0.003 microsieverts per year (0.0003 millirem per year) and equated that to an annual risk of fatal cancer of 1.5 in 10 billion (1.5×10^{-10}). For comparison, the individual dose standard set by the Environmental Protection Agency in 40 CFR Part 197 of 1.5×10^{-4} sieverts per year (15 millirem per year) for the maximally exposed individual; a factor of 50,000 times higher (DIRS 100018-National Research Council 1995).

The report states (DIRS 100018-National Research Council 1995), " … the 'linear hypothesis' implies that even very small increments to background doses might cause effects from cancer induction in the same ratio (5×10^{-4}) as larger doses. Using the linear hypothesis to calculate the effects of very low doses on large populations requires multiplying this factor by cumulative dose imposed on populations numbered in the trillions over the life of the repository.

"There are, however, important cautions to be noted with this procedure. With respect to small increments to natural background radiation levels, the BEIR V report (DIRS 100473-NRC 1990) states that:

> 'Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of risk model involves assumptions that remain to be validated. At low doses, a model-dependent interpolation is involved between the spontaneous incidence and the incidence at the lowest doses for which data are available. Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction or either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero' [Appendixes F and K of the EIS provide further details related to uncertainties resulting from use of the linear no-threshold hypothesis to predict health effects from exposure to low-level radiation.]
>
> "… Therefore, there is great uncertainty about the number of health effects that would be imposed on the global populations because of the difficulties in interpreting the risks associated with such small incremental risks from carbon-14 releases at Yucca Mountain."

Because of these large uncertainties, DOE considers estimates of global health effects to be highly speculative and therefore did not estimate global collective doses or health effects in the EIS. However, the Department agrees with the Environmental Protection Agency (64 *FR* 46976, August 27, 1999) and the National Commission on Radiation Protection (DIRS 101858-NCRP 1995) that, for purposes of optimizing protectiveness of design alternatives, estimation of population doses is merited. However, DOE believes that information important to design optimization can be obtained by estimating collective dose to the regional populations within 84 kilometers [50 miles] of the repository, thereby precluding the need to perform the more speculative, global dose health risk calculations. For these reasons, the EIS evaluated in detail potential radiological exposures to the maximally exposed individual and regional populations (within 84 kilometers [50 miles]) from both groundwater and atmospheric pathways. Results of these evaluations are presented in Sections 5.4 and 5.5 for waterborne and atmospheric releases, respectively.

7.5.7 (10814)
Comment - EIS000280 / 0008
The combination of engineered and natural barriers will ensure that the Yucca Mountain repository will protect the public health and safety and the environment for thousands of years.

Response
Thank you for your comment. Protection of the environment and public health and safety is the objective of DOE efforts for the proposed Yucca Mountain Repository.

7.5.7 (10816)
Comment - EIS000280 / 0009
Potential long-term releases of radiation from the repository are well within the proposed limits set by the Environmental Protection and the Nuclear Regulatory Commission.

Response
The analysis of the environmental consequences of long-term repository performance considered the release of radiological constituents via the groundwater pathway and atmospheric radiological emissions as discussed in Sections 5.4 and 5.5 of the EIS. As noted by the commenter, the estimated radionuclide releases would be within the limits set by both the Environmental Protection Agency and Nuclear Regulatory Commission for the proposed geologic repository.

7.5.7 (10873)
Comment - 010364 / 0008
And finally, must YMP [Yucca Mountain Project] employ the best available science? Both the President in a letter to Governor Guinn, State of Nevada; and the Honorable [Secretary] of Energy Mr. Spencer [Abraham] they have called to use the best scientific methods for investigation of YMP as a repository. However, it is apparent that YMP management is continuing to ignore the call for use [of] the best scientific methods for investigation of human health risk for complex mixtures.

Response
The impact of interest to the long-term assessment of potential human health effects from the Proposed Action is the induction of latent cancer fatalities. For potential cancer induction at low dose rates, the dose conversion factors and risk coefficients used for the EIS analysis (Section F.1.1.5 of the EIS) are consistent with recommendations by the National Council on Radiation Protection (DIRS 101882- and 101883-NCRP 1996) and the International Commission on Radiological Protection (DIRS 101075-ICRP 1977), and assume additive cell responses from mixed radiation. Although synergistic responses from mixed radiation (that is, where the combined effects are greater than the additive response) have been postulated, this is of research interest only at this time. Since the purpose of the EIS and of all National Environmental Policy Act evaluations is to provide information to decisionmakers, DOE believes it is not appropriate to use research models that include potential synergistic effects from mixed irradiation. However, the Department continues to monitor these research activities and any future recommendations by the scientific advisory groups that might contain such considerations.

Physiologically Based Pharmacokinetic (PBPK)-based internal dosimetry models recommended by the National Council on Radiation Protection (DIRS 101882- and 101883-NCRP 1996) and the International Commission on Radiological Protection (DIRS 101075-ICRP 1977) have been used in this EIS to estimate potential radiation dose. Although the use of PBPK models could be expanded to consider impacts from all chemical forms, the resulting effects from exposure to both radionuclides and heavy metals estimated for the EIS are quite small (see Chapter 5 for details). Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

Although there is literature regarding complex interactions between metals and radionuclides, it is largely research information that is not currently contained in consensus modeling. The models used in this EIS could be expanded to consider impacts from all chemical forms; however, the effects from exposure to both radionuclides and heavy metals estimated for the EIS would be quite small. Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

7.5.7 (10897)
Comment - EIS000447 / 0005
There would be little harm posed to radiation, less than one percent an average American receives from natural resources would be from Yucca Mountain. To think it is one percent we have from the background and we are not willing to take this risk is absolutely ridiculous.

Response
Thank you for your comment. DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency standards (40 CFR Part 197) and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 1.3 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and

10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

7.5.7 (10912)
Comment - EIS000379 / 0003
When we talk about ionizing radiation, it's something that just about cannot be mitigated. The effects of ionizing radiation have been well documented from as far back as Hiroshima, Nagasaki, up to more recently Chernobyl, and even in this country Three Mile Island, and some of these things are too recent for us to have the data yet to know how to evaluate them. These cancers have now had time to incubate, and we really don't know what the effects are.

Response
The potential for exposure to ionizing radiation can be mitigated. For example, time, distance, and shielding are three common ways used to mitigate and reduce the potential for radiation exposure. The effects of high doses of radiation exposure may also be mitigated, although this mitigation consists of medical intervention since the exposure has already occurred.

Health effects of radiation exposure can be placed in two categories: stochastic (random) and nonstochastic (deterministic). Stochastic effects are those that have a probability (not a certainty) of occurrence and include somatic effects such as latent fatal and nonfatal cancers, and genetic effects such as hereditary disorders that may occur in the progeny of exposed individuals (that is, future generations). The probability of the occurrence of these effects, not their severity, is affected by the amount of radiation exposure an individual receives. For the estimation of the probability of occurrence of these effects, DOE used the linear no-threshold hypothesis, which conservatively assumes that there is no level of radiation exposure below which stochastic health effects (cancer induction) could occur.

On the other hand, nonstochastic or deterministic effects are predicted to occur only after a certain amount of radiation exposure has occurred. These occurrence and severity of these effects (not probability of occurrence) are affected by the amount of radiation exposure an individual receives and include somatic effects such as cataracts, premature aging, infertility, emphysema and pulmonary fibrosis as well as teratogenic effects in children exposed in-utero such as microcephaly (smallness of the head) and mental retardation. Most of the health effects noted by the commenters are nonstochastic effects and would not be expected to occur even at doses thousands of times higher than those resulting from the Proposed Action.

DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency environmental protection standards (40 CFR Part 197) and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 1.3 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204) and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at (40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80-kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340 year period (that is, five 70-year generations). This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340 year period. Similar estimates have been made for impacts to populations exposed over 10,000 years (see Table 5-7).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (11049)
Comment - EIS000610 / 0013
Page 2-84 [3-84], Section 3.1.8.3. The discussion focuses on workers in a tunnel. There is no mention of workers who are not in the tunnel but will be exposed to the dust from the material removed from the drilling. What is the impact of strong winds moving the material to the public?

DOE's position is they will, quote, "use the experience gained during environmental studies facility [Exploratory Studies Facility] activities to design engineering controls to minimize future exposures."

What does that statement mean? How many will have a reduced quality of life, and how many will die? Are these people working for a company who will come under SIIS? That will cost the people of Nevada more money.

Response
Chapter 3 of the EIS describes the affected environment in the vicinity of Yucca Mountain to establish a baseline against which DOE can measure potential environmental impacts. Section 3.1 of the EIS describes the environmental conditions that will exist at and in the region of the proposed repository site at Yucca Mountain after the conclusion of site characterization activities. The potential impacts of these activities are described in Chapter 4 of the EIS. Section 4.1.2 of the EIS describes possible nonradiological and radiological impacts to air quality from preconstruction testing and performance confirmation, construction, operation and monitoring, and closure. Section 4.1.7 of the EIS describes the short-term (prior to completion of repository closure) health and safety impacts to workers (occupational impacts) and to members of the public from these same activities. DOE would use the engineering and practical experience gained during excavations in the Exploratory Studies Facility to ensure that exposures to workers during repository operations would be within regulatory limits and as low as reasonably achievable. Sections 4.1.2 and G.1 of the EIS evaluate surface exposures from excavated material to workers and the public. Overall, worker and public exposure to excavated material would be small fractions of regulatory limits. No deaths nor reduction in quality of life would be expected among workers or members of the public from these exposures.

NOTE: The quote noted by the commenter was incorrect in the Draft EIS and will be changed in the Final EIS to say, "use of the experience gained during exploratory..."

7.5.7 (11113)
Comment - EIS001207 / 0002
Have previous DOE Yucca Mountain Site calculations included radiation doses to the environment and surrounding population from 17 metric tons of nuclear weapons excess plutonium in cans placed in canisters filled with borosilicate glass containing intensely radioactive high-level waste? What adjustment's have been made by DOE Yucca Mountain Site Office to radiation dose(s) to a MEI [maximally exposed individual] and, thereby, health risks to the residents in vicinity of the Yucca Mountain Repository? The MEI is "assumed" to be the off-site person receiving the highest exposure at point of maximum contaminates 24 hours a day, 7 days a week, for the period of operations under analysis. Which "operational" standard is DOE applying to the Yucca Mountain HLRW [high-level radioactive waste] Disposal Site: the period of time HLRW is transported and placed in the site, 100 years, and/or 10,000 years, or the period of time when the HLRW has decayed to only half its radioactivity (100,000's of thousand years)? Has DOE included genetic impacts in MEI dose calculations, with and without 50 metric tons of can-in-canister and MOX [mixed-oxide] fuel recycled plutonium?

Response
DOE calculations of the potential human health impacts of immobilized plutonium or mixed-oxide fuel in the proposed Yucca Mountain Repository were not included in DOE studies prior to the Draft EIS. The *Yucca Mountain Science and Engineering Report* (DIRS 153849-DOE 2001) and the EIS include estimates of impacts from these materials. The EIS includes analysis of these materials for the operational period, for 10,000 years following repository closure, and for the calculation of peak dose beyond 10,000 years. However, for preclosure operations the inclusion of these materials makes no difference in impact calculations. The immobilized plutonium is contained within high-level radioactive waste canisters that would not be opened at Yucca Mountain. The mixed-oxide spent nuclear fuel is similarly contained in the fuel assemblies that would be transferred intact to disposal canisters. Operational impact estimates are presented in Section 4.1.7 of the EIS. Because of the projected limited quantity of these materials compared to the other spent nuclear fuel and high-level radioactive waste inventories, the inclusion of these materials does not significantly affect postclosure performance. Section 5.4 presents postclosure impact estimates.

The Nuclear Regulatory Commission defines operational standards in 10 CFR 63.111 for the period through permanent closure. The standard states, “During normal operations, and for Category 1 design basis events, the annual dose to any real member of the public, located beyond the boundary of the site shall not exceed a TEDE [total effective dose equivalent] of 0.25 mSv [millisieverts] (25 millirem) [10 CFR 63.111(a)(2)].” The postclosure performance standard set by the Environmental Protection Agency at 40 CFR 197.20 specifies an annual committed effective dose equivalent of 15 millirem to the reasonably maximally exposed individual from releases from the undisturbed Yucca Mountain disposal system as the standard for 10,000 years following disposal. The reasonably maximally exposed individual is defined in 40 CFR Part 197.21 as a hypothetical person who lives approximately 18 kilometers (11 miles) from the repository, has a diet and lifestyle representative of current residents of Amargosa Valley, Nevada, and drinks 2 liters [0.5 gallon] of water per day from wells drilled into the groundwater.

The updated performance analysis of the flexible design presented in the Final EIS projects that the Proposed Action would likely result in extremely small releases of radioactive contamination to the environment in the first 10,000 years after repository closure. These releases are estimated to result in an annual dose to the reasonably maximally exposed individual of less than 0.0001 millirem (see Section 5.4.2 of the EIS), which is more than 100,000 times less than the individual protection standard of 15 millirem per year set by the Environmental Protection Agency at 40 CFR Part 197, thus, DOE believes health impacts of any kind would be highly unlikely.

The potential for hereditary effects from exposure to ionizing radiation is discussed in Section F.1.1.5 of the EIS. It is about one-fourth of the potential risk of latent cancer fatality, so elsewhere in the EIS DOE has chosen to present only the latent cancer fatality estimates.

7.5.7 (11196)
Comment - EIS002108 / 0001
I want to comment briefly on a comment that was made by an earlier speaker. I want to assure all of the men in this room and maybe in Las Vegas and in the whole country that they will not be sterile in the next twenty years by anything that has to do with nuclear power or Yucca Mountain or activities associated with those. Jockey shorts I think are the cause that people mostly cite.

Now, you know, I apologize for sort of making light of a serious subject and I know that the speaker’s intentions were serious, but what I want to do is use that to illustrate the face that we should be not making decisions based on rhetoric, but we should be making decisions based on facts and experience and good science, and I’ve been sitting in this hearing room all day and I’ve heard, you know, a significant amount of rhetoric and I’ve heard not a lot of science in defense of that rhetoric. So I would just encourage us to kind of get back on that even keel, and to that extent, I want to talk about the facts that surround transportation safety.

Response
Thank you for your comment.

7.5.7 (11265)
Comment - 010008 / 0007
Spills will occur as will incidents at the storage facility. What will be the impact of these likely occurrences only an hour and a half away from a healthy population?

Response
Before beginning repository operations, DOE must have systems in place to prevent and mitigate spills. Because the spent nuclear fuel and high-level radioactive waste would be solid material, the potential for spills would be very small, mainly from liquids and fluids such as those used in any industrial operation.

The following sections of the EIS discuss the measures and plans DOE would use to protect onsite and offsite areas from spills or accidents at the repository site:

- Section 4.1.3.1 discusses the approaches DOE would follow during preconstruction testing and performance confirmation activities to minimize the effects on groundwater of potential releases of hazardous materials.

- Sections 4.1.3.2 and 4.1.3.3 contain discussions on potential contaminant spread to surface water and groundwater, respectively. The discussions include hazardous liquid materials that DOE would store or use on the site, the potential for release of the materials as a result of a spill, and the measures that DOE would institute to prevent their spread during construction, operation and monitoring, and closure.

- Section 4.1.4.4 contains a discussion on contamination that describes how DOE would clean up and dispose of soils contaminated by radiological or nonradiological hazardous materials.

- Section 4.1.8.1 discusses onsite radiological accidents. It notes that impact calculations show that the quantities of radioactivity released to the environment and the quantities of material deposited on the ground would be very low and below the Environmental Protection Agency Protective Action Guidelines, so interdiction would not be necessary.

- Section 4.1.8.2 discusses the control of releases of nonradiological hazardous materials in the event of an accident.

- Sections 9.3.3.1 and 9.3.3.2 discuss the mitigative measures that DOE would institute in the event of an onsite spill or accident to minimize the spread of the released contaminant (radiological and nonradiological) to or by surface water and groundwater, respectively.

7.5.7 (11345)
Comment - EIS002268 / 0006
The department must release all radiation health studies heretofore classified as secret so that good science can replace expedient science, to establish epidemiological studies for those nuclear workers not yet studied.

Response
DOE is unaware of any radiation health studies that remain classified. The Department has developed the Comprehensive Epidemiologic Data Resource Program to provide public access to health and exposure data concerning DOE installations. Most of the data are from epidemiologic studies conducted by DOE-funded researchers as part of the Worker Health and Mortality Study. In addition, the Comprehensive Epidemiologic Data Resource Program includes studies of populations residing near DOE installations and other studies of radiation health effects, such as classic studies of atomic bomb survivors and radium dial painters. This information is available on the Internet at http://cedr.llbl.gov/ or by contacting the DOE Office of Epidemiologic Studies in Germantown, Maryland.

7.5.7 (11413)

Comment - EIS002251 / 0011

So anyway with the DOE record of having admitted now that there are past cancers associated with the nuclear industry and with the Nevada Test Site, and they are willing to pay for some of the health effects, I think that to say that we have these few amounts of incidences and increasing of cancer is just totally ignorance.

Response

DOE is well aware of the potentially harmful effects of exposure to radiation. In addition, DOE recognizes that the risk of cancer, particularly the risk of cancer caused by ionizing radiation, is of concern to many citizens. DOE is committed to keeping radiation doses from Yucca Mountain-related preclosure activities below the regulatory radiation exposure limits and also to levels that are as far below these limits as is reasonably achievable. Some low levels of radiation exposure may occur from Yucca Mountain activities. DOE believes that it is very important that the risk of these exposures be evaluated using scientific evidence presented by the National Academy of Sciences, National Council on Radiation Protection and Measurements, and the International Commission on Radiological Protection. The current estimate of the risk of a latent cancer fatality from ionizing radiation is 0.0005 per rem received by an exposed population (0.0004 per rem received by an exposed worker population). In the vicinity of the repository (within 50 miles) DOE estimates that no individual would receive more than a few millirem (a thousandth of a rem) per year during operations (see Section 4.1.7 of the EIS). For the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the Environmental Protection Agency individual protection standard (40 CFR 197.20), which allows up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). In addition to the 10,000-year compliance period, DOE has evaluated potential impacts for the period of geologic stability at the repository (that is, 1 million years). These results show a mean peak dose rate that would be much lower than background levels (see Table 5-8 for details). For these levels of exposure, DOE believes that adverse health effects would be unlikely to occur.

7.5.7 (11753)

Comment - 010075 / 0001

Radon data fluctuations in Figures 3 and 4 in reference CRWMS M&O 2000d “Ventilation System Radon Review” indicate that the proposed repository host rocks are highly permeable. In evaluating the potential future doses from radionuclide transport, has this high permeability been used? And what is the rock permeability associated with these radon readings.

Response

Figures 3 and 4 of the *Ventilation System Radon Review* (DIRS 150246-CRWMS M&O 2000) show the correlation of hourly measured barometric pressure with hourly radon concentration measurements and hourly radon flux estimates in the Exploratory Studies Facility, which would form a portion of the repository main access drifts. These figures show that radon concentration and radon flux in the Exploratory Studies Facility are dependent upon the barometric pressure, showing the permeability of the host rock. Therefore, the permeability of the host rock is reflected in every estimate of radon concentration and radon flux shown, which were used to develop concentration and flux values used in the EIS. Estimates of rock permeability are not presented directly in the EIS because estimates of radon flux and radon concentration are more useful for estimating dose from radon and human health impacts.

7.5.7 (11842)

Comment - EIS001736 / 0007

I assume that those members of Congress who approved the first Nuclear Waste Policy Act in 1982 believed what their generous electric utility contributors had told them, that radioactive waste is just a political problem, not a technical one, and that the waste could be safely transported on our roads and rails and that a safe, permanent disposal location could be found. They maybe even were told that only a few latent cancer deaths would result. The electric utility lobbyists maybe even believed all that, but many people had challenged those claims long before Congress voted, and far more know today that radioactive waste is, of course, a political problem, a not-in-my-backyard or not-on-my highway problem; but that it is also a technical problem.

It was back in 1977 when I first learned about tritium, or radioactive hydrogen, and about how much tritium Union Electric was estimating it would create here in Missouri at the Callaway Plant. I read that Union Electric and the

U.S. Nuclear Regulatory Commission expected that the Callaway plant could quite possibly generate and release thousands of curies of tritium into the environment every year, into the air and the Missouri River through pipes and vents as a part of the routine operation of the plant. It would not take an accident. So I phoned a health physicist at Oak Ridge National Laboratory in Tennessee and asked him to tell me about tritium. He answered, “Tritium is no big deal, all it can do is destroy a DNA molecule.” That was back in 1977 when construction of the Callaway plant had barely begun.

Response
Thank you for your participation in the Yucca Mountain EIS process.

7.5.7 (12073)
Comment - EIS002311 / 0002
The DEIS’s conversion of the reference dose for uranium to a threshold concentration (in section 5.6.3) is arguably incorrect because the conversion factor is based upon a 153 pound person, disregarding the lower body weights of the more susceptible population of children.

Response
The use of a 70-kilogram (150-pound) person in conjunction with an average 2-liter (0.5-gallon) per day water ingestion rate is standard for risk assessment. People with smaller mass would be expected to have correspondingly less water intake per day. Since the reference dose is given as milligram of uranium (ingested in drinking water) per kilogram of body mass per day, as long as water intake and body mass are correlated the actual mass of the body is not an issue.

DOE believes that information provided in the EIS on use of acceptable models and parameters is consistent with the National Environmental Policy Act and sufficient to support the Secretary of Energy’s determination whether to recommend development of the Yucca Mountain site as a repository.

7.5.7 (12075)
Comment - EIS002311 / 0004
Section 5.10 of the 1999 DEIS is arguably incorrect about the following: “The number of cancer fatalities that would normally occur each year in the population in the Amargosa Valley (assuming a population of about 1,150 persons) would be about 2. This number is based on approximately 163 cancer fatalities per year per 100,000 population for males in the United States (NIH 1999). This comparison clearly indicates that the human health impacts associated with the Proposed Action would be very small for the population in general.” These statements are incorrect because: 1) the EIS bases the result of 2 fatalities per year on statistics that only monitored males, ignoring the other 50% of the population; and 2) the last sentence, “This comparison clearly indicates that the human health impacts associated with the Proposed Action would be very small for the population in general,” assumes that in order to suffer from a “human health impact,” a person must die.

Response
DOE has revised the EIS to use cancer incidence statistics for the entire Nevada population. The average annual mortality rate for cancer deaths per 100,000 persons in Nevada is 201.7, compared to a national rate of 200.3 (DIRS 153066-Murphy 2000). In addition, DOE has added information to note that cancer accounts for 23.2 percent of all U.S. deaths annually (DIRS 153066-Murphy 2000). However, even using this updated information, the annual number of expected cancer deaths in a population of 1,150 would still be 2.

DOE believes that no adverse radiation-related health effects from Yucca Mountain activities would be likely. The estimated levels of radiation exposure from Yucca Mountain operations would be very low – less than 2 millirem per year for the highest annual exposure (see Sections 4.1.2, 4.1.7, 5.4, and 5.10 of the EIS).

Because estimated radiation exposures would be so low, the occurrence of stochastic effects would be the principal risk from exposure to low levels of ionizing radiation. Stochastic effects include latent cancer fatalities, nonfatal cancers, and hereditary disorders. They have a probability of occurrence, with no threshold or minimum amount of radiation dose that must be received before they could occur. The International Commission on Radiological Protection (DIRS 101836-ICRP 1991) and the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993) have published radiation risk factors for these effects, which DOE has accepted for use in the

EIS. Nonfatal cancer and hereditary disorders would be 20 percent and as much as 26 percent, respectively, of the fatal cancer risk, which is 0.0005 per rem. Since the risk of these stochastic nonfatal effects would be about one-fourth or less of the fatal cancer risk, DOE only presented the estimates of fatal cancer risk. DOE has revised the radiation health primer in Section F.1 of the EIS to provide updated information.

7.5.7 (12178)
Comment - 010364 / 0004
The PBPK modeling is an important tool for improving the accuracy of human health risk assessment for hazardous substances in the environment. The proper use of PBPK model can reduce the uncertainties that currently exist in risk assessment, and provide more scientifically credible extrapolations across species, routes of exposure, metabolism and exertion. The PBPK modeling helps to identify the factors that are most important in determining the health risks associated with exposure to chemicals. The PBPK model provides a mean for estimating the impact of these factors both on the average risk to population and a specific risk to an individual [Clewell] (Celwell H.J., Toxicol. Lett. 79:207-217, 1996).

Response
Because of the reasons cited in this comment, the Physiologically Based Pharmacokinetic (PBPK)-based internal dosimetry models recommended by the National Council on Radiation Protection (DIRS 101882- and 101883-NCRP 1996) and the International Commission on Radiological Protection (DIRS 101075-ICRP 1977) have been used in this EIS to estimate potential radiation dose. Although the use of PBPK models could be expanded to consider impacts from all chemical forms, the resulting effects from exposure to both radionuclides and heavy metals estimated for the EIS are quite small (see Chapter 5 for details). Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

7.5.7 (12179)
Comment - 010364 / 0005
There is extensive literature review concerning interactions between wide range of metals, and radionuclides. However DOE-YMP management has not addressed the potential interactions between specific radionuclides, heavy metals and neutron poisoning elements.

Response
Although there is literature regarding complex interactions between metals and radionuclides, it is largely research information that is not currently contained in consensus modeling. The models used in this EIS could be expanded to consider impacts from all chemical forms; however, the effects from exposure to both radionuclides and heavy metals estimated for the EIS would be quite small. Thus, it is unlikely that the use of alternative models would increase the estimated effects or add meaningful information to the decisionmaking process.

7.5.7 (12181)
Comment - 010364 / 0002
In spite of the governmental, professional and quasi-governmental organization recommendations to the YMP [Yucca Mountain Project] management, they did not address all issues of complex mixtures in their Environmental Impact Statement (EIS) (Yucca Mountain Project Environmental Impact Statement Draft Proposal Appendix H-l, August 1999). This should have addressed complex mixtures including heavy metals found in the C-22 metal canisters such as (U [uranium], Mo [molybdenum], Cr [chromium]); neutron poisoning substances; (B [boron], Cd cadmium], Ce [cerium], Gd [gadolinium]) used for shielding in canister; and the long-lived radionuclides (Tc [technetium]-99, I [iodine]-129, Np [neptunium]-237, U-234, Pu [plutonium]-239, and Pu-242). Neither did they fully incorporate the tritium groundwater plume generated as a result of 260 underground nuclear explosions at the Nevada Test Site. The Yucca Mountain environmental impact statement ignored the use of a Physiologically Based Pharmacokinetic Model (PBPK) model, which is advocated by the EPA [Environmental Protection Agency] and the environmental community to assess the impact of complex mixtures.

Response
The EIS discusses the risks of exposure to ionizing radiation and hazardous chemicals separately where such exposures could exist. A good scientific foundation for adding the risks of exposure to radiation and chemicals does not currently exist, even if target tissues might be the same, because exposure pathways and cellular and molecular mechanisms of cancer induction can differ.

The inventory of chemically toxic materials that would be emplaced in the repository under the Proposed Action is identified by element in Section I.3 of the EIS. Based on this inventory, a screening analysis (described in Section I.6.1) identified which of the chemically toxic materials might pose a risk to human health. Only chromium, molybdenum, nickel, and vanadium were identified as posing such a risk, and these elements were further evaluated in a bounding consequence analysis, as described in Section I.6.2 (see Table 5-14 for results). This bounding analysis shows that the concentration of chromium, molybdenum, nickel, and vanadium in well water is calculated to be below the Maximum Contaminant Level Goal or yield intakes well below the Oral Reference Dose. Based on Environmental Protection Agency guidance (51 *FR* 34014; September 24, 1986), since the Hazard Index (sum of the Hazard Quotients) of these contaminant intakes is much less than unity, DOE believes that adverse health impacts resulting from consumption of such concentrations would be unlikely.

While it is not possible to scientifically address all of the research issues associated with complex mixtures of radionuclides and heavy metals at this time, it is possible to use consensus modeling approaches and assumptions for supporting the decisionmaking process associated with National Environmental Policy Act assessments. These research issues include potential synergistic effects from such exposures, and because they are research issues, there is currently no consensus modeling approach. Because the resulting effects from exposure to both radionuclides and heavy metals estimated for the EIS are quite small, DOE believes that it is unlikely that the inclusion of synergistic effects would add meaningful information to the decisionmaking process.

For the case of the tritium groundwater plume, because tritium has a 12.3-year half-life, and because of the long holdup times estimated for the proposed repository (thousands of years), it is not physically possible for these two plumes to interact because the tritium would be effectively decayed away within a few hundred years. Finally, the internal dosimetry models applied in the EIS are Physiologically Based Pharmacokinetic (PBPK) models, which use human metabolic data to describe the internal transport and deposition of radionuclides in bodily organs.

7.5.7 (12184)
Comment - 010364 / 0001
Several models for the action of mixed irradiation with two types of radiation have been proposed in the last two decades, but YMP management failed to include them in the EIS. Mixed irradiation is sometimes composed of more than two types of radiation, and for this type of mixed irradiation, no model has yet been proposed. It is of importance to assess the effect of mixed irradiation in terms of the environment, groundwater contamination, transportation accidents, space, and medicine.

Response
The models suggested by the commenter are based on limited research data and are generally applied to mixtures of low LET (photon) and high LET (neutron or alpha) radiation, in terms of cell death at high dose rates. The impact of interest to the long-term assessment of potential human health effects from the Proposed Action is the induction of latent cancer fatalities, not cell death. For potential cancer induction at low dose rates, the dose conversion factors and risk coefficients used for the EIS analysis (see Section F.1.1.5) are consistent with recommendations from national and international scientific advisory groups, and assume additive cell responses from mixed radiation. Although synergistic responses from mixed radiation (that is, where the combined effects are greater than the additive response) have been postulated, this is of research interest only at this time. In fact, one of the papers cited by the commenter (Suzuki, S. Radiation Research Society, 0033-7587/94, pp. 297-301) concludes: "...there has been no evidence for synergism of mixed irradiation..." and the terms synergism and synergistic should also not be applied to mixed irradiation unless a reasonable definition and evidence are provided. Since the purpose of the EIS and of all National Environmental Policy Act evaluations is provide information to decisionmakers, DOE believes it is not appropriate to use research models that include potential synergistic effects from mixed irradiation. However, the Department continues to monitor these research activities and any future recommendations by the scientific advisory groups that might contain such considerations.

7.5.7 (12407)
Comment - EIS001888 / 0334
[Clark County summary of comments it has received from the public.] Commenters believed that the repository EIS should address public health and safety issues including -- baseline and future health assessments: past exposures to radiation; dangers of, radiation; releases of radioactivity; exposure pathways and scenarios- effects of radiation on Native Americans; agriculture; human error and nuclear proliferation.

Response
Chapter 8 of the EIS discusses the impacts of the repository, along with the impacts from past, present, and reasonably foreseeable future actions in the affected area. In preparing this chapter, DOE reviewed many documents to determine where there was potential for cumulative impacts. These documents included resource plans by land-management agencies, EISs, environmental assessments, strategic plans, records of tribal meetings, and other documents prepared by Federal, state, local, and private organizations. The analyses and results described in Chapter 8 consider only those impacts from activities that have the potential to coincide in time and space with impacts from the repository. Based on some of the comments received on the Draft EIS and more recent information on activities at the Nevada Test Site, DOE modified several analyses in the Final EIS. The Department believes that the Final EIS analyzes a sufficient range of past, present, and reasonably foreseeable future actions that could contribute to cumulative impacts.

As part of its analysis of cumulative impacts in Chapter 8, DOE quantified, where possible, the total radiation dose that local residents have received. The Department calculated the total risk to the population based on the assumption that radiation risks from different exposures are additive.

With respect to person-specific exposure, DOE cannot account for each resident's past exposure to radiation. To do so would require accounting for person-specific lifestyle and habits, such as the frequency of cross-country airline flights, past residences in locations that might have substantially higher or lower cosmic radiation, and the frequency and nature of medical diagnostic tests and treatments. Rather, the Department used population risk factors. These factors account for the variety of individuals in the population, including differences in risk due to age. An estimate of impacts to specific groups of people (such as pregnant women, children, the elderly, and certain ethnic groups) was not made because such estimates would have greater uncertainty. The doses that have been calculated thus far for downwind residents have uncertainty associated with them that would tend to overshadow differences in risk to the various groups cited. The use of the average risk factors adequately covers all groups within the population and gives a reasonable estimate of the risk to the group as a whole.

Section 8.3.2.1 of the EIS describes the activities on the Nevada Test Site that could contribute to cumulative impacts with the proposed repository. Section 3.1.8.2 estimates the annual radiation dose to a hypothetical individual in Springdale, Nevada, from airborne radioactive materials release during past testing of nuclear weapons at the Nevada Test Site. Since issuing the Draft EIS, DOE has revised some of the analyses of impacts associated with the Nevada Test Site. Sections 8.2.2.2 and 8.4.2.7 now include information on radiation exposure from past nuclear weapons testing, and Section 8.3 includes updated estimates of future impacts to groundwater and air resources from activities on the Test Site. In addition, Section 8.4.2.7 of the Final EIS now incorporates the human health impacts from the transportation activities discussed in Section 8.4 (for example, Table 8-58 describes radiological and nonradiological impacts from waste transport between 1943 and 2047). Section 8.3 estimates the long-term future impacts to groundwater from potential migration of radiological and hazardous contaminants from the repository, the Nevada Test Site, and the Beatty low-level waste site.

Section 3.1.8.2 mentions that DOE made quantitative estimates of the offsite doses from releases from past weapons testing at the Nevada Test Site. In response to public comments, Appendix J of the Final EIS now contains maps showing routes used in analyzing impacts, and estimates radiological and nonradiological impacts for each state. This is in addition to the route maps that were already included in the Draft EIS (see Section 2.1.3.2 for national routes and Section 2.1.3.3 for Nevada maps). Based on this information and analyses, DOE has concluded that the cumulative impacts of waste transport, past testing of nuclear weapons, and other Federal and private programs involving radioactive materials in the State of Nevada would not be significant.

Readers interested in further information about the effects of past testing of nuclear weapons should refer to Institute of Medicine and National Research Council (DIRS 152469-1999).

A discussion of the role of the project in nuclear nonproliferation has been added to Chapter 1 of the EIS. The text states that internationally, permanent geologic disposal is the consensus on management of commercial spent nuclear fuel. The United States remains committed to a once-through fuel cycle and to disposing of commercial spent nuclear fuel in a geologic repository. This policy assumes that fuel originating in the United States and used in foreign research reactors would be disposed of in a U.S. repository. This approach supports the U. S. advocacy for limiting international trade in weapons-usable nuclear materials and signals our commitment to a policy of nonproliferation of nuclear materials.

7.5.7 (12781)
Comment - 010104 / 0004
Section 3.1.7: How much heat loading will occupational workers be exposed to in the drifts and other underground locations?

Response
Heat stress is an occupational hazard of which DOE is well aware, and DOE's worker protection program at the repository would take all appropriate measures to make sure workers do not suffer from heat stress. The potential for "heat loading" of workers, presumably meant to mean heating from emplaced waste packages, would be very small. Workers would not be in the direct vicinity of emplaced waste packages. Occasionally, workers could need to perform inspection or maintenance activities in the ventilation air downstream from the emplacement drifts. This air could be of elevated temperature, as high as 58ºC (136ºF) (Section 4.1.2.3.1). All appropriate measures to prevent worker heat stress would be taken in these instances.

DOE believes that information provided in the EIS on protection of repository workers from heat loads is adequate.

7.5.7 (12830)
Comment - 010305 / 0006
Why is risk assessment assumed to be caused by the hundreds of elements, their daughters, cousins and aunts that are omnipresent radionuclides? Why isn't the toxicological effects of highly toxic heavy metals that are known carcinogens tested? If D of I gets involved how can this project comply with ALARA standards if the public, workers both past and present die from silicosis and other repertory diseases? Using GENII-S along with the linear threshold theory for cancer exposure is dead wrong because it doesn't take into account DNA complex breakdowns, which cause high rates of cancer. How many deaths are allowed?

Response
The assessment of risk to the public during the preclosure period when the repository is open and ventilation is occurring focuses upon the release of radon-222 and its radioactive decay products. These radionuclides account for greater than 99 percent of the total dose to the public (Sections 4.1.2 and G.2). Exposures of workers to silica dust would be kept below regulatory limits established by the Occupational Safety and Health Administration, preventing the occurrence of silicosis. Potential exposure of members of the public to silica dust is evaluated in Section 4.1.2, and shown to be extremely small with no potential for health impacts. The health impacts of heavy metals that could be released during the postclosure period are addressed in Chapter 5 and Appendix I. There would be no such releases during the preclosure period. All potential exposure by members of the public and workers to all of these substances would be below applicable regulatory limits in all cases, and kept as low as reasonably achievable (ALARA).

The GENII-S computer code does not incorporate the linear no-threshold hypothesis, instead ending with the calculation of radiation dose received. The hypothesis is used as a basis for converting radiation dose to the estimated risk of latent cancer fatality. What exactly is meant by "complex DNA breakdowns" is not clear; however, the effect of radiation on DNA and the potential for causing cancer is addressed. The linear no-threshold hypothesis is the accepted national and international basis for estimating the risk from radiation exposure. Many radiation protection professionals now believe that this hypothesis is too conservative and there is some scientific evidence to support this viewpoint. Other individuals believe the hypothesis is nonconservative, but have little scientific evidence. Regardless of these other viewpoints, DOE has chosen to use the accepted national and international standards in estimating the risk of radiation exposure. In all cases the estimated radiation exposure to individual members of the public is very small. When summing these very small individual risks over an exposed population over the lifetime of the project, there is a calculated estimate of one or two latent cancer fatalities occurring. These impacts are discussed in Section 4.1.7.5 of the EIS.

7.5.7 (12907)
Comment - 010314 / 0015
What analyses were made of the potential impacts of escaped radioactivity on humans and other animals, and on plants and other living creatures if a lower-temperature operating mode is chosen that would defer the emplacement of the fuel into the repository for some decades and instead store the casks above ground?

Response
The potential impacts of using surface aging of spent nuclear fuel as part of the lower-temperature operating mode is examined fully in the Final EIS. There would be no "escape" of radionuclides from storage containers on the aging pads, since these containers would be sealed. Some gamma and X-ray radiation emitted from the fuel would penetrate the storage containers; workers or animals in the immediate vicinity could receive a dose of external radiation. Potential impacts to workers are considered in Section 4.1.7 of the Final EIS. All workers would receive radiation doses less than the regulatory limits and as low as reasonably achievable. Potential impacts to plants and animals are examined in Section 4.1.4. Potential radiation doses would be well below the threshold of impacts to these organisms. Potential impacts of accidents are considered in Appendix H. Accidents to storage containers on the aging pads was evaluated and determined to be an incredible event.

7.5.7 (13072)
Comment - 010248 / 0004
Estimates of the radiological impacts of the flexible design require additional technical basis.

Basis
The SDEIS (U.S. Department of Energy, 2001a, Section 3.1.7) states that "[e]xposed workers include both radiation workers and some general employees.... DOE used the total number of exposed worker-years to estimate potential impacts from the radiation dose received from this exposure, namely the number of latent cancer fatalities...." The SDEIS does not define the number of general employees, the lengths of their exposures, or the exposure levels associated with different phases of operation that were applied in estimating latent cancer fatalities.

In addition, the lower-temperature design option may require preclosure ventilation for a period beyond 300 years. Ensuring that the emplacement drifts remain clear and unobstructed from rockfall or drift collapse during this period is therefore important. The SDEIS does not appear to address the impacts of drift support system maintenance on worker exposure.

Recommendation
The FEIS should provide a more complete assessment of the radiological impacts of the flexible design, including maintenance activities associated with an extended preclosure period.

Response
In the Supplement to the Draft EIS total worker years are used as a primary impact indicator for occupational health and safety impacts. As noted on page 3-1, "The Department used the ratio of primary impact indicators to specific impacts in the Draft EIS to determine the Supplement impact estimates." Therefore, in the analysis the base ratio of involved (including radiation workers) workers to noninvolved (including general employees) workers was the kept the same as for the Draft EIS. The exposure [dose] levels used were the same as described in Appendix F of the Draft EIS. The total dose to each of these worker populations was changed accordingly for the total length flexible design being considered as compared to the Draft EIS high thermal load scenario. The additional time needed for repository monitoring and maintenance was included in the Supplement estimates. A complete analysis of worker impacts under the flexible design operating modes is presented in Section 4.1.7 of the Final EIS. Section 4.1.7.5 shows that over the duration of the project construction, operation and monitoring, and closure phases the dose to the maximally exposed worker is about the same as shown for the thermal load scenarios in the Draft EIS.

7.5.7 (13235)
Comment - 010244 / 0034
The fuel would arrive in a variety of transportation casks due to size and types. Commercial spent nuclear fuel would arrive as individual assemblies and placed into transportation casks or in dual-purpose canisters that would have to be opened. The Supplement fails to address the consequences of extra handling.

Response
As noted on page S-2 of the Supplement to the Draft EIS: "This supplement focuses on modification to the repository design and operating modes addressed in the Draft EIS; it does not analyze aspects of the Proposed Action that have not been modified, such as the transportation of spent nuclear fuel and high-level radioactive waste, or the No-Action Alternative. DOE will address the Proposed Action and the No-Action Alternative fully in the Final EIS."

7.5.7 (13379)
Comment - 010182 / 0020
Furthermore, how does keeping and repackaging the waste packages above ground protect the public and environment?

Response
Repackaging waste materials into disposal packages in surface facilities at the proposed repository is necessary to ensure long-term performance. However, radiation exposures from these activities are expected to represent less than one percent of the radiation exposure to the public from all other activities. Radon-222 and its decay products account for 99 percent of the radiation dose to the public from repository activities, because only very small quantities of man-made, noble gas radionuclides would be released from spent nuclear fuel handling activities (Section G.2.3.2).

DOE recognizes that the risk of cancer and other health effects caused by exposure to ionizing radiation is of concern to many citizens. Thus, in addition to keeping radiation doses within Environmental Protection Agency *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada* (40 CFR Part 197), and Nuclear Regulatory Commission licensing criteria (10 CFR Part 63), DOE is also committed to keeping radiation doses from Yucca Mountain-related preclosure activities to levels that are as low as is reasonably achievable. For example, in the vicinity of the repository (the area within 50 miles), DOE estimates short-term impacts from construction, operation and monitoring, and closure of the proposed repository would result in less than 2 millirem per year to the maximally exposed member of the public (see Table 4-35 of the EIS). This exposure is less than 15 percent of the 15-millirem limit promulgated at 40 CFR 197.4 and 10 CFR 63.204 and less than 1 percent of the annual 200-millirem dose to members of the public in Amargosa Valley from background levels of naturally occurring radon-222 and its decay products. For the flexible design, for the first 10,000 years after repository closure, the mean peak annual receptor dose to the reasonably maximally exposed individual would be more than 100,000 times less than the individual protection standards at 40 CFR 197.20 and 10 CFR 63.311, which allow up to 15-millirem-per-year dose rates during the first 10,000 years (see Table 5-6). The peaks would be even smaller at greater distances.

The EIS also provides estimates of lifetime doses and additional fatal cancers for entire populations that could be affected by the Proposed Action. For example, DOE estimates that for the lower-temperature operating mode, the potentially affected population within 80 kilometers (50 miles) of the repository (estimated to be 76,000 individuals in 2035), could receive as much as 4,000 person-rem over 341 years of operation that could result in as many as 2 additional cancer fatalities in the exposed population. This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the potentially exposed populations over a 340-year period (that is, five 70-year generations). This would represent an increase of 0.002 percent of the 89,000 cancer deaths expected to occur from natural causes in the exposed populations over a 340-year period. Similar estimates have been made for impacts to populations exposed over 10,000 years (see Table 5-7).

Although low levels of radiation exposure are estimated to result from the proposed action to construct, operate and monitor, and close the proposed geologic repository and the EIS provides estimates of latent cancer fatalities that could result from these small doses, these estimates are provided primarily to inform the decisionmaking process by enabling a quantitative comparison of impacts between the alternatives evaluated in this EIS. In all cases, estimates of latent cancer fatalities resulting from very small doses summarized in the EIS should be viewed as conservatively high; in fact, the uncertainties and conservatisms associated with these estimates (see Sections K.4.3.2 and F.1.1.5) are such that DOE believes that any adverse health impacts resulting from these exposures would be highly unlikely or nonexistent.

7.5.7 (13484)
Comment - 010260 / 0008
The exclusion zone needs to be expanded to more adequately protect the surrounding residents.

Sand filters need to be used in all ventilation shaft locations throughout the facility. The greatest technological measures need to be taken to ensure worker safety and the prevention of radioactive releases to the surrounding region. HEPA [high-efficiency particulate air] filters are not an adequate alternative. We are interested in how these filters will be disposed when their effectiveness expires.

Response
Potential impacts of accidents at the repository are examined in Section 4.1.8 and appendix H. These analyses indicate the area of land withdrawal and level of filtration on repository facilities provides adequate protection for members of the public from credible repository accidents. Some surface facilities, such as the Waste Handling Building, would use high-efficiency particulate air filters; the subsurface repository would not unless a release was detected. The filters would capture nearly all of the particulate radionuclides that are the main concern for dose to the public. The filters would not capture noble gas radionuclides. The main radionuclide that would be released from the subsurface repository during routine activities would be naturally occurring radon-222, also a noble gas, and neither high-efficiency particulate air nor sand filters would provide effective control of radon-222. In fact, sand filters are not considered to be a practical alternative for filtering of radionuclides at the repository or at other nuclear facilities.

7.5.8 AESTHETICS

7.5.8 (1368)
Comment - EIS000375 / 0003
The air quality in this part of the United States and visual acuity to see the moon and the stars is very high. This is a covenant resource that we oftentimes don't consider of value, but it is of value. Dark nights where astronomers can view stars, as well as the public can enjoy stars, is an important resource to Death Valley National Park.

We believe -- I haven't read it anywhere -- but we believe as a fairly safe presumption that given a 10,000-year security plan, which, again, I find a little hard to comprehend, will result in fences, guards, bright lights, somewhat similar, as has been mentioned in other ways, to a maximum security prison. Yucca Mountain is only 12 miles from Death Valley. We believe that will be an imposition on the scenic resources of Death Valley National Park, particularly at night. We believe that this project, if that is true, would significantly decrease this desert quality.

Response
DOE would provide night lighting at the proposed repository. This lighting could be visible from public access points to the south many miles from the repository. Ventilation stacks along the crest of Yucca Mountain could be visible if lighting atop the stacks was required. The effects of lighting from the repository would likely be less than the effects of light emanating from towns between the repository and Death Valley (Beatty, Amargosa Valley, and Pahrump). The lights from Las Vegas are most likely the dominant contributors to night lighting in southern Nevada. DOE has added a discussion of nighttime darkness as a resource around Yucca Mountain to Section 3.1.10 of the EIS. Outdoor night lighting at the Yucca Mountain Repository would be shielded and directed downward where possible.

7.5.8 (8091)
Comment - EIS000406 / 0011
The following issues need to be addressed and thoroughly analyzed concerning direct impacts to Lander County in a detailed manner:

Aesthetics effect

Response
The Carlin Corridor, one of five candidate rail corridors considered by DOE in Section 6.3 of the EIS, would pass through Lander County. About 85 percent of the 400-meter-wide (1,300-foot-wide) corridor crosses public land administered by the Bureau of Land Management. As a consequence, DOE used the Bureau's visual management

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Aesthetics effect

Response
The Carlin Corridor, one of five candidate rail corridors considered by DOE in Section 6.3 of the EIS, would pass through Lander County. About 85 percent of the 400-meter-wide (1,300-foot-wide) corridor crosses public land administered by the Bureau of Land Management. As a consequence, DOE used the Bureau’s visual management

guidelines to assess the corridor's scenic sensitivity. As described in Section 3.2.2.1.8 of the EIS, most of the Carlin Corridor crosses land in Lander County determined by the Bureau to be Visual-Class IV; Class III lands are crossed near Caliente and Class II lands are crossed or skirted also near Caliente and other areas (Section 3.1.10 describes the four visual resources classes). Section 6.3.2.1 of the EIS describes the potential impacts from sections of the rail corridor that pass through Lander County.

DOE recognizes that additional, site-specific information would be needed prior to either constructing a branch rail line or upgrading roads to support heavy-haul truck shipping. DOE believes, however, that sufficient information on impacts to visual resources is provided in Chapter 6 of the EIS to help make a decision about the transportation mode (rail or truck) and the specific corridor or heavy-haul truck route (see Section 1.1 of the EIS), if the repository was recommended and approved More detailed field surveys, government consultations, and National Environmental Policy Act reviews would be prepared if a decision was made to select either a specific rail alignment within a corridor, or an intermodal transfer station and associated heavy-haul truck route. These reviews could include more detailed analyses of impacts to visual resources, as well as the identification of additional mitigation measures to minimize any impacts that are identified.

7.5.8 (8353)
Comment - EIS001873 / 0041
P. 3-87. BLM visual resource classes are not in themselves very meaningful. Other agencies and organizations must be consulted.

Response
DOE used the Visual Resource Management classifications developed by the Bureau of Land Management to assess visual sensitivity because the rail corridors cross mostly public land administered by the Bureau. The Bureau has prepared many environmental documents that use this visual-assessment classification. DOE incorporated this approach into the repository EIS for consistency with the Bureau's approach, and to facilitate comparison with previous assessments conducted by the Bureau.

DOE agrees that factors other than the Visual Resource Management classifications are pertinent to assessing visual impacts. Therefore, DOE has included additional discussion in Sections 6.3.2.2 and 6.3.3.2 of the EIS of potential impacts to selected views from outside and inside each candidate rail corridor, and the visual impacts associated with the candidate sites for an intermodal transfer station.

7.5.8 (11166)
Comment - EIS000326 / 0002
We finally get there [Yucca Mountain] on the final day of our trip, and we can't get to the place that we wanted to get to, the campsite at the mountain, because a road had been washed out by a flood. And we couldn't pass this sort of wash because it was too radioactive, we were told. We couldn't camp in it, and we didn't want to go past it. We didn't want to go in it, so we had to stop. We stopped where we were to spend the night there in front of that wash. And we spent the night under the stars, and we developed a relationship with that mountain and with the land there. We had time with it. We woke up in the morning, and we discovered that this place which is so often thought of as arid. Maybe even people think there isn't very much life there because it's a desert. The desert -- it's a really complex place, and there's all kinds of life there: plants, animals, insects. Really, it was really vibrant; it was beautiful. And we all loved it, you know. And just along the lines of empathy that I was talking about within this room, I think it's a really big step for us but it's an important step that we start to recognize all these different life forms and empathy for them and put them into the equation, put everyone in this country into the equation, put every life form into the equation when we make any decisions, because we do not exist in spite of the life forms. We exist because of them.

Response
Thank you for your comment. DOE has documented the natural diversity of the Yucca Mountain region in Chapter 3 of the EIS.

7.5.9 UTILITIES, ENERGY, AND SITE SERVICES

7.5.9 (95)

Comment - 4 comments summarized

Commenters said that the discussion of electrical-power requirements in the EIS was insufficient and failed to adequately discuss alternatives or describe the potential impacts of onsite and offsite power-line construction or modification required to meet projected demand. Some said that the information included in Chapter 4 (impacts) should have been in Chapter 3 (affected environment). Others said that deferring impact analyses to future National Environmental Policy Act documents, as mentioned in the EIS, was not adequate because impacts cannot be determined from the "range of options" considered in the EIS. Other commenters requested that the Final EIS reflect the new ownership relationship between Nevada Power and Sierra Pacific Power Company.

Response

As described in Section 4.1.11.2 of the EIS, the current electric-power supply to Yucca Mountain from the Nevada Test Site would not be sufficient for future project needs. DOE would use electricity from renewable energy sources at the repository (DIRS 153882-Griffith 2001). The flexible design includes a 3-megawatt solar power generating facility that DOE would use in conjunction with commercially available power to meet the requirements of the repository. The solar facility, which could produce as much as 3.0 megawatts of power, would be a dual-purpose facility, serving as a demonstration of photovoltaic power generation and augmenting the overall repository electric power supply (as much as 7 percent). Impacts associated with the construction, operation, and maintenance of the solar power generating facility have been included in the impacts reported in Chapter 4 of the Final EIS.

In addition, though not part of the Yucca Mountain Proposed Action, DOE is investigating another proposal for renewable energy—a 4.9-square-kilometer (1,200-acre) "wind farm" on the Nevada Test Site that could provide electric power to the repository. As described in a recent draft environmental assessment (DIRS 154545-DOE 2001), this private-sector enterprise would be the Nation's second largest wind farm, with more than 500 wind turbines, each 55 meters (150 feet) tall. It would generate as much as 436 megawatts of electricity.

Section 4.1.11.2 also discusses the electrical requirements for the repository, along with several options under consideration by DOE to supply this electricity. The impacts of implementing each of these options was not examined in detail in the EIS, because it is not clear at this time how the electrical demand could best be met. Nevertheless, as stated in Section 4.1.11.2, electrical demand for the repository would be well within the expected regional capacity for power generation. Nevada Power's current planning indicates that it intends to maintain a reserve capacity of 12 percent. In 2010, at the beginning of the operation and monitoring phase of the repository, Nevada Power expects a net peak load of 5,950 megawatts and is planning a reserve of 714 megawatts (DIRS 103413-NPC 1997). The maximum 54-megawatt demand that the repository would require would be less than 1 percent of the projected peak demand in 2010, and less than 6 percent of the planned reserve. Thus, DOE expects that regional planning for future electrical needs would easily accommodate future demand at the repository and repository demand for electrical power would not constitute an important factor for regional decisionmaking. As discussed in Section 4.1.11.2, the estimated repository electric demand would exceed the current electric distribution system, but in all cases, upgrades would use the existing power corridors where possible to limit environmental impacts.

DOE believes that detailed analysis of specific electrical supply options now would be speculative. As mentioned in Section 4.1.11.2, depending on the option, additional National Environmental Policy Act analyses may be required.

With regard to the location of text in the EIS, Section 3.1.11.2 describes the existing electrical distribution and supply system in the affected area. DOE believes that the information in Section 4.1.11.2 on specific electrical requirements for the repository, and options for supplying this power, is not appropriate for Chapter 3.

The text of the EIS has been changed to reflect the merger of Sierra Pacific Power and Nevada Power in July 1999.

7.5.9 (175)
Comment - 24 comments summarized
Commenters noted that the Nevada State Engineer rejected DOE's request for a water appropriation for activities at the Yucca Mountain Repository. In view of this, some wanted to know how DOE was going to acquire water for the project. Others wanted to know if DOE would truck water to the site.

Response
DOE filed suits on March 2, 2000, in the U.S. District Court for the District of Nevada, and on March 3, 2000 in Nevada's Fifth Judicial District Court for injunctive relief to overturn the Nevada State Engineer's Ruling No. 4848, dated February 2, 2000, denying DOE's water-appropriation request for 430 acre-feet per year for repository construction and operation. The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest.

On September 21, 2000, the U.S. District Court Judge granted the State's motions to dismiss the DOE lawsuit. DOE appealed this ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE's suit. The case is pending.

DOE has not developed any other plans to acquire water for the proposed repository. Depending on the final ruling of the State Court, DOE could consider other options for obtaining the water needed to carry out its responsibilities under the NWPA. DOE would evaluate the need for additional environmental review at that time, consistent with National Environmental Policy Act requirements.

7.5.9 (1100)
Comment - EIS001896 / 0021
Section 4.1.11.2

There could be indirect impact on the City of Henderson in providing power to the Yucca Mountain site from Hoover Dam through Las Vegas to Mercury. The environmental consequences associated with adding power lines through the City of Henderson have not been addressed. In recent years, proposals for extensions and expansions of transmission lines in the City of Henderson have been required to be buried underground to avoid impacts to the general health, safety and welfare of our residents and visual impacts to the environment.

Response
No additional power lines would be required through the City of Henderson to support the additional capacity discussed in Section 4.1.11.2 of the EIS.

7.5.9 (4472)
Comment - 010140 / 0001
Page 3-19, fifth paragraph, how much electrical energy will be needed to refine the titanium?

Response
Because Yucca Mountain does not need large quantities of titanium for at least 75 years, any estimate of the resources required for the process would be speculative and out of date by the time production actually started.

7.5.9 (4563)
Comment - EIS001521 / 0077
Page 4-29, second paragraph--If the estimated water demands for repository development and emplacement activities exceed that for the lowest "regulated" yield for the Jackass Flats hydrographic area (in combination with other Nevada Test Site activities) under the l-t-l scenario, what is the identified source for the additional water?

Response
As indicated in Section 4.1.3.3 of the EIS, the highest annual demand for any of the operational scenarios would be about 0.36 million cubic meters (290 acre-feet) and would last for about 22 years. Annual water demand before and after this period would be lower. Even combined with the annual water demand from on-going Nevada Test Site activities in this area (0.34 million cubic meters or 280 acre-feet), the lowest estimate of perennial yield (0.72 million cubic meters or 580 acre-feet) for the western half of Jackass Flats would not be exceeded.

It should be noted that the lowest estimate of perennial yield identified in the EIS for the Jackass hydrographic area is not characterized as a “regulated” perennial yield value. As identified in the discussion of perennial yield in Section 4.1.3.3, a 1992 ruling by the Nevada State Engineer (DIRS 105034-Turnipseed 1992) described the perennial yield of the Jackass Flats hydrographic area as 4.9 million cubic meters (4,000 acre-feet). DOE has chosen to compare water demand values to the low estimate of perennial yield to be conservative in its evaluations of impacts.

7.5.9 (4568)
Comment - EIS001521 / 0082
Page 8-33, seventh paragraph--The discussion fails to mention that under the low thermal load waste-emplacement scenario, when combined with other Nevada Test Site ground-water usage, the 580 acre-feet per year yield value will be exceeded (see page 4-29, second paragraph).

Response
The groundwater discussion cited by the comment is in Section 8.2.3.2.1 of the EIS and deals with impacts associated with the inventory Modules 1 and 2, which the EIS considers to be “reasonably foreseeable future actions.” The comment is correct that the cumulative impact of water demand associated with on-going Nevada Test Site activities in the repository area is not discussed in this section. The cumulative impact of Nevada Test Site activities is, however, discussed in the next section of the EIS (that is, Section 8.2.3.2.2). This organization of text and contents is true for both the Draft and Final documents.

Current estimates of water demand for inventory Modules 1 and 2 action are lower than those described in the Draft EIS. As indicated in Section 8.2.3.2.1 of the EIS, the highest annual demand for any of the operational scenarios with Modules 1 and 2 would be about 0.39 million cubic meters (320 acre-feet) and would last for about 36 years. Annual water demand before and after this period would be lower. As described in Section 8.2.3.2.2, the repository demand under one of the lower-temperature scenarios, when combined with the annual water demand from ongoing Nevada Test Site activities in this area (0.34 million cubic meters or 280 acre-feet), would slightly exceed the lowest estimate of perennial yield (0.72 million cubic meters or 580 acre-feet) for the western half of Jackass Flats. The other operational modes, when combined with water demands for on-going Nevada Test Site activities, would be below this lowest estimate of perennial yield. None of the water demand estimates would approach the high estimate of perennial yield for the entire Jackass Flats hydrographic area, which is 4.9 million cubic meters (4,000 acre-feet). For a discussion of potential impacts, see Section 8.2.3.2.2 of the EIS.

7.5.9 (4569)
Comment - EIS001521 / 0083
Page 8-35, second paragraph--The statement about 280 acre-feet per year for water use is incorrect. According to page 3-56, Table 3-15, that value represents total water use for 1994 and not for just the Nevada Test Site “ongoing” activities, as the statement implies. How was the 280 acre-feet value determined? Table 3-15 shows that the total use from the Jackass Flats hydrographic area has been as high as 400 acre-feet (for 1996), and only 66 acre-feet of that total were for Yucca Mountain site-characterization activities. Will ongoing activities at Yucca Mountain and the Nevada Test Site decrease to a point where they require much less water?

Response
The table in Chapter 3 describes historical withdrawals of water from wells in the vicinity of Yucca Mountain. The value of 280 acre-feet (about 350,000 cubic meters) per year as identified in the comment is a planning estimate of what the Nevada Test Site might require in the future from the wells in this area, whether or not the proposed repository action is implemented. It comes from a *Nevada Test Site Resource Management Plan* as referenced in the EIS. This value is used consistently throughout the EIS (including Sections 4.1.3.3 and 8.2.3.2.2) as a water demand that would be cumulative (and from the same hydrographic area) with water demand from the Proposed Action.

With respect to the Chapter 3 table of water withdrawals, the comment is correct that the highest annual withdrawal shown in the table is 400 acre-feet. However, both the 66 acre-feet shown in the second column and the 180 acre-feet shown in the fourth, C-wells, column are attributed to Yucca Mountain site characterization activities. Withdrawals from the C-wells are identified separately because they were associated with groundwater hydrology testing and the water was put back into the ground.

The EIS evaluates estimated water demand from the proposed repository action by project phase (that is, performance confirmation, construction, operation and monitoring, and closure). As might be expected, water demand would vary during each phase of repository activities; the concurrent water demand for on-going Nevada Test Site activities in this area is assumed to stay constant at 280 acre-feet per year.

7.5.9 (5039)
Comment - 010212 / 0006
The Supplement introduces the plan to add renewable energy sources to the repository. These would be supplementary to upgrading the existing electric transmission and distribution service from the Nevada Test Site. These additions should help reduce off-site electricity requirements during periods when the renewables can meet some of the repository requirements.

The solar generating facility has some site impacts that are analyzed in the Supplement, although exact site is not identified yet. The possible development of a 436 MW wind farm on the Nevada Test Site, however, is not part of this proposed action. That may also contribute electricity to the repository but we gather it is an independent decision.

Response
The solar facility, which could produce as much as 3 megawatts of power, would be a dual-purpose facility, serving as a demonstration of photovoltaic power generation and augmenting the overall repository electric power supply (as much as 7 percent). The wind farm is a separate, privately funded project that would supply power to the commercial market. DOE would consider obtaining power from the facility for the Nevada Test Site or the repository, depending on availability and cost of the power.

7.5.9 (5621)
Comment - EIS001887 / 0247
Page 4-67; Section 4.1.11.1 - Impacts to Utilities, Energy, Materials, and Site Services from Performance Confirmation

This section should give more detail as to what existing sources and suppliers would be used; what wells would be pumped; and what regional suppliers of power would be used. Have there been any discussions with these existing sources and suppliers? Also, does this section cover performance confirmation activities throughout the operating life of the repository?

Response
Existing sources and suppliers of electricity would include Nevada Power Company and Valley Electric Association. Water and sewer would be provided by permitted on-site services. Water would be supplied by wells J-12/J-13 with the C-Well Complex as a backup water supply during construction and operation. No discussions with outside utility service companies have occurred.

The potential impacts discussed in Section 4.1.11 of the EIS apply during performance confirmation, construction, operation and monitoring, and closure of the repository. The performance confirmation period would extend until the start of repository closure; Section 4.1.11.2 describes those impacts.

7.5.9 (5996)
Comment - EIS001879 / 0021
p. 3-89, 4th paragraph

The discussion concerning wastewater treatment in southern Nye County is incorrect....the community of Beatty is not reliant on domestic septic systems. The EIS should be revised to accurately reflect the conditions in Nye County.

Response
Southern Nye County does not have a metropolitan area or a sanitation district comparable to Clark County. Most communities in this area rely primarily on individual dwelling or small communal wastewater-treatment systems, with the exception of Beatty, which has a municipal sewer service. DOE has revised Section 3.1.11 of the EIS.

7.5.9 (8839)
Comment - EIS000869 / 0013
Paragraph two [in Section 5.4.1.1] discusses the need for additional electrical power delivery to the Yucca Mountain site. With the heat being generated by the stored nuclear waste, why would there be a need for increased electrical power delivery. The excess heat units should be utilized for development of electrical energy instead of increasing electrical requirements.

Response
Although the technology exists for generating electricity from the residual thermal output of spent nuclear fuel, the design of the repository is not well suited for generating electricity from such an application. In addition, the installation of the necessary equipment could affect the ability of the repository to isolate waste. Regardless, such a technology would not entirely offset the electrical needs of the repository and DOE would still be required to obtain additional electricity for the repository.

7.5.9 (11016)
Comment - EIS001896 / 0014
Section 3.1.11.2

There could be indirect impact on the City of Henderson in providing power to the Yucca Mountain site from Hoover Dam through Las Vegas to Mercury. The environmental consequences associated with adding power lines through the City of Henderson have not been addressed. In recent years, proposals for extensions and expansions of transmission lines in the City of Henderson have been required to be buried underground to avoid impacts to the general health, safety and welfare of our residents and visual impacts to the environment.

Response
No additional power lines would be required through the City of Henderson to support the additional capacity discussed in Section 4.1.11.2 of the EIS.

7.5.9 (11246)
Comment - 010096 / 0021
Page 2-19 – The SDEIS should consider use of Pinyon-Juniper biomass from Lincoln County as an alternative to fuel oil for a central heating plant. Bureau of Land Management planned thinning of P-J [Pinyon-Juniper] woodlands over the life of the repository will result in large quantities of biomass.

Response
The design of the surface facilities continues to evolve as the overall design of the repository matures. DOE would continue to evaluate options for providing fuel sources for repository facilities.

7.5.9 (12167)
Comment - 010319 / 0013
[...a huge storage pool presents problems] with regard to where the water would come from for the purpose and where it would go after it was ready to be “gotten rid of.”

Response
The proposed site water system would receive water from the Nevada Test Site Well J13 and associated wells. Well water would supply both potable and nonpotable water needs. New pipelines, pumps, tanks and chlorination equipment would be constructed to provide for anticipated demand (see Section 2.1.2.1 of the EIS for details). For more information about the site water system, see Attachment II, Section 2.3, *Engineering Files for Site Recommendation*. (DIRS 123881-CRWMS M&O 2000)

DOE filed suits on March 2, 2000, in the U.S. District Court for the District of Nevada, and on March 3, 2000, in Nevada’s Fifth Judicial District Court for injunctive relief to overturn the Nevada State Engineer’s Ruling No. 4848, dated February 2, 2000, denying DOE’s water-appropriation request for 430 acre-feet per year for repository construction and operation. The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest.

On September 21, 2000, the U.S. District Court Judge granted the State's motions to dismiss the DOE lawsuit. DOE appealed the ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE's suit. The case is pending.

The proposed Yucca Mountain Repository design continues to plan on the use of water from Nevada Test Site water wells. DOE will review this plan and determine what action is necessary based on future court rulings.

DOE has not developed any other plans to acquire water for the proposed repository. Depending on the final ruling of the State Court, DOE may consider other options to carry out its responsibilities under the Nuclear Waste Policy Act, as amended.

As discussed in Section 3.1.12.4 of the Supplement to the Draft EIS, during the lifetime of Proposed Action, about 2 billion liters (530 million gallons) of sanitary sewage would be generated under the higher-temperature repository operating mode and as much as 4.1 billion liters (1.1 billion gallons) under the lower-temperature repository operating mode. About 1 billion liters (260 million gallons) of industrial wastewater would be generated under the higher-temperature mode and as much as 3.4 billion liters (900 million gallons) under the lower-temperature mode. Sanitary sewage and industrial wastewater for the flexible design would be slightly more than double the amounts for the Draft EIS design. As reported in the EIS, DOE would treat and dispose of sanitary sewage in onsite septic systems and industrial wastewater in onsite evaporation ponds.

7.5.9 (12236)
Comment - 010002 / 0002
Electrical Supply -- Aside from the commercially supplied electric power, the report discusses potentially constructing a 3-megawatt solar power generating facility. As far as I am aware the funds for constructing the Yucca Mountain Repository are derived from fees levied on nuclear utilities on a per nuclear MW-hr basis. It would not be right to use that money to construct a generation facility which in effect competes with utilities. (It would be like the government placing a surcharge on commercially sold beer and using those proceeds to construct an experimental brewery to compete with the commercial brewers!) If your response to this is that on-site generated electricity will lower operation costs which benefits the "member" utilities, then I say let the solar units be funded through private interests who compete with utilities for sales to the Yucca Mountain Project.

Response
The solar facility, if constructed, would be an operational element of the proposed repository and as such would be funded with both defense and Nuclear Waste Fund appropriations. At this time, the taxpayer portion of the total cost is expected to be about 30 percent.

The solar facility, which could produce as much as 3 megawatts of power, would be a dual-purpose facility, serving as a demonstration of photovoltaic power generation and augmenting the overall repository electric power supply (as much as 7 percent). As such, all of the generating capacity of the solar facility would be used to offset the baseload electrical requirements of the repository and none would be available for resale. Therefore, the facility would not be in direct competition with private utilities. If the 3-megawatt plant is built as a part of the Proposed Action it would be one of the largest operating solar/electric plants in the United States and would represent a significant advance in solar power applications.

7.5.9 (12237)
Comment - 010002 / 0003
The "wind farm" also described in this report purports to be a private-sector enterprise. This would be acceptable to me as long as Yucca Mountain purchases power from it on an open, competitive market.

Response
The wind farm is a privately funded project. DOE would evaluate the possibility of obtaining power from this facility for use at Yucca Mountain. DOE would expect that the owner of the facility would consider supplying power to DOE in the same way as any other customer who would buy power from the facility.

7.5.9 (12537)
Comment - 010242 / 0018
Page 2-18: Section 2.3.2.4.4 - Electric Power

The Supplement states, “The S&ER flexible design includes a 3-megawatt solar power generating facility that DOE would use in conjunction with commercially available power to meet the requirements of the repository.” The solar facility would be located near the North Portal Operations Area. The peak electrical demand for the repository operation would be 47 to 57 megawatts, and the addition of the solar power supplement would not alleviate the need to upgrade transmission capacity (Page 3-12). If solar power is to be developed for repository operations, it should be at least sufficient to offset the transmission upgrade need, thus eliminating the impacts of that activity. Doing otherwise would only unnecessarily increase the impacts of repository development and operation, e.g., disturbed land and hazardous waste (resulting from the need to replace the 27,000 solar panels at least once because of the long duration of operation).

Response
The solar power generating facility is a dual-purpose unit. It would provide up to 7 percent of the power needs of the repository, and would be a demonstration of the viability of photovoltaic solar power. If the 3-megawatt plant was built as a part of the Proposed Action, it would be one of the largest operating solar electric plants in the United States and would represent a significant advance in solar-power applications. Considering the present state of solar plant installation and operating experience, it would not be appropriate to build a larger plant at that time. However, it is possible that the size of the solar power generating facility at Yucca Mountain could be increased after operation of the facility verified efficient performance.

7.5.9 (12716)
Comment - 010073 / 0020
Page 2-19 - The SDEIS should consider use of Pinyon-Juniper biomass from White Pine and Lincoln County as an alternative to fuel oil for a central heating plant. Bureau of Land Management planned thinning of Pinyon-Juniper woodlands over the life of the repository will result in large quantities of biomass.

Response
The design of the surface facilities continues to evolve as the overall design of the proposed repository matures. DOE would continue to evaluate options for providing fuel sources for repository facilities.

7.5.9 (13002)
Comment - 010292 / 0009
On the subject of the Yucca Mountain site itself, the repository is projected to be there for a long, long time. Is the necessary water supply assured forever? What if, in spite of the best laid plans, the supply of electricity is insufficient for personnel safety?

Response
DOE filed suits on March 2, 2000, in the U.S. District Court for the District of Nevada, and on March 3, 2000, in Nevada’s Fifth Judicial District Court for injunctive relief to overturn the Nevada State Engineer’s Ruling No. 4848, dated February 2, 2000, denying DOE’s water-appropriation request for 430 acre-feet per year for repository construction and operation. The State Engineer based his denial on a finding that the requested use threatened to prove detrimental to the public interest.

On September 21, 2000 the U.S. District Court Judge granted the State’s motions to dismiss the DOE lawsuit. DOE appealed this ruling on November 16, 2000. On October 15, 2001, the Ninth U.S. Circuit Court of Appeals ordered a Federal judge to hear the DOE’s suit. The case is pending.

DOE has not developed any other plans to acquire water for the proposed repository. Depending on the final ruling of the State Court, DOE might consider other options to carry out its responsibilities under the NWPA.

As described in Section 4.1.11.2 of the EIS, the current electric-power supply to Yucca Mountain from the Nevada Test Site would not be sufficient for future project needs. Section 4.1.11.2 discusses the electrical requirements for the repository, along with several options under consideration by DOE to supply this electricity. The impacts of implementing each of these options was not examined in detail in the EIS, because it is not clear at this time how the electrical demand could best be met. Nevertheless, as stated in Section 4.1.11.2, electrical demand for the repository would be well within the expected regional capacity for power generation. Nevada Power's current planning indicates that it intends to maintain a reserve capacity of 12 percent. In 2010, at the beginning of the operation and monitoring phase of the repository, Nevada Power expects a net peak load of 5,950 megawatts and is planning a reserve of 714 megawatts (DIRS 103413-NPC 1997). The maximum 54-megawatt demand that the repository would require would be less than 1 percent of the projected peak demand in 2010, and less than 6 percent of the planned reserve. Thus, DOE expects that regional planning for future electrical needs would easily accommodate future demand at the repository.

7.5.9 (13110)
<u>Comment</u> - 010227 / 0028
While Shundahai Network supports the use of alternate and renewable energy as an alternative to nuclear power, it is shocking to consider that the yucca mountain project would not be using enough solar power to justify the production of transmission lines. The sun beams brightly on Yucca Mountain, and it is a good source of energy, however, if it is to be used in this project, solar should be the primary source of power at the site, and enough power should be generated and used to really get something out of it.

<u>Response</u>
The solar facility, which could produce as much as 3 megawatts of power, would be a dual-purpose facility, serving as a demonstration of photovoltaic power generation and augmenting the overall repository electric power supply (as much as 7 percent). If the 3-megawatt plant was built as a part of the Proposed Action it would be one of the largest operating solar electric plants in the United States and would advance solar-power applications. Considering the current state of solar plant installation and operating experience, it would not be feasible to build a larger plant at that time. However, it is possible that the size of the solar power generating facility at Yucca Mountain could be increased if operation of the facility verified efficient performance.

7.5.9 (13209)
<u>Comment</u> - 010244 / 0008
The SDEIS offers no explanation of the need for up to four times as much electrical energy and five times as much waste generation for the lower temperature alternative than the DEIS design.

<u>Response</u>
Both the higher-temperature and lower-temperature operating modes of the flexible design use electrically powered fans to provide forced flow air cooling to the repository emplacement drifts. The number of fans gradually increases from the start of emplacement to the completion of emplacement when all fans have been placed in operation. The fans continue to operate during monitoring for up to 300 years depending on the specific scenario. The Draft EIS scenarios included much smaller fans for ventilation and did not include the operation of fans for forced air cooling to the emplacement drifts. The substantially increased capacity of the fans, and operation of the fans for up to 300 years, are the reasons electrical power use for the flexible design scenarios is greater than the Draft EIS design.

7.5.9 (13349)
<u>Comment</u> - 010296 / 0009
Other potential sources of supplemental power (electricity) may need to be evaluated to reduce environmental impacts.

<u>Response</u>
The design of the surface facilities continues to evolve as the overall design of the proposed repository matures. DOE would continue to evaluate options for providing electrical power to repository facilities.

7.5.9 (13405)
<u>Comment</u> - 010296 / 0030
Nye County believes that the footprint of the repository can be reduced substantially. The extra demand on power and other resources may have adverse impact on the supply and demand in the Amargosa Valley area. It is not certain whether in either case the population growth is considered. DOE considers the fuel and other resources used for the Yucca Mountain project to be "small" compared to what is available in the region. Population growth in the

first 50 to 75 years of operation should be considered before such claims can be made. Population growth will put extra demand on these resources. Repository operation will be competing for these resources and may be restricting the growth in the area.

Response
DOE does not expect the repository to restrict growth in the region. The needs of the repository are well defined and very predictable so that they can be integrated into development plans and provide a base to support resource expansion. Population growth on the other hand is much less predictable and often out paces development because planning has not provided adequate resource development goals.

Electrical power demand in Nevada Power's service area has been increasing by about 6 percent per year, the highest rate in the nation. Nevada Power has used detailed forecasting and strategic planning to effectively accommodate the 6 percent growth rate. The repository electrical power needs would not be large in comparison to the growth rate and are very predictable. The repository should not place any limiting restriction on electrical power in the region to the extent that growth would be limited. Although other resources are not uniformly monitored and included in integrated planning, the regional suppliers have responded to and supported the regional growth rate for fuel and building materials. DOE expects that this historical response would continue and there would be no growth limitation.

7.5.9 (13406)
Comment - 010296 / 0031
The DSEIS goes on to identify several elements to meet the increased power requirement--an upgraded NTS distribution system; backup (diesel generator) power; a three MW solar generator; and the (currently speculative) 436 MW NTS wind farm. The DOE's electrical power plan sounds like a bunch of "cobbled together" elements, rather than a regional electric power system. Nye County believes that DOE should consider the needs of the area's regional grid and coordinate with other entities to develop a well-planned and integrated system.

Response
DOE considers electrical energy obtained from the NTS grid supported by regional suppliers as the primary source of power for the repository. The solar facility, which could produce as much as 3 megawatts of power, would be a dual-purpose facility, serving as a demonstration of photovoltaic power generation and augmenting the overall repository electric power supply (as much as 7 percent). The on-site diesel generators are used as back-up emergency units only and are an integral part of the facility design.

As discussed in Section 4.1.11.2 of the EIS, the NTS electrical power transmission system and regional transmission systems feeding the NTS grid would need to be upgraded to support the repository power needs. DOE expects to coordinate and negotiate with regional power suppliers to obtain the power required for the Repository. However, the fraction of regional power that would be needed by the repository is small.

7.5.10 MANAGEMENT OF SITE-GENERATED WASTE

7.5.10 (165)
Comment - 6 comments summarized
The State of Nevada, in several different comments, stated its belief that the proposed Yucca Mountain Repository could not use the Nevada Test Site (NTS) for low-level radioactive waste disposal. One comment expressed the concern that Yucca Mountain Repository low-level waste would not be NTS onsite-generated waste. The comment implied that for this reason the Yucca Mountain Project would be not be authorized to use NTS for low-level radioactive waste disposal. Other comments expressed the concern that NTS disposal would not be possible since NTS disposal facilities are intended solely for the disposal of defense low-level radioactive waste. These comments also expressed the concern that NTS would not be an appropriate disposal location for Yucca Mountain Repository waste because its waste would be commercial low-level radioactive waste due to the fact that the repository would be a Nuclear Regulatory Commission-licensed facility. Finally, another comment indicated the belief that no authority exists that would permit Yucca Mountain-generated low-level radioactive waste to be disposed of at NTS.

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CONVERSIONS

METRIC TO ENGLISH			ENGLISH TO METRIC		
Multiply	**by**	**To get**	**Multiply**	**by**	**To get**
Area					
Square meters	10.764	Square feet	Square feet	0.092903	Square meters
Square kilometers	247.1	Acres	Acres	0.0040469	Square kilometers
Square kilometers	0.3861	Square miles	Square miles	2.59	Square kilometers
Concentration					
Kilograms/sq. meter	0.16667	Tons/acre	Tons/acre	0.5999	Kilograms/sq. meter
Milligrams/liter	1[a]	Parts/million	Parts/million	1[a]	Milligrams/liter
Micrograms/liter	1[a]	Parts/billion	Parts/billion	1[a]	Micrograms/liter
Micrograms/cu. meter	1[a]	Parts/trillion	Parts/trillion	1[a]	Micrograms/cu. meter
Density					
Grams/cu. cm	62.428	Pounds/cu. ft.	Pounds/cu. ft.	0.016018	Grams/cu. cm
Grams/cu. meter	0.0000624	Pounds/cu. ft.	Pounds/cu. ft.	16,025.6	Grams/cu. meter
Length					
Centimeters	0.3937	Inches	Inches	2.54	Centimeters
Meters	3.2808	Feet	Feet	0.3048	Meters
Kilometers	0.62137	Miles	Miles	1.6093	Kilometers
Temperature					
Absolute					
Degrees C + 17.78	1.8	Degrees F	Degrees F – 32	0.55556	Degrees C
Relative					
Degrees C	1.8	Degrees F	Degrees F	0.55556	Degrees C
Velocity/Rate					
Cu. meters/second	2118.9	Cu. feet/minute	Cu. feet/minute	0.00047195	Cu. meters/second
Grams/second	7.9366	Pounds/hour	Pounds/hour	0.126	Grams/second
Meters/second	2.237	Miles/hour	Miles/hour	0.44704	Meters/second
Volume					
Liters	0.26418	Gallons	Gallons	3.78533	Liters
Liters	0.035316	Cubic feet	Cubic feet	28.316	Liters
Liters	0.001308	Cubic yards	Cubic yards	764.54	Liters
Cubic meters	264.17	Gallons	Gallons	0.0037854	Cubic meters
Cubic meters	35.314	Cubic feet	Cubic feet	0.028317	Cubic meters
Cubic meters	1.3079	Cubic yards	Cubic yards	0.76456	Cubic meters
Cubic meters	0.0008107	Acre-feet	Acre-feet	1233.49	Cubic meters
Weight/Mass					
Grams	0.035274	Ounces	Ounces	28.35	Grams
Kilograms	2.2046	Pounds	Pounds	0.45359	Kilograms
Kilograms	0.0011023	Tons (short)	Tons (short)	907.18	Kilograms
Metric tons	1.1023	Tons (short)	Tons (short)	0.90718	Metric tons
ENGLISH TO ENGLISH					
Acre-feet	325,850.7	Gallons	Gallons	0.000003046	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

a. This conversion is only valid for concentrations of contaminants (or other materials) in water.

METRIC PREFIXES

Prefix	Symbol	Multiplication factor
exa-	E	1,000,000,000,000,000,000 = 10^{18}
peta-	P	1,000,000,000,000,000 = 10^{15}
tera-	T	1,000,000,000,000 = 10^{12}
giga-	G	1,000,000,000 = 10^{9}
mega-	M	1,000,000 = 10^{6}
kilo-	k	1,000 = 10^{3}
deca-	D	10 = 10^{1}
deci-	d	0.1 = 10^{-1}
centi-	c	0.01 = 10^{-2}
milli-	m	0.001 = 10^{-3}
micro-	µ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}