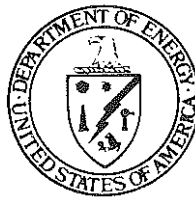


FINAL

Environmental Impact Statement

**Long-Term Management of the Existing
Radioactive Wastes and Residues at
the Niagara Falls Storage Site**



April 1986

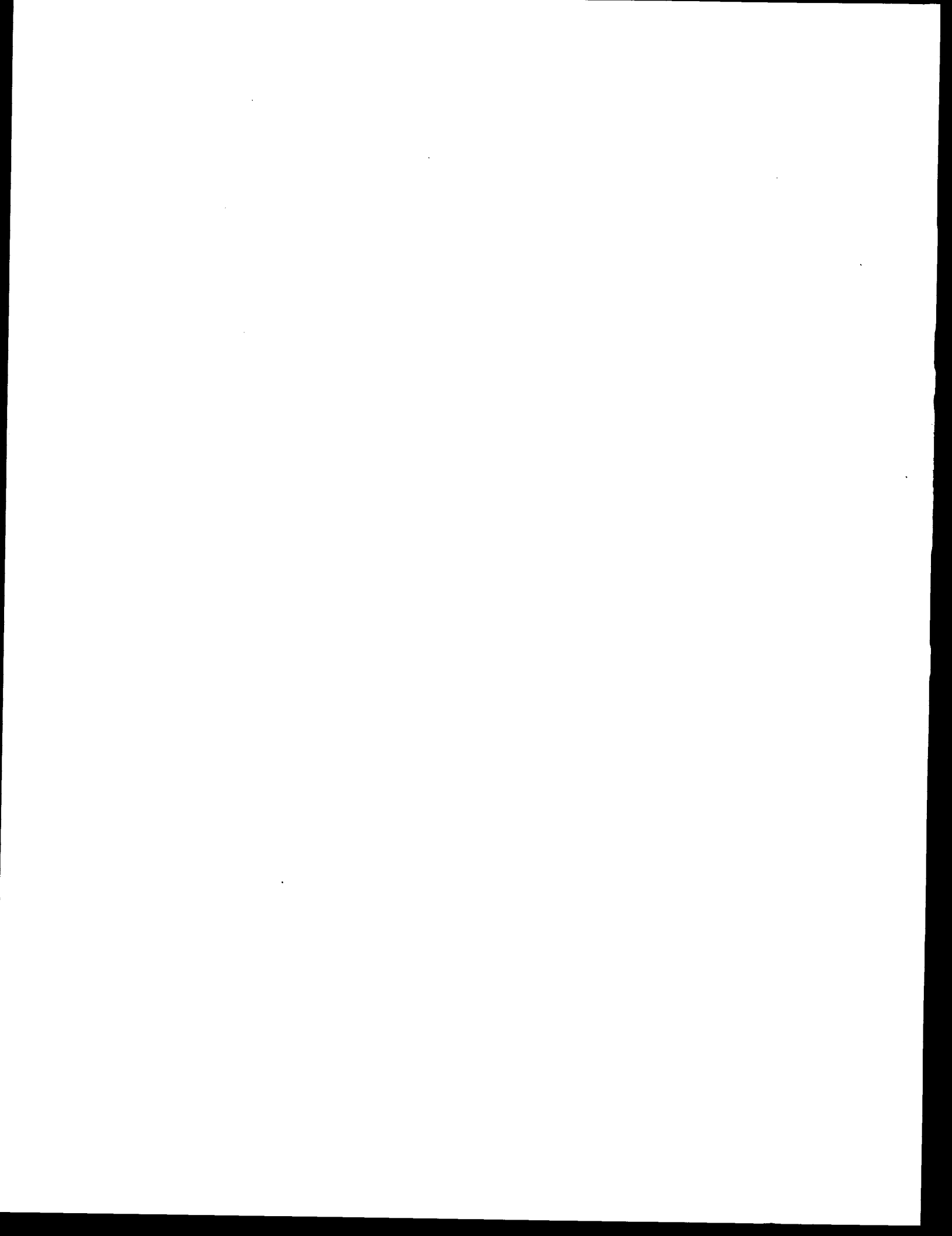
**U. S. Department of Energy
Washington, D.C. 20585**

FINAL
ENVIRONMENTAL IMPACT STATEMENT

LONG-TERM MANAGEMENT OF THE EXISTING RADIOACTIVE WASTES AND
RESIDUES AT THE NIAGARA FALLS STORAGE SITE

April 1986

U.S. Department of Energy
Washington, D.C.



COVER SHEET
FINAL ENVIRONMENTAL IMPACT STATEMENT
LONG-TERM MANAGEMENT OF EXISTING RADIOACTIVE
WASTES AND RESIDUES AT THE
NIAGARA FALLS STORAGE SITE

- a) Lead Agency: U.S. Department of Energy (DOE)
- b) Proposed Action: Long-term stabilization and control of existing radioactive wastes and residues at DOE's Niagara Falls Storage Site consistent with the guidance provided in the Environmental Protection Agency's regulations for uranium mill tailings (40 CFR 192).
- c) For additional copies or further information on this statement and program, please contact:

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Washington, DC 20585 (202) 252-4600

- d) Designation: Final EIS (FEIS)
- e) Abstract: The EIS assesses and compares several alternatives for long-term management and control of the existing radioactive wastes and residues at the Niagara Falls Storage Site (NFSS), Lewiston, New York. The alternatives include: (1) no action (continued interim storage at NFSS within a diked and capped containment area), (2) long-term management at NFSS (improved containment, with or without modified form of the residues), (3) long-term management at other DOE sites (Hanford, Washington, or Oak Ridge, Tennessee), and (4) offsite management of the residues at Hanford or Oak Ridge and either leaving the wastes at NFSS or removing them for disposal in the ocean. In addition to alternatives analyzed in depth, several options are also being considered, including: other modifications of residue form (vitrification and matrix isolation methods), modification of the basic conceptual designs, other containment design options, transportation routes, and transportation modes. Alternative 2 is DOE's preferred alternative.

The radiological health effects (primarily increased risk of cancer) associated with long-term management of the wastes and residues are expected to be much smaller than the nonradiological risks of occupational and transportation-related injuries and deaths. The increased risk of radiological health effects is estimated to range from 0.0013 to 0.24 for workers and from less than 0.0000005 to 0.30 for the general public as a result of actions that would be taken under the various alternatives. The greatest radiological risk for workers would occur if all the wastes and residues were removed to Hanford, whereas the greatest radiological risks for the general public would occur if the wastes were removed to the ocean and the residues were removed to Hanford. For the preferred alternative (long-term management at NFSS), the radiological risks for workers are estimated to range from 0.0051 to 0.10 and for the general public from less than 0.0000005 to 0.017--the higher risks being associated with treatment of the residues in Alternative 2a.

In comparison, the nonradiological risks are estimated to range from 0.0015 to 4 deaths and from 0.13 to 166 injuries. Both workers and the general public would incur these risks. The preferred alternative (long-term management at NFSS) is estimated to result in a risk of 0.12 deaths and 12 to 24 injuries.

For all alternatives, DOE would plan to take perpetual care of the waste containment areas and to restrict site access. If controls were partially lost (e.g., the containment area was not maintained), it is predicted that containment would still be effective for the design life (at least 200 years and, to the extent reasonably achievable, for 1000 years). Predicted time for erosion

of covers over the buried materials ranges from several hundred years to more than two million years, depending primarily on the use of the land surface. At all sites, releases of radioactive radon gas to the air through the earthen covers of the containment system are predicted to result in no significant adverse health effects. Also, at all sites, no offsite contamination of groundwater is predicted for the 1000-year design life. If all controls ceased, there would be risk of human intrusion into the contaminated materials. A 1-m (3-ft) layer of riprap (rock) in the earthen cover for preferred Alternative 2 is intended to discourage such intrusion. An additional intruder barrier over the more radioactive residues, such as a slab of reinforced concrete, is also being considered.

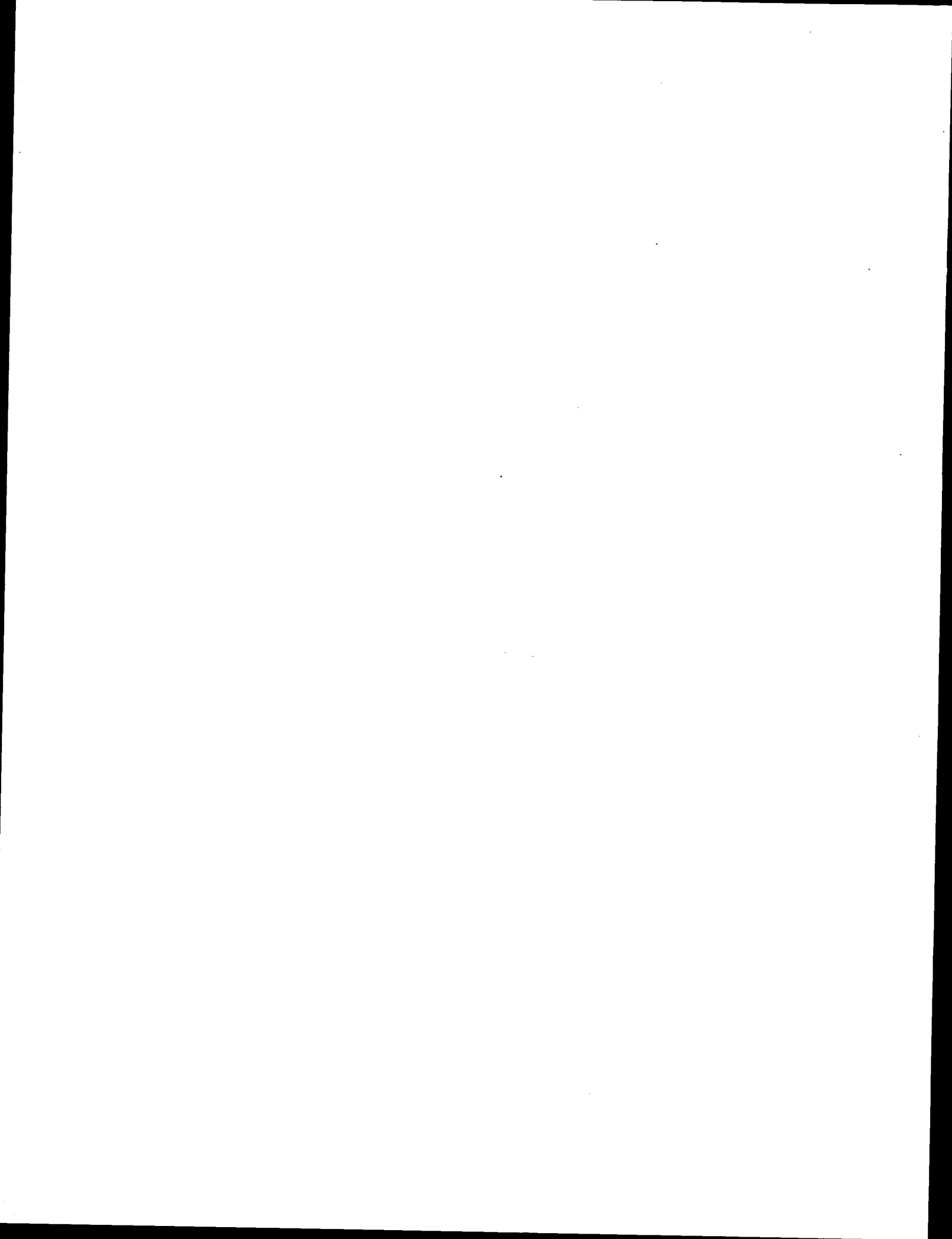
- f) The Department has identified Alternative 2 (long-term management at NFSS) as the preferred alternative. Not less than 60 days after publication of the notice of availability of the Final EIS, a Record of Decision will be published in the Federal Register.

FOREWORD

This Final Environmental Impact Statement (Final EIS) is issued by the U.S. Department of Energy (DOE). It assesses the environmental impacts of various alternatives for the long-term management of existing radioactive wastes and residues stored at the Niagara Falls Storage Site (NFSS) near Lewiston, New York. These wastes and residues resulted from the processing of uranium ores. About 11,000 m³ (15,000 yd³) of residues and 180,000 m³ (240,000 yd³) of wastes are stored within a diked containment area at NFSS.

Although ongoing interim remedial actions involved improving the containment of the wastes and residues, DOE must decide how to manage these radioactive materials for the long term. Therefore, in accordance with the National Environmental Policy Act of 1969 (NEPA), as implemented by the regulations promulgated by the Council on Environmental Quality (CEQ) (40 CFR 1500-1508, November 1978) and DOE's implementing guidelines (45 FR 20694, March 28, 1980), DOE has prepared this Final EIS to provide environmental input to this decision. A Notice of Intent to prepare this FEIS was issued February 1, 1983, and a public scoping process was conducted. The Draft EIS was issued in August 1984. Public comment on the Draft EIS was received both in writing and at public meetings. After considering all comments, DOE is issuing this Final EIS. DOE will then issue a Record of Decision not less than 60 days following publication of the notice of availability of the Final EIS.

The format of this EIS follows the suggested format in the CEQ regulations. Section 1 documents the purpose and need for a decision. Section 2 summarizes and compares alternatives and predicted environmental impacts. Section 3 summarizes the affected environments at NFSS and alternative sites. Section 4 provides detailed information on analyses of the environmental consequences of the various alternatives. Section 5 presents the names and professional qualifications of the persons responsible for preparing the statement. More detailed information and analyses are provided in several appendices.



SUMMARY

The Niagara Falls Storage Site (NFSS) is located in the Town (Township) of Lewiston, Niagara County, New York, about 30 km (19 mi) north of Buffalo. The current site is part of a former Manhattan Engineer District (MED) site, which in turn was part of the former Lake Ontario Ordnance Works (LOOW). Beginning in 1944, the MED used the site for storage of radioactive residues that resulted from the processing of uranium ores during development of the atomic bomb. Additional residues were brought to the site for several years after World War II. The U.S. Department of Energy (DOE) is now responsible for the site.

Baseline conditions assumed for analysis of all alternatives for long-term management of the NFSS radioactive residues (from processing of uranium ores) and wastes (mostly contaminated soils) in this Final Environmental Impact Statement (Final EIS) are those conditions projected to exist upon completion of ongoing interim remedial actions in 1986*. At that time, all radioactive residues and wastes will be consolidated within a diked containment area in the southwest corner of NFSS. The diked area will contain about 11,000 m³ (15,000 yd³) of residues and 180,000 m³ (240,000 yd³) of wastes. The residues are located within a reinforced concrete structure at the bottom of the large pile of wastes. The residues account for less than 6% of the total volume of contaminated materials but almost 99% of the radioactivity. Most of the uranium was removed during processing of the ores; therefore, the radioactive contaminants in the residues and wastes are the naturally occurring decay products of uranium. The radioactivity will not diminish appreciably for thousands of years.

Although the interim remedial actions involve improving the containment of the wastes and residues and will result in reducing emissions of radioactive substances from the site and providing better control of the site, DOE must decide how to manage the radioactive wastes and residues for the long term. In addition to engineering, costs, and other considerations, environmental impacts will be factored into this decision. Therefore, in accordance with the National Environmental Policy Act (NEPA), DOE has prepared this Final EIS to assess and compare the potential environmental impacts of various alternatives for long-term management of the radioactive wastes and residues at NFSS.

DOE conducted a scoping process to determine the alternatives to be analyzed, the significant issues to be analyzed in depth, and the issues to be eliminated from further detailed study. Based on public and technical scoping input, the following alternatives were defined for analysis in this EIS:

Alternative 1: No Action--Alternative 1 would involve continued storage of all residues and wastes within the diked containment area in the southwest corner of NFSS. The containment area is surrounded by a dike and subsurface clay cutoff wall and is covered with a multilayered 1.4 m (4.5 ft) cap of clay and soil.* The entire NFSS site would remain under DOE ownership and control in perpetuity.

Alternative 2: Long-Term Management at NFSS in Perpetuity--DOE's Preferred Alternative

Alternative 2a: Long-Term Management at NFSS, Modified Containment--Under Alternative 2a, further actions would be taken to improve the long-term containment of the wastes and residues at NFSS. Such actions would include removal and temporary storage of the upper layers of the interim cap and construction of a long-term cap. The long-term cap would be 1.7-m (5.5-ft) thicker than the interim cap and would have extra clay and a layer of riprap (graded layers of gravel and rock). Only the containment area and a small buffer zone would be retained under DOE ownership and control in perpetuity.

Alternative 2b: Long-Term Management at NFSS, Modified Containment Plus Modified Form--Under Alternative 2b, in addition to the improved containment system described for Alternative 2a, the residues would be modified physically and chemically to reduce the rate of long-term migration of contaminated materials from NFSS. The residues would be removed from the containment area and processed to extract potentially valuable constituents (e.g., uranium, cobalt, nickel, molybdenum, and lead). Once processed, the vitrified (glass) residue slag and some precipitates would be reburied in the diked containment area, the processing facilities would be decontaminated and demolished, and the entire waste-containment area would be covered with the long-term cap. Only the containment area and a small buffer zone would be retained under DOE ownership and control in perpetuity.

*As of April 1986, the interim cap has been constructed over all of the containment area except the southern portion where the residues are located. In this EIS, the conceptual design for the interim cap included a 0.15-m (0.5-ft) sand layer between the clay and soil. A minor design modification eliminated this sand layer.

Alternative 3: Long-Term Management at Other Sites.

Alternative 3a: Long-Term Management at an Arid Site (Hanford)--Under Alternative 3a, both the residues and the wastes would be excavated from the containment area at NFSS and transported by truck to a radioactive waste-management site (218W5 Area) on the DOE Hanford Reservation near Richland, Washington. The residues would be packaged in large metal containers and transported on either flat-bed trailers or in shielded vans. The wastes are classified as nonradioactive under current transportation regulations and would be shipped in large dump trucks. About 16,000 truckloads would be needed to transport the wastes and residues over 4000 km (2500 mi) to Hanford. Following transport of the wastes and residues to the Hanford site, the excavated areas would be filled and regraded and NFSS would be released for other use. At Hanford, the contaminated materials would be buried in about 42 trenches in a manner similar to current practices for burial of other types of solid radioactive wastes at the Hanford Reservation. The residues and wastes would be covered with 3 m (10 ft) of local earthen materials, including a layer of riprap (with any necessary modifications to ensure compliance with 40 CFR 192). The wastes and residues would be controlled in perpetuity.

Alternative 3b: Long-Term Management at a Humid Site (Oak Ridge)--Under Alternative 3b, all the NFSS wastes and residues would be excavated and transported by truck to the Pine Ridge Knolls site on the DOE Oak Ridge Reservation near Oak Ridge, Tennessee. About 16,000 truckloads would be required, with a transportation distance of about 1200 km (750 mi). Following transport of the wastes and residues to the Oak Ridge site, the excavated areas at NFSS would be filled and regraded and NFSS would be released for other use. At Oak Ridge, the wastes and residues would be stabilized in several mounds. The mounds would be covered with a long-term cap similar to the cap at NFSS for Alternatives 2a and 2b. The wastes and residues would be controlled in perpetuity.

Alternative 4: Offsite Storage of Residues with Wastes at NFSS or Ocean Disposal

Alternative 4a: Storage of Residues at Hanford/Long-Term Management of Wastes at NFSS--Under Alternative 4a, the residues would be excavated, packaged, and transported to Hanford as in Alternative 3a. About 1,600 truckloads would be needed. The residue packages would be buried in 10 trenches at Hanford. The wastes would remain at NFSS and would be covered with a long-term cap identical to that described for Alternative 2a. The containment areas and small buffer zones at both NFSS and Hanford would be maintained and monitored in perpetuity.

Alternative 4b: Offsite Storage of Residues at Hanford/Ocean Disposal of Remaining Wastes--Under Alternative 4b, the residues would be excavated, packaged, and transported to Hanford as described for Alternative 4a. All remaining wastes would be excavated, transported in bulk in dump trucks to a dock in the New York/New Jersey harbor area, loaded onto barges, and transported to the 106-Mile Ocean Waste Disposal Site (Site 106) for dispersal. After removal of all wastes and residues from the site, NFSS would be released for other use. Only the residue containment area and a small buffer zone at Hanford would be maintained and monitored in perpetuity.

Alternative 4c: Offsite Storage of Residues at Oak Ridge/Long-Term Management of Waste at NFSS--Under Alternative 4c, the residues would be excavated, packaged, and transported to Oak Ridge as in Alternative 3b. About 1,600 truckloads would be needed. The residue packages would be stabilized in mounds and covered with a long-term cap similar to that described for Alternative 3b. The wastes would remain at NFSS and would be covered with a long-term cap identical to that described for Alternative 2a. The containment areas and small buffer zones at both NFSS and Oak Ridge would be maintained and monitored in perpetuity.

Alternative 4d: Offsite Storage of Residues at Oak Ridge/Ocean Disposal of Remaining Wastes--Alternative 4d is identical to Alternative 4c except that the NFSS wastes would be disposed in the ocean instead of remaining at NFSS. Ocean disposal would be the same as for Alternative 4b. After removal of all wastes and residues from the site, NFSS would be released for other use. Only the residue containment area and a small buffer zone at Oak Ridge would be maintained and monitored in perpetuity.

In addition to the alternatives analyzed in depth, several options are also considered, including options for (1) retrieval, packaging, and loading of contaminated materials, (2) modifications of the residue form (including various vitrification and matrix isolation methods), (3) modifications of the basic conceptual containment designs, (4) other containment design concepts, (5) transportation routes, and (6) transportation modes.

Implementation of any of the alternatives would permanently commit some land to use for radioactive waste management. Near-surface burial of the NFSS residues (and, in some alternatives, the wastes as well) would also unavoidably commit the federal government (or its successor) to perpetual care of the burial sites because the residues and wastes will remain hazardous for thousands of years. For alternatives 4a and 4c, two sites would be maintained and monitored in perpetuity.

Implementation of any of the action alternatives would expose workers to risk of injury and death associated with construction and earth-moving activities, ranging from an estimated risk of 12 injuries

and 0.0064 deaths in the case of Alternative 2a (modified containment at NFSS) to 100 injuries and 0.044 deaths for Alternative 3a (all wastes and residues at Hanford). Transport of the wastes and residues (Alternatives 3a, 3b, 4a, 4b, 4c, and 4d) would expose workers and the general public to injuries and deaths associated with transportation accidents, ranging from an estimated 2.5 injuries and 0.15 deaths for Alternative 4c (residues only to Oak Ridge) to 66 injuries and 3.9 deaths for Alternative 3a (all wastes and residues to Hanford).

The radiological health impacts (primarily increased risk of cancer) would be smaller than the risks of occupational and transportation-related injuries and deaths. During the action period, the risk is estimated to range from 0.0013 additional health effects for workers in Alternative 1 (site maintenance workers) to 0.24 additional health effects for workers in Alternative 3a (all wastes and residues moved to Hanford). For the general public, the risk is estimated to range from less than 0.0000005 additional health effects for Alternatives 1 and 2a to 0.30 additional health effects for Alternative 4b (residues to Hanford, wastes to ocean).

For Alternative 2 (preferred alternative), the release of radioactive radon gas through the thick earthen cover is estimated to be about the same as that which naturally escapes from the soils in the area because of the natural radioactivity in all soils. The maximum increased radiation dose to a nearby resident is estimated to be less than 0.001 mrem/yr. This compares with 2.0 mrem/yr that such a person would receive if he/she moved to Buffalo, New York, because of the increase in cosmic radiation at the higher altitude.

The long-term radiological risks to the general public are expected to be small. Even if site maintenance ceased in 200 years and there was very erosive use of the land, the number of additional adverse health effects at the year 1000 are estimated to range from less than 0.0000005/million persons/year for Alternatives 2a, 2b, 3b, 4c, and 4d (residues in the humid climate at NFSS or Oak Ridge) to 0.0061/million persons/year for Alternatives 4a and 4b (residues in the arid climate at Hanford). Long-term radiological risks to the general public are expected to be highest for Alternatives 3a, 4a and 4b, primarily because of the much higher releases of radon gas from the residues in the arid climate at Hanford.

For all alternatives, DOE would plan to take perpetual care of the waste containment areas and to restrict access to the site. Even if controls were partially lost (e.g., the containment area was not maintained), it is predicted that containment would still be effective for the design life (at least 200 years and, to the extent reasonably achievable, for 1000 years). Predicted time for erosion of the multilayered earthen covers ranges from several hundred years to more than 2 million years, depending on the use of the land surface. Given such uncertainties, there is no significant difference between alternatives with respect to erosion of the covers.

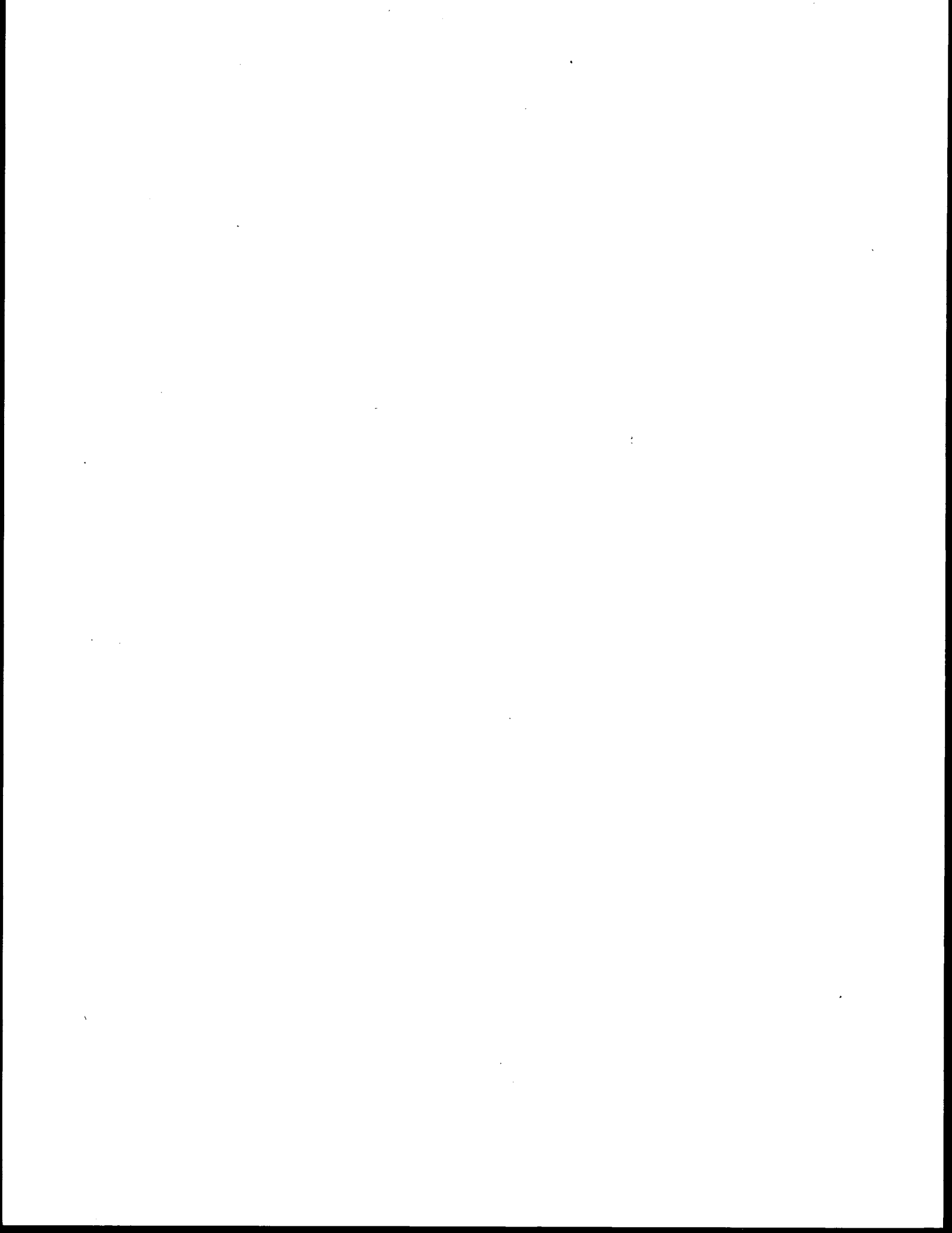
For all alternatives, no offsite contamination of groundwater is predicted for the 1000-year design life. DOE plans to implement a groundwater monitoring program in order to detect migration before contaminants reached the site boundary and to take any necessary corrective actions.

Dispersal of the slightly contaminated wastes in the ocean at Site 106 (Alternatives 4b and 4d) is not expected to result in any significant impacts on the ocean environment or to pose any significant radiological risk to humans. A potential institutional obstacle to implementation of Alternative 4b or 4d is the need to obtain an ocean dumping permit from the U.S. Environmental Protection Agency and the uncertainty as to how the wastes will be classified for ocean disposal purposes.

Implementation of any of the alternatives would require a commitment of money for long-term management of the NFSS residues, and, for some alternatives, the wastes as well. Estimated initial commitments for the action alternatives range from about \$3.2-6.3 million for Alternative 2a (modified containment at NFSS) to about \$130-260 million for Alternative 3a (move all wastes and residues to Hanford). Long-term commitments for perpetual care are estimated to range from \$43,000/yr for Alternatives 4b and 4d (residues only at Hanford or Oak Ridge) to \$130,000/yr for Alternatives 4a and 4c (in which two different sites must be managed).

DOE plans to take perpetual care of the NFSS site. A 1-m (3-ft) thick layer of riprap (rock) in the earthen cover over the wastes under preferred Alternative 2 is intended to discourage human intrusion into the contaminated materials.

Alternative 2 is DOE's preferred alternative. Maintenance and monitoring of the NFSS interim storage system (Alternative 1) will continue until implementation of the long-term alternative. The long-term alternative selected for implementation will be identified in the Record of Decision. At the time of implementation, DOE will determine the final design features of the waste containment system and the residue form. At all times, DOE will continue to keep the public as well as federal, state, and local officials apprised of DOE plans, actions, and monitoring results.



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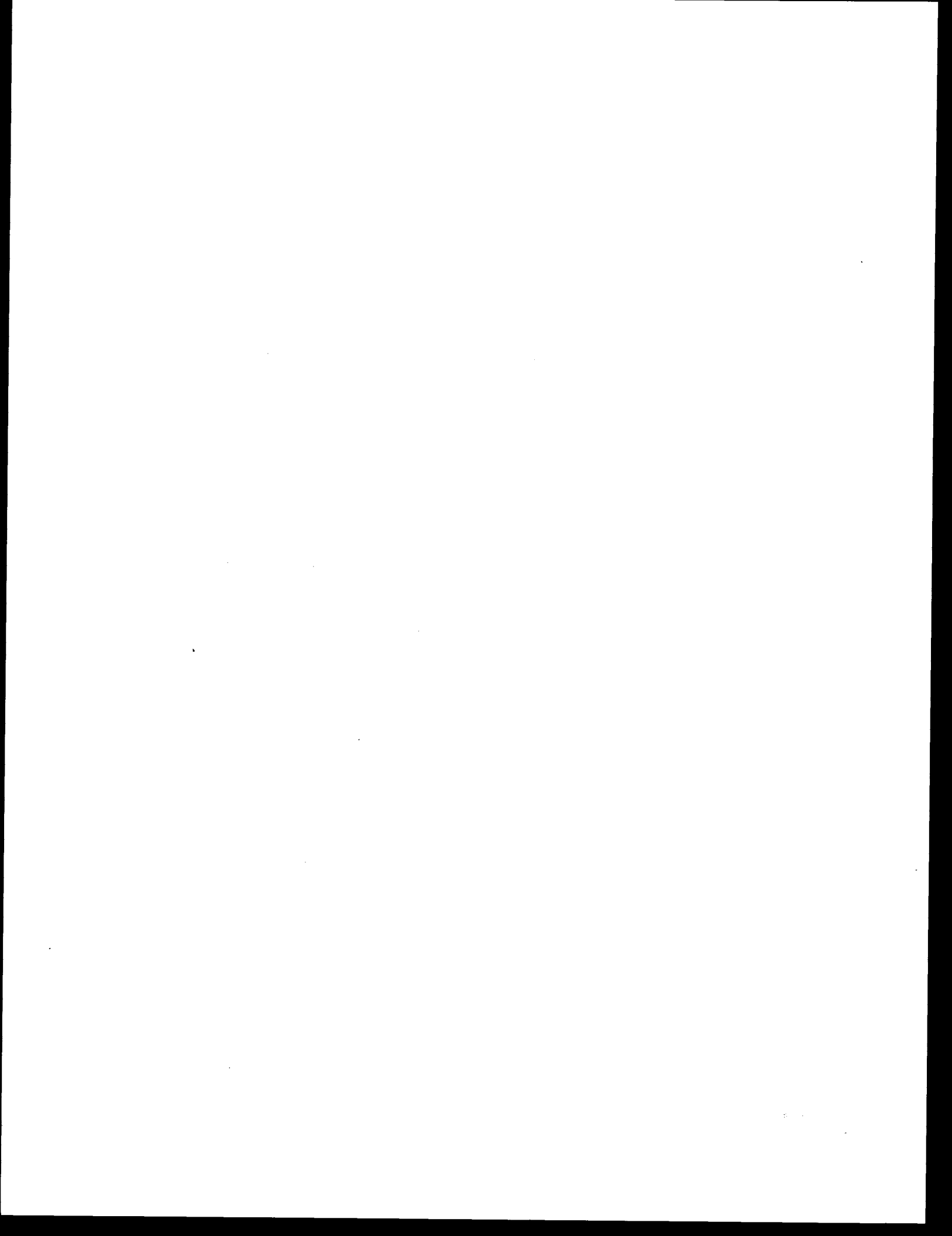
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1. PURPOSE AND NEED FOR DECISION

1.1 INTRODUCTION AND BRIEF HISTORY

The Niagara Falls Storage Site (NFSS) is located in the Town (township) of Lewiston, Niagara County, New York, about 30 km (19 mi) north of Buffalo, New York (Figure 1.1). The current 77-ha (190-acre) site is part of a former 610-ha (1500-acre) Manhattan Engineer District (MED) site, which in turn was part of the former Lake Ontario Ordnance Works (LOOW). Beginning in 1944, the MED used the site for storage of radioactive residues that resulted from the processing of uranium ores (pitchblende) during development of the atomic bomb. Additional residues were brought to the site for several years after World War II.

Subsequent to MED, responsibility for the site has been transferred to the U.S. Atomic Energy Commission (AEC), the U.S. Energy Research and Development Administration (ERDA), and the U.S. Department of Energy (DOE). The site is currently administered by the Oak Ridge Operations Office of DOE and operated by Bechtel National, Inc. It is fenced and access is limited.

1.2 SUMMARY DESCRIPTION OF NFSS RESIDUES AND WASTES

The baseline for analysis of all alternatives for the long-term management of the NFSS residues and wastes in this Environmental Impact Statement (EIS) is assumed to be the condition of NFSS projected to exist upon completion in 1986 of the interim remedial actions that are currently under way.* At that time, all radioactively contaminated wastes (mostly soils) and residues (from processing of uranium ores) will be consolidated within a 3.4-ha (8.5-acre) diked containment area in the southwest corner of NFSS (Figure 1.2). This area will contain about 190,000 m³ (250,000 yd³) of contaminated materials. The area will be surrounded by a dike and subsurface clay cutoff wall. The cutoff is keyed into an existing layer of gray clay.** The containment area will have an earthen cover consisting of layers of clay (0.9 m [3 ft]) and soil (0.45 m [1.5 ft])--totaling 1.4 m (4.5 ft) (see Section 2.1 for conceptual design drawing).***

For purposes of analysis in this EIS, the NFSS contaminated materials are separated into two groups: (1) residues and (2) wastes (Table 1.1). The residues and wastes are described in detail in Section 3.1.7. The 11,000 m³ (15,000 yd³) of residues consist of the K-65, the combined L-30/F-32, and the L-50 residues--all of which will be stored in buildings within the diked area upon completion of interim remedial actions (Figure 1.2). The residues account for less than 6% of the total volume of contaminated materials stored at NFSS but almost 99% of the radium-226 inventory. The radium-226 concentrations in the residues range from 3,300 to 220,000 pCi/g and average 67,000 pCi/g. Radium-226 is a naturally occurring radionuclide that results from the decay of uranium-238. Soils in the Niagara Falls area naturally contain about 2 pCi/g of radium-226.

Until recently, these residues were owned by Afrimet-Indussa, Inc., an American firm incorporated in the state of New York and controlled by Union Miniere, a Belgian firm. During World War II, Afrimet supplied the federal government with uranium ore (pitchblende) from the Belgian Congo but retained ownership of the residues because of the radium and other, potentially recoverable, valuable elements that remained in the residues after the uranium was extracted.

Afrimet held a license from the state of New York for storage of the radioactive materials at NFSS and had a storage lease agreement with DOE. The lease agreement expired in June 1983. As a result of DOE negotiations with Afrimet, and in consideration of common defense and security arrangements between the United States and the government of Belgium, Afrimet and DOE signed an agreement

*The impacts associated with the interim activities are not covered in this EIS on long-term management. The interim actions are addressed in separate documents (U.S. Dep. Energy 1982a, 1982b, 1983a, 1983b).

**The depth and thickness of the gray clay layer is variable, and it is not known if this layer is continuous underneath the diked area.

***As of April 1986, the interim cap has been constructed over all of the containment area except the southern portion where the residues are located. In this EIS, the conceptual design for the interim cap included a 0.15-m (0.5-ft) sand layer between the clay and soil. A minor design modification eliminated this sand layer.

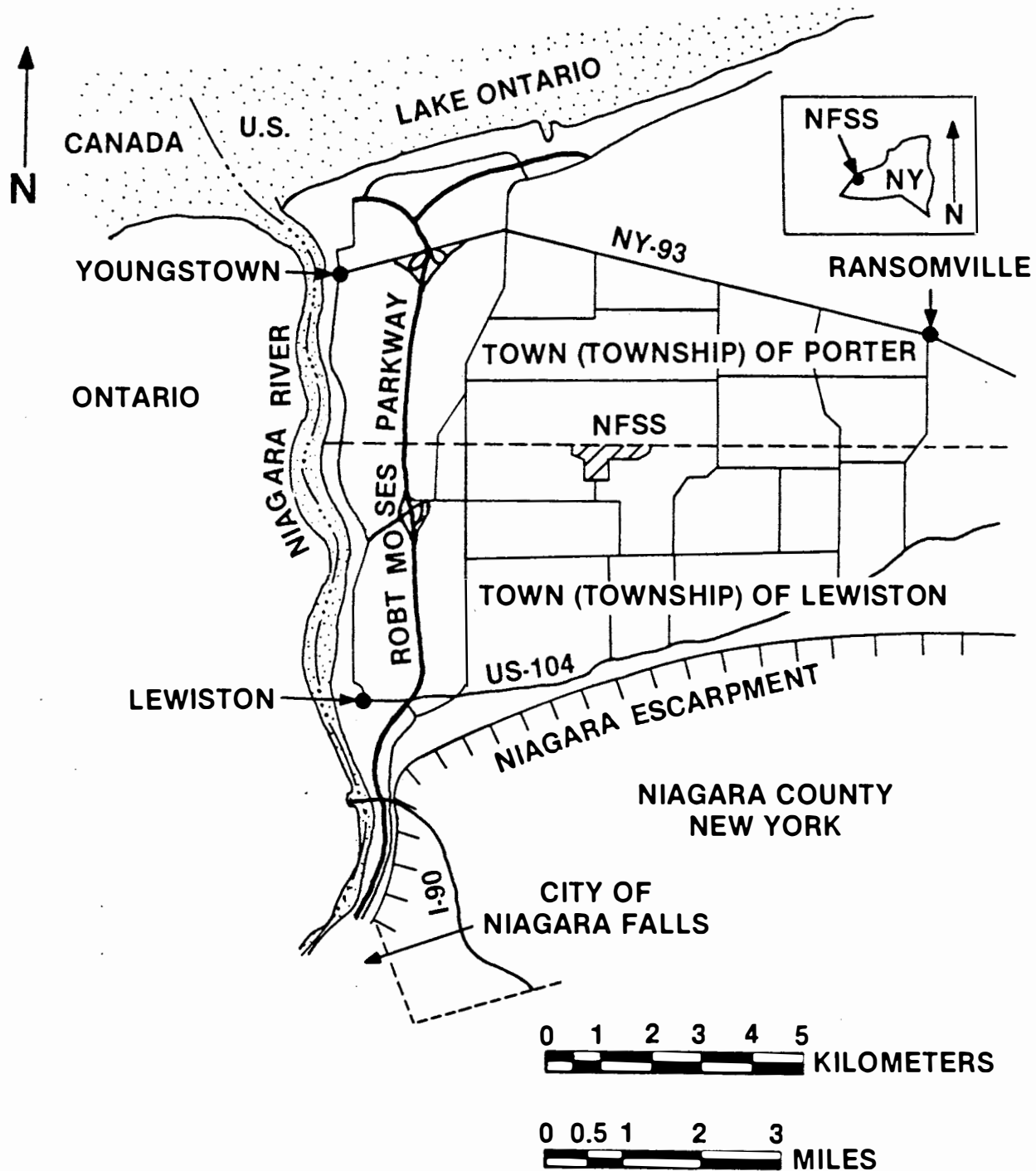


Figure 1.1. Niagara Falls Storage Site Location Map.

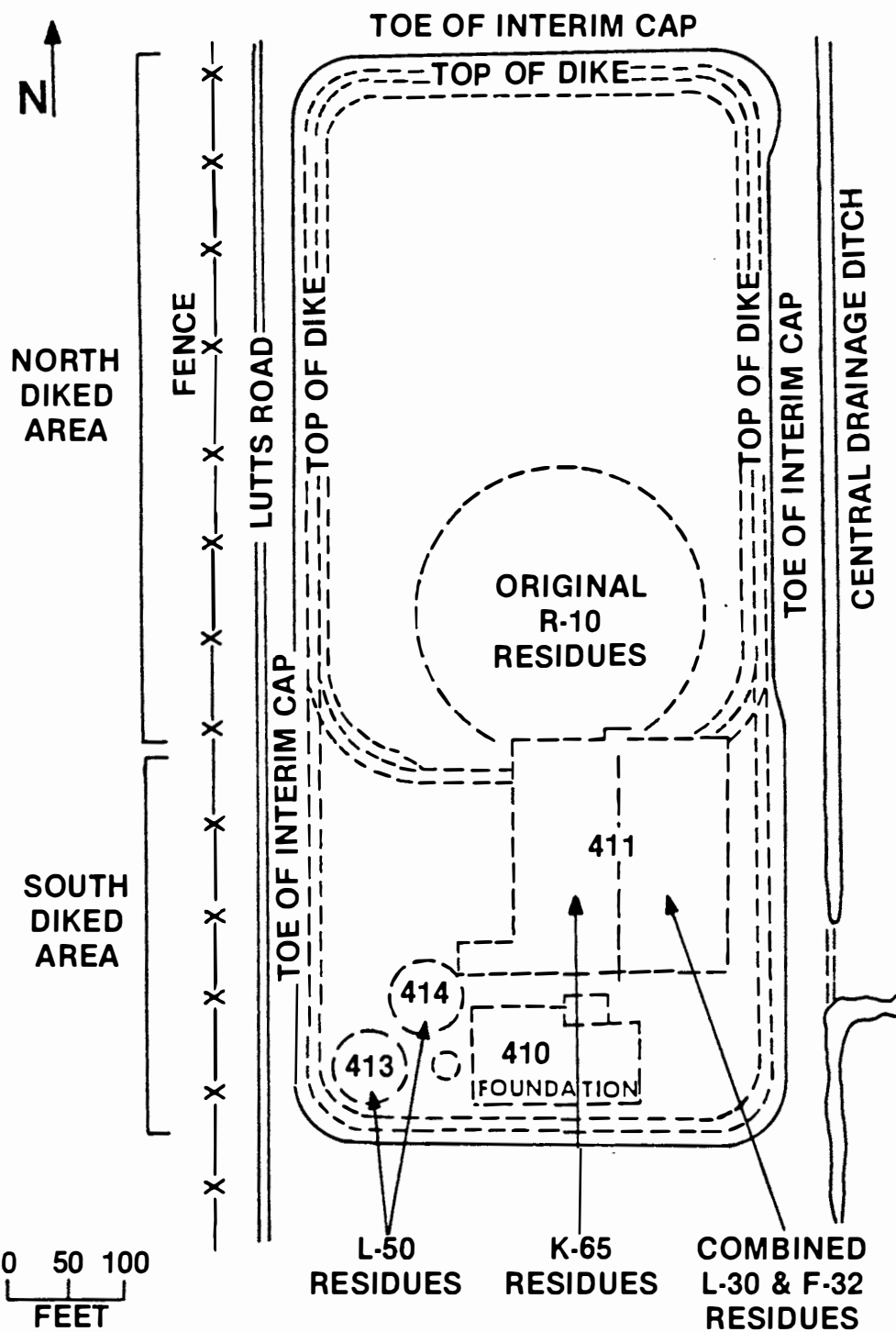


Figure 1.2. Plan View of the Waste-Containment Area in the Southwest Corner of NFSS Upon Completion of Interim Remedial Actions in 1986. Based on drawing provided by Bechtel National, Inc. Note: The exact placement of the K-65 and combined L-30/F-32 residues in Building 411 has been changed, but this has not changed the impacts predicted in this EIS.

Table 1.1. Radioactive Materials at NFSS†¹

Description	Volume (m ³)† ²	Average Radium-226 Concentration (pCi/g)† ³	Radium-226 Inventory (Ci)
Residues† ⁴	11,000	67,000	870
Wastes† ⁵	<u>180,000</u>	<u>36</u>	<u>7.8</u>
Total	190,000	3,800	880

†¹ All values rounded to two significant figures. See Section 3.1.7 for details.

†² Estimated volumes. More precise estimates will be available after completion of interim remedial actions.

†³ Dry weight concentrations.

†⁴ Includes K-65, L-30/F-32, and L-50 residues. During the interim remedial actions, the volumes of residues were found to be less than the estimates used in the analyses in this EIS.

†⁵ Includes all remaining contaminated materials, primarily slightly contaminated soils.

effective July 1, 1983, whereby Afrimet will pay DOE \$8 million and DOE took title to the residues and released Afrimet from its obligations with respect to the residues (U.S. Dep. Energy 1983d).

The 180,000 m³ (240,000 yd³) of NFSS wastes consist primarily of slightly contaminated soils that have an average radium-226 concentration of 36 pCi/g. Detailed descriptions of the NFSS residues and wastes are given in Section 3.1.7.

1.3 DECISION TO BE MADE

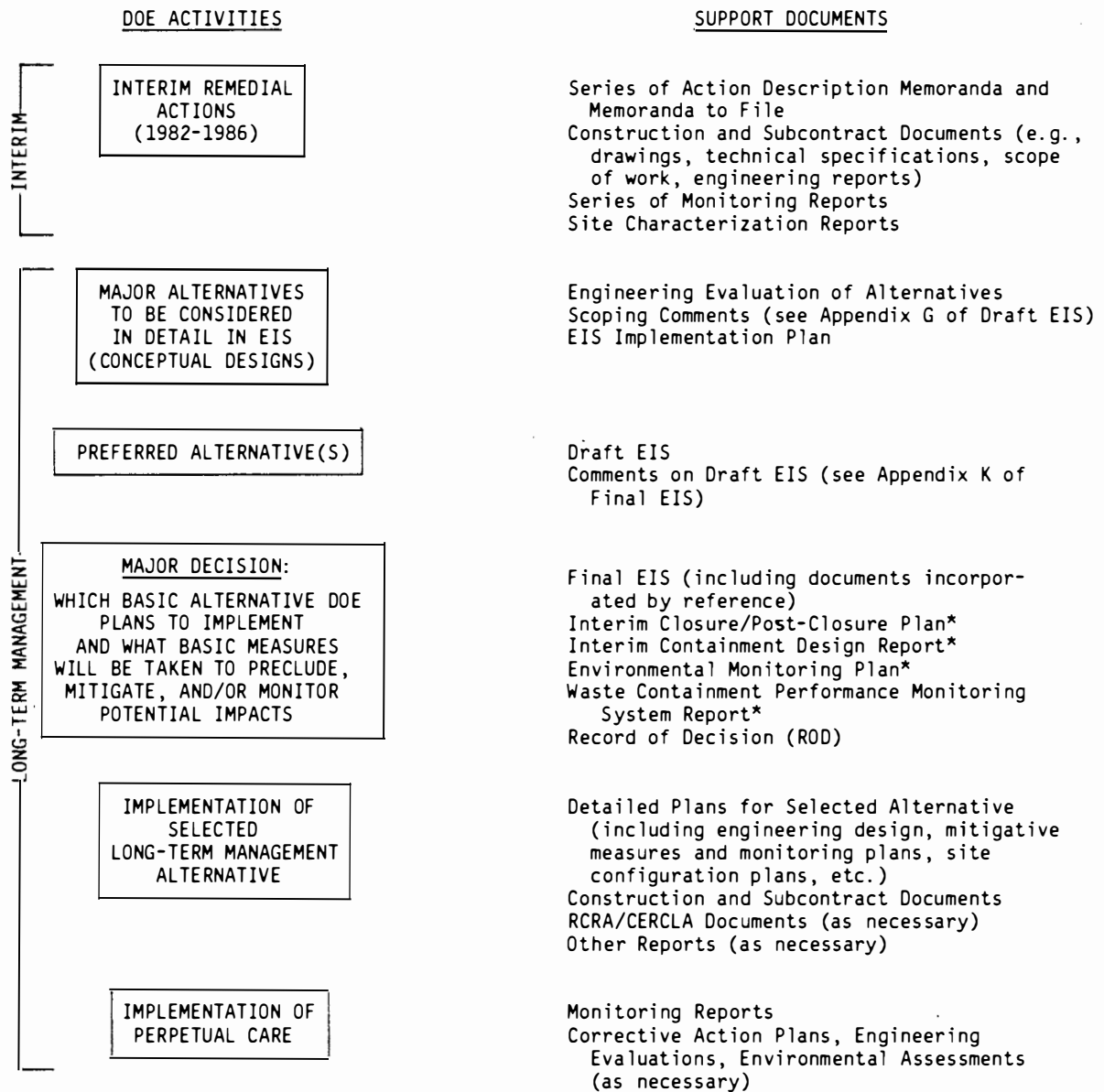
Although the planned interim remedial actions involve placing the wastes and residues into a more secure condition and will result in markedly reduced emissions of radioactive substances from the site, DOE must decide how to manage the radioactive wastes and residues for the long term. In addition to engineering, cost, and other considerations, environmental impacts will be factored into this decision. Therefore, in accordance with the National Environmental Policy Act (NEPA), DOE prepared this EIS to assess and compare the potential environmental impacts of various alternatives for the long-term management of the radioactive wastes and residues at NFSS. The DOE decision-making process and supporting documents for NFSS are summarized in Figure 1.3.

1.4 EIS SCOPING

In accordance with regulations of the Council on Environmental Quality (CEQ) and DOE guidelines for implementing NEPA, the Department issued a Notice of Intent (NOI) to prepare this EIS (U.S. Dep. Energy 1983c) and conducted a scoping process to determine the alternatives to be analyzed in the EIS, the significant issues to be analyzed in depth, and the issues to be eliminated from further detailed study. Details of the scoping process are given in the Implementation Plan for this EIS (U.S. Dep. Energy 1984), and a summary is provided in Appendix G. Both technical and public scoping input were considered. Public input included presentations made at two public meetings held in Lewiston, New York, on February 17 and 19, 1983; presentations made at a public meeting held in Oak Ridge, Tennessee, on October 19, 1983; and letters received by DOE regarding the scope of the EIS. Technical scoping input was provided by Bechtel National, Inc., Argonne National Laboratory, DOE Operations Offices at Oak Ridge and Richland, DOE Headquarters, and state agencies (New York Departments of Environmental Conservation, Labor, and Health). The preliminary list of potential issues presented in the NOI was revised as a result of the scoping process. In particular, radiological contamination of the oceanic environment was added as a primary issue. Further discussion is given in Appendix G regarding the reasons for retaining or rejecting specific issues for detailed consideration in this EIS.

Based on the public and technical input, four basic alternatives were defined for analysis in this EIS:

1. No Action--Continue interim storage of all existing wastes and residues at NFSS in the diked and capped containment area in the southwest corner of NFSS.



*Will be finalized before ROD.

Figure 1.3. Niagara Falls Storage Site: DOE Decision-Making Process.

2. Long-Term Management at NFSS--Carry out further actions to improve the containment of the stored wastes and residues or, in addition to improved containment, to modify the form of the residues to reduce long-term migration of contaminated materials from NFSS.
3. Long-Term Management at Other Sites--Remove all wastes and residues from NFSS and transport them to another site for long-term management.
4. Offsite Storage of Residues--Remove the more radioactive residues to another site and either leave the wastes at NFSS or remove them for disposal in the ocean.

The first three alternatives were suggested in the NOI. Based on public and technical input to the scoping process, the fourth alternative was added. Although a preferred alternative was not identified in the Draft EIS, a preferred alternative (Alternative 2, Long-Term Management at NFSS) is identified in this Final EIS, as required by CEQ regulations.

The term "long-term management" is used in this EIS instead of the term "disposal" for those alternatives wherein the NFSS wastes and residues will remain on land. The term disposal has a connotation of permanent emplacement with no further management. Because the radionuclides in the NFSS wastes and residues have relatively long half-lives and the potential hazard will not diminish appreciably for thousands of years, there will be a continuing need for management of these materials. Thus, the term long-term management is used. The potential environmental impacts under conditions of continuing management (maintenance, monitoring, and corrective actions as necessary) and under conditions of loss of management are assessed in this EIS. The time periods for analysis and the assumptions about management controls for each time period are given in Section 4.

1.5 RELATED FEDERAL PROJECTS

The Department has recently prepared environmental impact statements for other programs and other sites under its Remedial Action Program, including:

- U.S. Department of Energy. 1983. "Final Environmental Impact Statement, Remedial Actions at the Former Vitro Rare Metals Plant Site, Cannonsburg, Washington County, Pennsylvania." DOE/EIS-0096-F (2 volumes). July 1983.
- U.S. Department of Energy. 1984. "Final Environmental Impact Statement, Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah." DOE/EIS-0099-D. July 1984.
- U.S. Department of Energy. 1985. "Final Environmental Impact Statement. Remedial Actions at the Former Vanadium Corporation of America Uranium Mills Site, Durango, LaPlata County, Colorado." DOE/EIS-0111F. October 1985.

In addition, the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency have prepared EISs on various related programs, proposed standards, and specific sites, including:

- U.S. Nuclear Regulatory Commission. 1983. "Final Environmental Impact Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois." Docket No. 40-2061, Kerr-McGee Chemical Corporation. Office of Nuclear Material Safety and Safeguards. May 1983.
- U.S. Environmental Protection Agency. 1982. "Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192)." Vols. 1 and 2; EPA 520/4/82-013-1, -2. Office of Radiation Programs. October 1982.
- U.S. Environmental Protection Agency. 1980. "Final Environmental Impact Statement (EIS) for 106-Mile Ocean Waste Disposal Site Designation." Oil and Special Materials Control Division, Marine Protection Branch, Washington, DC. February 1980.

1.6 SUMMARY OF POTENTIALLY APPLICABLE LAWS AND REGULATIONS

Major laws and regulations that may be potentially applicable to the various alternatives are presented in Table 1.2. Detailed discussions of several major institutional issues associated with environmental regulation are given in Section 4.7 and Appendix D. Copies of DOE Orders are available for public inspection at the NFSS EIS public reference locations.

Table 1.2. Major Laws and Regulations That May Potentially Be
Applicable to the Various Alternatives

FEDERAL LAWS AND EXECUTIVE ORDERS

Atomic Energy Act, as amended
 Department of Energy Organization Act
 National Environmental Policy Act
 Comprehensive Environmental Response, Compensation, and Liability Act of 1980
 Clean Air Act
 Clean Water Act (Federal Water Pollution Control Act, as amended)
 Resource Conservation and Recovery Act (Solid Waste Disposal Act)
 Safe Drinking Water Act
 River and Harbor Act
 Marine Protection Research and Sanctuaries Act
 Ocean Dumping Amendments Act of 1982
 Surface Transportation Assistance Act of 1982
 Endangered Species Act
 Fish and Wildlife Coordination Act
 Archeological and Historic Preservation Act
 Archeological Resources Protection Act
 Hazardous Materials Transportation Act
 Noise Control Act
 Executive Order 12088, Federal Compliance with Pollution Control Standards
 Executive Order 11514, Protection and Enhancement of Environmental Quality
 Executive Order 11991, Relating to the Protection and Enhancement of Environmental Quality
 Executive Order 11738, Providing for Administration of the Clean Air Act and the Federal Water Pollution Control Act with Respect to Federal Contracts, Grants, or Loans
 Executive Order 11807, Occupational Safety and Health Programs for Federal Employees
 Executive Order 11490, Assigning Emergency Preparedness Functions to Federal Departments and Agencies

DOE ORDERS AND CRITERIA

1540.1 Materials Transportation and Traffic Management
 5440.1B Implementation of the National Environmental Policy Act
 5480.1A Environmental Protection, Safety, and Health Protection Program for DOE Operations
 5480.2 Hazardous and Radioactive Mixed Waste Management
 5481.1 Safety Analysis Review System
 5482.1A Environmental, Safety, and Health Appraisal Program (Oak Ridge and Hanford Alternatives)
 5483.1 Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities
 5484.1 Environmental Protection, Safety, and Health Protection Information Reporting Requirements
 5484.2 Unusual Occurrence Reporting System
 5500.2 Emergency Planning, Preparedness, and Response for Operations
 5700.6A Quality Assurance
 5820.2 Radioactive Waste Management
 Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites (Rev. 1, July 1985)

Table 1.2. Continued

STATE LAWS*New York

New York State Environmental Conservation Law

Washington

Plan for Implementation, Maintenance, and Enforcement of the National Ambient Air Quality Standards in the State of Washington

Water Quality Standard of the State of Washington

Tennessee

Tennessee Air Quality Act

Tennessee Water Quality Control Act

*Note: State and local transportation laws do not apply to DOE shipments of the NFSS wastes and residues (see details in Appendix D).

REFERENCES (Chapter 1)

- U.S. Department of Energy. 1982a. Action Description Memorandum, Niagara Falls Storage Site. Proposed 1982 Interim Remedial Action (R-10 Pile Stabilization). Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. April 1982.
- U.S. Department of Energy. 1982b. Action Description Memorandum, Niagara Falls Storage Site. Proposed Interim Remedial Action for Buildings 413 and 414. Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. April 1982.
- U.S. Department of Energy. 1983a. Action Description Memorandum, Niagara Falls Storage Site. Proposed Interim Remedial Actions for FY 1983. Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. February 1983.
- U.S. Department of Energy. 1983b. Action Description Memorandum, Niagara Falls Storage Site. Proposed Interim Remedial Actions for FY 1983-85 Accelerated Program. Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. June 1983.
- U.S. Department of Energy. 1983c. Long-Term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site: Notice of Intent to Prepare an Environmental Impact Statement and Conduct a Public Scoping Meeting. Fed. Regist. 48(22):4522 (February 1, 1983).
- U.S. Department of Energy. 1983d. Contract of Agreement and Settlement; Lease Agreements AT(40-1)-2427 and AT(40-1)-2429. Effective 1 July 1983. Signed 26 August 1983 by J. LaGrone (Contracting Officer), Department of Energy, and V. Shick (President and Chief Executive Officer), Afrimet-Indussa Inc.
- U.S. Department of Energy. 1984. Implementation Plan for the Environmental Impact Statement, Long-Term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site. January 1984.

2. COMPARISON OF ALTERNATIVES

Following is a summary comparison of the various alternatives considered to be reasonably available to DOE for long-term management of the NFSS wastes and residues. A description of the conceptual design and general technical aspects of each alternative is presented.* Further technical details--including other engineering, management, and transportation options--are presented in Appendices C, D, and E of this document and in an engineering report by Bechtel National, Inc. (1984). Cost estimates are given in Appendix F.

The environmental impacts associated with each alternative are summarized based on the detailed analyses presented in Section 4. Because of the radioactive nature of the naturally occurring radionuclides in the NFSS wastes and residues, all environmental impacts (both radiological and nonradiological) are analyzed in terms of three time frames:

- Action Period (approximately 10 years): The period during which physical actions such as transportation, stabilization, ocean dumping, etc., will take place.
- Maintenance and Monitoring Period (10 to 200 years): For the alternatives involving management on land, the period during which the wastes and residues will continue to be managed.** Containment structures will be maintained, radioactive releases to the environment will be monitored, and periodic corrective remedial actions will be taken, as necessary. Human access to the waste-management areas will be limited, and the federal government will continue to own the sites and use them solely for waste-management purposes.
- Long-Term Period (200 to 1000 years): Two cases, involving different degrees of loss of control, are assessed:

Case A: Loss of Monitoring, Maintenance, and Corrective Actions. Monitoring, maintenance, and corrective actions will cease, but access will continue to be limited and the federal government will continue to own and use the sites solely for waste-management purposes. The effects of natural processes on waste containment and the gradual release of radionuclides to the environment are assessed.

Case B: Loss of All Controls. Not only will monitoring, maintenance, and corrective actions cease, but access, land-use, and ownership controls will cease as well. Human intrusion into the wastes is assumed to occur.

The reasons for selecting these time periods and assumptions for analysis are presented in the introduction to Section 4. Detailed discussions of possible measures to mitigate predicted impacts are discussed under each subject in Section 4.

The potential environmental impacts associated with all three time periods are analyzed. The impacts associated with the actual implementation of an alternative can often be greater than the cumulative impacts associated with the disposal site for hundreds to thousands of years. However, because the decision to be made is what alternative should be implemented for long-term management of the NFSS wastes and residues, the various ways that the containment systems may eventually fail and the various pathways by which radioactive substances could be dispersed into the environment are given particular attention. Major factors having input into the radiological analysis are: (1) erosion and other physical effects on site integrity, (2) groundwater contamination, (3) biological effects on the containment systems, and (4) human intrusion into the contaminated materials. All of these factors are interrelated and, at a given time in the future, any one of these factors could be dominant with respect to radiological impacts on either individuals or the general population.

*Both technical descriptions of alternatives and predicted impacts are discussed using the verb "will." This should be interpreted to mean that something will occur if the alternative is implemented as described.

**The federal government plans to take perpetual care of the NFSS wastes and residues. However, because it is unreasonable to assume that maintenance and monitoring will continue for the duration of time that the wastes and residues will remain radioactively hazardous (hundreds of thousands of years), the 200-year maintenance and monitoring period is used as a reference point for purposes of analysis in this EIS. If maintenance and monitoring continues longer than 200 years, costs will be higher (Appendix F), but impacts due to failure of the containment system will be delayed.

The NFSS wastes and residues are similar to mill tailings. As noted in the EPA regulations on mill tailings (U.S. Environ. Prot. Agency 1983), such wastes are "hazardous to man because: (1) decay products of radon may be involved and increase lung cancer; (2) individuals may be exposed to gamma radiation from the radioactivity in the tailings; and (3) radioactive and toxic materials from tailings may be ingested with food or water The first of these hazards is clearly the most important." The radon gas pathway will be the major contributor to population doses associated with the various alternatives for managing the NFSS wastes and residues. Relatively few people could theoretically use contaminated groundwater at the sites considered for long-term management, and impact to an intruder would result only if controls ceased and intrusion occurred.

Descriptions of the NFSS wastes and residues, the existing environments at the various sites, and the transportation routes are presented in Section 3. The analysis of monetary costs associated with implementation of each alternative, including costs of maintenance and monitoring for 200 years, is presented in Appendix F. The technical and environmental impacts of the various alternatives are summarized in Tables 2.1 and 2.2. The alternatives considered are:

- 1: No action
- 2a: Long-Term Management at NFSS: Modified Containment
- 2b: Long-Term Management at NFSS: Modified Containment Plus Modified Form
- 3a: Long-Term Management at Hanford
- 3b: Long-Term Management at Oak Ridge
- 4a: Long-Term Management of Residues at Hanford, Wastes at NFSS
- 4b: Long-Term Management of Residues at Hanford; Ocean Dispersal of Wastes
- 4c: Long-Term Management of Residues at Oak Ridge, Wastes at NFSS
- 4d: Long-Term Management of Residues at Oak Ridge; Ocean Dispersal of Wastes

2.1 ALTERNATIVE 1: NO ACTION

2.1.1 Description

Alternative 1 encompasses the continued storage of all 190,000 m³ (250,000 yd³) of residues and wastes within the 3.4-ha (8.5-acre) diked containment area in the southwest corner of NFSS (Figure 1.2). The containment area is surrounded by a dike and subsurface clay cutoff wall and is capped with 1.4 m (4.5 ft) of clay and soil (Figure 2.1).^{*} The entire 77-ha (190-acre) NFSS site will remain under DOE ownership and control (Section 4.6.2). Monitoring, maintenance, and corrective actions, as needed, are assumed to continue for 200 years. Maintenance will include mowing of the surface grass cover to prevent tree growth on the cap, repair of all cap failures, replacement of eroded soils from the cap, and ditch dredging and culvert cleaning to ensure site drainage. A major technical uncertainty for this alternative is the durability of the interim cap and the frequency and extent of needed corrective actions in the future. There will be no action costs (e.g., no containment, improvement, excavation, storage, or reburial) associated with this alternative, and perpetual care costs (for monitoring and maintenance) are expected to be about \$120,000/yr (Appendix F).

2.1.2 Summary of Impacts

Because there will be no action in this alternative, there will be essentially no impacts during the action period. Only minute amounts of radon-222 gas (above background levels) will be released from the buried wastes at NFSS (Section 4.1.2). The residues are buried so deeply that the radon-222 (radon gas) in the residues will decay to solid decay products before it diffuses to the surface of the containment area. Radon-222 releases from the NFSS diked containment area during the action period (10 years) will result in less than 0.0000005 additional adverse health effects (primarily cancers--Table 2.2, Sections 4.1.2 and 4.1.4) in the exposed population of 3.8 million people. Maintenance and monitoring workers are expected to receive a 10-year cumulative radiation dose resulting in 0.0013 adverse health effects (Table 2.2 and Sections 4.1.3 and 4.1.4).

Because there will be no transportation in this alternative, there will be no transportation-related injuries and deaths. The small amount of maintenance and monitoring for the 10-year action period is expected to result in negligible occupational injuries and deaths (Table 2.2 and Section 4.6).

^{*}As of April 1986, the interim cap has been constructed over all of the containment area except the southern portion where the residues are located. In this EIS, the conceptual design for the interim cap included a 0.15-m (0.5-ft) sand layer between the clay and soil. A minor design modification eliminated this sand layer.

Table 2.1. Summary of Technical Aspects of the Various Alternatives for Long-Term Management of the NFSS Wastes and Residues

Technical Aspect	Alternative 1	Alternative 2a	Alternative 2b	Alternative 3a	Alternative 3b
Ultimate location of the wastes and residues	All at NFSS (Lewiston, NY)	All at NFSS (Lewiston, NY)	All at NFSS (Lewiston, NY)	All at Hanford 218W5 Area (Hanford, WA)	All at Oak Ridge Pine Ridge Knolls site (Oak Ridge, TN)
Long-term management design	Diked containment area with interim cap	Diked containment area with long-term cap	Diked containment area with long-term cap	Trenches	Mounds
Residue treatment	No	No	Resource recovery and vitrified residue slag	No	No
Truck transportation (residues classified as "radioactive"; wastes classified "nonradioactive")	No	No	No	Residues, 1600 trips; wastes, 15,000 trips; 130 million miles round-trip, 5 years total	Residues, 1600 trips; wastes, 15,000 trips; 42 million miles round-trip, 2 years total
Estimated costs:					
Action period	--	\$3.2 to \$6.3 million;	\$4.4 to \$18 million;	\$130 to \$260 million;	\$67 to \$130 million;
Perpetual care	\$120,000/yr	\$85,000/yr	\$85,000/yr	\$85,000/yr	\$85,000/yr
Technical Aspect	Alternative 4a	Alternative 4b	Alternative 4c	Alternative 4d	
Ultimate location of the wastes and residues	Residues at Hanford; wastes at NFSS	Residues at Hanford; wastes in ocean	Residues at Oak Ridge; wastes at NFSS	Residues at Oak Ridge; wastes in ocean	
Long-term management design	Residues in trenches; wastes in diked containment area	Residues in trenches; wastes dispersed in ocean at Site 106	Residues in mounds; wastes in diked containment area	Residues in mounds; wastes dispersed in ocean at Site 106	
Residue treatment	No	No	No	No	
Truck transportation (residues classified as "radioactive"; wastes classified "nonradioactive")	Residues, 1600 trips; 13 million miles round-trip, 2 years total	Residues, 1600 trips; wastes, 15,000 trips; 43 million miles round-trip, 2 years total	Residues, 1600 trips; 4.9 million miles round-trip, 2 years total	Residues, 1600 trips; wastes, 15,000 trips; 34 million miles round-trip, 2 years total	
Estimated costs:					
Action period	\$20 to \$40 million	\$50 to \$99 million;	\$13 to \$26 million;	\$42 to \$84 million;	
Perpetual care	\$130,000/yr	\$43,000/yr	\$130,000/yr	\$43,000/yr	

Table 2.2. Summary of Environmental Impacts Associated with the Various Alternatives for Long-Term Management of the NFSS Wastes and Residues

Environmental Impact	Alternative 1	Alternative 2a	Alternative 2b	Alternative 3a	Alternative 3b
Projected injuries and deaths:					
Transportation	None	0.19 injuries, 0.11 deaths	0.19 injuries, 0.11 deaths	66 injuries, 3.9 deaths	22 injuries 1.4 deaths
Occupational (nontransp.)	0.13 injuries, 0.0015 deaths	12 injuries, 0.0064 deaths	24 injuries, 0.012 deaths	100 injuries, 0.044 deaths	100 injuries, 0.042 deaths
Additional radiological health effects (primarily cancers) resulting from actions:					
General public	<0.0000005	<0.0000005	0.017	0.090	0.066
Workers	0.0013	0.0051	0.10	0.24	0.15
Additional radiological health effects (cancers) at year 1000 (assuming loss of control at 200 years and erosive land use)	<0.00021 per million persons per year	<0.0000005 per million persons per year	<0.0000005 per million persons per year	0.00074 per million persons per year*	<0.0000005 per million persons per year
Time to erode cap (assuming loss of controls at year 200)	650 to 1,100,000 years	1,300 to 2,200,000 years	1,300 to 2,200,000 years	1,500 to 1,800 years	2,400 to 420,000 years
Onsite well contamination:					
Radium-226--					
At year 1000	1,100 pCi/L	380 pCi/L	42 pCi/L	None	None
Time to reach maximum concentration	1,800 yr	3,600 yr	3,600 yr	35,000 yr	7,000 yr
Other chemicals	Negligible	Negligible	Negligible	Negligible	Negligible
Radon-222 gas releases from buried wastes and residues:					
Until year 201	Negligible	Negligible	Negligible	29 pCi/m ² /s*	Negligible
At year 1000	9.6 pCi/m ² /s	Negligible	Negligible	110 pCi/m ² /s*	Negligible
Land-use commitment	Temporary (NFSS)	Permanent (NFSS)	Permanent (NFSS)	Permanent (Hanford)	Permanent (Oak Ridge)
Ocean disposal impacts	None	None	None	None	None

Table 2.2. Continued

Environmental Impact	Alternative 4a	Alternative 4b	Alternative 4c	Alternative 4d
Projected injuries and deaths:				
Transportation	6.9 injuries, 0.44 deaths	22 injuries, 1.3 deaths	2.5 injuries, 0.15 deaths	17 injuries, 1.0 deaths
Occupational (nontransp.)	36 injuries, 0.018 deaths	85 injuries, 0.038 deaths	42 injuries, 0.018 deaths	91 injuries, 0.040 deaths
Additional radiological health effects (cancers) resulting from actions:				
General public	0.054	0.30	0.040	0.28
Workers	0.18	0.20	0.12	0.13
Additional radiological health effects (cancers) at year 1000 (assuming loss of control at 200 years and erosive land use)	0.0061 per million persons per year*	0.0061 per million persons per year*	<0.0000005 per million persons per year	<0.0000005 per million persons per year
Time to erode cap (assuming loss of controls at year 200)	Hanford, 2,300 to 2,800 yr; NFSS, 1,300 to 2,200,000 yr	Hanford, 2,300 to 2,800 yr; wastes in ocean	Oak Ridge, 1,800 to 310,000 yr; NFSS, 1,300 to 2,200,000 yr	Oak Ridge, 1,800 to 310,000 yr; wastes in ocean
Onsite well contamination:				
Radium-226--				
At year 1000	Hanford, None; NFSS, 3.6 pCi/L	None	Oak Ridge, None NFSS, 3.6 pCi/L	None None
Time to reach maximum concentration	Hanford, 35,000 yr; NFSS, 3,600 yr	Hanford, 35,000 yr; wastes in ocean	Oak Ridge, 7,000 yr; NFSS, 3,600 yr	Oak Ridge, 7,000 yr; wastes in ocean
Other chemicals	Negligible	Negligible	Negligible	Negligible
Radon-222 gas releases from buried wastes and residues:				
Until year 201	Hanford, 300 pCi/m ² /s;* NFSS, Negligible	Hanford, 300 pCi/m ² /s*	Oak Ridge, Negligible; NFSS, Negligible	Oak Ridge, Negligible
At year 1000	Hanford, 1,100 pCi/m ² /s;* NFSS, Negligible	Hanford, 1,110 pCi/m ² /s*	Oak Ridge, Negligible; NFSS, Negligible	Oak Ridge, Negligible
Land-use commitment	Permanent (Hanford) Permanent (NFSS)	Permanent (Hanford)	Permanent (Oak Ridge) Permanent (NFSS)	Permanent (Oak Ridge)
Ocean disposal impacts	None	Negligible	None	Negligible

*If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

NORTH

NFSS
ALTERNATIVE 1

SOUTH

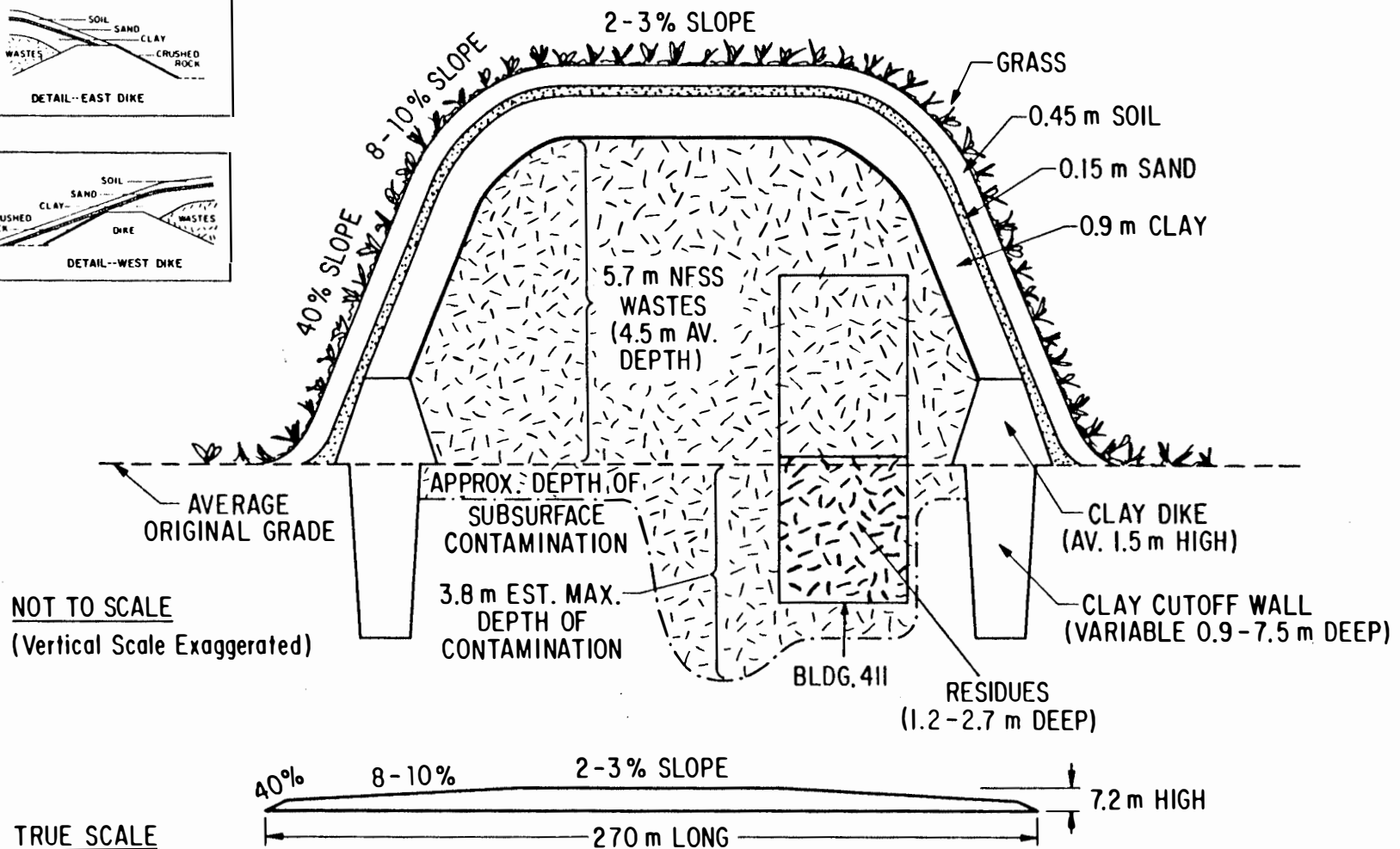
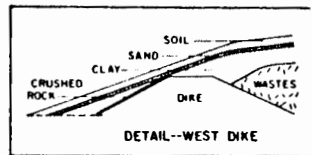
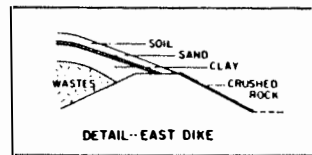


Figure 2.1. Conceptual Design for Interim Management of NFSS Wastes and Residues at NFSS, Alternative 1--No Action. NOTE: As of April 1986, the interim cap has been constructed over all of the containment area except the southern portion where the residues are located. In this EIS, the conceptual design for the interim cap included a 0.15-m (0.5-ft) sand layer between the clay and soil. A minor design modification eliminated this sand layer.

During the maintenance and monitoring period, various physical and biological forces will tend to gradually diminish the integrity of the containment system (Section 4.2 and 4.3). However, the monitoring system will be designed to detect changes in the containment system and any increase in radioactive releases to the environment; corrective actions will be taken as necessary. The drainage system (ditches) above and below NFSS will need to be controlled and maintained so that the containment system is not jeopardized (Section 4.2.1). Cumulative radiological releases, doses, and health effects are expected to continue to be insignificant (Table 2.2, Sections 4.1.2 and 4.1.4). Any failure of the containment system (expected to be less durable than under the other NFSS alternatives) will probably generate negative publicity with attendant social impacts (Section 4.6).

During the long-term period, if all controls cease, the cap will continue to erode and will not be repaired. Complete erosion of the cap is projected to take from 650 to 1,100,000 years, depending primarily on the use of the land (Section 4.2.1). The integrity of portions of the cap could be jeopardized earlier by gullying, slumping, flooding, extended drought, severe earthquake, or biotic intrusion (Sections 4.2 and 4.3). At year 1000, under the most erosive land use, there will be increased releases of both radon-222 and particulates from the exposed wastes. Because only the wastes will be exposed at that time (the residues will be buried very deeply), the radon releases are expected to be very low (only 9.6 pCi/m²/s--Table 2.2 and Section 4.1.2). The resulting additional health effects in the exposed population will be insignificant (0.00021 health effects/million persons/year).

If controls cease, a "resident-intruder" could intrude into the contaminated area, build a house in the contaminated materials, eat contaminated food grown in an onsite garden, and drink contaminated water from a well located at the edge of the contaminated area (see Section 4.1.2). By far the most significant radiological pathway, both in terms of dose and adverse health effects, is the inhalation of radon-222 gas (and its radioactive decay products) with resulting dose to the resident-intruder's bronchial epithelium (lining of the lung) and consequent increased risk of lung cancer. Assuming that the NFSS wastes and residues are not dispersed at the time of intrusion, the resident-intruder will incur a dose of 8,000,000 mrem/yr to the bronchial epithelium (Section 4.1.2). This dose is expected to result in death within a few years (excluding other causes of death). If controls are maintained or if a method of disposal involving greater confinement of the residues is implemented (Appendix C, Section C.3), the risk of this impact occurring will be decreased.

Radiological and nonradiological (chemical) contamination of groundwater at NFSS is expected to be localized (Sections 4.2 and 4.4). The radium-226 concentration in water from a theoretical well drilled into the near-surface aquifer adjacent to the diked containment area in the year 1000 is projected to be about 1,100 pCi/L (Table 2.2 and Section 4.2.2). The peak concentration is expected to be reached in about 1800 years. Wells drilled into this aquifer have limited yield, and because of the extremely slow migration of contaminants from the diked containment area, only a few people (e.g., one family) are expected to be affected. In the long term, the subsurface clay cutoff wall is expected to provide little or no retardation of contaminant migration (Section 4.2.2).

2.1.3 Mitigative Measures

The long-term impacts can be reduced by continuing to monitor and take any necessary corrective actions. Impacts to a person drinking contaminated well water can be mitigated by instituting controls against use of well water from the near-surface aquifer on or near the NFSS containment area (Section 4.2.2).

2.2 ALTERNATIVE 2a: LONG-TERM MANAGEMENT AT NFSS, MODIFIED CONTAINMENT

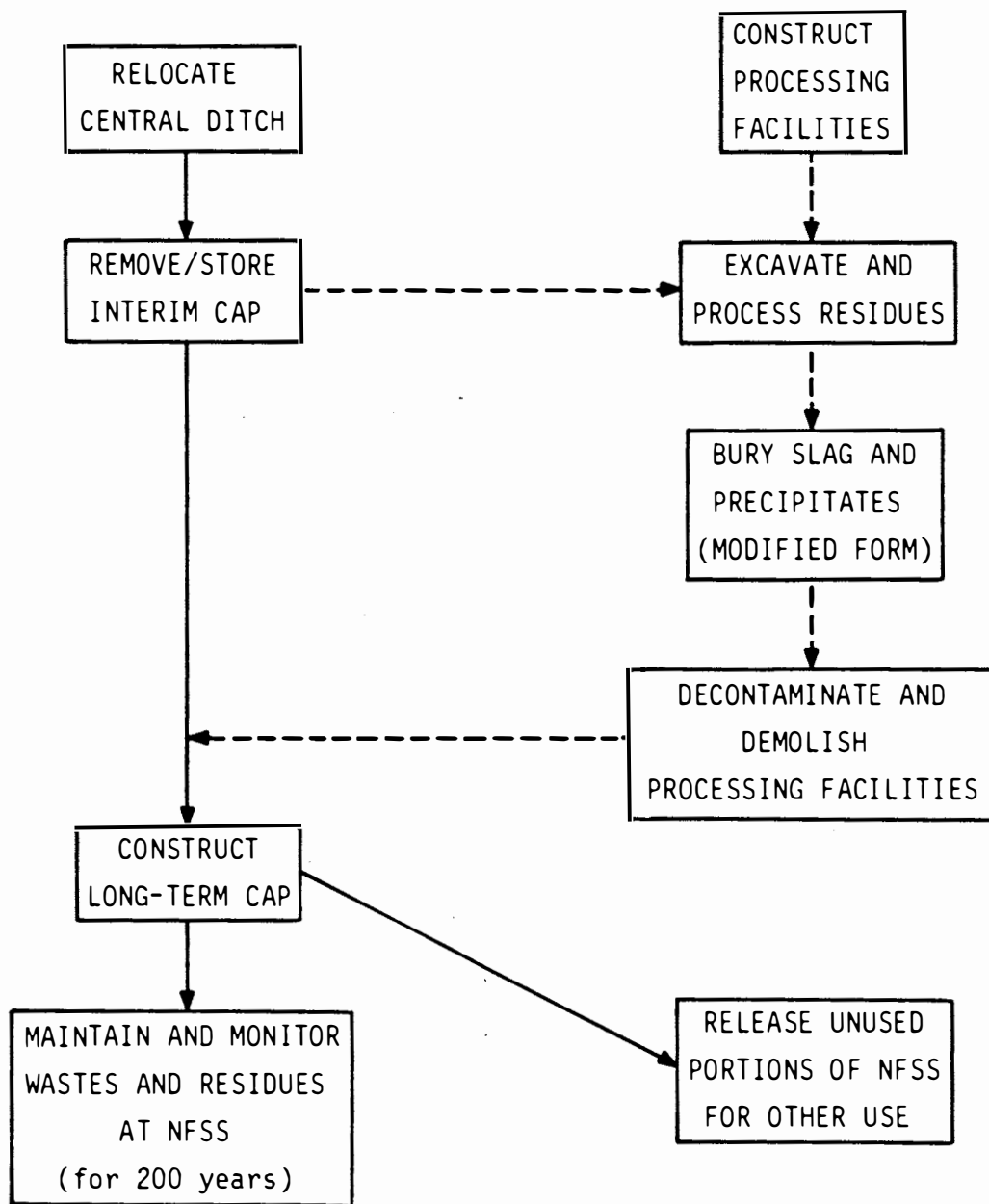
2.2.1 Description

Under Alternative 2a, further actions will be taken to improve the long-term containment of the wastes and residues at NFSS. Such actions include removal and temporary storage of the upper layers of the interim cap and construction of a long-term cap. The sequence of the major activities is presented in Figure 2.2. The conceptual design for the long-term cap is presented in Figure 2.3. Long-term cap construction will entail enlargement of the waste containment area and will necessitate relocation of the central ditch. The long-term cap is 1.7-m (5.5-ft) thicker than the interim cap and will have 1.5 m (5 ft) of clay, 0.15 m (0.5 ft) of sand, 1 m (3 ft) of riprap (graded layers of gravel and rock), another 0.15 m (0.5 ft) of sand, and 0.45 m (1.5 ft) of topsoil. About 110,000 m³ (140,000 yd³) of fill material will have to be imported to NFSS. Other containment options are discussed in Appendix C.

It is assumed that following construction of the long-term cap, the site will be maintained and monitored for 200 years. Only the actual waste containment area, plus a small buffer zone and service area totaling 16 ha (39 acres), will be retained under DOE ownership and control (Section 4.6.2). The remaining 61 ha (150 acres) of the NFSS will be released for other use.

Modified Containment
(2a and 2b)

Modified Form
(2b only)



KEY

- Activities common to both 2a and 2b
 - - - - -→ Activities in 2b only

Figure 2.2. Alternatives 2a and 2b--Long-Term Management at NFSS: Major Activities.

NORTH

NFSS

SOUTH

ALTERNATIVES 2a AND 2b

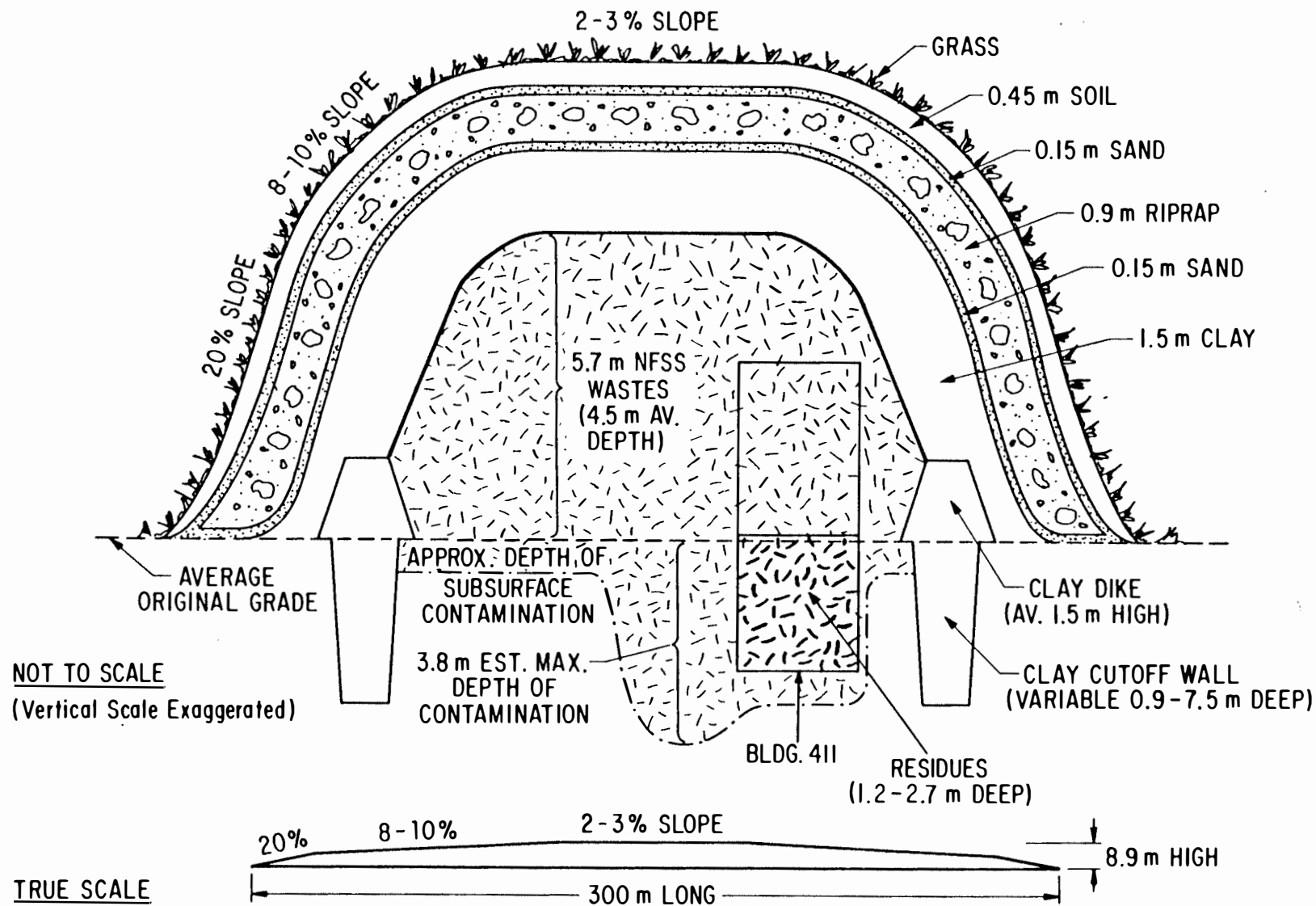


Figure 2.3. Conceptual Design for Long-Term Management of NFSS Wastes and Residues at NFSS, Alternatives 2a and 2b.

It is estimated that implementation of this alternative will cost about \$3.2 to \$6.3 million, and perpetual care costs are expected to be about \$85,000/yr (Appendix F).

2.2.2 Summary of Impacts

As in the no-action alternative (1), radiological impacts to the general public near NFSS are expected to be insignificant for Alternative 2a (Table 2.2 and Section 4.1.2). Releases of radon-222 gas from the diked containment are expected to be negligible (Table 2.2 and Section 4.1.2). Workers constructing the long-term cap will incur negligible additional adverse health effects from radiation exposures (0.0051 health effects, primarily cancers) (Table 2.2 and Sections 4.1.3 and 4.1.4).

During the long-term period, if controls cease at 200 years, the modified containment system will delay exposure of the contaminated materials. After 1000 years, even under the most erosive land use, there will be a cover over the contaminated materials. Consequently, doses to the general public will be lower than in Alternative 1 (no action)--less than 0.0000005 health effects/ million persons/yr (Table 2.2, Sections 4.1.2 and 4.1.4). A potential resident-intruder will receive the same high dose as in Alternative 1 (8,000,000 mrem/yr to the bronchial epithelium--Section 4.1.2). The addition of the riprap layer in the cap may initially discourage intrusion.

Because fill materials will be transported relatively short distances to NFSS for construction of the long-term cap, transportation-related injuries and deaths are expected to be negligible (Table 2.2 and Section 4.6).

As in the other alternatives, it is expected that maintenance and monitoring activities will initially offset the various physical and biological forces acting to diminish the integrity of the containment system. If controls cease at 200 years, it is estimated that it will take from 1,300 to 2,200,000 years for the long-term cap to completely erode, depending primarily on land use (Table 2.2 and Section 4.2.1). The integrity of portions of the cap could be jeopardized earlier by gullyng, slumping, flooding, extended drought, severe earthquake, or biotic intrusion--although the risk of such adverse effects on the containment system are expected to be less than for the interim cap in Alternative 1 (Sections 4.2 and 4.3).

As in Alternative 1, radiological and nonradiological (chemical) contamination of groundwater at NFSS is expected to be slow and localized under Alternative 2a. Because of the improved cap, the concentrations in water from a theoretical onsite well at 1000 years are expected to be less than in Alternative 1 (380 pCi/L for radium-226--Table 2.2 and Section 4.2.2). The concentration of radium-226 in the onsite well is expected to peak at a later date (3,600 years--Table 2.2 and Section 4.2.2).

2.2.3 Mitigative Measures

Mitigative measures for Alternative 2a are the same as those discussed for Alternative 1.

2.3 ALTERNATIVE 2b: LONG-TERM MANAGEMENT AT NFSS, MODIFIED CONTAINMENT PLUS MODIFIED FORM

2.3.1 Description

In Alternative 2b, in addition to the improved containment system described for Alternative 2a, the residues will be modified physically and chemically to reduce the rate of long-term migration of contaminated materials from NFSS. The residues will be removed from the containment area and processed to extract valuable constituents (e.g., uranium, cobalt, nickel, molybdenum, and lead). Possible procedures that could be used are discussed in Appendix C of this report and in an engineering report by Bechtel National (1984). Once processed, the vitrified (glass) residue slag and precipitates will be reburied in the diked containment area, the processing facilities will be decontaminated and demolished, and the entire waste-containment area will be covered with the long-term cap. The unused portions of NFSS will be released for other use. The sequence of the major activities for Alternative 2b is presented in Figure 2.2.

Before implementation of Alternative 2b is possible, several technical questions relating to the residue-modification process must be resolved. More detailed chemical analyses of the residues will be required and laboratory experimentation will be necessary to determine the effectiveness of the extraction process and the long-term leachability of the slag and precipitates. A potential limitation to the implementation of this alternative is achievement of an acceptable level of residual contamination in the metals that are extracted from the residues (Appendix C).

It is estimated that it will cost from \$4.4 to \$18 million to implement Alternative 2b, and perpetual care costs will be about \$85,000/yr (Appendix F).

2.3.2 Summary of Impacts

With removal of the protective cover system and the excavation and processing of the residues, radon-222 and particulate releases will increase during the action period. As a result, the doses to

the general public and resulting health effects will be higher for Alternative 2b than for Alternatives 1 or 2a (Section 4.1.2). However, cumulative doses to the critical organs are expected to result in negligible additional health effects (only 0.017 health effects in the exposed population of 3.8 million people--Table 2.2 and Section 4.1.2). During the maintenance and monitoring period and the long-term period, radon-222 emissions and resulting doses and health effects will be similar to those for Alternative 2a. Modifying the form of the residues will not affect radon-222 emissions from the containment area because emissions from the deeply buried residues are not expected to reach the surface of the waste-containment area even if the residues are not modified. The long-term health effects to the general public will remain negligible (Table 2.2 and Section 4.1.4). Assuming that radon-222 emissions from the modified residues are reduced by a factor of 10 in the long term (see Appendix C), a resident-intruder will receive a lower dose, amounting to 800,000 mrem/yr to the bronchial epithelium (Section 4.1.2).

Because there will be more activities involved in implementing Alternative 2b, the risk of worker injuries and deaths, transportation-related injuries and deaths, and radiation health effects associated with occupational exposures will be higher than for the no-action alternative (Table 2.2, Sections 4.1.4 and 4.6). However, such impacts will still be negligible. The NFSS containment area will be permanently committed to waste-management use.

Modification of the form of the residues will not markedly reduce groundwater impacts. The concentration of radium-226 in a theoretical onsite well at year 1000 is predicted to be about 42 pCi/L; the time to reach peak concentrations is predicted to be the same as in Alternative 2a--3,600 years (Table 2.2 and Section 4.2.2).

2.3.3 Mitigative Measures

Mitigative measures for Alternative 2b are the same as those described for Alternative 1.

2.4 ALTERNATIVE 3a: LONG-TERM MANAGEMENT AT ARID SITE (HANFORD)

2.4.1 Description

Under Alternative 3a, both the residues and the wastes will be excavated from the containment area at NFSS and transported on trucks to a waste-management site (218W5 Area) on the DOE Hanford Reservation near Richland, Washington (Figure 2.4).^{*} The residues will be packaged in large metal boxes and transported either on flat-bed trailers or in shielded vans. The wastes are classified as nonradioactive under current transportation regulations and will be shipped in large dump trucks. The possible advantages and disadvantages of various methods of removal and packaging, as well as other modes of transportation, are discussed in Appendices C and D. About 16,000 truckloads will be needed to transport all 190,000 m³ (250,000 yd³) of wastes and residues. Major interstate highway systems will be followed through 11 states, over a distance of approximately 4000 km (2500 mi) (Section 3.5). Following transport of all wastes and residues to the Hanford site, the excavated areas will be filled and regraded, and NFSS will be released for other use.

At Hanford, the contaminated materials will be buried in trenches in a manner similar to current practices for other types of solid radioactive wastes on the Hanford Reservation (U.S. Energy Res. Devel. Admin. 1975). Burial of the NFSS wastes and residues will require approximately 42 trenches, each 300-m (1000-ft) long, 14-m (47-ft) wide, and 4.8-m (14-ft) deep (Figure 2.5). The residues and wastes will be covered with 3 m (10 ft) of local earthen materials--including 0.9 m (3 ft) of excavated soils, 0.9 m (3 ft) of graded riprap, and another 1.2 m (4 ft) of excavated soils. About 150,000 m³ (200,000 yd³) of riprap will have to be imported to the burial site (Appendix D). Other containment options are discussed in Appendix C. The waste-management site at Hanford will cover about 56 ha (140 acres), including 38 ha (95 acres) in the actual waste-containment area (Section 4.6.2). The sequence of these activities is presented in Figure 2.6.

The cost to implement this alternative is expected to range from \$130 to \$260 million, and perpetual care costs will be about \$85,000/yr (Appendix F).

2.4.2 Summary of Impacts

Implementation of Alternative 3a will result in increased radon-222 and particulate releases which will affect the general public surrounding NFSS, Hanford, and along the transportation route.

^{*}Analysis of alternative sites within the DOE Hanford Reservation is beyond the scope of this EIS (Appendix G). The DOE Richland Operations Office has identified the 218W5 area as being a site that is reasonable to assume for purposes of analysis and comparison of alternatives in this EIS. It is an extension of a large area that is being used for disposal of wastes generated on the Hanford Reservation, and it is potentially available for disposal of the NFSS wastes and residues. Site-specific information is available for this site.

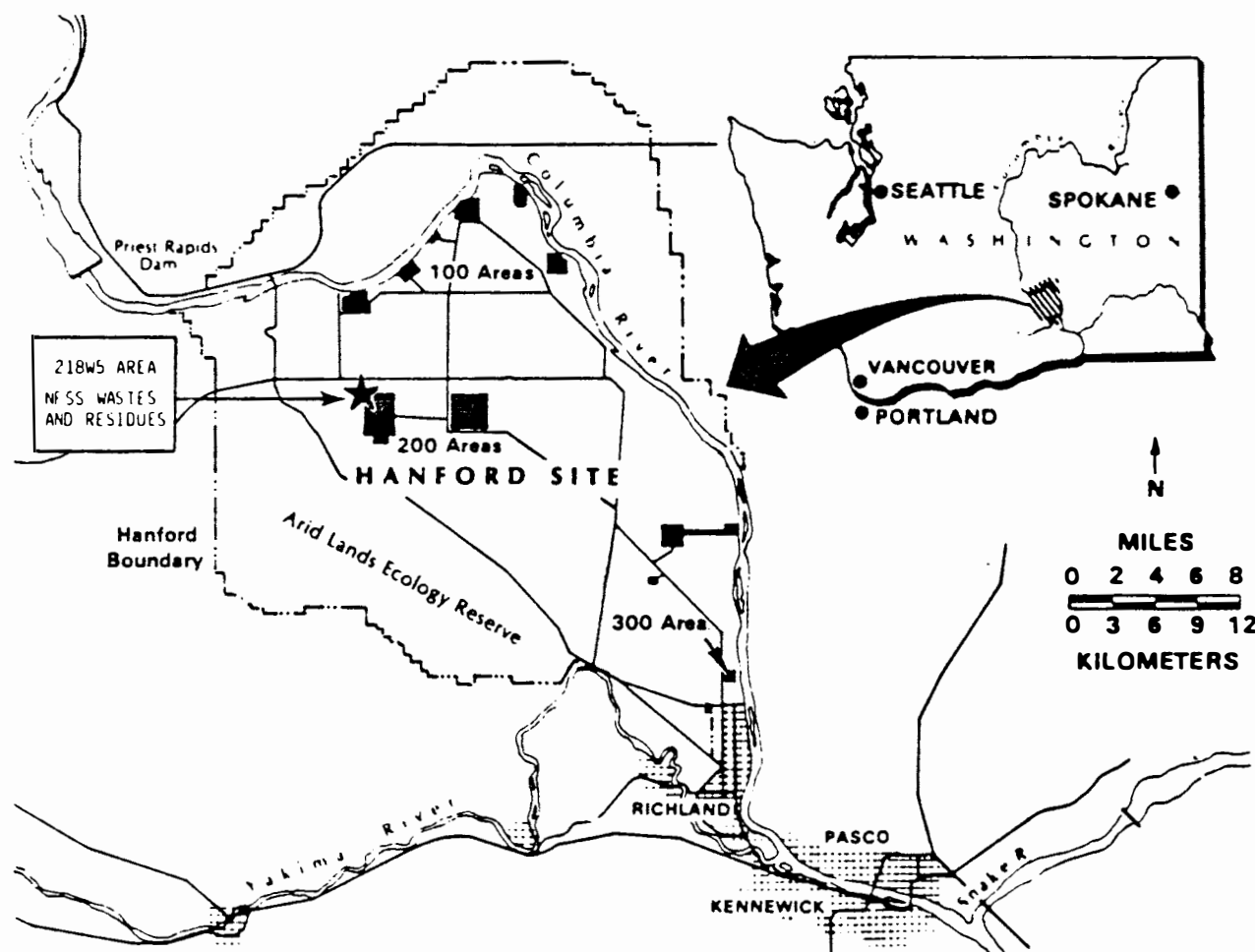


Figure 2.4. Location of the NFSS Waste-Management Site on the Hanford Reservation. Source: Adapted from Sula et al. (1982).

Releases during the action period will result in doses to the general public that are higher than for the no-action alternative (1), but the resulting radiological health effects will still be insignificant (0.090 health effects in the exposed population of several million people at NFSS, Hanford, and along the transportation route--Table 2.2 and Section 4.1.4). Radiological health effects for workers are expected to be higher than for the general public (0.24 health effects) but will also be negligible (Table 2.2 and Section 4.1.4). During the maintenance and monitoring period, radon-222 emissions from the wastes and residues buried in the soil-covered trenches at the arid Hanford site will be much higher than emissions from the clay-covered containment area at NFSS. A radon release rate of 29 pCi/m²/s is predicted (Table 2.2 and Section 4.1.2).^{*} Even though the exposed population is much smaller near Hanford, the higher radon-222 emissions are expected to result in a higher cumulative dose to the general public near Hanford (Section 4.1.2). The resulting health effects will also be higher, but still negligible (0.016 health effects over the maintenance and monitoring period--in a population of 240,000 people--Section 4.1.4). At 1000 years, assuming all controls cease at 200 years

^{*}If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

HANFORD
ALTERNATIVE 3a

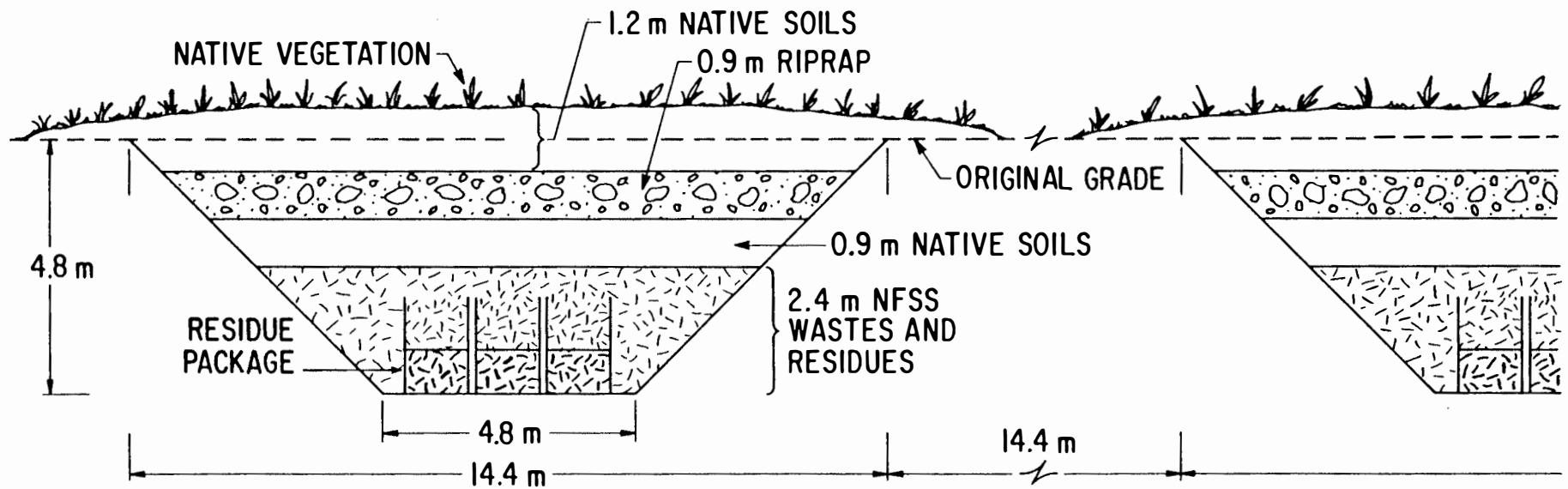


Figure 2.5. Conceptual Design for Management of NFSS Wastes and Residues at Hanford, Alternative 3a.

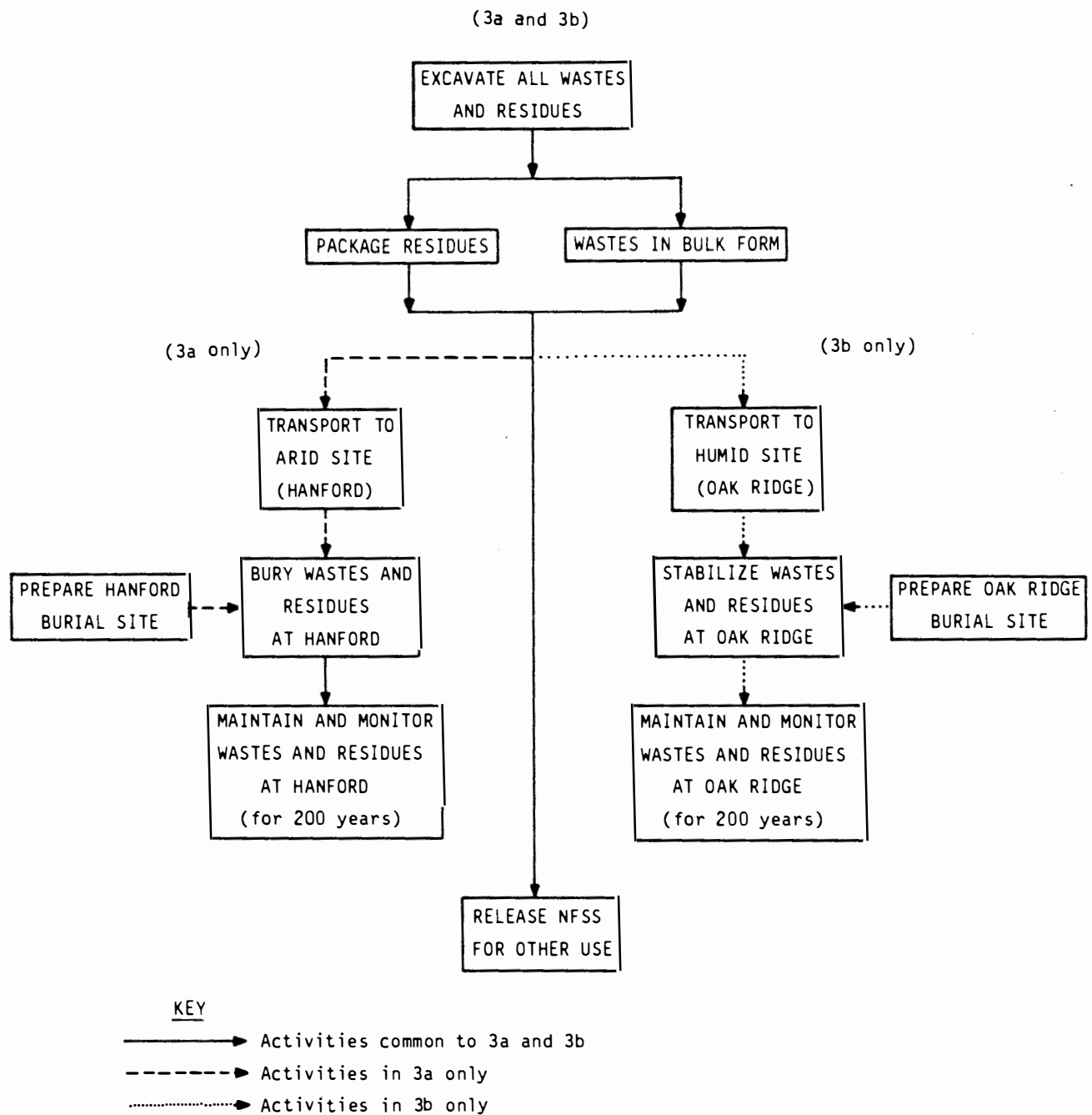


Figure 2.6. Alternatives 3a and 3b--Long-Term Management at Other Sites: Major Activities.

and assuming erosive use of the land, the radon releases will increase to about 110 pCi/m²/s. Radiological health effects associated with such releases are expected to be insignificant, amounting to 0.0022 health effects/million persons/yr (Table 2.2 and Section 4.1.4). Overall, although movement of the NFSS wastes and residues to an arid site such as Hanford will decrease radiological risk associated with groundwater contamination (see later discussion), the total radiological risk will be much greater (although insignificant).

Because of the increased size of the burial area at Hanford relative to NFSS and because the residues will not be concentrated in one area as at NFSS, the dose to a resident-intruder's bronchial epithelium will be less at Hanford (400,000 mrem/yr) than at NFSS (Section 4.1.2). However, this dose will still result in a significant health risk to the resident-intruder.

Because of the great depth to groundwater and the low rates of infiltration at the arid Hanford site, radiological and nonradiological (chemical) contamination of groundwater is not expected to occur for thousands of years (Sections 4.2.2 and 4.4). Peak concentrations of radium-226 in a theoretical onsite well are not expected to be reached until 35,000 years (Table 2.2).

Implementation of Alternative 3a is expected to result in a significant risk of injury and death. Transportation-related injuries and deaths are expected to be 66 and 3.9, respectively. Occupational injuries and deaths are expected to be 100 and 0.044, respectively (Table 2.2 and Section 4.6). Implementation of this alternative will also permanently commit a small amount of additional land at the Hanford Reservation to waste-management use.

2.4.3 Mitigative Measures

Radon release rates at Hanford could be reduced by burying the residues deeper (Section 4.1.2 and Appendix C). Continuation of controls would mitigate against potential loss of containment and intrusion into the waste-management site.

2.5 ALTERNATIVE 3b: LONG-TERM MANAGEMENT AT A HUMID SITE (OAK RIDGE)

2.5.1 Description

In Alternative 3b, all the NFSS wastes and residues will be excavated and transported by truck to the Pine Ridge Knolls site on the DOE Oak Ridge Reservation near Oak Ridge, Tennessee (Figure 2.7).^{*} Approximately 16,000 truckloads will be transported over major interstate highway systems, crossing five states, and covering approximately 1200 km (750 mi) (Section 3.5). Following transport of all wastes and residues to the Oak Ridge site, excavated areas at NFSS will be filled and regraded and NFSS will be released for other use.

The wastes and residues will be stabilized in several mounds on top of the knolls at the Pine Ridge Knolls site. The mounds will be covered with a long-term cap similar to that described for NFSS (Figure 2.8). Other containment options are discussed in Appendix C. Large amounts of fill material (530,000 m³ [700,000 yd³] of clay, rock and soil) will have to be imported to the Pine Ridge Knolls site to construct the containment system (Appendix D). A total of 24 ha (60 acres) will be needed at the Oak Ridge site, including 12 ha (29 acres) for the actual waste-containment area (Section 4.6). A major technical uncertainty in implementing this alternative is whether or not there will be enough space on top of the knolls.

The cost of implementing Alternative 3b is estimated to range from \$67-130 million, and perpetual care costs will be about \$85,000/yr (Appendix F).

2.5.2 Summary of Impacts

During the action period, the general public at NFSS, Oak Ridge, and along the transportation route will be exposed to radioactive emissions from the NFSS wastes and residues. The decreased transportation distance to Oak Ridge (versus Hanford) will not significantly affect the cumulative population doses. Therefore, the resulting health effects will be almost identical (0.006 health effects--Table 2.2 and Section 4.1.4). Doses to workers, and resulting health effects will be insignificant and lower because of the decreased transportation distance (0.15 health effects--Table 2.2 and Section 4.1.4). Radon-222 releases from the containment area at Oak Ridge are expected to be

^{*}Analysis of alternative sites within the DOE Oak Ridge Reservation is beyond the scope of this EIS (Appendix G). The DOE Oak Ridge Operations Office has identified the Pine Ridge Knolls site as being a site that is reasonable to assume for purposes of analysis and comparison of alternatives in this EIS. It is potentially available for disposal of the NFSS wastes and residues and it is not committed or proposed for disposal of wastes generated on the Oak Ridge Reservation. Site-specific information is available for this site.

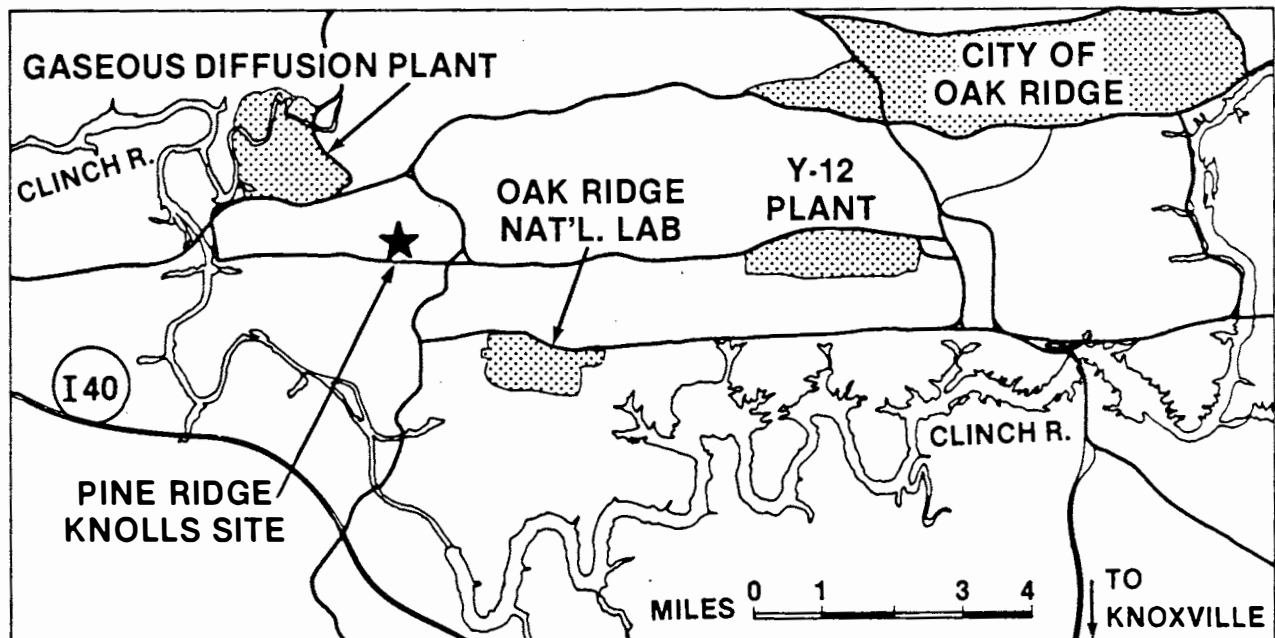
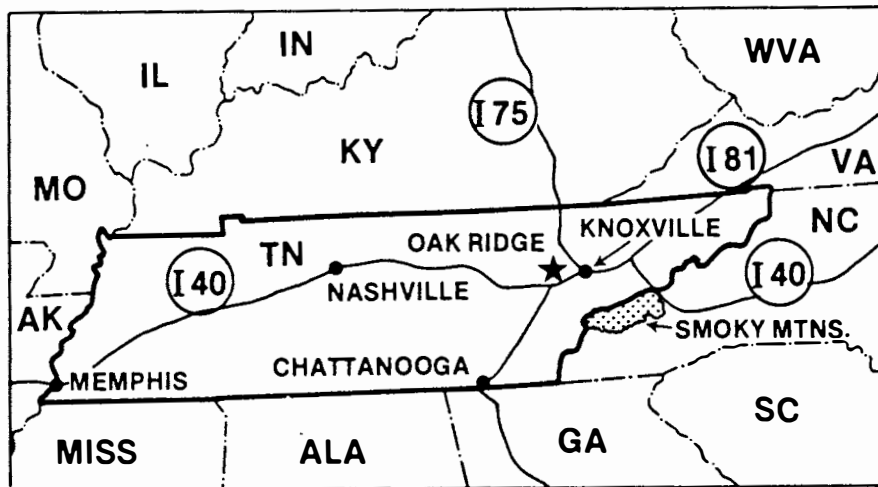


Figure 2.7. Location of Potential Site for Long-Term Management of NFSS Wastes and Residues at Oak Ridge (Pine Ridge Knolls Site).

OAK RIDGE **ALTERNATIVE 3b**

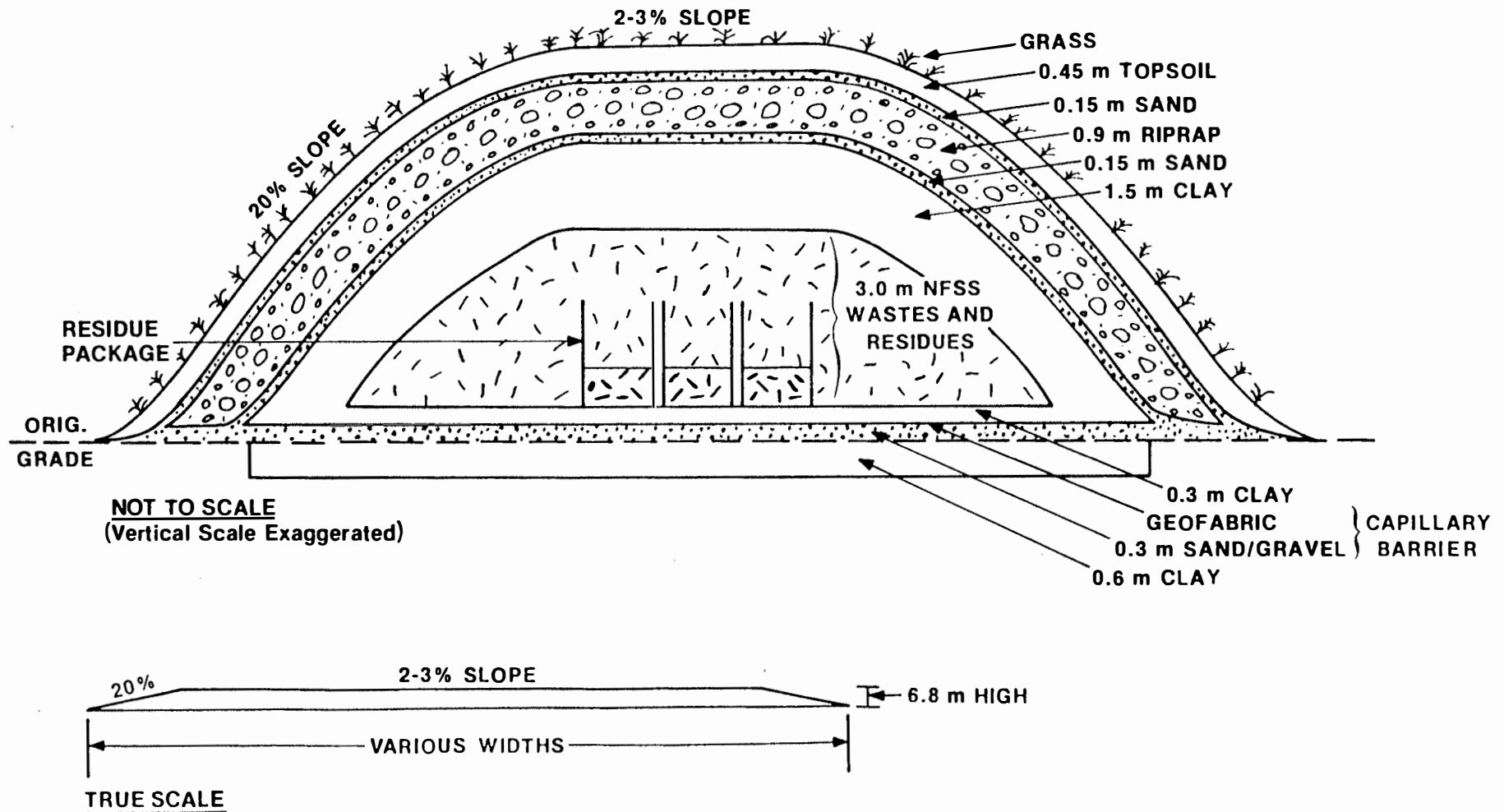


Figure 2.8. Conceptual Design for Long-Term Management of NFSS Wastes and Residues at Oak Ridge, Alternative 3b.

negligible, both during the maintenance and monitoring period and at 1000 years (assuming loss of controls at 200 years and most erosive land use--Table 2.2 and Section 4.1.2). Resulting radiological health effects will be insignificant (Table 2.2 and Section 4.1.4).

Because of the increased size of the burial area at Oak Ridge relative to NFSS (thus lowering the average radionuclide concentrations in the burial area and spreading the residue containers among the wastes), the risk to the resident-intruder is expected to be about the same as at Hanford (Section 4.1.2).

Transportation-related injuries and deaths are expected to be slightly lower for Alternative 3b than for Alternative 3a (Hanford) (22 injuries and 1.4 deaths--Table 2.2 and Section 4.6), but they will still be significant. Occupational injuries and deaths will be about the same. Implementation of this alternative will result in the permanent commitment of land to waste management at the Oak Ridge Pine Ridge Knolls Site. There are competing demands for this site for other potential developments (Section 4.6.2). There may be significant impact (traffic congestion and road deterioration) associated with the high amount of truck traffic on local roads near Oak Ridge. In addition to the trucks hauling the NFSS wastes and residues, there will be about three times as many trucks hauling fill material for the containment system (Appendix D and Section 4.6.3). Peak traffic will average about one truck every minute on work days during two construction seasons.

Vertical migration of radiological and nonradiological (chemical) contaminants from the NFSS wastes and residues to the groundwater at Oak Ridge is expected to be very slow and, because of the larger groundwater flow, the contaminants will be diluted more than at NFSS (Section 4.2.2). It is predicted that groundwater contamination will not occur by the year 1000, and the concentration of radium-226 in a theoretical onsite well is not expected to peak until 7000 years (Table 2.2 and Section 4.2.2). No significant nonradiological contamination of groundwater is expected (Section 4.4).

2.5.3 Mitigative Measures

The potential impacts associated with the high volume of truck traffic at Oak Ridge might be mitigated to some extent by careful planning and timing of operations (Section 4.6). The intruder impacts can be avoided by continuing to control against intrusion.

2.6 ALTERNATIVE 4a: STORAGE OF RESIDUES AT HANFORD/LONG-TERM MANAGEMENT OF WASTES AT NFSS

2.6.1 Description

Under Alternative 4a, the residues will be excavated, packaged, and transported to Hanford as in Alternative 3a. Only one-tenth as many truck trips, i.e., 1600, will be needed. The packages will be buried in 10 trenches 300-m (1000-ft) long (Figure 2.9). Much less imported fill material (37,000 m³ [48,000 yd³] of riprap) will be required at Hanford. The residues will remain stored in the packages to allow near-term retrieval for possible processing or other disposition. About 21 ha (53 acres), including 9.3 ha (23 acres) for the actual waste-containment area, will be required (Section 4.6).

The wastes will remain at NFSS and will be covered with a long-term cap identical to that described for Alternative 2a (Figure 2.10). About 120,000 m³ (160,000 yd³) of imported fill material will be required. DOE will maintain and monitor both the NFSS and Hanford sites. The sequence of major activities for Alternative 4a is presented in Figure 2.11.

The estimated cost to implement this alternative is from \$20 to \$40 million, and perpetual care costs (for the two sites) will be about \$130,000/yr (Appendix F).

2.6.2 Summary of Impacts

The NFSS residues account for 99% of the radionuclide inventory; thus, removal and transport of only the residues to Hanford will result in approximately the same radiological releases and associated impact as removal and transport of both the wastes and residues (Section 4.1.2). The general public and workers will incur 0.054 and 0.18 additional radiological health effects, respectively (Table 2.2 and Section 4.1.4). Because the buried residues will not be covered with the NFSS wastes in this alternative (the wastes will remain at NFSS) and because the native sandy soils that will be used to cover the residues have a higher radon-diffusion coefficient than the NFSS wastes, the radon-222 emissions are expected to be higher, i.e., 300 pCi/m²/s* (Table 2.2 and Section 4.1.2).

*If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternatives 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

HANFORD
ALTERNATIVES 4a AND 4b

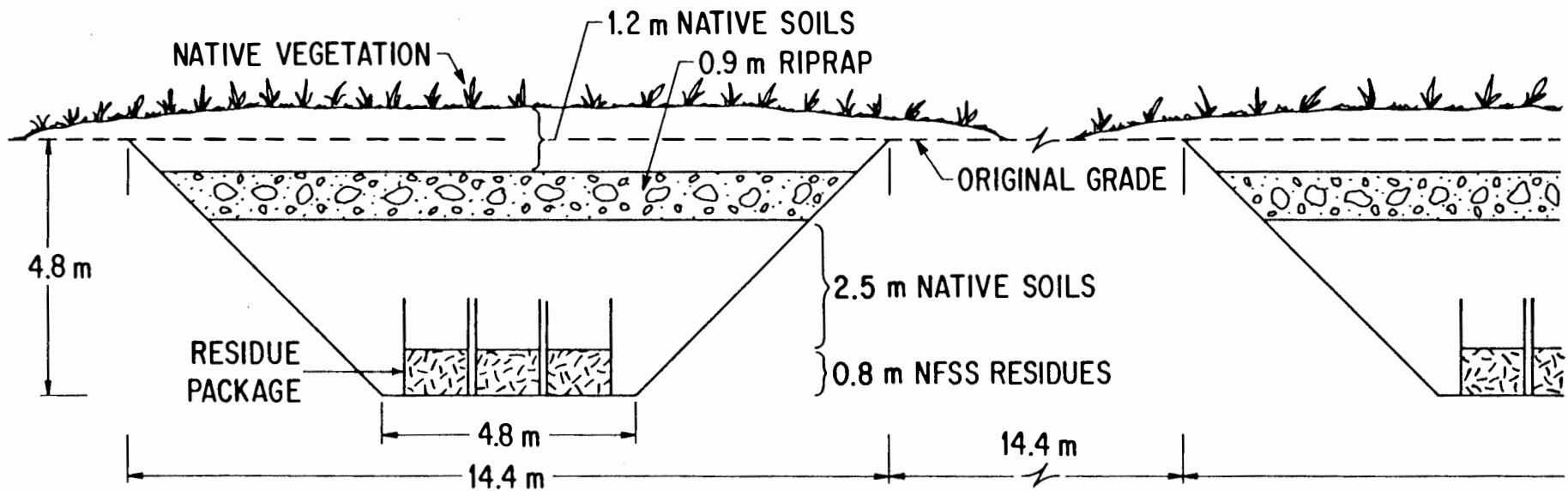


Figure 2.9. Conceptual Design for Management of NFSS Residues at Hanford, Alternatives 4a and 4b.

NORTH

NFSS

SOUTH

ALTERNATIVES 4a AND 4c

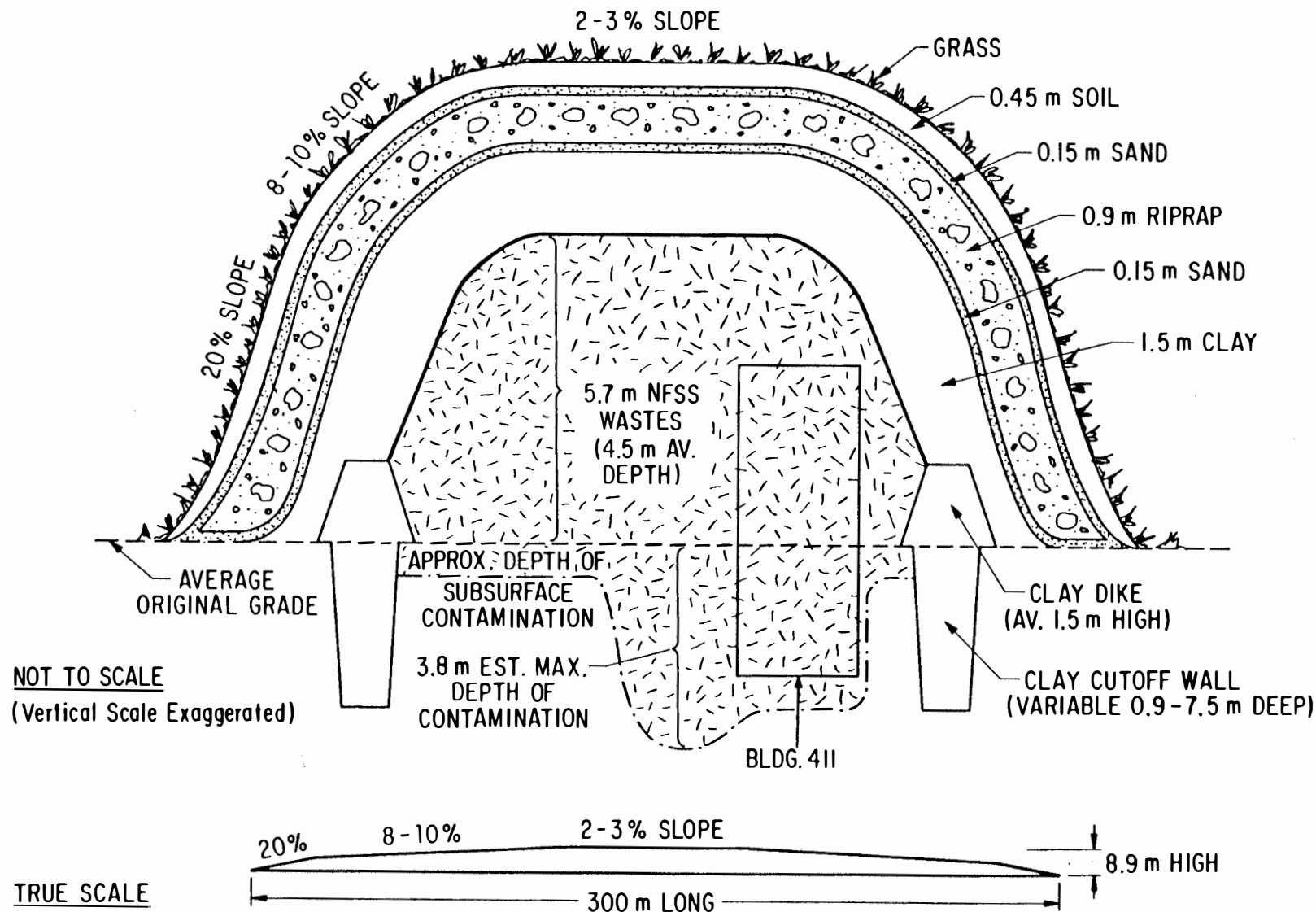


Figure 2.10. Conceptual Design for Long-Term Management of NFSS Wastes at NFSS, Alternatives 4a and 4c.

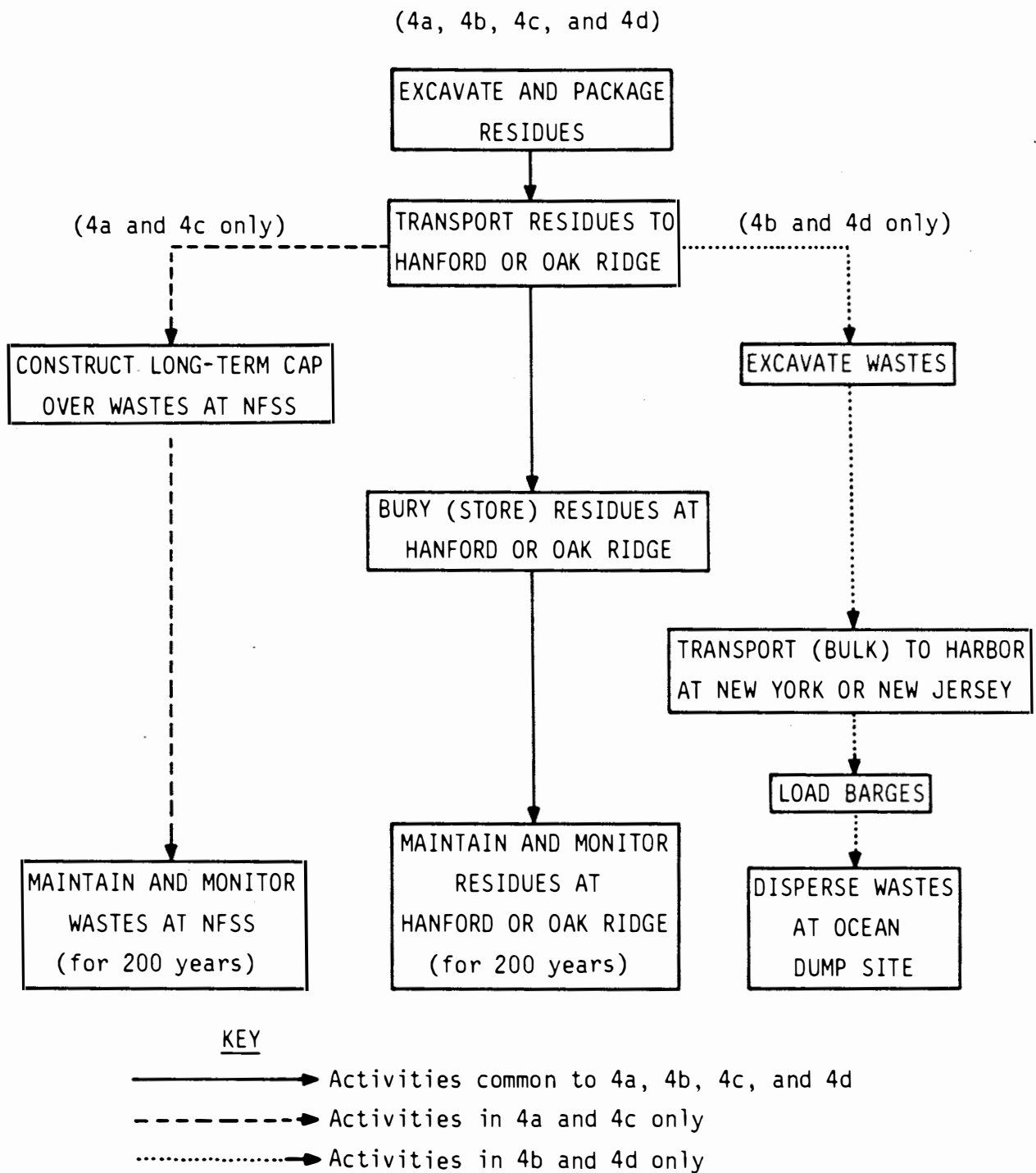


Figure 2.11. Alternatives 4a, 4b, 4c, and 4d--Offsite Storage of Residues: Major Activities.

However, the expected number of additional adverse health effects associated with such releases is still expected to be extremely low--an additional 0.14 health effect in the exposed population of 240,000 people during the maintenance and monitoring period (Sections 4.1.2 and 4.1.4). At the year 1000, assuming loss of controls at 200 years and erosive land use, the radon release rate will increase to 1,100 pCi/m²/s (Table 2.2 and Section 4.1.2). Resulting adverse health effects will, however, still be negligible--0.0061 health effects/million persons/yr (Table 2.2 and Section 4.1.4). The risk to a resident-intruder at Hanford will be higher in Alternative 4a than in Alternative 3a (dose of 1,600,000 mrem/yr to the bronchial epithelium--Section 4.1.2) because the residues will not be effectively diluted by the wastes and the average concentration of radionuclides in the waste-containment area will be higher. The risk to a resident-intruder at NFSS will be substantially reduced (4,300 mrem/yr to the bronchial epithelium) because only the wastes will remain at NFSS.

Estimated transportation-related injuries and deaths will be much lower because only the residues will be transported (6.9 injuries and 0.44 deaths--Table 2.2 and Section 4.6). Worker injuries and deaths will likewise be less because the large volume of wastes will not be moved (36 injuries and 0.018 deaths--Table 2.2 and Section 4.6). Implementation of Alternative 4a will result in permanent commitment of two sites to waste management.

2.6.3 Mitigative Measures

Radon release rates at Hanford could be reduced by burying the residues deeper or covering them with clay (Section 4.1.2 and Appendix C). Other mitigative measures are the same as those previously discussed for Alternatives 2a at NFSS and 3a at Hanford.

2.7 ALTERNATIVE 4b: OFFSITE STORAGE OF RESIDUES AT HANFORD/OCEAN DISPOSAL OF REMAINING WASTES

2.7.1 Description

Under Alternative 4b, the residues will be removed, packaged, and transported to Hanford as described for Alternative 4a. All remaining wastes will be excavated, transported in bulk in dump trucks to a dock in the New York/New Jersey harbor area (Figure 2.12), loaded onto barges, and transported to the 106-Mile Ocean Waste Disposal Site (Site 106) for dispersal. A more detailed description of the ocean dumping operations is presented in Appendix E.

Following excavation and removal of all wastes and residues from NFSS, the excavated areas will be filled and graded and the site will be released for other use. The sequence for the major activities to be accomplished under Alternative 4b is illustrated in Figure 2.11. A potential institutional obstacle to implementation of Alternative 4b is the need to obtain an ocean dumping permit from the U.S. Environmental Protection Agency and the uncertainty as to how the wastes will be classified for ocean disposal purposes (Section 4.7).

The estimated cost of implementing Alternative 4b is \$50 to \$99 million, and perpetual care costs for the residues at Hanford will be about \$43,000/yr (Appendix F).

2.7.2 Summary of Impacts

During all time periods, the impacts at Hanford for Alternative 4b will be the same as those for Alternative 4a. During the action period, the total population doses to the general public (at NFSS, Hanford, the Harbor, and along transportation routes) will be greater than for any of the other alternatives, resulting in an expected 0.30 additional health effects (Table 2.2 and Section 4.1.4). This is mainly because of assumed particulate releases from the NFSS wastes as they are transported through the densely populated New York metropolitan area. This impact may actually be much less because the wastes will be covered and releases may be less than assumed. This impact is nonetheless insignificant considering the several million people in the exposed populations at NFSS, Hanford, the Harbor, and along transportation routes. Radiological doses to workers are expected to result in about 0.20 additional health effects (Table 2.2 and Section 4.1.4).

No health effects associated with ocean disposal of the wastes are expected beyond the action period (Section 4.1.2). The maximum potential dose to an individual is expected to be about 0.0072 mrem (whole body) and 0.084 mrem (bone)--Section 4.1.2). Because of the low radionuclide inventory of the wastes and the effective dispersal of the wastes in the ocean, the concentrations of both the radiological and nonradiological contaminants associated with the wastes is expected to be negligible and generally indistinguishable from the naturally occurring concentrations of these elements in the ocean (Section 4.5 and Appendix E).

The impacts at Hanford during the maintenance and monitoring period, during the long-term period, and to the resident-intruder will be the same as for Alternative 4a.

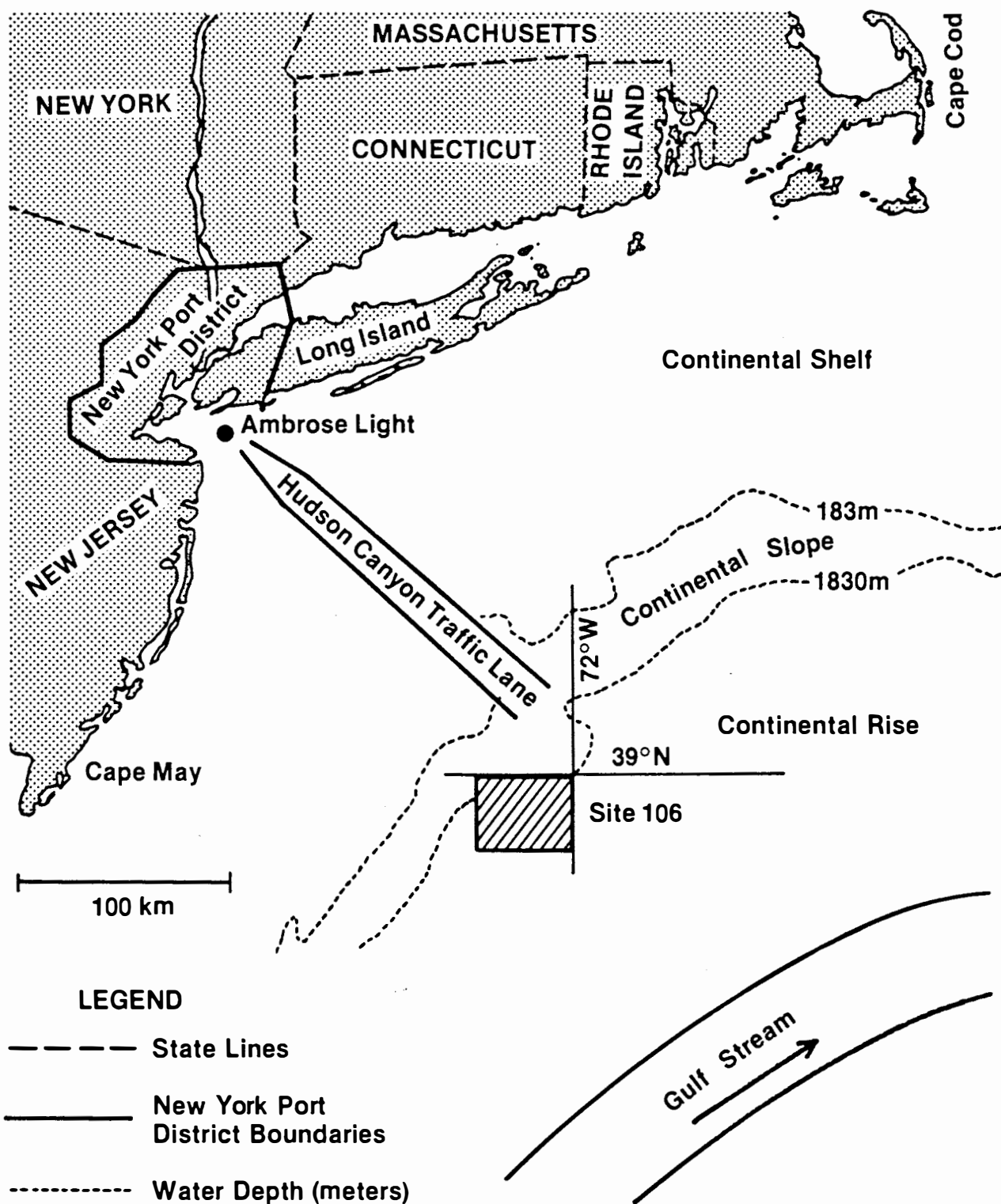


Figure 2.12. Location of Site 106 for Ocean Disposal of NFSS Wastes.

2.7.3 Mitigative Measures

In addition to the mitigative measures previously discussed, the potential doses associated with release of particulates along transportation routes could be reduced by ensuring that the wastes are well covered during transport and/or by avoiding transporting the wastes through densely populated areas (e.g., by going to a different harbor).

2.8 ALTERNATIVE 4c: OFFSITE STORAGE OF RESIDUES AT OAK RIDGE/LONG-TERM MANAGEMENT OF WASTES AT NFSS

2.8.1 Description

In Alternative 4c, the residues will be shipped to Oak Ridge, Tennessee, stabilized in one or two large mounds on the knolls at the Pine Ridge Knolls site, and covered with a long-term cap similar to that described for Alternative 3b. The conceptual design of a mound at the Oak Ridge site is illustrated in Figure 2.13. Less imported fill material will be required at Oak Ridge (120,000 m³ [160,000 yd³]) and the imported fill required at NFSS will be about the same (100,000 m³ [130,000 yd³])--Appendix D). About 13 ha (33 acres) of land will be needed, including 2.7 ha (6.7 acres) for the actual waste-containment area (Section 4.6). The procedures for managing the remaining contaminated wastes at NFSS will be identical to those described for Alternative 2a. The sequence of all major activities is presented in Figure 2.11.

The estimated cost of implementing Alternative 4c is \$13 to \$26 million, and perpetual care costs (for the two sites) will be about \$130,000/yr (Appendix F).

2.8.2 Summary of Impacts

During the action period, the radiological impacts to the general public will be about the same for Alternative 4c as for Alternative 4a (remove residues to Hanford instead of Oak Ridge)--Table 2.2 and Section 4.1.4). During both the maintenance and monitoring period and the long-term period, the impacts to the general public will be the same at Oak Ridge as for Alternative 4c (in which both the wastes and residues are moved to Oak Ridge--Table 2.2 and Section 4.1.4). Worker radiological health effects will also be about the same as in Alternative 4a (Table 2.2 and Section 4.1.4). Radiological impacts will be negligible. The risk to a resident-intruder at Oak Ridge for Alternative 4c will be somewhat higher than for Alternative 3b at Oak Ridge because the residues will not be effectively diluted by the wastes, and thus the average radionuclide concentrations in the waste-containment area will be higher. The dose to a resident-intruder's bronchial epithelium will be about 2,200,000 mrem/yr (Section 4.1.2). The risk to a resident-intruder at NFSS will be significantly reduced because only the wastes will remain at NFSS (Section 4.1.2).

All other impacts are expected to be about the same as previously described for Alternatives 2a (NFSS), 3b (Oak Ridge), and 4a (movement of residues only to Hanford). Groundwater impacts at NFSS are expected to be reduced because of removal of the residues, but groundwater impacts at Oak Ridge will be the same.

2.8.3 Mitigative Measures

Mitigative measures for Alternative 4c are the same as those previously discussed for Alternatives 2a (NFSS) and 3b (Oak Ridge).

2.9 ALTERNATIVE 4d: OFFSITE STORAGE OF RESIDUES AT OAK RIDGE/OCEAN DISPOSAL OF REMAINING WASTES

2.9.1 Description

Alternative 4d is identical to Alternative 4c except that the NFSS wastes will be disposed in the ocean instead of remaining at NFSS. The sequence of major activities for Alternative 4d is illustrated in Figure 2.11. The estimated cost of implementing this alternative is \$42 to \$84 million, and perpetual care costs for managing the residues at Oak Ridge will be about \$43,000/yr (Appendix F).

2.9.2 Summary of Impacts

During all time periods, the impacts at Oak Ridge will be the same as those discussed for Alternative 4c. The impacts at the ocean disposal site will be the same as discussed for Alternative 4b. The total impacts during the action period will be about the same as for Alternative 4b (Table 2.2 and Sections 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6).

2.9.3 Mitigative Measures

Mitigative measures for Alternative 4d are the same as those previously described for Alternatives 2a (NFSS), 3b (Oak Ridge), and 4b (wastes to ocean).

OAK RIDGE

ALTERNATIVES 4c AND 4d

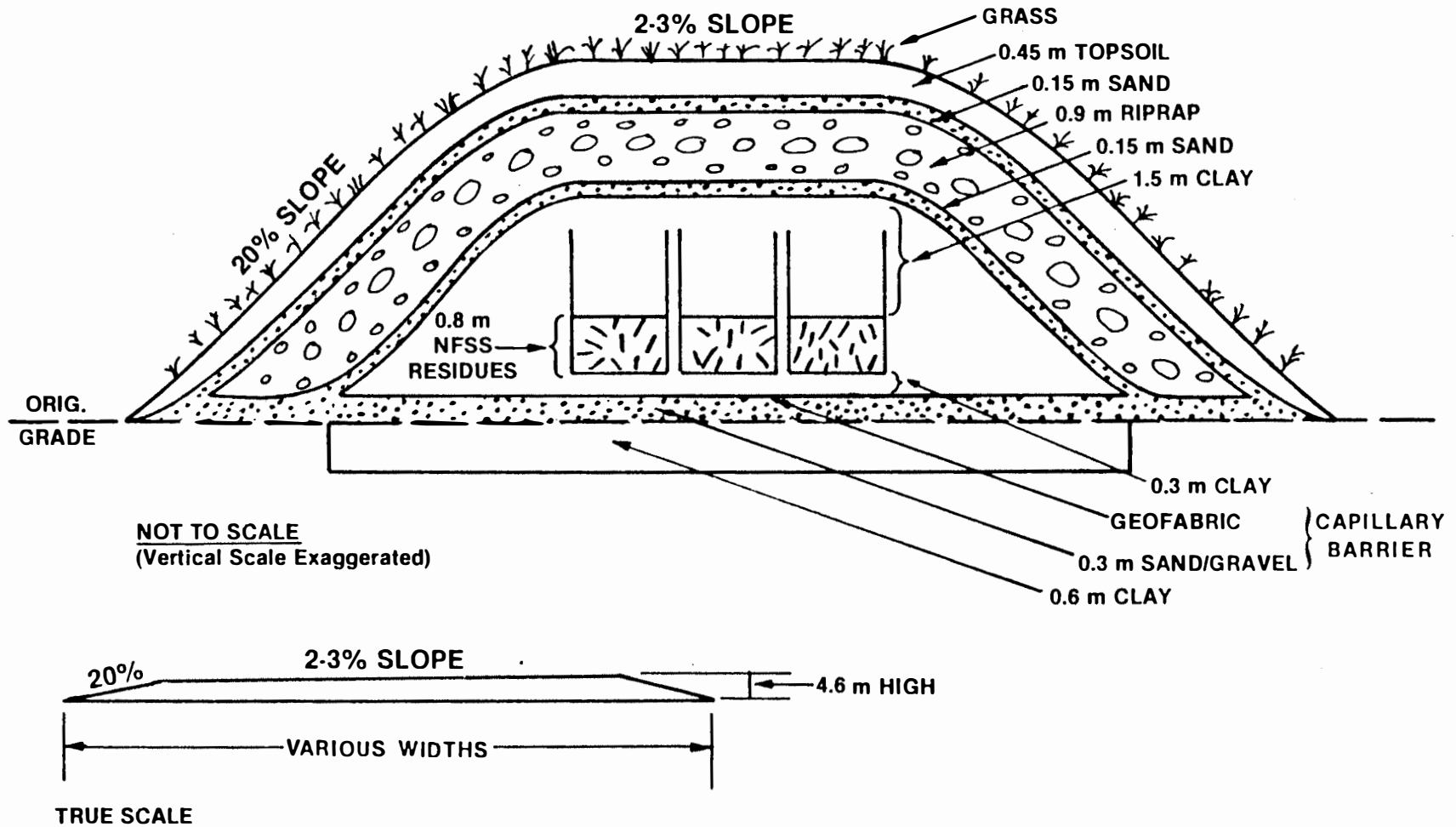


Figure 2.13. Conceptual Design for Long-Term Management of NFSS Residues at Oak Ridge, Alternatives 4c and 4d.

2.10 SUMMARY OF MAJOR UNAVOIDABLE ADVERSE IMPACTS AND IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Implementation of any of the alternatives will permanently commit some land to management of at least the NFSS residues, and in some alternatives, the NFSS wastes as well. The near-surface burial of the NFSS wastes and residues commits the federal government (or its successor) to perpetual care of the burial sites because the residues and wastes will remain hazardous for thousands of years.

Implementation of any of the action alternatives will unavoidably expose workers to risk of injury and death, ranging from a risk of 12 injuries and 0.0064 deaths in the case of Alternative 2a (modified containment at NFSS) to 100 injuries and 0.044 deaths for Alternatives 3a and 3b (all wastes and residues at Hanford or Oak Ridge). Transport of the wastes and residues will unavoidably expose workers and the public to injuries and deaths associated with transportation accidents, ranging from 2.5 injuries and 0.15 deaths for Alternative 4c (residues only to Oak Ridge) to 66 injuries and 3.9 deaths for Alternative 3a (all wastes and residues to Hanford).

An unavoidable adverse economic impact is the commitment of money to long-term management of the NFSS wastes and residues. Initial commitments for the action alternatives range from about \$3.2 to \$6.3 million for Alternative 2a (modified containment at NFSS) to about \$130 to \$260 million for Alternative 3a (move all wastes and residues to Hanford). Long-term commitments for perpetual care are estimated to range from \$43,000/yr for Alternatives 4b and 4d (residues only at Hanford or Oak Ridge) to \$130,000/yr for Alternatives 4a and 4c (in which two different sites must be managed).

For all alternatives, if controls cease, there will be eventual unavoidable dispersion of the radioactive materials to the environment. Prediction of how and when this will occur, and the resulting environmental impact, is beyond current predictive capabilities. If it is assumed that all controls cease in 200 years, predicted loss of the covers over the buried materials ranges from several hundred years to more than two million years, depending on the use of the land surface.

Groundwater will eventually be unavoidably contaminated in all alternatives. At theoretical wells located onsite next to the containment areas, radium-226 concentrations are predicted to peak from 1,800 years at NFSS in Alternative 1 (no action) to 35,000 years at Hanford (Alternative 3a, 4a, or 4b).

2.11 SUMMARY OF OTHER TRANSPORTATION OPTIONS CONSIDERED

There are three potential modes of transport for the NFSS residues and wastes: truck, rail, and barge. Truck transport of all wastes and residues was assumed for purposes of detailed analysis of the alternatives considered in this EIS. Barge transport has been shown to be unreasonable (Bechtel Natl. 1984). Several options were also considered that make use of rail transportation (Appendix D, Section D.5). These other transportation options fall into three categories: (1) site to site on rail, (2) rail with one or two offsite transfers between truck and rail, and (3) rail with truck trailers on flatcars (TOFC). It should be pointed out that even in the cases for which the rail move begins and ends onsite, trucks will still be required to transfer materials between the rail spur and the containment area or disposal location.

The transportation options that were considered in addition to truck-only transport are shown in Table 2.3. Determining the best option for transporting NFSS wastes and residues from the NFSS containment area to the alternative disposal sites requires analysis of many complex trade-offs. The requirements for construction, equipment, material-handling, and mitigation, as well as potential environmental impacts vary among the options. These requirements and impacts are summarized in Table 2.3. Within each of the particular options, there are several considerations for the rail portion of the move that will influence the rates and environmental impacts. Among these are whether or not the railcars move in dedicated trains or general-manifest trains and whether or not the railroads own the railcars. Use of dedicated trains will affect turnaround time and routing which, in turn, will affect equipment costs and environmental impacts. Railcar ownership affects rail rates charged and capital investment required. In addition, the rates that a railroad will charge are uncertain because they will be influenced by the special requirements imposed for NFSS wastes and residues (routing, transit time, etc.), by the railroad's perception of potential hazards, and by concerns about adverse public reaction. The actual rates can only be determined by negotiation with the railroads.

The key environmental trade-offs for these other transportation options are: (1) the number of waste/residue transfers to be made--with consequent potential increased releases of radioactive materials to the environment as well as impacts associated with construction and decontamination/decommissioning of the transfer facilities, (2) the proportionate number of transport miles to be covered by truck and train--because of the higher per mile risks of injury and death associated with truck transport, and (3) the number of rail spurs to be constructed--with consequent construction impacts and dedication of land.

Table 2.3. Transportation Options Using Rail†¹

Site/Options	Facilities	Transportation Equipment Requirements† ²	Offsite Handling	Mitigation	Environmental Impacts
<u>HANFORD</u>					
Truck offsite to rail, rail to Hanford, truck to trenches	Offsite transfer facility at Niagara Falls with trailer washing facility Railcar washing facility at Hanford	Low	Yes	Covers and washing required for both trailers and rail- cars	Spills and radio- active releases during offsite handling
Truck onsite to rail, rail to Hanford, truck to trenches	Rail spur to NFSS Railcar washing facility at Hanford	Lowest	No	Covers and washing for railcars only	Rail spur con- struction
Truck to Buffalo, NY, TOFC ramp; rail to Pasco, WA, TOFC ramp; truck to disposal trenches	Trailer washing facility at Hanford	High	No	Covers and washing for trailers only	Similar to truck- only, less risk of transportation- related injury or death
<u>OAK RIDGE</u>					
Truck offsite to rail, rail to Oak Ridge Reservation, truck to disposal mounds	Offsite transfer facility at Niagara Falls with trailer washing facility Offsite transfer facility at Oak Ridge with railcar washing facility Trailer washing facility at Pine Ridge Knolls site	Low	Yes, two locations	Covers and washing for railcars and trailers in two locations	Spills and radio- active releases during offsite handling

Table 2.3. Continued

Site/Options	Facilities	Transportation Equipment Requirements†2	Offsite Handling	Mitigation	Environmental Impacts
<u>OAK RIDGE</u> (Continued)					
Truck offsite to rail, rail to Pine Ridge Knolls site, truck to disposal mounds	Offsite transfer facility at Niagara Falls with trailer washing facility	Low	Yes	Covers and washing for railcars and trailers	Spills and radioactive releases during offsite handling
	Rail spur to Pine Ridge Knolls site				Rail spur construction
	Railcar washing facility at Pine Ridge Knolls site				
Truck onsite to rail, rail to Oak Ridge Reservation, truck to disposal mounds	Rail spur to NFSS	Low	Yes	Covers and washing for railcars and trailers	Rail spur construction
	Offsite transfer facility at Oak Ridge with railcar washing facility				Spills and radioactive releases during offsite handling
	Trailer washing facility at Pine Ridge Knolls site				
Truck onsite to rail, rail to Pine Ridge Knolls site, truck to disposal mounds	Rail spur to NFSS and rail-spur to Pine Ridge Knolls site	Lowest	No	Covers and washing for railcars only	Rail spur construction in two locations
	Railcar washing facility at Pine Ridge Knolls site				
Truck to Buffalo, NY, TOFC ramp; rail to Knoxville, TN, TOFC ramp; truck to disposal mounds	Trailer washing facility at Pine Ridge Knolls site	High	No	Covers and washing for trailers only	Similar to truck-only, less risk of transportation-related injury or death

Table 2.3. Continued

Site/Options	Facilities	Transportation Equipment Requirements† ²	Offsite Handling	Mitigation	Environmental Impacts
<u>OCEAN</u>					
Truck offsite to rail, rail to rail/barge transfer, barge to disposal	Offsite transfer facility at Niagara Falls with trailer washing facility Rail to barge transfer facility with railcar washing facility	Low	Yes, two locations	Covers and washing for trailers and railcars	Spills and radioactive releases during offsite handling at two locations
Truck onsite to rail, rail to rail/barge transfer, barge to disposal	Rail spur to NFSS Rail to barge transfer facility with railcar washing facility	Lowest	Yes	Covers and washing for railcars only	Rail spur construction Spills and radioactive releases during offsite handling
Truck to Buffalo TOFC ramp, rail to Elizabeth, NJ, TOFC ramp, truck to truck/barge transfer, barge to disposal	Truck to barge transfer facility with trailer washing facility	High	Yes	Covers and washing for trailers only	Spills and radioactive releases during offsite handling

†¹ This table summarizes information presented in Appendix D, Section D.5.

†² For actual numbers of railcars, trailers, and tractors for various project durations, see Appendix D, Table D.10.

Of the several options involving rail transport of the NFSS wastes and residues, none offer a clear advantage over truck-only transport in terms of both costs and environmental impacts. Which transportation option is "best" is likely to be different for each type of residue and waste and for each offsite disposal alternative. The costs are uncertain because rates have to be negotiated with individual railroads and there are complex trade-offs between capital investments for facilities and equipment and operating costs. Finally, the most economical option may not necessarily be the option with the least environmental impacts. A more detailed discussion of rail transportation options is presented in Appendix D, Section D.5.

REFERENCES (Chapter 2)

- Bechtel National, Inc. 1984. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. DOE/OR/20722-1. Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. January 1984.
- Sula, M.J., W.D. McCormack, R.L. Dirkes, K.R. Price, and P.A. Eddy. 1982. Environmental Surveillance at Hanford for CY-1981. PNL-4211. Prepared by Pacific Northwest Laboratory, Richland, WA, for the U.S. Department of Energy.
- U.S. Energy Research and Development Administration. 1975. Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington. ERDA-1538.
- U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR 192. Fed. Regist. 48(3):590-609 (January 5, 1983).

3. AFFECTED ENVIRONMENT

Following are descriptions of the affected environments at NFSS, the three alternative sites to which the NFSS wastes and residues could be taken (Hanford, Oak Ridge, or the ocean disposal site), and the transportation routes.

3.1 NIAGARA FALLS STORAGE SITE (NFSS)

3.1.1 Topography, Geology, Soils, Seismology, and Mineral Resources

The Niagara Falls Storage Site (NFSS) is located south of Lake Ontario on the Ontario Plain that begins at the base of the Niagara Escarpment (Figure 1.1) and slopes gently northwest towards Lake Ontario. The plain is relatively flat and featureless except for a few broad shallow valleys and the Niagara River Valley that lead to Lake Ontario. Elevations at NFSS are uniform, ranging between 96 and 105 m (315 and 344 ft) MSL; the lower elevations correspond to three man-made drainage ditches on the site and the higher elevations correspond to the top of the diked waste containment area in the southwest corner of the site. The natural site elevation is approximately 98 m (320 ft) MSL.

The bedrock of the region is composed of relatively undeformed, flat-lying sedimentary rocks over a basement of metamorphic rock. A 270-m (900-ft) sequence of shales and siltstones of the Queenston Formation lies at the base of the Niagara Escarpment and comprises the uppermost bedrock unit under NFSS. The Queenston Formation underlies NFSS at a depth of approximately 15 m (50 ft) (Acres American 1981). Unconsolidated glacial deposits overlie the Queenston Formation on the Ontario Plain. At NFSS, these deposits consist of five major stratigraphic units (Figure 3.1) (Acres American 1981; Wehran Eng. Corp. 1979).

The silty-loam soils within the vicinity of NFSS belong to the Rhinebeck-Ovid-Madalin association. These soils are nearly level to gently sloping, deep, and somewhat to very poorly drained. They have moderately fine to fine-textured subsoils and are of medium to low value for farming. Poor natural drainage is the major limitation to uses such as farming or urban development (Higgins et al. 1972). Soils within NFSS have been classified in the Niagara County, New York, Soil Survey as "made land" (Higgins et al. 1972). Made land consists of areas that have been filled with stone, brick, and other wastes and covered with a thin mantle of soil material. The properties of made land vary widely over the NFSS. Under the interim actions, much of the surface soil has either been removed in site cleanup operations or used as borrow material to place in the diked area.

The NFSS lies within the Central Stable Tectonic Region (Eardley 1962). Historically, earthquakes within this region have generally been of moderate seismic intensity (VI and VII or less on the Modified Mercalli scale). Near NFSS in western New York and adjoining Ontario, there is a small seismically active area (Hadley and Devine 1974) that is associated with an earthquake event that occurred near Attica, New York, 40 km (25 mi) southeast of NFSS (Fox 1970). The configuration of the seismic zone around Attica is not well defined, but earthquakes in the Attica seismic zone appear to govern the maximum historical intensity at NFSS.

No natural resources of importance are known to exist beneath the NFSS facility. Although clay of the region has been used historically in the manufacture of bricks, no manufacturing facilities currently exist near NFSS. Limestone, sand, and gravel are mined and natural gas fields have been identified in the region; however, none of these resources has been identified or mined in the NFSS area itself (Erie Niagara Co. Reg. Plan. Board 1978b).

3.1.2 Hydrology, Water Use, and Water Quality

3.1.2.1 Surface Water

The natural surface drainage patterns for the NFSS area are illustrated in Figure 3.2. Historically, only Fourmile, Sixmile, and Twelvemile creeks could have received runoff from NFSS. Streamflows for Fourmile, Sixmile, and Twelvemile creeks consist of natural surface runoff, agricultural drainage, and treated and institutional waste discharges (N.Y. State Dep. Environ. Conserv. 1975). The creeks are intermittent through much of their reaches, and they discharge into Lake Ontario.

In the 1940s, a system of ditches was constructed (as part of the Lake Ontario Ordnance Works) to drain surface waters to the central drainage ditch. Sixmile Creek, which originally flowed through the site, was diverted to the southwestern drainage ditch just outside the southwest corner of the site boundary, and surface waters from the southeast area that had flowed east into Twelvemile Creek

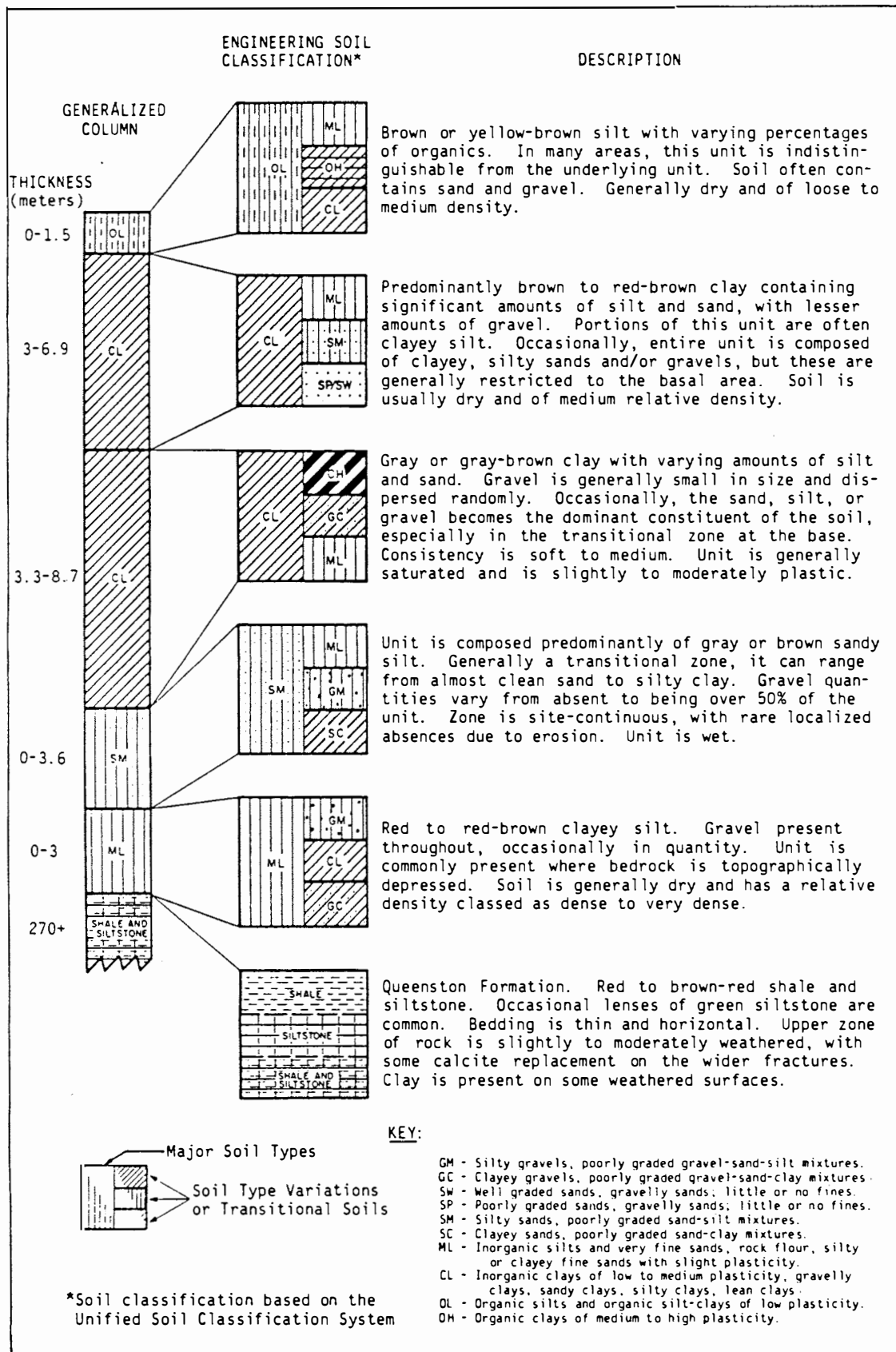


Figure 3.1. Generalized Geologic Column of Formations Under the Niagara Falls Storage Site. Source: Adapted from Acres American (1981).

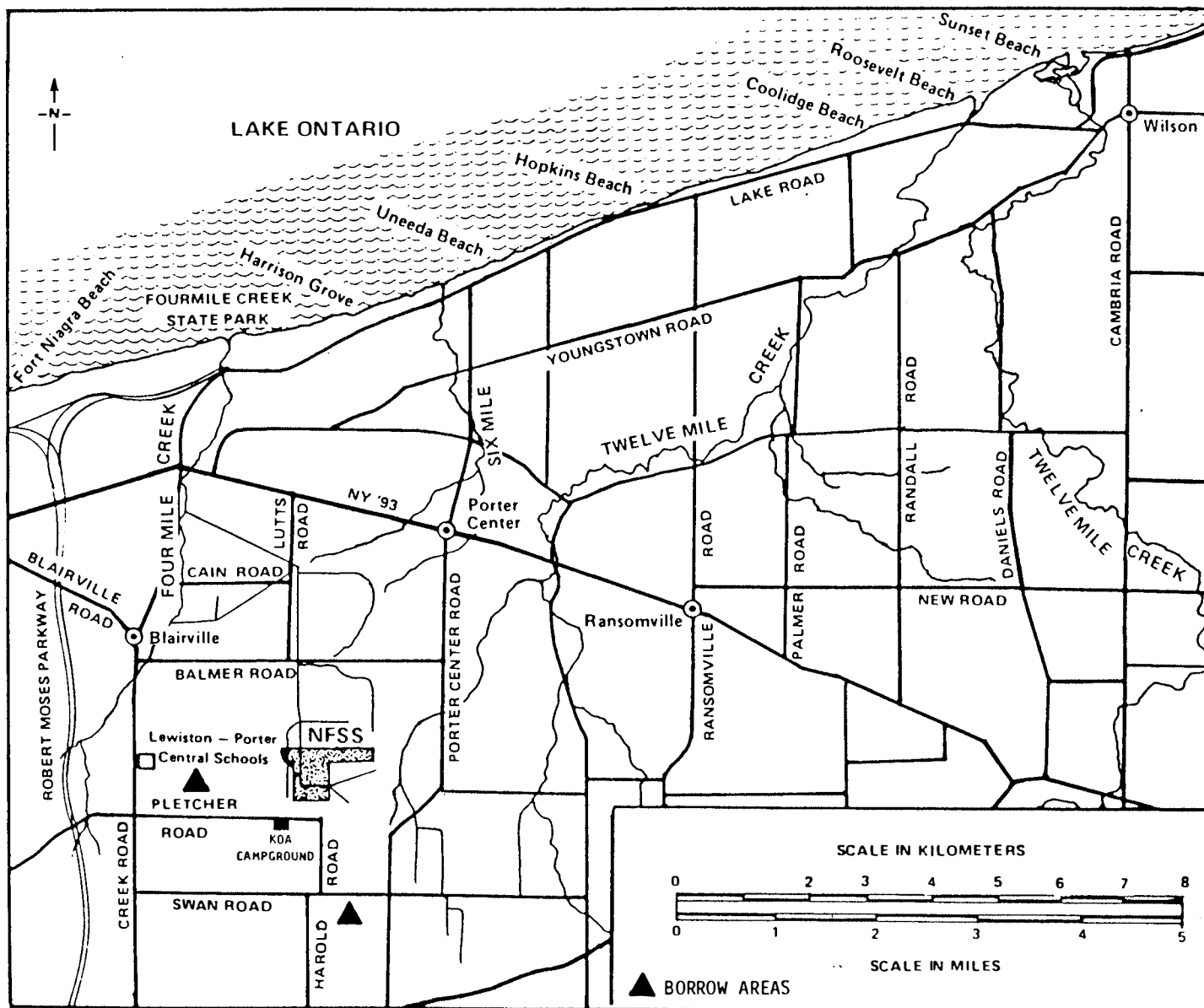


Figure 3.2. Natural Surface Drainage Patterns in the NFSS Area.
Adapted from Anderson et al. (1981--Figure 6.2).

were diverted to the South-31 ditch and then to the central ditch (Aerospace Corp. 1982). The existing man-made drainage system of the NFSS and surrounding area is illustrated in Figure 3.3. Site runoff via the central ditch discharges into Fourmile Creek.

The 100-year flood level within NFSS is estimated to be approximately 97 m (319 ft) MSL, and flooding is generally contained within the central drainage ditch (Acres American 1981; U.S. Dep. Housing Urban Dev. 1980). Major runoff occurs during the spring and, for most of the year, there is very little surface flow. Ponded water is common at NFSS during and following spring snowmelt.

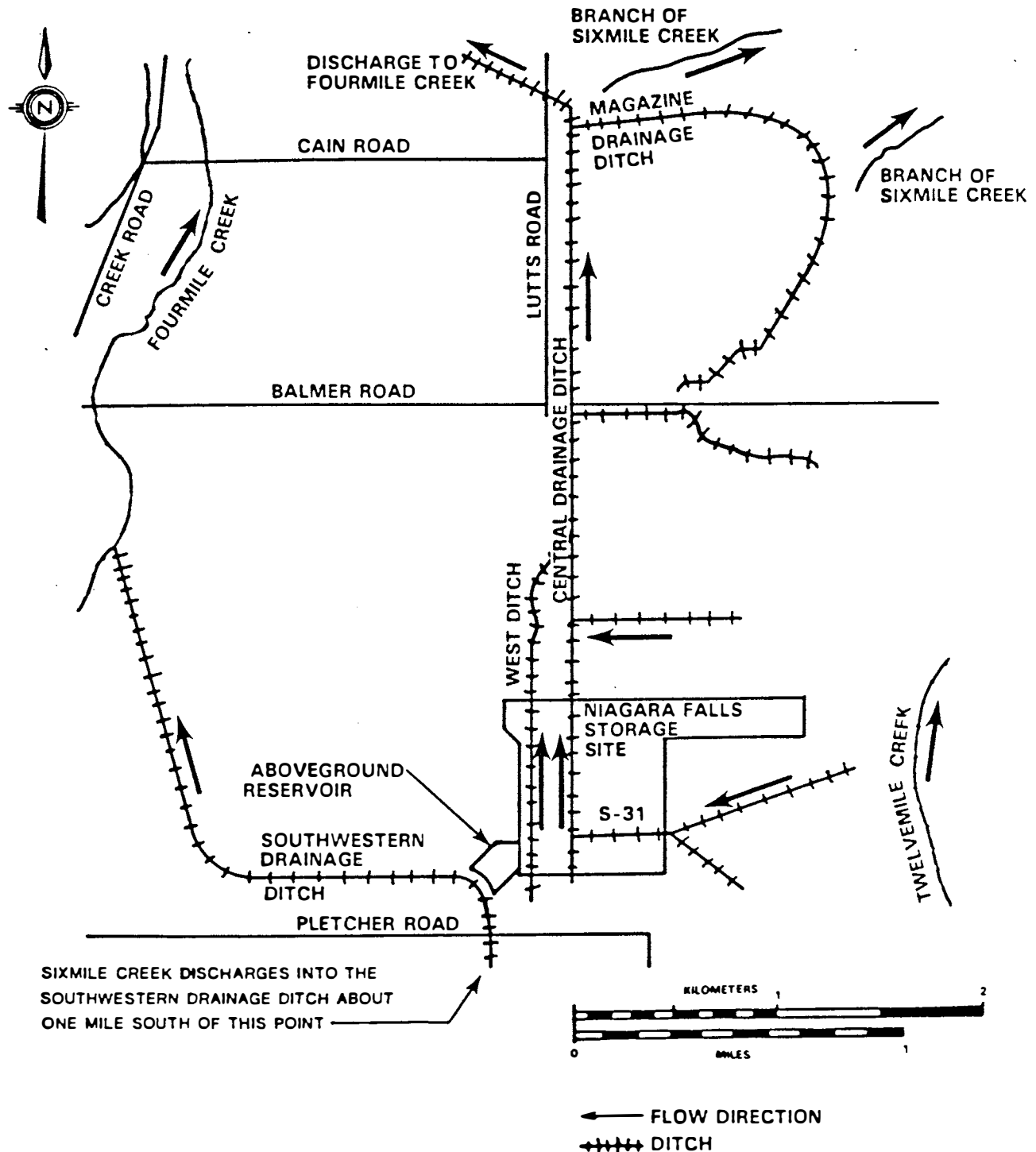


Figure 3.3. Surface Water Drainage at NFSS and in the Surrounding Areas. (Source: Bechtel National, Inc. (1984b) (originally modified from Acres American 1981).

In 1975, the entire length of Fourmile Creek was classified as "water quality limiting."* However, since that time, the Lewiston-Porter Central Schools have discontinued their discharge to the creek upon connection to the Town of Lewiston Sewage Treatment Plant; and the three remaining discharges (Bell Aerosystems, Whitnor Chemicals, and Fourmile Creek State Park) have upgraded their treatment to conform to New York State criteria governing intermittent streams (N.Y. State Dep. Environ. Conserv. 1975). DOE has a State Pollutant Discharge Elimination System (SPDES) permit (see Table 4.52) to discharge to the central drainage ditch, but upon completion of the interim remedial actions in 1985, no further discharges are anticipated. Currently, discharges from the SCA hazardous wastes landfill north of NFSS are piped to the Niagara River rather than the central ditch.

No nonradiological water quality information is available for the NFSS drainage ditches. Prior to the interim actions, central drainage ditch sediments had elevated concentrations of cobalt, nickel, copper, barium, lithium, fluorine, and cesium. West drainage ditch sediments had elevated concentrations of sodium, cobalt, and lithium (Anderson et al. 1981). Under the interim remedial actions, much of these contaminated sediments were removed from the ditches and placed within the diked containment area (Figure 1.2).

Approximately 90% of the population in Niagara and Erie counties is served by surface water supply systems. Surface water from Lake Erie serves 65% of the population and surface water from the upper Niagara River serves 25% of the population. Communities north of the Niagara Escarpment (and as far as 80 km [50 mi] from NFSS), including Lewiston and Porter townships, receive much of their water from Lake Erie and the Niagara River via the Niagara County Water District (Erie Niagara Co. Reg. Plan. Board 1978a).

Fourmile, Sixmile, and Twelvemile creeks are used primarily for boating and fishing (N.Y. State Dep. Environ. Conserv. 1975). At their confluence with Lake Ontario, both Fourmile and Twelvemile creeks are designated as recreational areas with public swimming sites (Erie Niagara Co. Reg. Plan. Board 1978a).

3.1.2.2 Groundwater

Within Niagara County, groundwater is present in both the surficial glacial deposits and the underlying bedrock. The three most significant water-bearing zones at NFSS are (1) the intermittent sand lenses found 3 to 6 m (10 to 12 ft) below ground surface (upper soil aquifer), (2) the brown gravelly sand-silt layer found 9 to 12 m (30 to 40 ft) below ground surface (lower soil aquifer), and (3) the weathered and fractured upper surface (about 3- to 4.5-m [9.9- to 15-ft] thick) of the Queenston Formation beginning about 15 m (50 ft) below ground surface (bedrock aquifer). None of these water-bearing zones are major aquifers.

Numerous extensive sand lenses or pockets were found during trench operations for construction of the dike and subsurface cutoff wall around the waste-containment area in the southwest corner of the site (Bechtel Natl. 1984a). Borings in the east dike area encountered 2-m (7-ft) thick lenses of sand, gravel, and cobbles. Isolated sand and gravel lenses 4.6-m (15-ft) thick were encountered in the north dike area. A sand and gravel deposit more than 7-m (20-ft) thick was encountered in the west dike area. These lenses are recharged by percolating water. No detailed information is available on the hydraulic conductivity or yield of these sand deposits. Depending on the surface moisture regime (rain, snowmelt, etc.), the moisture content of these sand lenses can vary from dry to saturated. Interconnection of the sand lenses has not been demonstrated.**

Shallow wells have been drilled to the surficial unconsolidated deposits near NFSS and, although water supplies are limited, the wells have yields sufficient for limited use (Johnston 1964). The zone that contains the sand lenses is referred to as the upper soil aquifer or upper aquifer. The average permeability of the brown sand aquifer (lower soil aquifer) is about 2×10^{-5} to 2×10^{-6} cm/s (Acres American 1981). The direction of groundwater flow in this aquifer is uncertain.

There is a network of underground pipes in the southern portion of the diked containment area. The location of known pipes is shown in Figure 3.4. During the interim remedial actions, these pipes were either removed or grouted to inhibit or prevent the potential migration of contaminated groundwater along these pipes.

The lower soil aquifer is generally continuous and confined*** by the less permeable overlying gray clay and underlying red till. This aquifer is recharged by leakage through the overlying

*"Water Quality Limiting" is defined as waters that do not meet state stream standards and would not be expected to meet standards even after application of "best practical treatment" required by the 1972 Federal Water Pollution Control Act. The classification of Fourmile Creek has apparently not been revised since 1975.

**Bechtel National, Inc., is monitoring some of the sand lenses surrounding the containment area to determine whether or not the suspected disconnection of the sand lenses exists.

***This aquifer has a piezometric surface that is above the surface elevation of the aquifer.

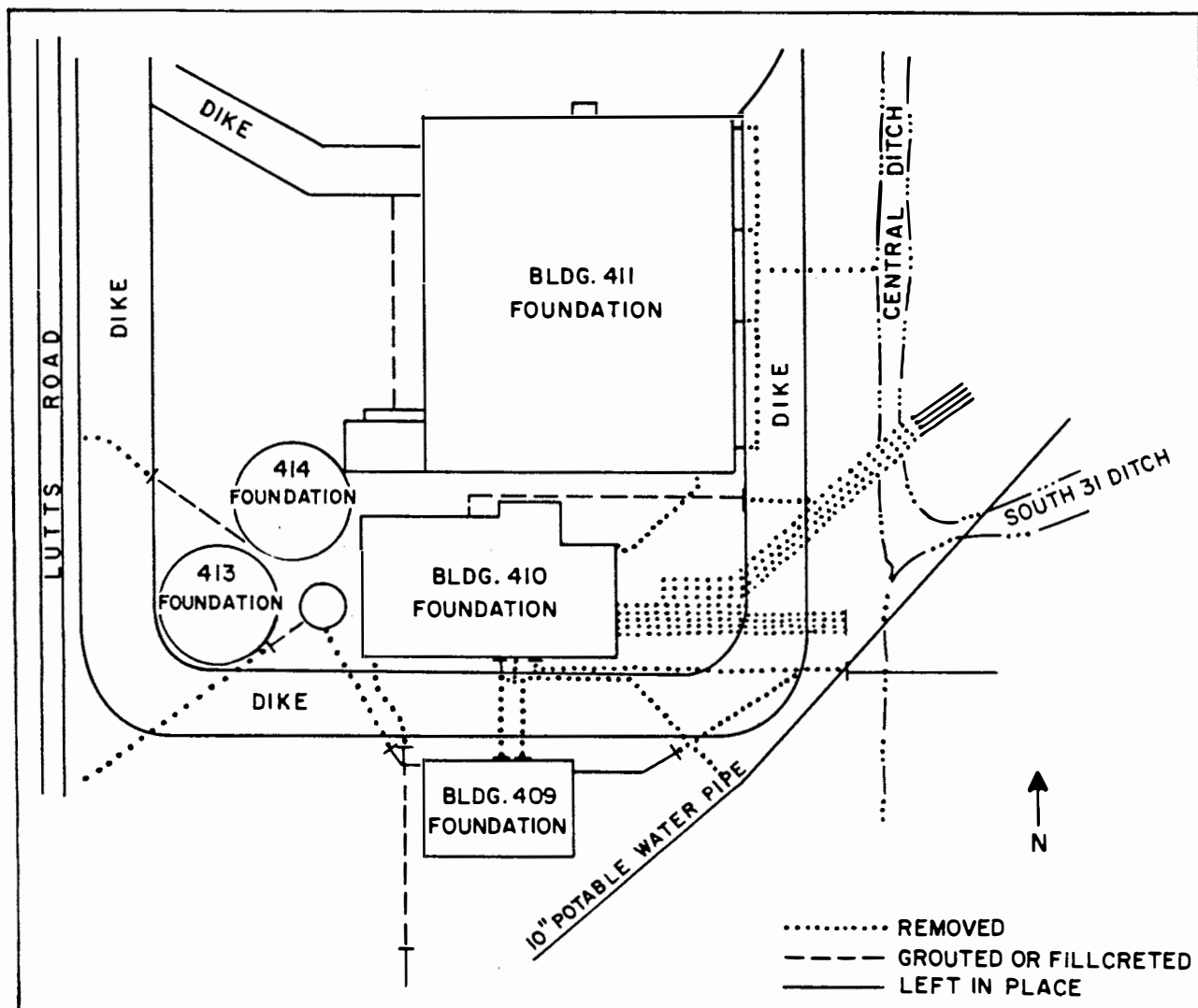


Figure 3.4. Location and Fate of Underground Pipes at NFSS. Adapted from drawing of Bechtel National, Inc. (Drawing No. 15-DD19-C-03).

unconsolidated deposits and by upward migration of water from the Queenston Formation. Water in this aquifer flows towards the northwest and discharges into Lake Ontario, the Niagara River, and local streams and drainage ditches. The average permeability in this aquifer is 1.3×10^{-3} cm/s (Wehran Eng. Corp. 1979), and the groundwater gradient across NFSS is 0.001 (Acres American 1981).

The major zone of groundwater movement is in the weathered and fractured zone (bedrock aquifer) in the upper portion of the Queenston Formation. Where the red till is absent, this aquifer is connected with the lower soil aquifer. At NFSS, the groundwater gradient of the bedrock aquifer is 0.001 (Acres American 1981). Well yields from this aquifer are typically less than $0.0004 \text{ m}^3/\text{s}$ (7 gpm). Well yields of less than $0.00006 \text{ m}^3/\text{s}$ (1 gpm) are estimated for the lower unweathered sections of the Queenston Formation (Johnston 1964).

The groundwater from all aquifers underlying NFSS is of low quality for drinking water (Acres American 1981). Groundwater from the Queenston aquifer is less alkaline than that from the upper aquifers. It is also more highly mineralized with higher concentrations of sulfate, chloride, calcium, sodium, iron, and magnesium (Johnston 1964). Trace concentrations of lead, barium, nickel, copper, chromium, cobalt, selenium, and zirconium have been detected in water samples collected by Battelle Columbus Laboratory from periphery wells on the west side of NFSS and from the waste containment area (Anderson et al. 1981). Details of water quality sampling performed in July 1981 can be found in a report by Acres American (1981). (Discussion of background groundwater quality relative to potential increases associated with burial of the NFSS wastes and residues is given in Section 4.4).

Groundwater is used to supply approximately 10% of the population of Niagara and Erie counties, primarily for small domestic and farm supplies in rural sections. Most of this water is obtained from the Lockport Dolomite aquifer, which is absent north of the Escarpment at NFSS. At NFSS, only very small supplies can be obtained from the Queenston shale (Johnston 1964; Erie Niagara Co. Reg. Plan. Board 1978b). Groundwater supplies at NFSS are generally of low yield and poor quality. Only the Middleport area (eastern Niagara County) is dependent on groundwater for municipal water (Erie Niagara Co. Reg. Plan. Board 1978b). The upper aquifers in the glacial deposits near NFSS are sometimes capable of supplying adequate groundwater for domestic uses, although these supplies may be depleted during dry seasons.

The results from monitoring several wells located around the containment area are presented in annual monitoring reports (U.S. Dep. Energy 1983c, 1983d, 1984).

3.1.3 Climate and Meteorology

Niagara County has a humid, continental climate that is moderated by Lakes Erie and Ontario. Average annual precipitation is 83 cm (33 in.), which is fairly evenly distributed throughout the year. Approximately 140 cm (56 in.) of snow falls, primarily between November and March (Acres American 1981). The wind is predominantly from the southwest.

3.1.4 Ecology

Western New York is considered to be within the distribution of the beech-maple forest association (VanKat 1979), but the nature of NFSS soils--i.e., deep, very poorly drained, and poorly aerated (Higgins et al. 1972)--suggests that, prior to agricultural development in the 1800s, the vegetation of the site was likely a red maple-white oak forest type adapted to these wet conditions (Braun 1972; Garrison et al. 1977). This is further supported by the predominance of maple, ash, and oak in the canopy of wooded areas of the site.

The native and agricultural ecosystems of NFSS were completely destroyed by U.S. Army construction activities during the early 1940s (Anderson et al. 1981). Since the mid-1940s, most of the site has been untended until recent interim remedial actions. As part of these cleanup activities, about two-thirds of the NFSS has now been cleared of vegetation. Prior to the interim remedial actions, two other terrestrial plant communities occurred at NFSS: a northern shrub community and a pasture-grass community (Anderson et al. 1981). It is likely that these communities were actually old-field communities in the later stages of old-field succession (Mellinger and McNaughton 1975).

The forest, shrub, and pasture grass communities provided habitat for a variety of wildlife. Although no quantitative wildlife surveys have been conducted on the site, mammals that have been observed on NFSS (Anderson et al. 1981) and that are common to Niagara County are typical of those encountered in forested and shrub-dominated areas. Surveys of bird populations on and in the vicinity of NFSS indicate that at least 60 species breed or are thought to breed in the area. No information concerning amphibians and reptiles of the NFSS is available, but it is expected that species characteristic of the forests and agricultural communities of the area (Shelford 1974) are present.

No species designated as threatened or endangered under state or federal law are known to occur in the immediate vicinity of NFSS. However, the site is located within the distribution of a number of species considered endangered under the federal Endangered Species Act (Pub. L. 93-205). Among these are the bald eagle, American peregrine falcon, and Indiana bat (U.S. Fish Wildl. Serv. 1980). The arctic falcon is thought to migrate through the state of New York but does not nest there. The local office of the U.S. Fish and Wildlife Service had no comments on the NFSS alternatives relative to endangered species (Hamilton 1983).

Aquatic biota are restricted to the drainageways that carry surface runoff from the site (Figure 3.3). The plant communities of the largest ditches (central ditch, west ditch, and South-31 ditch) were dominated by cattails and various marsh grasses (Anderson et al. 1981) prior to the excavation of radioactively contaminated sediments as part of interim remedial actions. Although the interim actions completely destroyed the cattail-marsh grass community, it is likely that this community will become reestablished in these drainageways within a few years.

Little is known of the biota of Fourmile Creek. It has been reported that the creek supports a limited spring migration for salmonids such as coho salmon and rainbow trout (Erie Niagara Co. Reg. Plan. Board 1978a). The creek also supports spawning populations of northern pike and a variety of panfish. Fourmile Creek is also regularly stocked with chinook salmon by the New York State Department of Environmental Conservation (1981).

3.1.5 Land Use

The NFSS is currently enclosed by a fence and is used only for storage of radioactive residues and wastes. Most of the site is zoned "I-2, Industrial, no houses permitted" with the exception of the northwest portion of the site which is zoned "I-1 Industrial, houses permitted".

Land uses immediately adjacent to the site are varied. A hazardous waste disposal facility operated by SCA Chemical Waste Services is located north and east of the site. A sanitary landfill operated by Modern Disposal, Inc., is adjacent to the east side of NFSS. South of the site is federal government property controlled by the General Services Administration, which is used for training construction equipment operators. There is also a sanitary landfill south of the site, which is owned by the town of Lewiston. West of the facility is a Niagara Mohawk Power Corporation transmission line corridor. Property west of the site is privately owned. All these properties are located on land that was once part of the original Manhattan Engineering District site (Figure 3.5).

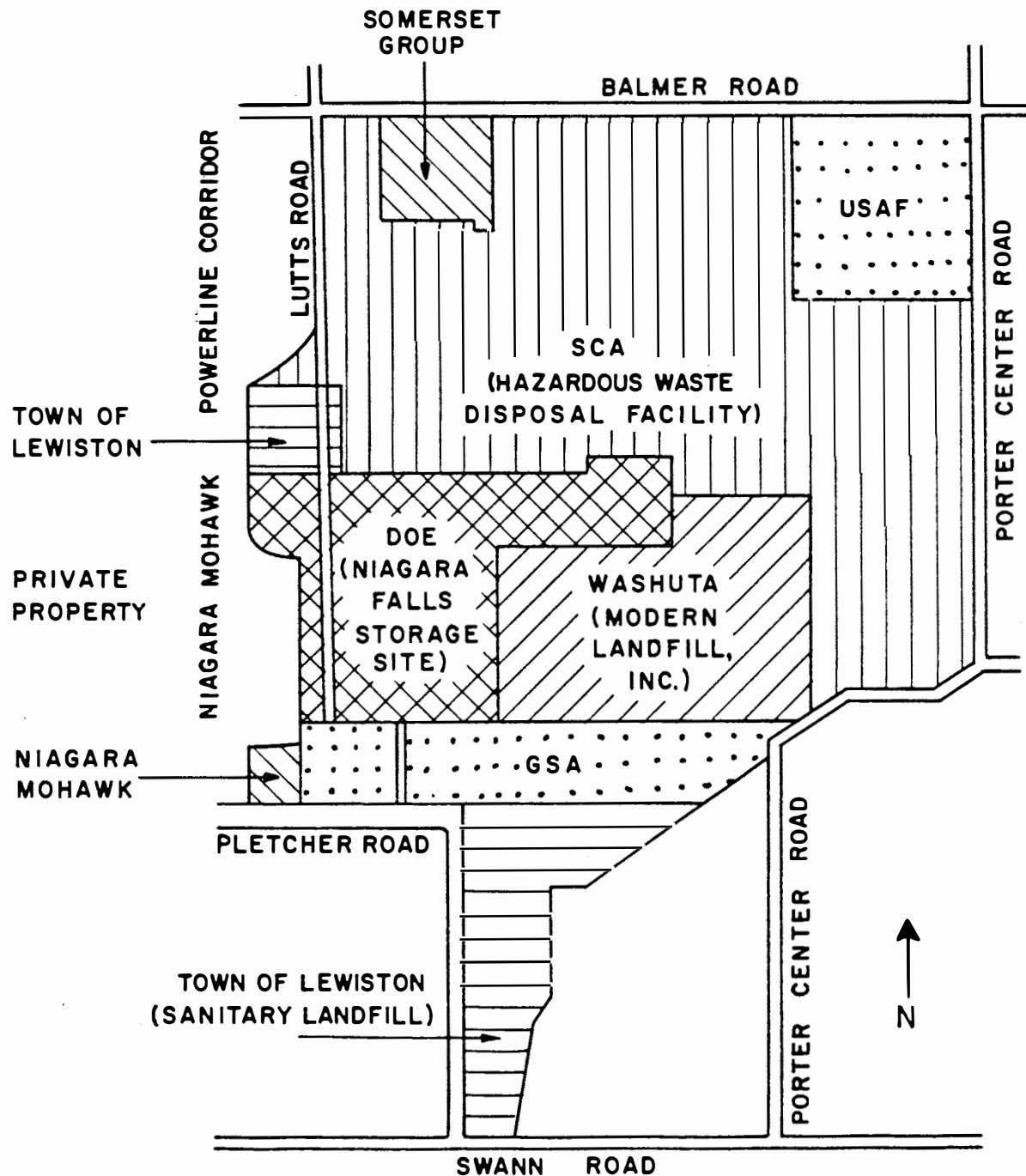


Figure 3.5. Current Ownership of the Original Manhattan Engineer District Site at the Lake Ontario Ordnance Works.

Relative to the waste containment area, the nearest permanent residence is 1.1 km (0.7 mi) southwest, there is a trailer park 2.6 km (1.6 mi) northwest on Balmer Road, the Lewiston-Porter Central Schools are located approximately 2.4 km (1.5 mi) west on Blairville/Creek Road, and SCA Chemical Waste Services personnel work outdoors 1.2 km (0.7 mi) to the north. During the summer, there are campers at the KOA campground 0.7 km (0.4 mi) southwest on Pletcher Road. Hunters occasionally use the area west of the Niagara Mohawk corridor. There are several residences along Pletcher and Creek roads.

Land uses within the towns (townships) of Lewiston and Porter are predominantly rural and include row-crop agriculture, orchards, recreational areas, old abandoned fields, and second-growth forests. Limited population growth in the area is projected, and the area is expected to remain rural through the year 2000 (Table 3.1). A recreational area, Fourmile Creek State Park, is located at the confluence of Fourmile Creek and Lake Ontario, about 3 km (2 mi) downstream from the central drainage ditch (Figure 3.2).

Table 3.1. Existing (1975) and Projected (2000) Land Uses for the Towns (Townships) of Lewiston and Porter and for Niagara County†¹

Location	Status of Land Use	Percent of Land Area						
		Residential	Commercial/Public/Semipublic	Industrial	Forest/Brush/Outdoor Recreation/Vacant	Agriculture	Water/Wetland	Transportation
Town of Lewiston (10,000 ha)	Existing	7.7	6.2	1.0	32	44	7.7	1.4
	Projected	8.0	6.5	1.0	32	43	7.7	1.4
Town of Porter (8,500 ha)	Existing	4.1	4.6	1.5	26	62	0.3	1.6
	Projected	4.2	4.8	1.5	26	62	0.4	1.6
Niagara County (140,000 ha)	Existing	6.4	2.1	1.7	20	65	3.5	0.9
	Projected	6.6	2.2	1.8	20	65	3.6	0.9

†¹ All values rounded to two significant figures.

Data from Interstate Commerce Commission (1981).

3.1.6 Population and Socioeconomics

3.1.6.1 Population

The primary areas of population near NFSS are the towns of Lewiston, Porter, Niagara, and Niagara Falls City--all in Niagara County. From 1970 to 1980, there was a small percent decline in population in Niagara County and the town of Porter, a small percent increase in the town of Lewiston (Mathiason 1981), and somewhat larger population changes in the town of Niagara (+15%) and in Niagara Falls City (-17%) (see Table 3.2). From the available data, it appears that Niagara County and its bordering counties (Erie, Genesee, and Orleans) have been experiencing similar patterns of population change since 1960 (U.S. Bur. Census 1977).

Almost three-quarters of the population of Niagara County live in urban areas. Population density in Niagara County in 1980 was about 170 persons/km² (430 persons/mi²) (U.S. Bur. Census 1982). The populations located within a 16-km (10-mi) and an 80-km (50-mi) radius of NFSS are estimated at 1,400,000 and 3,800,000, respectively, including populations of both the United States and Canada. The U.S. 1980 census data were supplied by Urban Decision Systems (1983). The Canadian population is based on population density data supplied by Statistics Canada Ottawa (1983).

3.1.6.2 Economy

The current economic situation in Niagara County and its municipalities is similar to that of nearby areas and the nation as a whole. Although the population of Niagara County declined 6.3% between 1959 and 1979, total employment declined only 0.9% over the same time period (Econ. Consult. Organ. 1982). This disparity reflects the national trend toward increased female labor force participation rates and a strengthening of the service and retail trades (N.Y. State Dep. Labor 1982).

Table 3.2. Population and Percent Population Change
in Niagara County and Selected Municipalities,
1970-1980

Location	1970	1980	Percent Change
Niagara County	236,000	227,000	-4
Town of Lewiston	15,900	16,200	+2
Town of Porter	7,430	7,250	-2
Town of Niagara	8,370	9,650	+15
Niagara Falls City	85,600	71,400	-17

Source: Mathiason (1981).

Niagara County experienced a slightly higher rate of unemployment in 1981 (9.9%) in comparison to the United States as a whole (7.6%) because a disproportionate number of industries in local areas were particularly hard hit by the recession (N.Y. State Dep. Labor 1982--p. 11-24). Although few data are available to quantify Niagara County's dependence on the tourist industry, nearby Niagara Falls (12 km [7.5 mi]) is an international tourist attraction and there are many tourist-related businesses in the area.

3.1.6.3 Public Facilities

There are 16 police and 29 fire stations scattered throughout Niagara County, most of which are full-time protection units. Six major hospitals are located within 26 km (16 mi) of the site, the closest of which is 8 km (5 mi) away. Additionally, there are 11 schools within 2.4 to 11 km (1.5 to 7 mi) of NFSS, with a combined school enrollment in 1982 of about 22,000 students (Brado 1982). The Lewiston-Porter Central Schools are closest to NFSS (within 2.4 km) and have a combined enrollment of just over 3000 students.

There are several parks and recreational areas near the site. Of the 10 parks in the area, 6 are state-owned, 1 is owned by Niagara County, and 3 are municipal parks. Historic sites located near NFSS include the Frontier House (6.4 km SW), Lewiston Mound (6.4 km SW), Lewiston Portage Landing (7.2 km SW), and Old Fort Niagara (7.2 km NW) (Erie Niagara Co. Reg. Plan. Board 1978a). Two primary attractions, the Our Lady of Fatima Shrine and the Lutz Century Farm, are located within 3.2 km (2 mi) of the site. None of these sites is located along the roads that will be used to transport the NFSS wastes and residues to other sites.

Major highway transportation routes near the site are State Route 93 to the north, U.S. Route 104 to the south, and the Robert Moses Parkway and State Route 18 (Blairville/Creek Road) to the west (Figures 1.1 and 3.2). The region is served by Consolidated Rail and the Norfolk & Southern Railroad (see Appendix D).

The 1981 traffic count data on an hourly and yearly basis along key sections of the transportation routes that could be used to transport NFSS wastes to other sites are listed in Table 3.3. The local route to the interstate highway system (Section 3.5.1) is in a semirural area. Several private residences are located along the route.

3.1.7 Radiological Characterization of NFSS Residues and Wastes

The radiological baseline for analysis of all alternatives in this EIS is the condition of NFSS that is projected to exist upon completion of the scheduled interim remedial actions in 1985 (U.S. Dep. Energy 1982a, 1982b, 1983a, 1983b). For purposes of analysis in this EIS, the contaminated materials at NFSS have been divided into two groups: (1) residues (from processing of uranium ores) and (2) wastes (mostly soils). Upon completion of interim actions, all residues and wastes will be consolidated within a 3.4-ha (8.5-acre) diked area in the southwest corner of NFSS (Figure 1.2). This area will contain about 190,000 m³ (250,000 yd³) of contaminated materials (Table 3.4) having an average radium-226 concentration of 3,800 pCi/g (Table 3.5). The area will be surrounded by a dike and subsurface clay cutoff wall and will be capped with 0.9 m (3 ft) of clay, 0.15 m (0.5 ft) of sand, and 0.45 m (1.5 ft) of soil. (The depths of the various materials and cover layers are presented in Figure 4.3.)

3.1.7.1 Residues

For purposes of analysis in this EIS, the residues consist of the K-65 residues, the combined L-30 and F-32 residues, and the L-50 residues for a total of 11,000 m³ (15,000 yd³) (Table 3.4). The

Table 3.3. 1981 Traffic Count Data Along Sections of Potential Local Transportation Routes

Route No. or Name	Section Length (km)	Section Description		Count Year	Estimated for Count Year ^{†1}	
		From	To		AADT	DH
Balmer Road ^{†2}	6.1	1800 ft west of Dickersonville Road	Rt. 18	1982	530	
18 ^{†3}	2.7	CR 86, Blairville Road	Pletcher Road	1981	3,400	210
18	1.2	Pletcher Road	CR 9, Swann Road	1978	3,300	200
18	2.8	CR 9, Swann Road	Rt. 104, Ridge Road	1981	3,550	260
104	1.1	Rt. 18	Acc. Rbt. Moses Pkwy, Rt. 18F	1979	4,800	310
104	0.5	Acc. Rbt. Moses Pkwy, Rt. 18F	Rt. 18	1979	9,700	710
104	1.2	Rt. 18	Rt. 265, Military Road	1979	14,200	1,040

^{†1} AADT = Annual Average Daily Traffic; DH = Design Hourly Volume (30th highest hourly traffic volume in one direction).

^{†2} Data from Wilson (1982).

^{†3} These and all remaining data from New York State Department of Transportation (1982).

residues formerly belonged to Afrimet-Indussa, an American firm incorporated in the state of New York and controlled by Union Miniere, a Belgian firm. As a result of a recent international agreement (Section 1), the residues now belong to the U.S. government and are the responsibility of DOE. Upon completion of interim actions, most of the residues (K-65 and combined L-30/F-32) will be stored in Building 411 within the diked area (Figure 1.2). The L-50 residues are stored in Buildings 413 and 414. The residues account for less than 6% of the total volume of contaminated materials at NFSS but contain 871 Ci of radium-226, or almost 99% of the NFSS radium-226 inventory. The average radium-226 concentration of these residues is 67,000 pCi/g (Table 3.5).

K-65 Residues. The K-65 residues (stored in the bottom of Building 411 as of completion of interim remedial actions in 1985) resulted from the processing of high-grade African pitchblende ore containing 40-50% uranium oxide (Anderson et al. 1981). Most of the uranium was removed, and the radium was precipitated as radium sulfate in the residues. Several metal hydroxides (iron, aluminum, manganese) and other impurities such as precious metals (Anderson et al. 1981) were also precipitated. Some precious metals (e.g., gold, platinum, palladium, silver) were extracted from some shipments of the ore prior to processing for uranium.

The K-65 residues exist as a wet clay containing about 30% water. Two distinct types of materials are present within the residues: 73% is characterized as "slimes" (particle size <37 μ m) containing recrystallized compounds including radium-contaminated barium sulfate (Table 3.6), and the remainder is sand (particle size >37 μ m). Most of the radium (average radium-226 concentration of 220,000 pCi/g) is found in the "slimes" fraction. Based on a gamma-ray spectral analysis of the K-65 residues (Anderson et al. 1981), it appears that lead-214, bismuth-214, and lead-210 are in secular equilibrium (see Glossary) with the parent radionuclide, radium-226. No information is available regarding the thorium-230 (parent radionuclide of radium-226) content of the residues, and it is thus assumed that the radium-226 and thorium-230 were in secular equilibrium in the pitchblende ore and that only the uranium was removed during processing. Therefore, because of thorium-230 decay, the radium-226 concentrations will remain approximately the same throughout the 1000-year period during which impacts are analyzed in this EIS (Section 4). Anderson et al. (1981) estimated the uranium-238 concentrations in these residues to be between 470 to 650 pCi/g (140 to 1965 ppm). The residues contain small amounts of other radionuclides resulting from decay of the small amount of uranium-235 (Anderson et al. 1981).

L-30 Residues. The L-30 residues (stored in Building 411 as of completion of interim remedial actions in 1985) resulted from the extraction of uranium from low-grade pitchblende containing about 10% uranium oxide. Based on a gamma-ray spectral analysis of the L-30 residues, it appears that uranium-238 concentrations vary greatly, ranging from 280 to 1660 pCi/g (830 to 5000 ppm) (Anderson et al. 1981). The average radium-226 concentration is about 12,000 pCi/g (Table 3.5), and it appears that the daughters of radium-226 are in equilibrium with the parent radionuclide.

Table 3.4. Estimated Volumes of Contaminated Materials at NFSS
as of Completion of Interim Remedial Actions in 1985

I. Residues			II. Wastes					
Description	Volume† ¹		A. Contaminated Soils, R-10 Residues, etc.			B. Contaminated Portions of Containment System		
	m ³	yd ³	Description	m ³	yd ³	Description	m ³	yd ³
K-65	3,000	4,000	R-10 area, 1972 cleanup above ground† ²	11,500	15,000	413/414 covers (over L-50 residues)	750	1,000
L-30/F-32† ³	6,500	8,500	R-10 area, 1980, below ground† ⁴	26,500	35,000	1/5 N dike† ⁶	3,000	4,000
L-50	1,500	2,000	N dike area, 1982 add'l† ⁵	12,000	15,500	1/5 S dike† ⁶	750	1,000
			N dike area, 1983-1985 add'l† ⁷	30,500	40,000	S dike backfill† ⁸	7,000	9,000
			Bldg. 411 covert† ⁷	9,000	11,500	1/5 interim cap over N + S diked areas† ¹⁰	10,500	14,000
			N + S dike area (remaining bottom)† ⁹	10,000	13,000			
			S dike area buildings and rubble	9,000	11,500			
			S dike area, add'l from other vicinity properties† ⁸	14,000	18,000			
Subtotal	11,000	14,500		122,500	159,500		22,000	29,000
20% Contingency	NA	NA		24,500	32,000		4,500	6,000
			Middlesex sands (residues)	Neglig.	Neglig.			
			R-10 residues	7,000	9,500			
TOTAL	11,000	14,500		154,000	201,000		26,500	35,000

GRAND TOTAL†¹ = 190,000 m³ (250,000 yd³)

- †¹ Rounded to nearest 500 m³ (500 yd³); grand total rounded to two significant figures. During the interim remedial actions, the volumes of residues were found to be less than the estimates used in the analyses in this EIS.
- †² About 11,500 m³ (15,000 yd³) of contaminated soils were placed in the R-10 area during a 1972 remedial action. Analysis of the data for core samples taken in 1980 (Anderson et al. 1981) generally confirms this amount. Based on the Anderson data and an engineering drawing of the R-10 area prior to commencement of interim remedial actions in 1982, there were about 18,500 m³ (24,000 yd³) of contaminated soils and residues (with radium-226 concentrations greater than 15 pCi/g) above the original grade in the R-10 area (covering about 1.6 hectares or 4 acres). Subtracting the 7,000 m³ (9,500 yd³) of R-10 residues, there were about 11,000 m³ (14,500 yd³) of contaminated soils above ground.
- †³ The L-30 and F-32 residues have been combined during the interim remedial actions.
- †⁴ Based on the core samples taken in 1980 (Anderson et al. 1981) and the abovementioned drawing, there was an estimated 26,500 m³ (35,000 yd³) of contaminated soils (greater than 15 pCi/g radium-226) below the original grade. It was conservatively assumed that the 15 pCi/g contaminated contour approached the shape of an upside-down wedding cake. The greatest depth of contamination was 3.75 m (12.5 ft). For alternatives involving removal of NFSS wastes, it is also assumed that after excavation of these contaminated soils, the area would be backfilled with clean soil materials such that the top 15 cm (6 in.) would not exceed radium concentrations of 5.0 pCi/g.
- †⁵ It is assumed that the portion with radium-226 concentrations between 5 and 15 pCi/g could not be practicably separated from the portion with concentrations greater than 15 pCi/g.
- †⁶ It is assumed that it would be practicable to selectively remove about 0.6 m (2 ft) of clay material from the insides of the dikes as contaminated material for shipment offsite. It is also assumed that any decision to remove such materials would be within the next few years such that radionuclides from contaminated materials stored within the diked areas would not have had sufficient time to migrate through the clay dikes more than 0.6 m (2 ft).
- †⁷ Of the estimated 39,400 m³ (51,500 yd³) of contaminated materials to be cleaned up both onsite and offsite during the 1983-1985 interim remedial actions, about 30,600 m³ (40,000 yd³) would be placed in the north dike area and 8,800 m³ (11,500 yd³) would be placed over the dewatered residues in Bldg. 411.
- †⁸ There are several properties in the vicinity of NFSS that were recently surveyed to determine if contaminated materials occur in sufficient concentrations to necessitate removal of these materials and placement within the diked areas at NFSS. Such cleanup will be part of the ongoing interim remedial actions, the completion of which is assumed to be the base case under the no-action alternative for this EIS. In addition to the space occupied by the buildings, rubble, and residues within the south diked area, there is an additional volume of 20,600 m³ (27,000 yd³) that could be filled with any materials from these vicinity properties, supplemented with uncontaminated (clean) fill material, as necessary, to provide a base for the interim cap over the entire diked area. Estimates for respective amounts of contaminated and clean fill materials will not be available until radiological survey reports have been finalized, the need for interim remedial action established, and preliminary engineering studies made. For purposes of analysis in this EIS, it is therefore assumed that 13,800 m³ (18,000 yd³) will be slightly contaminated vicinity-property materials and 6,900 m³ (9,000 yd³) will be clean fill and that all of this material would have to be treated as contaminated for removal under the offsite alternatives.
- †⁹ 3.4 hectares minus 1.6 hectares (1980 R-10 pile area) minus 0.2 hectares (dikes) = 1.6 hectares. 1.6 hectares × 0.6-meter deep (assumed average depth of contamination) = 10,000 m³ [8.5 acres minus 4 acres (1980 R-10 pile area) minus 0.5 acre (dikes) = 4 acres. 4 acres × 2-feet deep (assumed average depth of contamination) = 13,000 yd³].
- †¹⁰ 3.4 hectares × 0.3 m (assume top 1.2 meters can be removed as uncontaminated materials) = 10,500 m³ [8.5 acres × 1 foot (assume top 4 feet can be removed as uncontaminated materials) = 14,000 yd³].

Table 3.5. Estimated Radium-226 Inventory in Contaminated Materials at NFSS as of Completion of Interim Remedial Actions in 1985

Description	Volume† ¹ (m ³)	Density		Average Conc. (dry wt.)† ⁴ of Ra-226 (pCi/g)	Ra-226 Inventory (Ci)
		Dry† ² (kg/m ³)	Damp† ³ (kg/m ³)		
<u>Residues</u>					
K-65 residues	3,000	1,150† ⁵	1,800	220,000† ⁶	775† ⁷
L-30 residues† ⁸	6,000	1,240† ⁵	1,800	12,000† ⁶	90† ⁷
F-32 residues† ⁸	500	1,180† ⁵	1,800	300† ⁶	0.1† ⁷
L-50 residues	<u>1,500</u>	1,050† ⁵	1,800	<u>3,300†⁶</u>	<u>6†⁷</u>
SUBTOTAL	11,000	--	--	67,000	871
<u>Wastes†⁹</u>					
R-10 area 1980, incl. R-10 residues	45,000	1,200† ¹⁰	1,800	95† ⁶	5.2† ¹¹
Remaining contaminated soils, etc.	83,500	1,200† ¹⁰	1,800		
Contaminated portions of containment system	22,000	1,200† ¹⁰	1,800	16† ¹²	2.6† ¹²
20% contingency on non- residue materials	<u>29,000</u>	1,200† ¹⁰	1,800		
SUBTOTAL	179,000	--	--	36	7.8
GRAND TOTAL	190,000	--	--	3,800	879
		<u>% of Total Volume</u>	<u>% of Total Ra-226 Inventory</u>		
K-65 residues		1.5		88	
L-30/F-32 residues		3.4		10	
L-50		<u>0.8</u>		<u>0.7</u>	
TOTAL		5.8		99	

†¹ Rounded to nearest 500 m³. Grand totals rounded to two significant figures. During the interim remedial actions, the volumes of residues were found to be less than the estimates used in the analyses in this EIS.

†² Based on volumes and dry weights reported in Anderson et al. (1981). Approximately equal to density of dry clay as reported in Peele and Church (1941). The NFSS residues are expected to be similar to clays as they are composed primarily of particles smaller than 37 µm (Litz 1974).

†³ Considering the particle-size distribution for the residues (Litz 1974) and the nature of the contaminated soils that comprise most of the wastes, it is expected that the damp residues and wastes will both have densities similar to wet clay (Peele and Church 1941) upon completion of interim remedial actions.

†⁴ Damp weight concentrations (condition of residues and wastes as stored in the dikes area at NFSS upon completion of remedial actions) will be less. To obtain damp weight concentrations, multiply dry weight concentrations by a factor of 1.2 ÷ 1.8, or 0.67.

†⁵ Densities based on weights and volumes as reported in Table 3-1 of Anderson et al. (1981). Assumed to be dry weights since the calculated densities roughly correspond to the density of dry clay (1200 kg/m³) as reported in Peele and Church (1941).

†⁶ Geometric mean of data given in Anderson et al. (1981).

†⁷ Estimated inventory based on dry weights times estimated average concentrations as reported in Anderson et al. (1981).

†⁸ The L-30 and F-32 residues have been combined during the interim remedial actions.

†⁹ Volumes of wastes taken from Table 3.4.

†¹⁰ Assumed density of dry clays (Peele and Church 1941); about the same as dry densities of residues.

†¹¹ Estimated inventory based on average concentration (dry weight) × volume × dry density.

†¹² No data available. Because most of the soil materials cleaned up during the 1982-1985 remedial actions were contaminated as a result of erosion of the original R-10 residues, it is assumed that the total radium-226 inventory of these materials is no greater than half of the 1980 R-10 pile inventory, or about 2.6 Ci. The average concentration of the 134,500 m³ is therefore 16 pCi/g.

Table 3.6. Physical Characteristics of NFSS Residues and Wastes

	Volume (m ³)	Percent of Particle Size (μm)† ¹						
		>840	840-240	240-150	150-74	74-44	44-37	<37
<u>I. Residues</u>								
K-65	3,000	4.1	9.5	1.8	5.2	4.0	2.3	73.1
L-30/F-32	6,500	17.1	7.0	1.9	5.4	3.8	5	59.7
L-50	1,500	17.1	7.0	1.9	5.4	3.8	5	59.7

	Volume (m ³)	Percent of Particle Size (μm)† ²						
		>20 (sands)	20-2 (silts)	<2 (clays)				
<u>II. Wastes</u>								
Primarily soils	180,000	37	26	37				

†¹ Data from Litz (1974).

†² Assumed particle-size distribution based on characterization of NFSS contaminated wastes as primarily clayey soils.

F-32 Residues. The relatively small amount of F-32 residues (combined with the L-30 residues in Building 411 as part of the interim remedial actions) also resulted from the extraction of uranium from African pitchblende ore. Although no spectrographic analysis appears to have been carried out for these residues, inventory data suggest that the uranium-238 concentration is 1300-2200 pCi/g (4000-6500 ppm) and the radium-226 concentration is about 300 pCi/g (Anderson et al. 1981).

L-50 Residues. The L-50 residues (stored in Buildings 413 and 414) are the by-product of treatment of African pitchblende ores containing approximately 7% uranium oxide. Uranium-238 concentrations range from 330 to 700 pCi/g, and the radium-226 concentration is about 3300 pCi/g (Anderson et al. 1981).

3.1.7.2 Wastes

For purposes of analysis in this EIS, the "wastes" consist of all contaminated materials not defined as residues. The wastes total about 180,000 m³ and have an average radium-226 concentration of 36 pCi/g (Table 3.5). The wastes consist of two groups of materials: (1) the R-10 pile in 1980 and (2) the remaining wastes and contaminated portions of the containment system.

R-10 Pile in 1980. In 1980, the R-10 pile consisted of one large continuous pile of contaminated soils and what had originally been the U.S. government-owned R-10 residues. The R-10 residues resulted from the processing of a pitchblende ore containing about 3.5% uranium oxide. In 1946, about 7,000 m³ of these residues were placed on the ground north of Building 411. The wind and rain gradually eroded these residues into the ditches and other portions of the site. Radionuclides were also leached into the ground underneath the pile. In 1972, some of the nearby soils contaminated by wind and water erosion from the pile were cleaned up and placed on top of the pile. Based on reanalysis of survey data obtained by Anderson et al. (1981), the R-10 pile in 1980 (above and below ground) contained approximately 45,000 m³ of contaminated materials having radium-226 concentrations greater than 15 pCi/g (11,500 m³ from 1972 cleanup, 26,500 m³ below ground, and 7,000 m³ of the original residues). The average uranium-238 concentration in 1980 was 1.7 pCi/g and the average radium-226 concentration was 95 pCi/g (Table 3.5).

Remaining Wastes and Contaminated Portions of Containment System. Since 1980, contaminated soils and sediments have been added to the diked area around the R-10 pile. These wastes resulted from cleanup of onsite and offsite areas under the interim remedial actions. Portions of the containment system (dikes, cover, underlying soils) will be contaminated as a result of being in contact with the contaminated wastes (Tables 3.4 and 3.5). In addition, experience thus far during the interim remedial actions indicates that additional soils and cover materials (20% contingency) will probably have to be treated as contaminated under alternatives involving removal of the wastes to another location. The total amount of remaining wastes and contaminated portions of the containment system is therefore estimated to be 134,000 m³.

Because most of the remaining wastes and contaminated portions of the containment system were contaminated as a result of erosion and leaching from the R-10 pile, it is assumed that the total

radium-226 inventory of these materials is no greater than half the inventory in the 1980 R-10 pile, or about 2.6 Ci. The average radium-226 concentration of these materials is therefore about 16 pCi/g (Table 3.5).

3.1.8 Nonradiological Characteristics of NFSS Residues and Wastes

3.1.8.1 Residues

Concentrations of nonradiological elements in the residues are given in Table 3.7. The K-65 residues have much less cobalt, nickel, and copper and more rare earths, palladium, molybdenum, and lead than do the other residues. The L-30 residues have more uranium. All the residues have a small amount of gold, platinum, and the other noble metals. It should be noted that broad ranges of concentrations have been reported for lead and uranium in the K-65 residues and for uranium, iron, copper, and nickel in the L-30 residues. These differences are thought to result from the heterogeneity of the residues rather than from uncertainties in experimental sampling techniques.

3.1.8.2 Wastes

The NFSS wastes are neutral to slightly basic. The elemental composition of portions of the 180,000 m³ of wastes is given in Table 3.8. The range of concentrations represent samples from different locations. Weighted average concentrations for the entire 180,000 m³ are also shown in Table 3.8. Because most of the wastes are contaminated native soils, the ranges of concentrations occurring in uncontaminated soils (worldwide) are also given for comparison.

In 1980, one or more locations in the R-10 pile had concentrations of cobalt, nickel, copper, lead, and uranium that appear to be in excess of naturally occurring concentrations. In the central ditch sediments, fluorine, cobalt, nickel, barium, and uranium appear to be in excess of natural concentrations (Table 3.8).

There are also organic chemicals in the NFSS wastes. During the interim remedial actions, the central ditch north of NFSS was excavated and radioactively contaminated sediments were placed in the diked containment area at NFSS. Some of the ditch sediments were contaminated with organic pesticides and other organic compounds (Haywood 1983; Urbanczyk 1983). Characterization of the organic contamination is limited because only nine samples were analyzed and, for some of the samples, the analyses were not sensitive (high upper limits were reported). For analysis in this EIS, it is assumed that these organically contaminated wastes comprise 2% of the total NFSS wastes.* Estimated concentrations of organic chemicals are presented in Table 3.9.

3.2 HANFORD

The Hanford Reservation** is a large, federally owned site of approximately 1500 km² (570 mi²) operated by DOE. It has not been open to the general public since 1943. Except for a few hectares occupied by energy facilities, the Hanford Reservation has been designated as a National Environmental Research Park (U.S. Nucl. Reg. Comm. 1981) and is available for environmental research that is compatible with DOE activities at Hanford.

The Hanford Reservation is divided into five major subareas: (1) the 100 Area, which borders on the Columbia River in the northern section of the Reservation and is the area where plutonium production reactors were constructed, (2) the 200 Area, which is located in the central area of the Reservation and is the area where the nuclear fuel, waste processing, and waste storage facilities are located, (3) the 300 Area, which is located near the town of Richland and is the area where the research and development laboratories and the Fuel Fabrication Facility are located, (4) the 400 Area, which is located north of the 300 area and is the site of the Fast Flux Test Reactor, and (5) other areas that are not designated under the 100, 200, 300, or 400 areas and are considered to be part of the 600 area (U.S. Energy Res. Dev. Admin. 1975). The northwest corner of the 200-West area (designated as the 218W5 area) is the alternative site used for purposes of analysis in this EIS.*** A map of

*This amounts to 3600 m³, which is a conservatively high estimate based on the amount of material excavated from the ditches.

**The name of the "Hanford Reservation" has recently been changed to the "Hanford Site." However, the older, more familiar name is used throughout this EIS to distinguish the large Reservation from the small specific site within the Reservation that is assumed for disposal of the NFSS wastes and residues.

***Analysis of alternative sites within the DOE Hanford Reservation is beyond the scope of this EIS (Appendix G). The DOE Richland Operations Office has identified the 218W5 area as being a site that is reasonable to assume for purposes of analysis and comparison of alternatives in this EIS. It is an extension of a large area that is being used for disposal of wastes generated on the Hanford Reservation, and it is potentially available for management of the NFSS wastes and residues. Site-specific information is available for this site.

Table 3.7. Concentrations of Nonradiological Elements in the NFSS Residues†¹,†²

Element	Concentration (ppm)						Weighted Average† ⁴
	K-65		L-30† ³		L-50		
	Average	Range	Average	Range	Average	Range	
Arsenic	5	--	27	15-50	31	20-50	2
Barium	30,000	--	6,100	1,900-20,000	20,000	--	15,000
Boron	300	--	140	100-200	100	--	172
Cadmium	<5	--	<1	--	<1	--	2.1
Cerium	2,000	--	1,200	1,000-1,500	240	200-300	1,200
Cesium	1	--	1.4	1-2	0.71	0.5-1	1.2
Chromium	100	--	244	200-300	140	100-200	180
Cobalt	2,000	--	5,100	2,600-10,000	7,700	5,900-10,000	4,700
Copper	500	--	2,300	1,100-5,000	2,400	2,000-3,000	1,800
Fluorine	30	--	39	30-50	50	--	37
Gold	0.2	--	0.37	<0.2-0.7	<0.2	--	0.28
Iodine	1	--	0.35	0.3-1	0.55	0.3-1	0.68
Iron	5,000	--	26,000	10,000-66,000	20,000	--	19,000
Lanthanum	2,000	--	1,000	--	220	100-500	1,100
Lead	56,000	33,000-95,000	13,000	7,500-23,500	4,900	3,200-7,600	23,000
Lithium	100	--	200	--	200	--	170
Manganese	100	--	31,000	20,000-50,000	71,000	50,000-100,000	30,000
Molybdenum	10,000	--	860	500-1,500	300	--	3,300
Mercury	0.5	--	0.3	--	0.5	--	0.5
Neodymium	1,000	--	160	50-500	100	--	390
Nickel	3,000	--	17,000	6,200-50,000	24,000	20,000-30,000	14,000
Niobium	50	--	24	20-30	14	10-20	30
Palladium	20	--	3.5	2-6.2	2.4	2-3	8
Platinum	<0.5	--	0.32	0.2-<0.5	<0.5	--	0.41
Praesodymium	2,000	--	55	20-150	24	20-30	590
Selenium	100	--	50	--	39	30-50	62
Silver	<3	--	1	<0.5-<2	<0.5	--	1.4
Strontium	500	--	240	200-300	240	200-300	310
Tellurium	20	--	24	20-30	39	30-50	26
Thorium	5	--	2.4	2-3	1.4	1-2	4.8
Uranium	3,800	500-30,000	5,000	830-30,000	790	300-2,100	3,900
Vanadium	2,000	--	2,400	2,000-3,000	2,400	2,000-3,000	1,500
Yttrium	30	--	39	30-50	30	--	35
Zinc	100	--	77	30-200	200	--	100
Zirconium	300	--	100	--	71	50-100	140

†¹ Adapted from Anderson et al. (1981--Appendix F and Tables 3-2, 3-3, and 3-4) and Litz (1974).

†² For many elements, two or more analyses were performed. The lack of range for an entry indicates agreement among the analyses or that only one analysis was completed. Averages are geometric means of the high and low values in the range or are the single number reported.

†³ The small amount of F-32 residues have been combined with the L-30 residues during the ongoing interim remedial actions, but the resulting concentrations of elements in the combined residues will be almost the same as in the L-30 residues.

†⁴ Weighted averages based on: K-65, 28%; L-30, 55%; L-50, 18%.

Table 3.8. Concentrations of Nonradiological Elements in the NFSS Wastes

Element	Concentration (ppm)							Natural Soil† ³ (Worldwide)
	R-10 Pile in 1980† ¹		New Naval Waste Area† ¹		Onsite Central Ditch Sediments† ¹		Weighted Average† ²	
	Average	Range	Average	Range	Average	Range		
Arsenic	1.6	0.5-5	1.2	0.5-3	1.2	0.5-3	1.4	0.1-40
Barium	230	100-500	100	20-500	500	50-5000	280	100-3000
Cadmium	0.3	--	0.2	--	0.2	--	0.26	--
Cerium	22	5-100	5.5	1-30	14.1	2-100	17.7	3-170
Chromium	24	20-30	16	5-50	45	10-200	28	5-1500
Cobalt	100	5-2000	7.7	2-30	55	10-300	75	0.05-65
Copper	141	20-1000	24	3-200	45	10-200	99	2-250
Fluorine	17	3-100	20	10-50	141	10-2000	48	20-700
Iron	14,000	10,000-20,000	31,000	10,000-100,000	22,000	10,000-50,000	19,000	2000-550,000
Lanthanum	14	2-100	4.5	1-20	7.1	1-50	11	2-180
Lead	51	4-650	17	<0.4-740	4.5	<0.4-51	34	2-300
Lithium	244	200-300	63	20-200	95	30-300	180	3-350
Manganese	450	200-1000	450	200-1000	450	100-2000	450	20-10,000
Mercury	0.3	--	0.4	--	0.3	--	0.3	0.1-40
Nickel	240	20-3000	16	5-50	100	10-1000	170	2-750
Selenium	0.77	<0.3-<2	0.55	<0.3-<1	0.55	<0.3-<1	0.68	--
Silver	0.23	--	0.14	--	0.14	--	0.19	--
Strontium	100	50-200	77	30-200	122	30-500	100	4-2000
Uranium	14	1-200	5.5	0.1-300	14	1-200	13	0.7-9
Vanadium	95	30-300	22	10-50	141	30-100	96	3-500
Zinc	4.4	2-10	10	1-100	4.4	1-20	5.2	1-900
Zirconium	100	10-1000	17	3-100	12	5-30	66	60-2000

†¹ Adapted from Anderson et al. (1981--Section 6, Appendix A, and Appendix I). Ranges as reported in Anderson et al. (1981). Averages are geometric means of the high and low values in the range or are the single number reported.

†² Because these are the only wastes for which comparable elemental data are available, a weighted average for the total 180,000 m³ of wastes was obtained by weighting the concentrations as follows: R-10 Pile, 60%; New Naval Waste Area, 15%; and Onsite Ditch Sediments, 25%.

†³ Adapted from Bowen (1979). Data from heavily polluted soils, soils near ore bodies, and serpentine soils have been excluded.

Table 3.9. Concentrations of Various Organic Chemicals in the NFSS Wastes

Chemical	Estimated Average Concentration in NFSS Wastes ^{†1,†2} (ppb)
PCBs	<26
Lindane, etc. ^{†3}	<10
Toxaphene	<13
Heptachlor	<10
Chlordane	<10
Dieldrin	<10
Phenol	<10
Benzo(a)pyrene	<10

†¹ Values given are the larger of 2% of the average concentrations for the nine samples reported in Haywood (1983) and Urbanczyk (1983)--assuming organically contaminated wastes comprise 2% of the total NFSS wastes--or 10 ppb (which was the detection limit in the cited studies).

†² The symbol < indicates that some of the sample concentrations were reported as upper limits.

†³ Includes several isomers of benzene hexachloride.

the Hanford Reservation showing the location of the various areas, including the potential NFSS waste management area, is shown in Figure 3.6.

3.2.1 Topography, Geology, Soils, Seismology, and Mineral Resources

The Hanford Reservation is located on the Columbia River alluvial plain within the central part of the Pasco Basin in the Columbia Basin geologic province. The Reservation is bounded to the west and north by large ridges (Saddle Mountain and Rattlesnake Hills); to the east by the Columbia River; and to the southeast by the confluence of the Yakima and Columbia rivers (U.S. Energy Res. Dev. Admin. 1975; Brown and Isaacson 1977). The 200-West Area is located near the west central portion of the Reservation on an ancestral Columbia River bar. Elevations in this area range from 200 to 220 m (650 to 715 ft) above mean sea level.

Most of the Reservation is underlain by coarse-grained sediments deposited by several glacial floods. Because of the continuously semiarid climate in this region for nearly 12,000 years, these surficial sediments have been only slightly weathered. Sediments at or near the ground surface range from coarse boulder and cobble gravel in the extreme northern section of the Reservation to coarse sand in the southern section. As a result of the semiarid to arid environment, the entire Reservation has been blanketed by as much as 15 m (50 ft) of windblown deposits ranging from very fine sands and silts to coarse sands. Numerous live dunes and relict dune features also exist within the Reservation. On the west side of the 200-West Area, adjacent to the Yakima and Rattlesnake hills, the sediments grade into silts and fine sands (U.S. Energy Res. Dev. Admin. 1975).

The Columbia River Plateau Physiographic Province was formed by a 3,700-m (12,000-ft) thick sequence of basaltic lava flows. Deformation of the accumulated lava created the Pasco Basin (U.S. Energy Res. Dev. Admin. 1975; Brown and Isaacson 1977). The major stratigraphic units underlying the Hanford Reservation in order of decreasing depth are (Figure 3.7): (1) the Columbia River Basalts, which exist to depths of greater than 3200 m (10,400 ft), (2) the Ringold Formation, consisting of semiconsolidated sediments that were transported and deposited by the ancestral Columbia River and accumulated to depths of 400 m (1300 ft), (3) unconsolidated sands, silts, and gravels, and buried former river channels of the Hanford Formation that were carried into the area by glacial floodwaters, and (4) windblown silt (loess), in part weathered to clay, and fine sand that overlies part of the eroded surface of the Ringold Formation (U.S. Energy Res. Dev. Admin. 1975; Brown and Isaacson 1977). The major stratigraphic units in the unsaturated zone (above the water table) underlying the 200-West Area are (1) windblown silt, (2) the Hanford Formation, and (3) the upper portion of the Ringold Formation (Figure 3.8). The thickness of the unsaturated sediments ranges from 55 to 81 m (180 to 265 ft) beneath the 200-West Area.

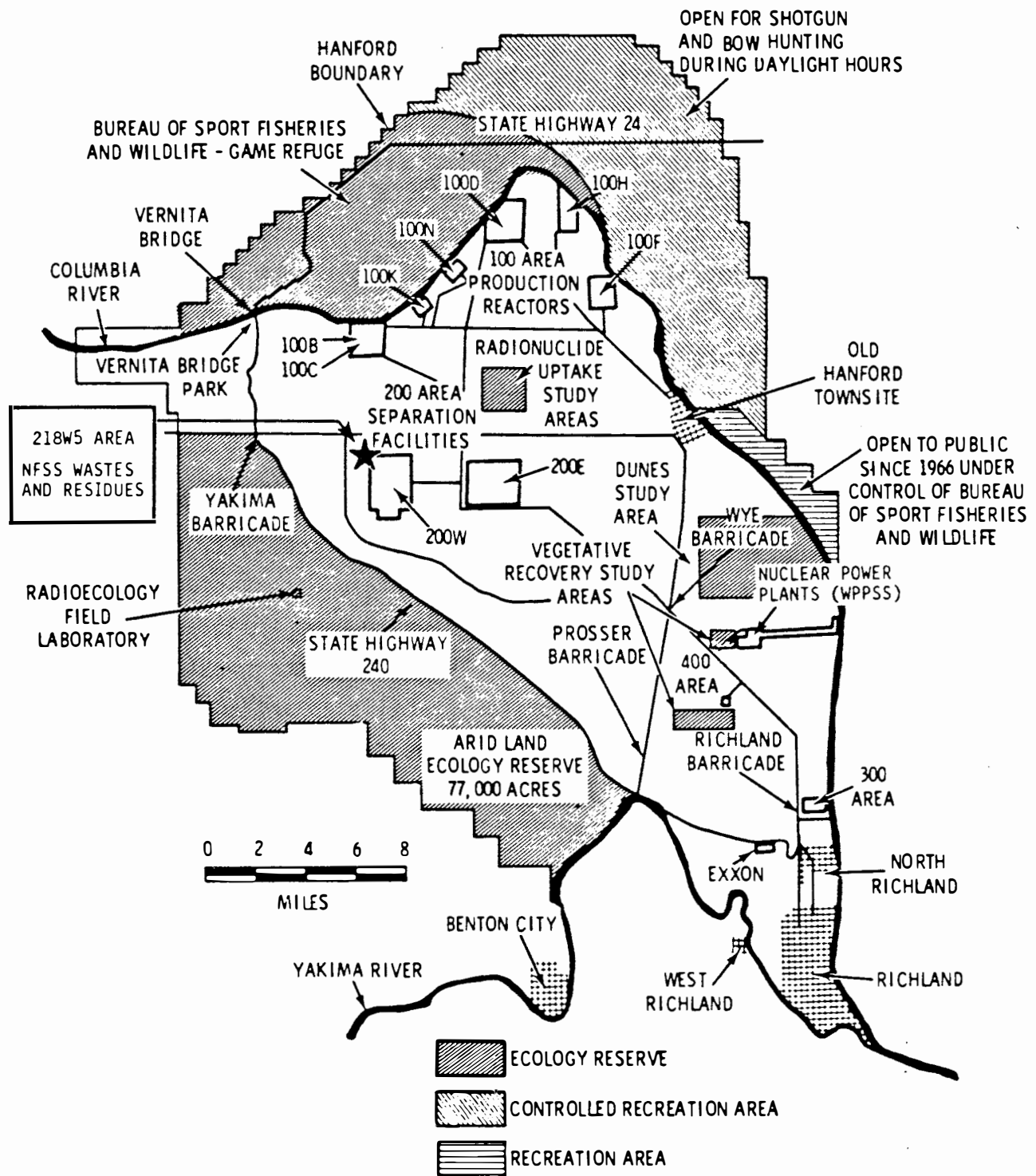


Figure 3.6. Map of the Hanford Reservation. Source: U.S. Energy Research and Development Administration (1977).

Eastern Washington is in a region of low to moderate seismicity that lies between the western Washington and eastern Montana zones of considerably greater seismicity. Earthquakes with intensities of MM (Modified Mercalli) VII have occurred in the region (U.S. Energy Res. Dev. Admin. 1975). No clearcut relationships of epicenters to specific surface faults or structures capable of faulting are recognized in the Hanford area (U.S. Energy Res. Dev. Admin. 1975).

No mineral resources have been identified within the 200 Area or the Hanford Reservation.

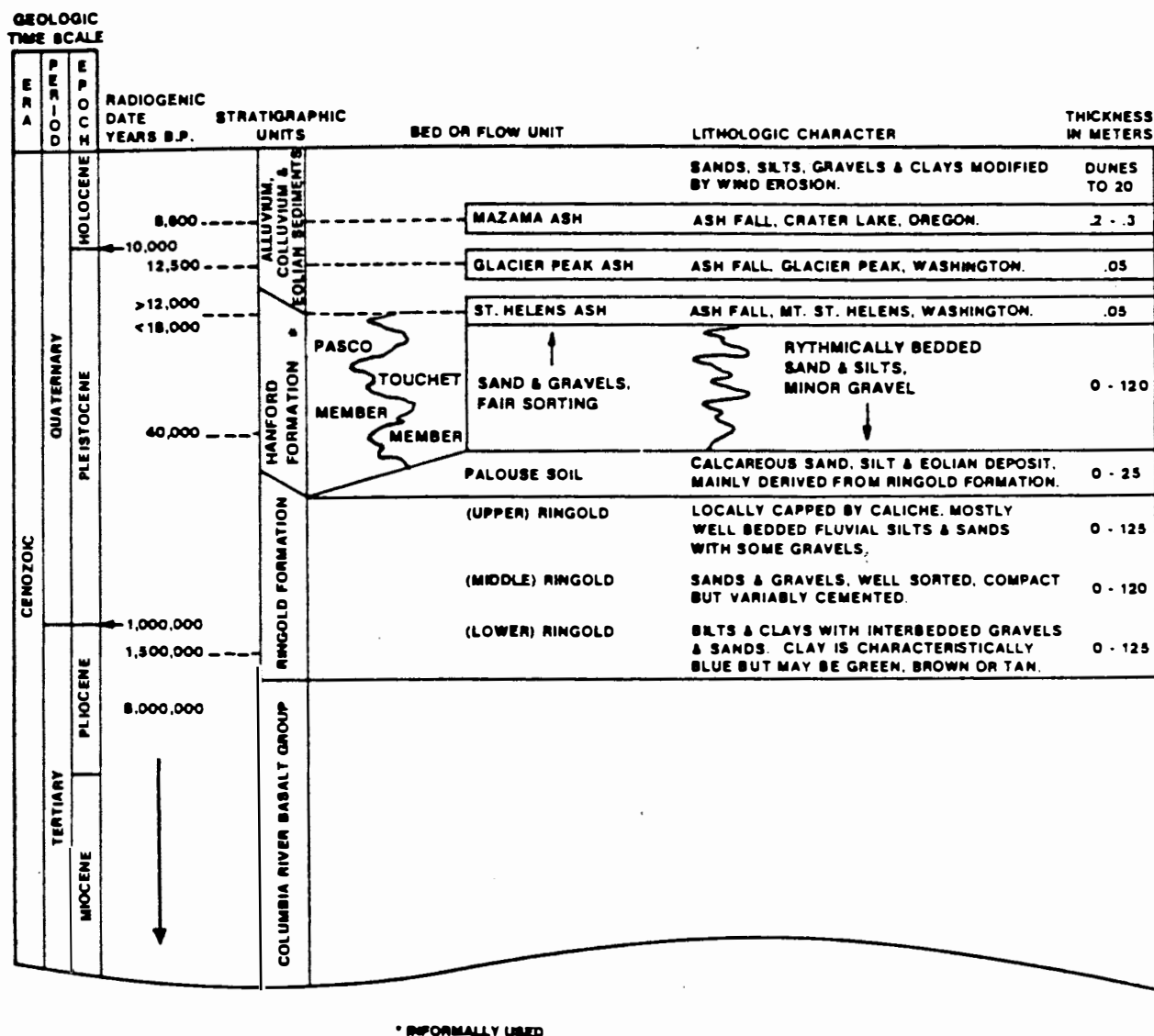


Figure 3.7. Stratigraphic Units at the Hanford Site.
Source: Brown and Isaacson (1977).

3.2.2 Hydrology, Water Use, and Water Quality

3.2.2.1 Surface Water

The Columbia River, which is north and east of the site (Figure 3.9), is the dominant hydrologic feature in the Hanford area. Flow in the Columbia River is influenced by water usage, including upstream reservoir projects. In the Hanford reach of the Columbia River, the water is of excellent quality and is used for municipal drinking at Richland and Pasco. Municipal water intakes are located both above and below the confluence of the Yakima and Columbia rivers.

An ephemeral stream that drains the 200-West area, Cold Creek (Figure 3.9), has a relatively short reach (about 1 km in length). On rare occasions, flow is sufficient to increase the reach to 10 km (6 mi). Cold Creek Valley ends at the Yakima River about 48 km (30 mi) southeast of the 200-West Area.

The potential for flooding is generally confined to areas near the Columbia River, which is normally about 75 to 90 m (250 to 300 ft) below the 200-West Area. The 200-West site is about 60 to 75 m (200 to 250 ft) above the probable maximum flood level (U.S. Army Corps Eng. 1969; U.S. Dep. Energy 1982d).

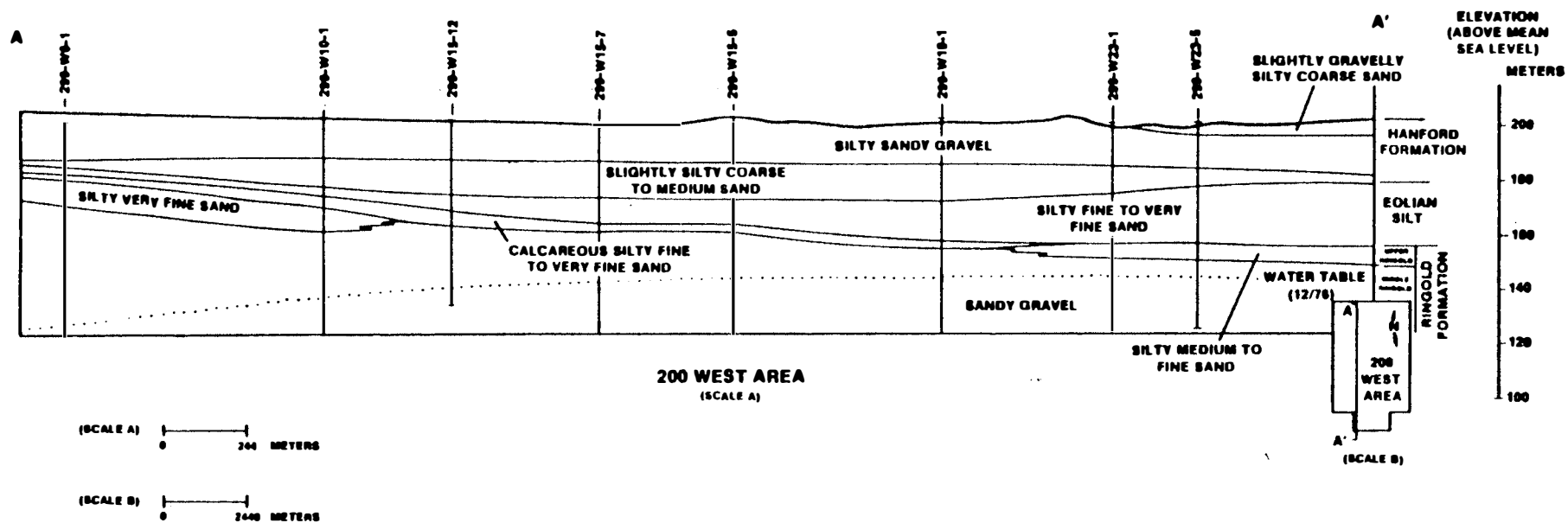


Figure 3.8. Geologic Cross Section of the 200-West Area.
Source: Brown and Isaacson (1977).

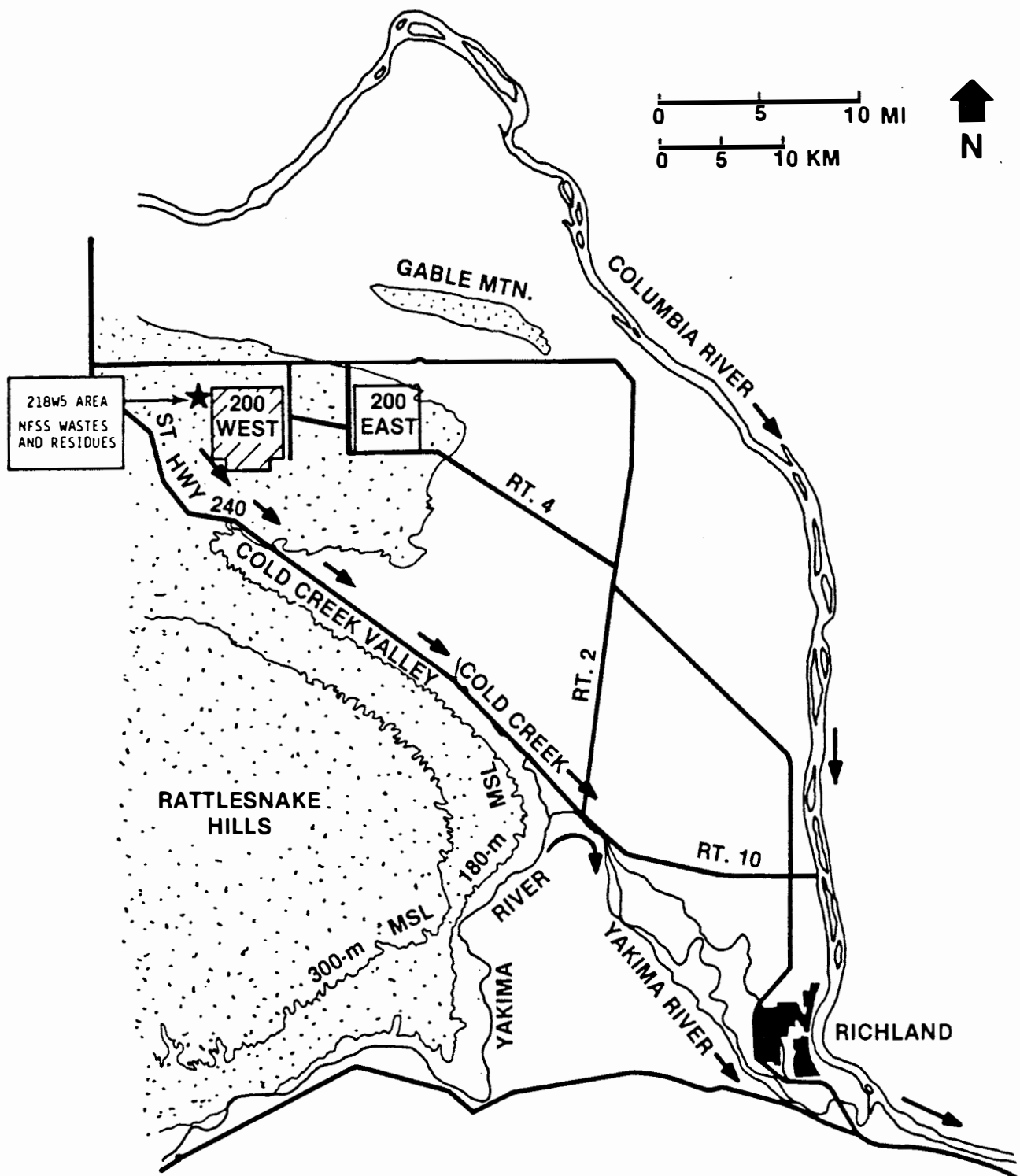


Figure 3.9. Surface Water Drainage from the 200-West Area.

3.2.2.2 Groundwater

In the Pasco Basin, groundwater is found in both the sedimentary deposits and basalt bedrock. Groundwater occurs unconfined in the sedimentary deposits, although locally confined zones exist. Water in the basalt bedrock occurs mainly under confined conditions. The general elevation and configuration of the unconfined aquifer are shown in Figure 3.10. It appears that the water table under the 200 Area is about 46 to 100 m (150 to 328 ft) beneath the ground surface. More moisture is evaporated from the ground than is recharged by precipitation, and the unsaturated zone is generally very dry (Brown and Isaacson 1977). The bottom of the unconfined aquifer is not a continuous surface; in some areas, the bottom is the basalt bedrock and in other areas it is the silt/clay zones of the Ringold Formation.

Precipitation does not directly reach the water table from the flat desert plateau (U.S. Dep. Energy 1982d). The aquifer receives natural recharge from creek valleys west of the 200 Area and from runoff along the Rattlesnake Hills (Figure 3.9). Artificial recharge enters the aquifer from waste-processing and -disposal activities that create two groundwater mounds in the 200 Area (Figure 3.10). The principal direction of flow is eastward from the recharge areas to the Columbia River (Figure 3.11), which is a sink for groundwater discharge.

The hydraulic characteristics of the unconfined aquifer are quite variable (U.S. Energy Res. Dev. Admin. 1977). The vertically averaged hydraulic conductivity for the unconfined aquifer in the 218W5 Area ranges from 1.2 to 6 m/day (3.9 to 20 ft/day). Values for the storage coefficient ranging from 0.0008 to 0.2 have been estimated for the Hanford area from field tests (U.S. Energy Res. Dev. Admin. 1977), but the typical range of storage coefficient values for unconsolidated sediments is 0.05 to 0.4. Hydraulic properties of the upper confined aquifers are presented in several reports (U.S. Energy Res. Dev. Admin. 1975, 1977; Brown and Isaacson 1977; Gephart et al. 1979).

Groundwater in the Hanford area also exists in the interflow zones of the basalt flows and in sedimentary interbeds. The uppermost confined aquifers appear to be hydraulically connected to the overlying unconfined aquifer (Brown and Isaacson 1977). Recharge to the confined aquifers results from precipitation and streamflow in the mountains west of Hanford; and the groundwater in these confined aquifers has the same general west-to-east movement towards the Columbia River.

3.2.3 Climate and Meteorology

The climate of the Hanford site is semiarid. Most of the direct precipitation evaporates or is transpired by plants; the remainder becomes runoff and infiltration. The average annual precipitation is 16 cm (6.3 in.), of which 42% occurs during the November-January period and only 10% occurs in the July-September period (U.S. Energy Res. Dev. Admin. 1977). The average summer temperature is 23°C (73°F), and the average winter temperature is 0°C (32°F).

At the Hanford meteorological station (located between the 200-West and 200-East areas), prevailing winds are from NNW through NW. The strongest winds tend to be from the SW and gusts often exceed 64 km/h (40 mph). Tornadoes are relatively rare and tend to be small, causing little or no damage when they do occur (U.S. Energy Res. Dev. Admin. 1975).

3.2.4 Ecology

The 200-West Area is located within an area of sagebrush/cheatgrass-Sandberg's bluegrass vegetation (Uresk et al. 1977). This plant community is typical of a shrub-steppe ecosystem adapted to arid conditions. Community structure is dominated by low, widely spaced shrubs along with various grasses and forbs (between 45 and 70% of the ground surface is covered by vegetation). The lack of native herbaceous cover in this community tends to favor invasion of Russian Thistle (tumbleweed)--a weedy, introduced species. Wildfires are a common occurrence on the Hanford Reservation, and fire is especially destructive to this plant community because big sagebrush is killed by burning and large perennial grasses that can survive fire are absent. Thus, recovery of herbaceous vegetation following fire is quite slow (U.S. Energy Res. Dev. Admin. 1975).

Small mammals occurring on the 200 Area plateau include mice, pocket gophers, voles, rabbits, and coyotes (Uresk et al. 1977). Mule deer are occasionally present near the waste ponds in the 200 Area. Badgers also occur in low numbers on the site. It is thought that badgers burrowed into wastes in the nearby B-C crib disposal area during the 1950s or early 1960s (Uresk et al. 1977), allowing jack-rabbits access to the radioactive materials. These materials were subsequently dispersed to other portions of the Reservation via rabbit feces and wind or water dispersion of loose contaminated materials brought to the surface by the rabbits.

Birds are an important element of the shrub-steppe ecosystem, and 27 species are known to breed in this habitat on the Hanford Reservation (Uresk et al. 1977). However, only a few species are considered abundant, including the western meadowlark, horned lark, sage sparrow, and black-billed magpie.

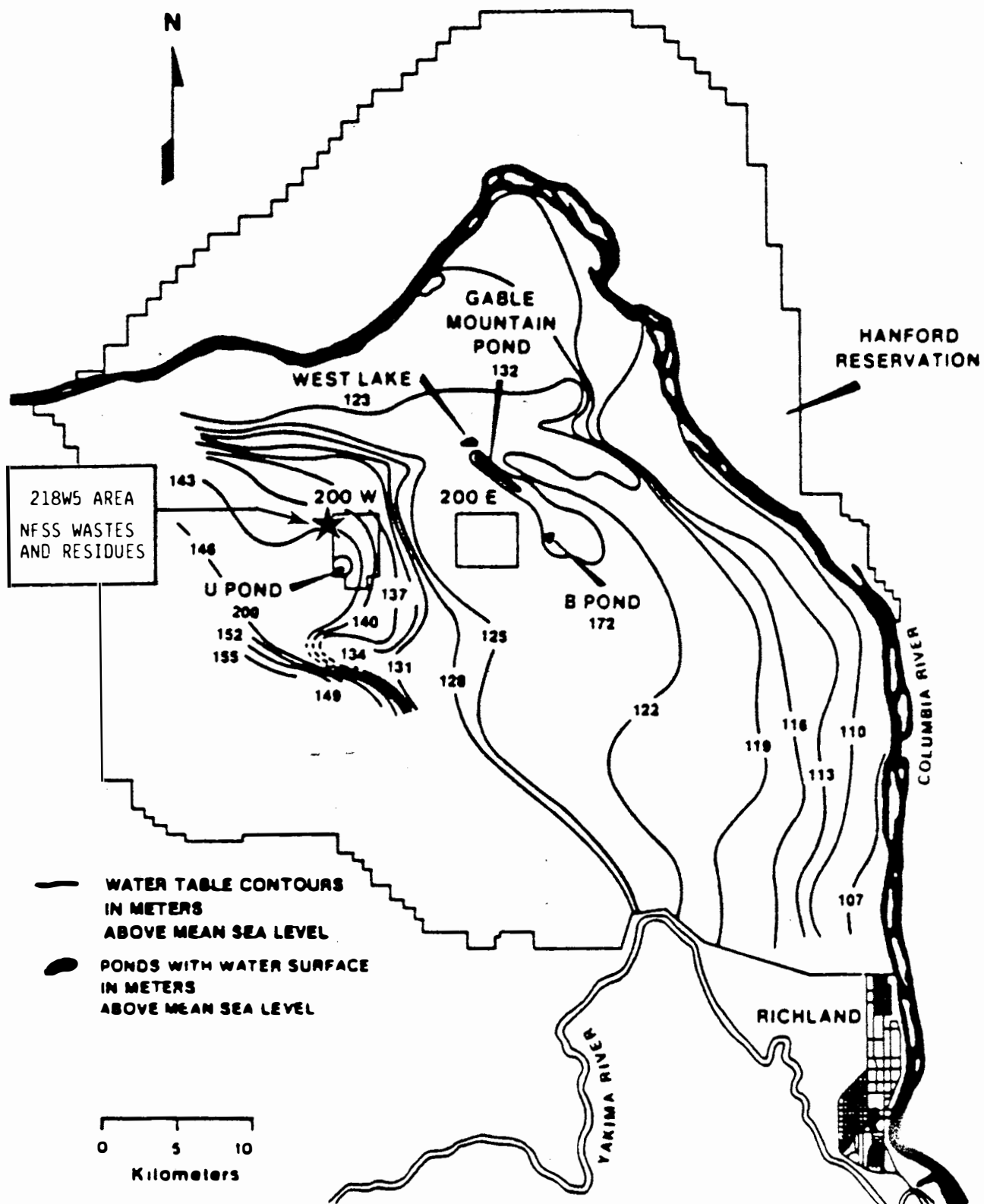


Figure 3.10. Water Table Contour Map for Hanford Area, January 1977.
Source: Brown and Isaacson (1977).

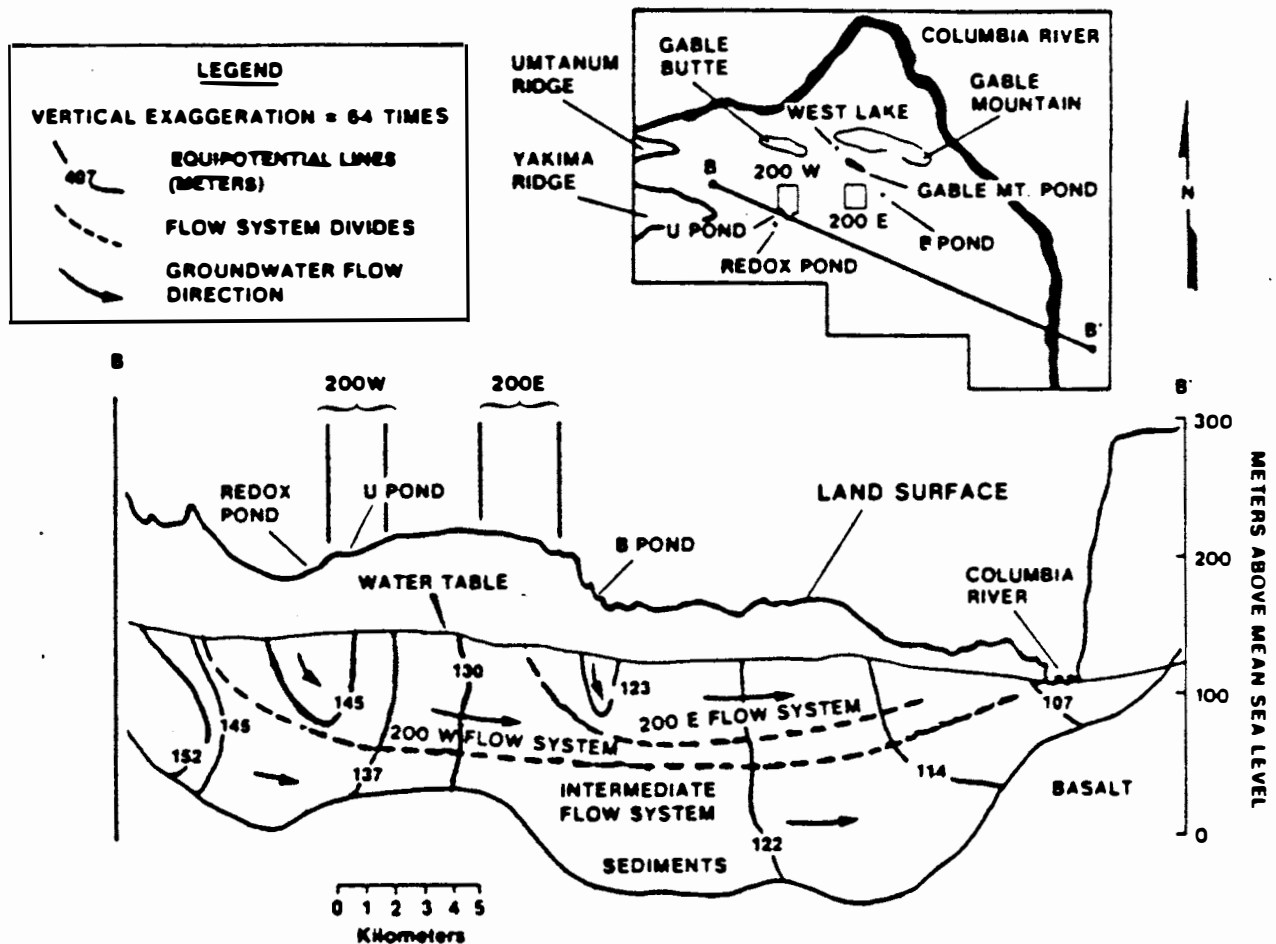


Figure 3.11. Regional Flow System at Hanford Area.
Source: Brown and Issacson (1977).

Lizards are perhaps the most common reptile species on the 200 Area plateau (Uresk et al. 1977). Snake species present in the sagebrush/cheatgrass-Sandberg's bluegrass plant community include the western yellow-bellied racer, gopher snake, and striped whipsnake.

Invertebrates (insects, etc.) play important roles in the shrub-steppe community. Beetles and ants are often the major herbivores, and they play an important role in the soil communities.

No aquatic habitat occurs in the 218W5 area at the Hanford Reservation.

No endangered or threatened species of vascular plants are known to occur in the 200-West Area (U.S. Energy Res. Dev. Admin. 1975; Uresk et al. 1977). However, some endangered or threatened raptors use the site, including the American peregrine falcon and bald eagle which migrate across the site.

3.2.5 Land Use

In addition to the five subareas of the Hanford Reservation discussed in Section 3.2, an area located in the southwest corner of the Reservation has been reserved for long-term ecological studies (U.S. Energy Res. Dev. Admin. 1977). North of the Columbia River is a wildlife refuge (also located on the Reservation) operated by the Bureau of Sport Fisheries and Wildlife. Also to the north of the River is a controlled recreation area used for shotgun and bow hunting and a controlled hunting area east of the old Hanford townsite operated by the Washington State Department of Game (U.S. At. Energy Comm. 1972).

The land-use and zoning status of areas surrounding the Hanford Reservation are varied (U.S. Energy Res. Dev. Admin. 1977). Land use includes residential, commercial, industrial, agricultural, recreational, and undeveloped. The region is sparsely vegetated and suited primarily for

grazing, although large areas of land have recently been brought under irrigation. The major urbanized areas are the towns of Richland, Kennewick, and Pasco located to the southeast of the Reservation in Benton and Franklin counties.

3.2.6 Population and Socioeconomics

3.2.6.1 Population

The Hanford site is located primarily in Benton County, with portions in Franklin and Grant counties. Other nearby counties include Yakima and Kittitas. The closest population center is the city of Richland, which is located about 50 km (30 mi) southeast of the 200-West Area. The populations of four of the five counties increased from 1970 to 1980 (Table 3.10). The city of Richland experienced a 28% increase over this same time period. County population densities in 1980 ranged from 4 persons/km² (Kittitas County) to 24 persons/km² (Benton county). The 1981 population located within a 16-km (10-mi) and an 80-km (50-mi) radius of the meteorological station near the 200-West burial area has been estimated at 0 and 258,000, respectively (U.S. Energy Res. Dev. Admin. 1975).

Table 3.10. Population Data for the Hanford Reservation Area, 1970-1980

	1970† ¹		1980† ²		% Increase in Population 1970-1980
	Population	Population Density (no./km ²)	Population	Population Density (no./km ²)	
County					
Benton	67,500	15	109,000	25	+61
Franklin	25,800	8	30,000	9	+16
Grant	41,900	6	48,500	7	+16
Yakima	145,000	13	173,000	16	+19
Kittitas	25,000	4	24,900	4	-0.4
City					
Richland	26,300	-	33,600	-	+28

†¹ U.S. Bureau of the Census (1970b--pp. 49-15/49-20).

†² U.S. Bureau of the Census (1980b).

3.2.6.2 Economy

The economy of the counties near the Hanford area is based primarily on agriculture and on energy research and production. Between 1970 and 1980, the civilian labor force in the bicounty (Benton-Franklin) area increased from 38,000 to 74,000 (U.S. Nucl. Reg. Comm. 1981). The civilian labor force in the area is also disproportionally represented by service industry jobs compared to other counties in the state.

3.2.6.3 Public Facilities

Because the Hanford site is a federal facility dedicated to nuclear energy research and production as well as a natural reserve, there are no population centers or public facilities such as schools and hospitals within an 8-km (5-mi) radius of the 200-West Area. However, because of rapid population growth in nearby Benton and Franklin counties, public services such as schools, public parks, police and fire protection, water supply, and sewage treatment experienced some problems in the latter part of the 1970s.

There have been numerous findings of archaeological and cultural resources on the Hanford Reservation. Prehistoric, historic, and ethnohistoric sites are reported for the Hanford Reservation and in the nearby counties of Benton, Grant, and Franklin. Ethnographic settlements of the Wanapun Indians are reported to have persisted in the area (particularly along the Columbia River) until the establishment of the Hanford Atomic Works in 1943. In earlier eras, fur traders and wagon trains passed through the area, and several historic homesteads may have been located on the Reservation (Rice 1968). An archaeological survey has been conducted on a portion of the 1700 km² Reservation by foot and automobile (Rice 1968). Three resource localities and 26 archaeological sites were identified, including campsites,

flaking floors, fishing stations, and an historic site. Additional sites have been found during surveys conducted for specific areas on the Reservation as part of investigations associated with particular energy projects (U.S. Nucl. Reg. Comm. 1981). Because the Reservation-wide reconnaissance did not identify any cultural resources in the 200-West Area, the 218W5 site has not been surveyed for the presence of cultural resources. The State of Washington, Office of Archaeology and Historic Preservation, has recommended that professional cultural resource surveys of the area be conducted (Wash. Off. Archaeol. Hist. Preserv. 1983).

The U.S. Department of the Interior (1980, 1983) has listed 18 properties in the National Register of Historic Places for the Hanford region (Table 3.11).

Table 3.11. National Historic Places near Hanford

Location	Description
<u>Benton County</u>	
Paterson vicinity	Telegraph Island Petroglyphs: 2 mi SW of Paterson on Telegraph Island
Prosser vicinity	Benton County Courthouse: Dudley Avenue and Market Street (12-12-76)
Prosser vicinity	Prosser Steel Bridge
Prosser vicinity	Glade Creek Site: SE of Prosser
Richland vicinity	Hanford Island Archaeological Site: 18 mi N of Richland
Richland vicinity	Hanford North Archaeological District: 22 mi N of Richland
Richland vicinity	Locke Island Archaeological District: about 25 mi N of Richland
Richland vicinity	Rattlesnake Springs Sites: 25 mi NW of Richland
Richland vicinity	Ryegrass Archaeological District: in Hanford Works Reservation along Columbia River
Richland vicinity	Snively Canyon Archaeological District: about 25 mi NW of Richland
Richland vicinity	Wooded Island Archaeological District: about 7 mi N of Richland
Richland vicinity	Paris Archaeological Site, Hanford Works Reservation
<u>Franklin County</u>	
Lyons Ferry vicinity	Marmes Rockshelter: 1 mi N of Lyons Ferry on W side of Palouse River, National Historic Landmark
Richland vicinity	Savage Island Archaeological District: 15 mi N of Richland
Pasco	Moore, James House
Pasco	Pasco-Kennewick Bridge
Pasco	Pasco-Carnegie Library

Source: U.S. Department of the Interior (1980, 1983).

Major highway transportation routes onto the Hanford reservation include Route 10 and State Route 240 (see Figure 3.20). Barges with up to 2700-MT (3000-ton) capacities can navigate the Columbia River from the Pacific Ocean to the Hanford area. The Burlington Northern railroad currently operates in the Hanford area, and there is a DOE-owned railroad system on the Hanford Reservation (U.S. At. Energy Comm. 1972).

3.2.7 Existing Radiological Environment

The Hanford Reservation and vicinity contains several nuclear-related facilities that have been operating since 1943 (Figure 3.12). At one time, nine federal government plutonium production reactors were in operation, but only one remains active. Other government facilities include a reactor fuel-reprocessing plant, reactor fuel-manufacturing facilities, the DOE Pacific Northwest Laboratories (research and development laboratories), and the Fast Flux Test Facility. Radioactive wastes are stored or disposed in the 100, 200, and 300 areas. Privately leased facilities include the Washington Public Power Supply System nuclear generating station, a radioactive waste burial site, and the Exxon nuclear fuel fabrication plant.

Liquid radioactive wastes are stored on the Hanford Reservation in large underground tanks, cribs, and evaporation ponds (U.S. Energy Res. Dev. Admin. 1975). Solid radioactive wastes are buried

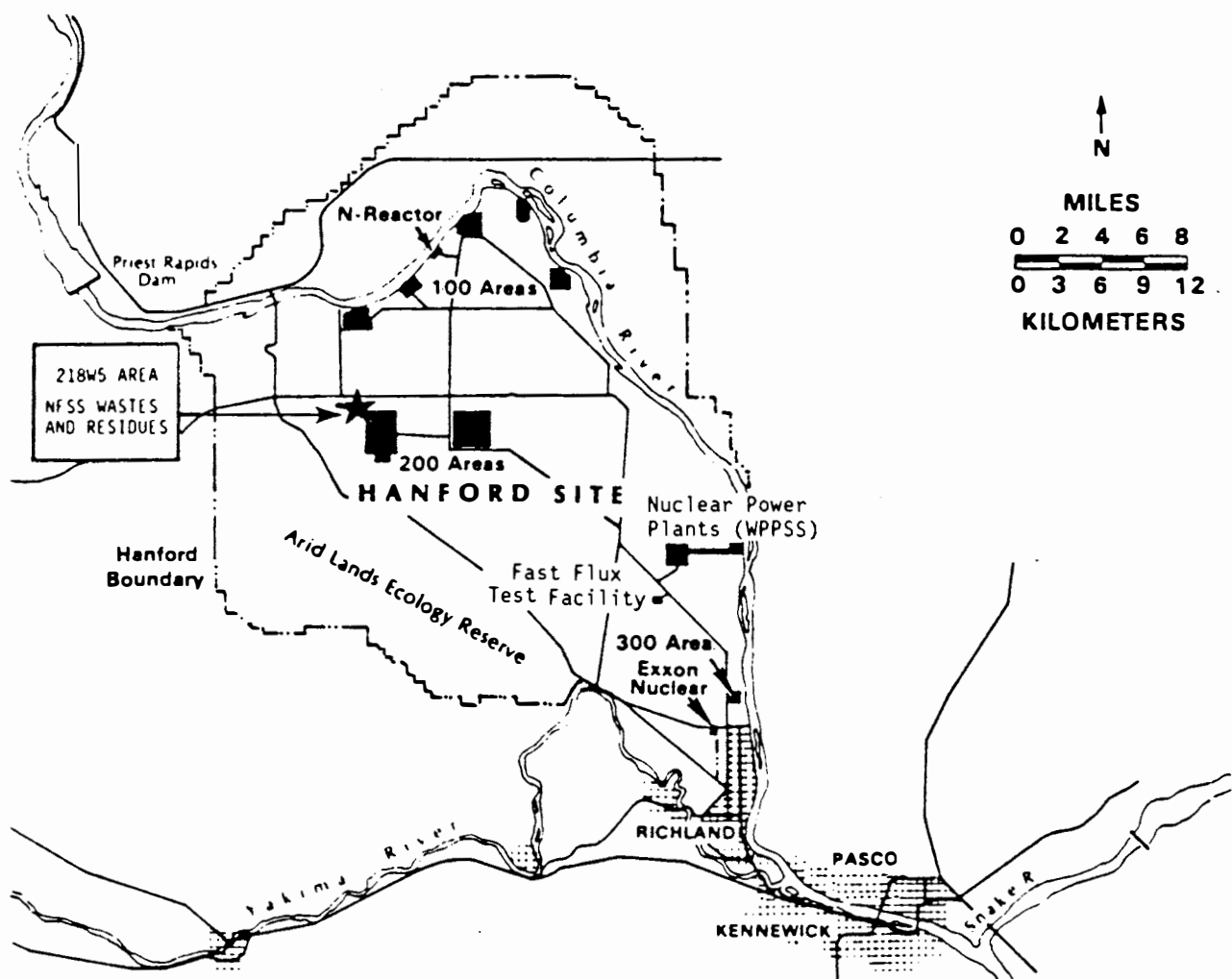


Figure 3.12. Nuclear-Related Facilities on the Hanford Reservation.
Source: Adapted from Sula et al. (1982).

in trenches, the transuranic portion of which is packaged in retrievable form. The radioactive waste inventory at Hanford is: 183,000 m³ (530 million Ci) of high-level liquid sludge and salt cake stored in underground tanks; 102,000 m³ of low-level waste (1 million Ci); 193,120 m³ of solid transuranic wastes and between 57,200 to 500,000 m³ of soils contaminated with transuranic nuclides (160,000 Ci) buried in trenches; and 11,035 m³ of transuranic defense wastes in retrievable storage (U.S. Dep. Energy 1982f--Tables 0.3, 3.3, 3.4 and Figure 4.1).

The Hanford area has an extensive environmental monitoring program to determine the contribution of Hanford activities to radiation levels (Sula and Blumer 1981; Sula et al. 1982). Radioactive emissions from Hanford nuclear-related activities during 1981 were calculated to result in a whole-body dose of 0.03 mrem/yr to an offsite maximally exposed individual; the 50-year dose commitment to the population within an 80-km radius was calculated to be 4 person-rem (Sula et al. 1982). The individual dose from natural background radiation sources in Washington is approximately 100 mrem/yr (Nat'l. Council. Radiat. Prot. Measure. 1975).

3.3 OAK RIDGE

The Oak Ridge Reservation is a federally owned site of approximately 15,000 ha (37,500 acres). It is located about 40 km (25 mi) west of Knoxville, Tennessee. Most of the Reservation is either being used for ongoing programs or has been designated as a protected area (U.S. Dep. Energy 1980). The three major building complexes on the Reservation (Figure 3.13) include the Oak Ridge National Laboratory (research), the Y-12 Plant (nuclear weapons), and the Gaseous Diffusion Plant (uranium enrichment). The building complexes are located throughout the valley portions of the Reservation and

are interconnected by a system of roads. A buffer zone has been provided around each facility for security, safety, and future expansion purposes. Approximately 80% of the Reservation is forested (U.S. Dep. Energy 1982e).

For purposes of analysis in this EIS, it is assumed that the NFSS wastes and residues will be managed at the Pine Ridge Knolls site.* This site is located in the west-central portion of the Oak Ridge Reservation (Figure 3.13) and is part of what is commonly known as the Exxon site. For management of the NFSS wastes and residues, only about 40 ha (100 acres) on top of the knolls immediately south of Pine Ridge will be developed. The Exxon site comprises a much larger area, including a large buffer zone, for a proposed nuclear fuel reprocessing plant (Exxon Nucl. Co. 1977; U.S. Dep. Energy 1980). At present, the site is no longer being considered for a reprocessing plant.

3.3.1 Topography, Geology, Soils, Seismology, and Mineral Resources

The Oak Ridge Reservation is located in the western portion of the Valley and Ridge Physiographic Province. This subregion is characterized by a series of northeast-southwest trending ridges and intervening valleys. The ridges are breached at irregular intervals by stream channels that otherwise follow the trend of the valleys. The Clinch River (Figure 3.13) borders the Oak Ridge Reservation to the south and east (U.S. Dep. Energy 1979).

North of the Pine Ridge Knolls site is Pine Ridge (Figure 3.14), which reaches elevations of 320-340 m (1050-1100 ft). Chestnut Ridge lies south of the site and reaches an elevation of about 300 m (1000 ft). Bear Creek Valley (elevation 240-270 m [800-900 ft]) lies between the two ridges. The elevation on the Pine Ridge Knolls reaches approximately 290 m (950 ft) MSL.

The bedrock that is exposed over most of the Oak Ridge Reservation consists of the Rome Formation and the Conasauga, Knox, and Chickamauga groups, with lower and middle Paleozoic sandstones, siltstones, shales, and cherty carbonates. Folding and faulting of these units during the late Paleozoic era resulted in alteration of these rock types and the creation of an imbricate pattern of units inclined like shingles to the southeast. Subsequent differential weathering and erosion of these units resulted in the trellis drainage pattern and the ridge and valley topography. In general, the ridges developed in areas underlain by resistant sandstone, siltstone, and the more siliceous limestones and dolomites. The valleys are typically broader than the ridges and have been formed in areas underlain by the more erodible shales and more soluble nonsiliceous limestones and dolomites.

The Pine Ridge Knolls site is underlain by the Rome Formation and the Conasauga Group (Figure 3.15). About 230 m (740 ft) of continuous Rome Formation--composed predominantly of siltstone, sandstone, and shale (240 to 300 m [800 to 1000 ft] in thickness)--has been observed at the site. The Conasauga Group overlies the Rome Formation and underlies Pine Ridge Knolls and Bear Creek Valley. The Conasauga Group is approximately 550 m (1800 ft) thick and is predominantly composed of shale, with siltstone and limestone.

No limestone/dolomite sinks have been found within the Pine Ridge Knolls site; however, such solutioning is known to occur in some units of the Conasauga Group, and it is possible that solution cavities could form in this area in the future. No signs of developing landslides have been observed along the slope (Exxon Nucl. Co. 1977).

Soils in the Ridge and Valley Province are usually strongly leached, acidic, and low in organic content, and they have low exchange capacities (less than 10 milliequivalents per hundred grams of soil) (U.S. Dep. Energy 1979). The sandstones and shales of the Rome Formation and the Conasauga Group geologic units that form Pine Ridge typically produce fine to very fine sandy loam soils. The dominant surface soils in the Pine Ridge Knolls site are Lehigh stony, fine sandy loams and Apison very fine sandy loam (Swann et al. 1942). The Apison sandy loam is generally shallow (less than 30 cm or 12 in.), contains much shale from the underlying parent material, and requires careful management if used for pasture or crops. The Lehigh sandy loam overlies sandstone or shale parent material and is 36 cm (14 in.) or greater in thickness. Drainage in this soil is excessive and the soil is characterized as unfit for production of crops and very poorly adapted to pasture. Both soils are suited for forestry (Swann et al. 1942).

The maximum earthquake for the region (an event with a 16% probability of occurring once in 50 years) was predicted as having a maximum intensity of MM VI to VIII (U.S. Dep. Energy 1980). The Oak Ridge Reservation is crossed by two major thrust faults: the Copper Creek fault in the southeastern part of the Reservation, and the Whiteoak Mountain fault in the northwestern part. No

*Analysis of alternative sites within the DOE Oak Ridge Reservation is beyond the scope of this EIS (Appendix G). The DOE Oak Ridge Operations Office has identified the Pine Ridge Knolls site as being a site that is reasonable to assume for purposes of analysis and comparison of alternatives in this EIS. It is potentially available for management of the NFSS wastes and residues, and it is not committed or proposed for disposal of wastes generated on the Oak Ridge Reservation. Site-specific information is available for this site.

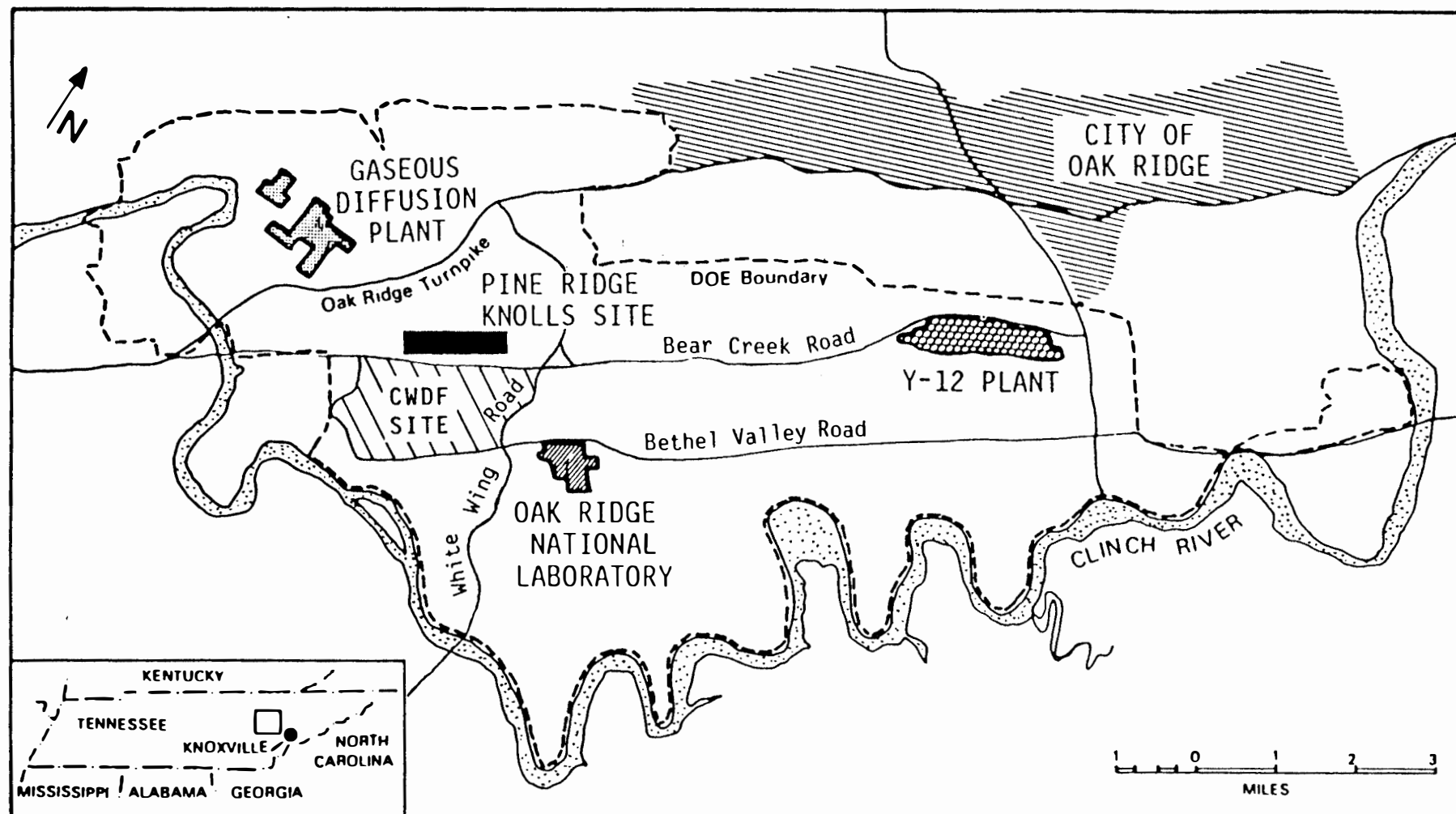


Figure 3.13. Location of Potential Waste-Management Area for NFSS Wastes and Residues (Pine Ridge Knolls Site). Source: Modified from U.S. Department of Energy (1982e).

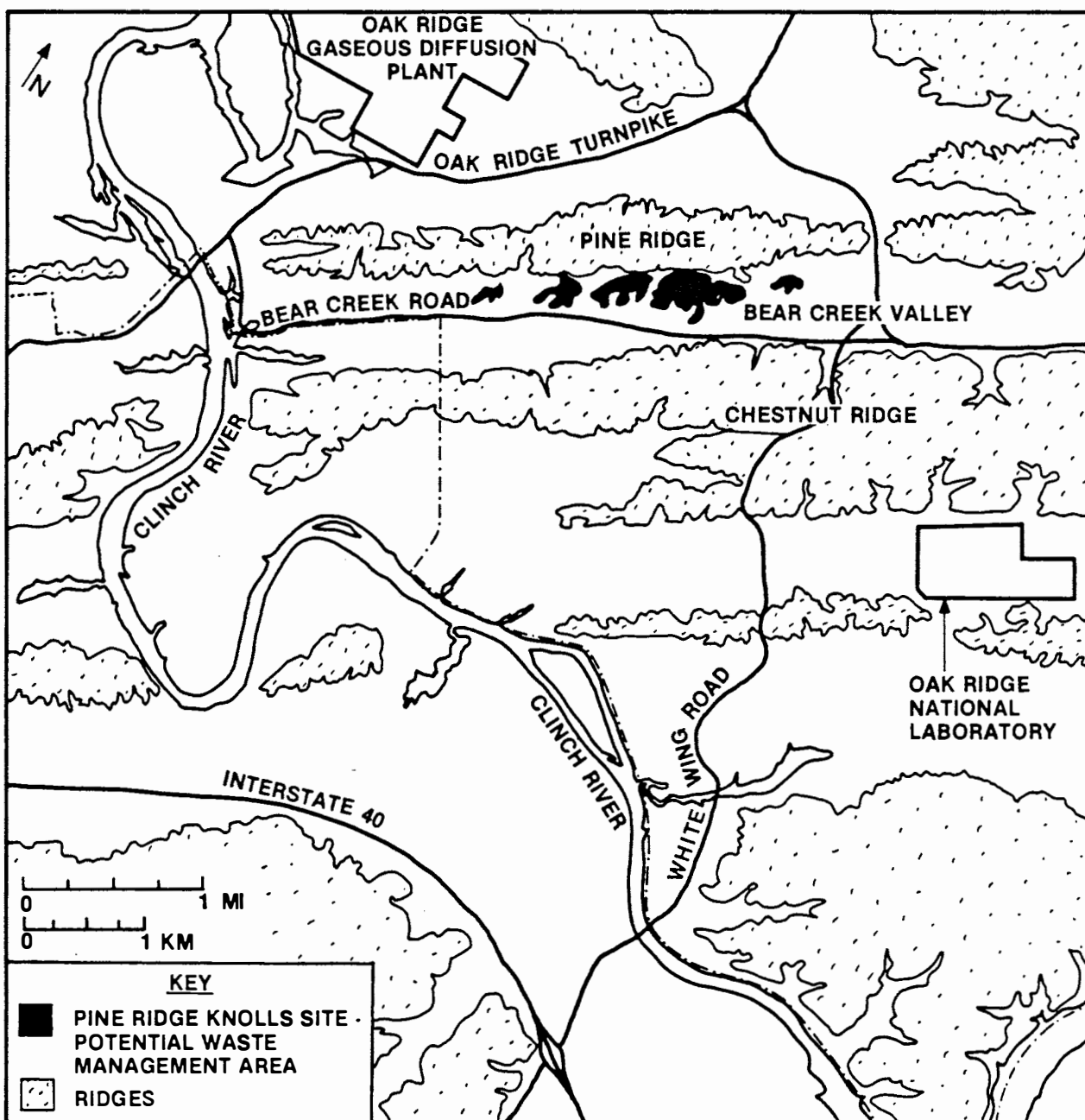


Figure 3.14. Topographic Features near the Pine Ridge Knolls Site.

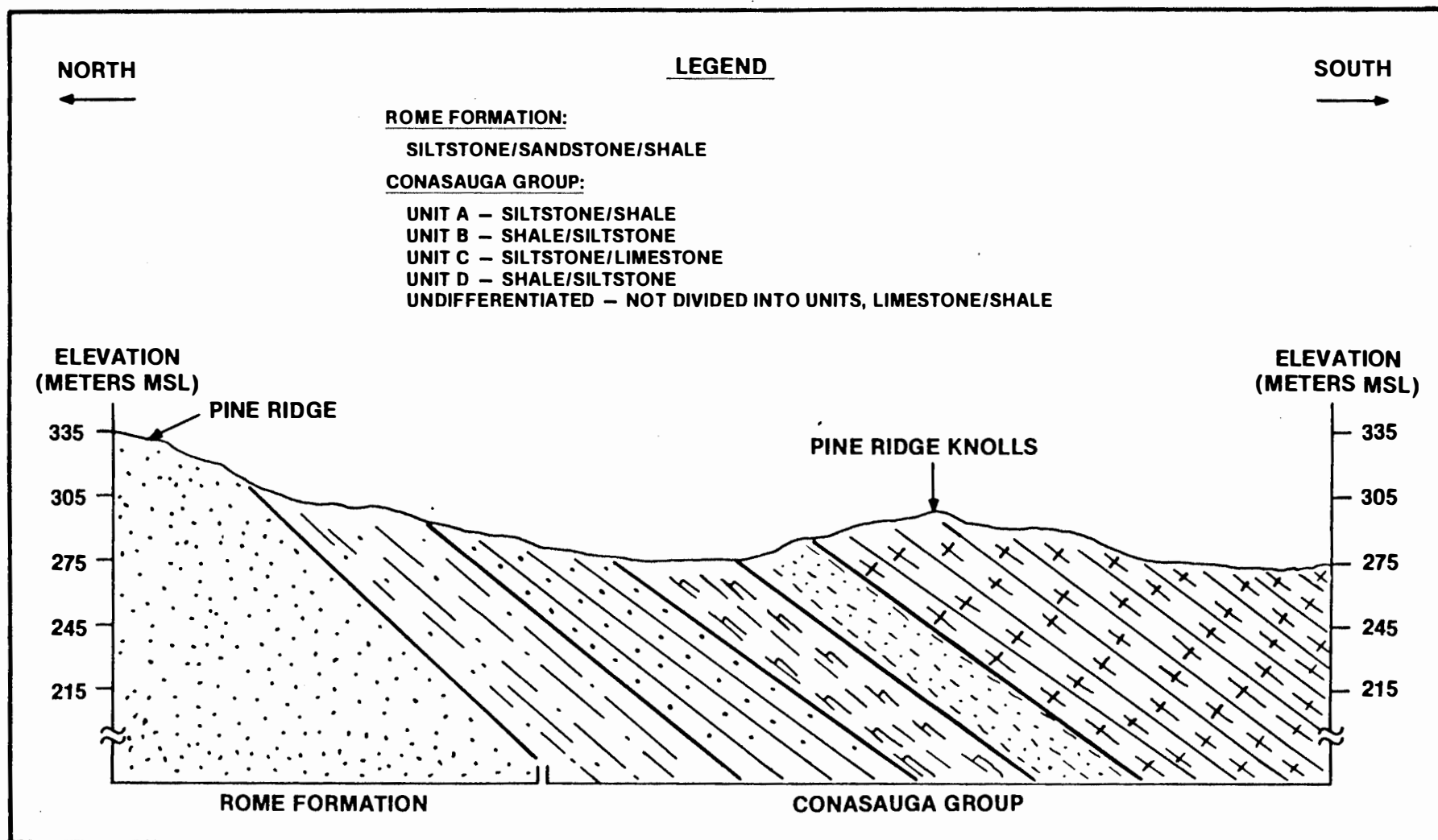


Figure 3.15. Bedrock Underlying the Pine Ridge Knolls Site at Oak Ridge.
Source: Adapted from Exxon Nuclear Company (1977).

evidence has been found of activity associated with these faults during the past 230 million years (U.S. Nucl. Reg. Comm. 1977, 1982). No correlation between the minor seismic activity occurring in the region and known tectonic structures has been confirmed (U.S. Dep. Energy 1982e).

The upper beds of the Conasauga Group are used in many places in Tennessee as a source of quarry stone for road aggregate (U.S. Dep. Energy 1979). No mining of this formation occurs in Bear Creek Valley or Pine Ridge Knolls.

3.3.2 Hydrology, Water Use, and Water Quality

3.3.2.1 Surface Water

The climate at the Oak Ridge site is humid. The average annual precipitation is 140 cm (56 in.) (Natl. Oceanic Atmos. Admin. 1973), of which approximately 60% is lost through evapotranspiration and 40% becomes runoff to surface waters and recharge to the groundwater.

The Pine Ridge Knolls site is drained by tributaries of the Clinch River (Figure 3.16). Grassy Creek drains most of the site and flows southwest along the northern edge of Chestnut Ridge. The easternmost portion of the site drains into Bear Creek, which flows northwesterly into East Fork Poplar Creek to Poplar Creek and west into the Clinch River. The Clinch River, which discharges to the Tennessee River, is the source of most water used in the Oak Ridge area and supplies Clinton, Oak Ridge, and the DOE facilities. Wastewaters from these areas are returned to the Clinch River.

Clinch River flow is principally regulated by Norris Dam, located about 90 km (55 mi) upstream (east) of the proposed site. However, the immediate influence on river flow in the site vicinity is Melton Hill Dam, which is located about 8 km (5 mi) upstream from the site. Flow below the Melton Hill Dam has averaged 220 m³/s (7800 cfs) since 1963. River flow in the site vicinity can be upstream,

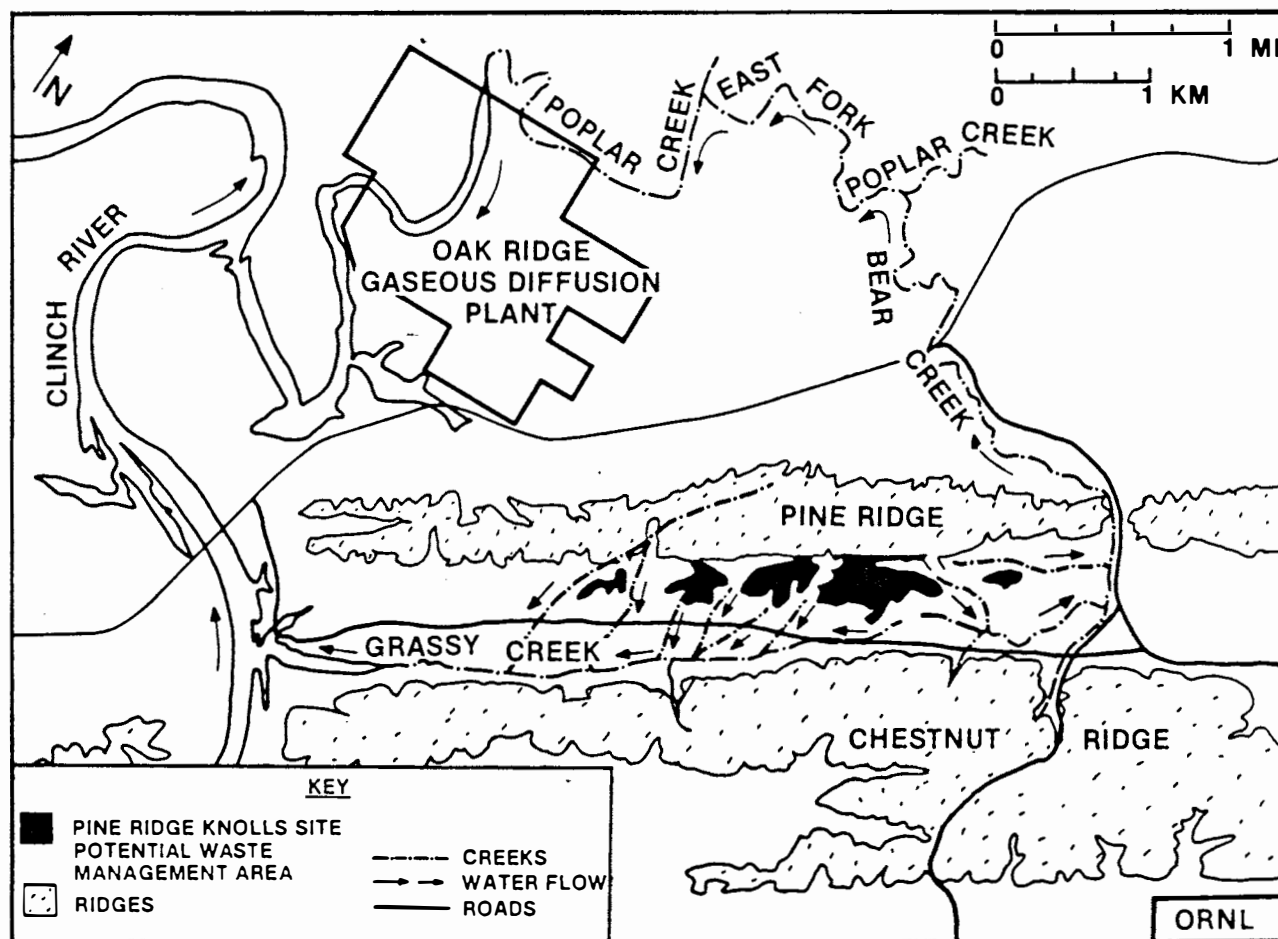


Figure 3.16. Surface Water Drainage at the Pine Ridge Knolls Site.

downstream, or quiescent, depending on the mode of operation of dams on the Clinch and Tennessee rivers. Through controlled discharges, these dams have greatly reduced the potential for flooding. The Pine Ridge Knolls site is not located in a floodplain.

Several creeks in the Oak Ridge area have been found to contain substantial amounts of contaminants (Marshall 1983). Mercury and other contaminants have been found in the East Fork of Poplar Creek. Bear Creek and White Oak Creek are also contaminated with radioactive materials. Grassy Creek, which drains most of the Pine Ridge Knolls site, has a mostly undeveloped watershed and is relatively uncontaminated.

3.3.2.2 Groundwater

As discussed previously, Pine Ridge Knolls is underlain by interbedded sandstone and shale of the Rome Formation and also by the more easily weathered and eroded shale and limestone of the Conasauga Group. The Rome Formation is a poor aquifer, with most of the groundwater occurring in the solution channels of the carbonate members and less of the groundwater available in fractures of the sandstones and shales. Groundwater in the Conasauga Group is usually found in fractures and solution cavities in the limestones of the upper part of the group. The yields are sufficient for domestic and industrial use.

Groundwater in the Pine Ridge area is generally encountered under unconfined conditions in weathered rocks and residual soils that overlie less weathered rocks (Exxon Nucl. Co. 1977). However, artesian conditions have been noted during periods of high water levels in relatively low-lying groundwater discharge areas. Recharge of groundwater in the area is mostly derived from local precipitation. Recharge occurs over the entire area and is most effective in those areas where the overburden soils are thin or permeable. Springs and seeps are common in the Pine Ridge Knolls area.

Groundwater levels follow the topography of the site, and groundwater movement is from topographically high areas to topographically low areas with a gradient of about 3% (Exxon Nucl. Co. 1977). Depth to the water table varies with seasonal recharge. Onsite investigations during portions of one year indicated that the water table lies about 4 m (13 ft) below the ground surface (Exxon Nucl. Co. 1977).

Based upon laboratory permeability tests, the maximum measured values of permeability for shallow residual soils from the site were found to be about 2.8×10^{-5} cm/s; onsite permeability tests in auger holes in weathered rock and soil indicated a range of permeability values from 2.2×10^{-5} to 3.4×10^{-3} cm/s (Exxon Nucl. Co. 1977). An effective porosity of 0.025 and a dispersivity coefficient of 0.9 m (3 ft) were determined for the areal aquifer based on the results of chloride tracer tests (Exxon Nucl. Co. 1977).

3.3.3 Climate and Meteorology

The climate at Oak Ridge is warm and humid. Summers are dominated by warm, moist air from the Gulf of Mexico. In the winter, cold, dry air masses from Canada are warmed as the air crosses the Cumberland Mountains and moves down the eastern slopes to the Oak Ridge area (U.S. Nucl. Reg. Comm. 1977). Precipitation averages 130 cm (53 in.) annually, and the relative humidity averages 70%. The maximum 24-hour rainfall is about 20 cm (8 in.). Snow is infrequent, but sometimes occurs in sufficient quantity to hinder traffic and outdoor activities.

Winds on the ridges blow predominately from the SW and WSW, although winds from the ENE are also frequent. Remnants of hurricanes and tropical storms occasionally affect the area (U.S. Nucl. Reg. Comm. 1977).

3.3.4 Ecology

The Pine Ridge Knolls site has two naturally occurring forest associations: oak-pine and oak-hickory (Nelson and Zillgitt 1969). Nearly pure stands of Virginia pine occur as successional forest, particularly on drier areas. Red cedar occurs occasionally in nearly pure stands, particularly on drier areas with limestone substrate. Cove hardwoods--including yellow poplar and white oak--occupy mesic, well-drained sites. Bottomland hardwoods--including sycamore, sweet gum, and elm--occur on less well-drained areas. Both steepness and aspect of slope have bearing on the distribution of forest types currently occupying the area. The oak-pine and mixed hardwood forest types probably represent climax vegetation on the site, and likely will not be replaced by natural succession barring catastrophic events that would destroy vegetation over large areas. Two types of catastrophic events apparently have had varying influence on the current status of the hardwood and pine forests. Burn-scarred trunks of hardwood trees indicate that fire has played a role in forest reproduction and understory vegetation. Secondly, infestations of the pine bark beetle during the past decade have killed pine trees and resulted in the growth of mixed pine and hardwoods (except in some areas where pines have been replanted).

A total of 251 species of birds are listed for Knox County (Howell and Monroe 1957). Of this total, 144 are considered as resident during all or some portion of the year, 51 as permanent residents, 42 as winter residents, and 51 as summer residents; the remainder are migrants, accidentals, and/or visitants. The Pine Ridge Knolls site contains a less diverse bird population because it lacks grassland and well-developed aquatic habitats. Of 96 species of birds that have been observed in the area (Exxon Nucl. Co. 1977), 45 are permanent residents, 7 are winter residents, 38 are summer residents, and the remaining 6 species are believed to be present only during migration. Four species of upland game birds occur regularly (bobwhite, ruffed grouse, American woodcock, and mourning dove), but hunting is not permitted in the area.

The larger mammals occurring on the site are predominantly associated with forested habitat (e.g., whitetailed deer, cottontail rabbits, gray squirrels, opossums, striped skunks, and mink). Small mammals occupying the site are shrews, mice, and voles. Flying squirrels are also found in the area.

A diversified group of amphibians and reptiles occurs within the region. The taxonomic groups represented by the greatest number of species are snakes (21) and salamanders (20), followed in order by frogs and toads (13), turtles (10), and lizards (7).

Five terrestrial animal species considered endangered by the U.S. Fish and Wildlife Service (1983) have been observed on or around the Oak Ridge Reservation. Mammal species are limited to the Indiana bat and the gray bat (Howell and Dunaway 1959). The Indiana bat inhabits caves and hollow trees, the latter habitat perhaps allowing the species to occur on the Reservation although neither species has been reported there (Proj. Manage. Corp. and Tenn. Val. Auth. 1975; Exxon Nucl. Co. 1977; U.S. Nucl. Reg. Comm. 1977; Boyle et al. 1982). Federally endangered and threatened bird species observed in the vicinity of the Reservation are the bald eagle (endangered, southern race; threatened, northern race--observed along the Clinch River), the peregrine falcon (endangered--not observed on the Reservation, but reported from neighboring Knox County), and the red-cockaded woodpecker (endangered--known to occur in Cumberland County about 80 km [50 mi] from the Reservation. Additionally, the eastern cougar has been sighted on the Reservation and thus should be considered part of the species range. However, the eastern cougar may be extirpated, with sightings actually being individuals of the western cougar race that have been released or escaped from captivity (Boyle et al. 1982).

Thirteen species of terrestrial fauna known or expected to occur on the Reservation are classified as endangered or threatened by the state of Tennessee (Hatcher, undated). These include the federally listed species above. Additional species include the Tennessee cave salamander (threatened), Bachman's (pinewoods) sparrow (endangered), sharp-shinned hawk (threatened), osprey (endangered), marsh hawk (threatened), Bewick's wren (threatened), Cooper's hawk (threatened), and the grasshopper sparrow (threatened). The sharp-shinned hawk and Bachman's sparrow have been observed on the Reservation and the other five bird species are expected to occur there (Kitchings and Mann 1987; Boyle et al. 1982; U.S. Dep. Energy 1982e).

No listed or proposed endangered and threatened plant species occur on Pine Ridge Knolls (U.S. Fish Wildl. Serv. 1983). However, two species that may occur on the site are under status review: Appalachian bugbane (Cimicifuga rubifolia) and Carey's saxifrage (Saxifraga careyana). Appalachian bugbane occurs in rich, sheltered, steep limestone bluffs whereas Carey's saxifrage occurs in wooded limestone bluffs. Both habitat types occur within Pine Ridge Knolls. Although those species are not legally protected under the Endangered Species Act, care should still be taken to avoid adversely impacting them.

None of the plant species listed as endangered by the state of Tennessee (Comm. Tenn. Rare Plants 1978) have been found on the Reservation. Several plant species found on the Reservation are rare, threatened, or of special concern, but they are primarily found in the designated natural areas of the Reservation (Kitchings and Mann 1976), not on Pine Ridge Knolls site. In addition to these species, Kitchings and Mann (1976) have listed plant species of special interest or of limited distribution within the Reservation, but none of these species occurs on Pine Ridge Knolls.

Only two bodies of water are contiguous to the Pine Ridge Knolls area, Grassy Creek and Bear Creek (see Section 3.3.2). Grassy Creek originates from a series of hardwater springs and has alternating pool and riffle habitats. It flows in a southwesterly direction and discharges into the Clinch River. Various bottom types include rock, gravel, sand, and mud. The creek probably serves as a spawning area for fish species from the Clinch River that tend to migrate to backwaters on up tributaries. Watercress grows in portions of this uncontaminated creek, and the phytoplankton and periphyton support zooplankton and a highly diverse benthic fauna. There is a diverse fish population in Grassy Creek (Exxon Nucl. Co. 1977). Bluegill is the major gamefish, threadfin shad is the dominant forage fish, gizzard shad is dominant in weight, and carp is the dominant rough fish in number and weight.

Bear Creek is larger than Grassy Creek and receives discharges from past and present disposal activities at the Y-12 plant (McMaster 1967). These discharges include known seepage from a series of disposal ponds and possible seepage or runoff from waste-burial areas. Except for some plant growth near the Y-12 plant, the upper portion of the stream is almost devoid of biota. The species diversity

is low and indicates poor water quality. Silt, in addition to gravel and mud, comprises a great part of the substrate material. The dominant gamefish in Bear Creek is rock bass, the most abundant forage fish is the common shiner, and the most abundant rough fish is the white sucker (Exxon Nucl. Co. 1977).

3.3.5 Land Use

The Pine Ridge Knolls site is within the corporate boundaries of the city of Oak Ridge. The city of Oak Ridge is located in Anderson and Roane counties, and is part of the Knoxville Standard Metropolitan Statistical Area. Oak Ridge is also classified as a subregional center of the East Tennessee Development District. This district is rural in character with agricultural, forest, and recreational lands comprising 95% of the 16-county area in 1979 (U.S. Dep. Energy 1982e--Table III-1). Oak Ridge Reservation is located within Anderson and Roane counties, where most of the land is rural in nature. The Pine Ridge Knolls site is in Roane County. The land-use category breakdown for the counties is shown in Table 3.12. The city of Oak Ridge has expressed interest in acquiring DOE land (between building complexes) for development purposes. Proposed development includes residential areas, industrial sites, an airstrip, and disposal of city sewage sludge on forested lands (U.S. Dep. Energy 1980).

Table 3.12. Land-Use Data for Anderson and Roane Counties, Tennessee^{†1}

Land-Use Category	Anderson County		Roane County	
	Hectares	Percentage	Hectares	Percentage
Residential	3,255	3.8	2,097	1.9
Commercial	146	0.2	93	0.1
Industrial	134	0.2	413	0.4
Recreational	4,170	4.8	28,749	25.5
Agricultural	22,834	26.5	33,887	30
Public and quasipublic	3,053	3.5	1,968	1.7
Forested	46,567	54.0	35,126	31.1
Oak Ridge Reservation	6,077	7.0	10,453	9.3

^{†1} Source: Data (hectares) from U.S. Department of Energy (1982e--Table III-2); data originally from East Tennessee Development District (1979).

There are no federally designated national wetlands or federally maintained wildlife refuges, parks, or forests near the Pine Ridge Knolls site (U.S. Dep. Energy 1982e). Although there are several small swampy areas within the Oak Ridge Reservation, none are located on the Pine Ridge Knolls site. Twenty-five natural areas within the Reservation have been identified as having scientific value because of species composition or stage of ecological development (U.S. Dep. Energy 1982c). There are no unique natural or cultural areas located on the Pine Ridge Knolls site (U.S. Dep. Energy 1980). The site is not suitable for agricultural use due to the poor soil and steep slopes. About 5,300 ha (13,000 acres) of the Reservation has been designated as a National Environmental Research Park (not including the Pine Ridge Knolls site).

In 1975, Exxon Nuclear Company, Inc., expressed an interest in the purchase or lease of a 1000-ha (2500-acre) site on the Oak Ridge Reservation for a proposed nuclear fuel reprocessing plant (U.S. Dep. Energy 1980). Although the site area is no longer being considered for a reprocessing plant, the Pine Ridge Knolls site is located within the proposed Exxon plant site and buffer zone area. Various portions of the Oak Ridge Reservation also are used for the storage and disposal of wastes, including: disposal of solid wastes (see Section 3.3.7) in near-surface landfills; disposal of liquid wastes in underground rock formations (by the hydrofracture method); and disposal of fly ash, cinders, construction wastes, oil, chemical liquid wastes (treated prior to discharge), and combustible and decomposable wastes by various disposal/storage methods (U.S. Dep. Energy 1980). West Chestnut Ridge, located directly south of the Pine Ridge Knolls site, has been proposed for development of a Central Waste Disposal Facility (CWDF) for disposal of radioactive wastes from the various facilities on the Oak Ridge Reservation (see Figure 3.13).

Interstates 40 and 75 and several local roads serve the site (see Section 3.5 for transportation routes). The Norfolk-Southern and Louisville & Nashville railroads currently operate in the Oak Ridge region. Barges can navigate on the Tennessee River to Knoxville and on the Clinch River to Clinton.

3.3.6 Population and Socioeconomics

3.3.6.1 Population

The Oak Ridge Reservation is located in Anderson and Roane counties, and the Pine Ridge Knolls site is in Roane County. Other nearby counties include Knox, Loudon, and Morgan. The major population centers within 80 km (50 mi) of the site include the cities of Knoxville and Oak Ridge. According to Census Bureau data (Table 3.13), the populations of all five counties near the Oak Ridge site increased from 11.7 to 24.5% between 1970 and 1980. The population size of the cities of Knoxville and Oak Ridge changed only marginally during the decade of the 1970s. Population density in 1980 ranged from 12/km² (31/mi²) for Morgan County to 243/km² (629/mi²) for Knox county. The populations located within a 16-km (10-mi) and an 80-km (50-mi) radius of the Pine Ridge Knolls site have been estimated at about 54,600 and 756,700, respectively, in 1980 (Exxon Nucl. Co. 1977).

Table 3.13. Population Data for the Oak Ridge Reservation Area, 1970-1980

	1970† ¹		1980† ²		% Change in Population, 1970-1980
	Population	Population Density (no./km ²)	Population	Population Density (no./km ²)	
County					
Anderson	60,300	70	67,300	78	+12
Knox	276,300	210	319,700	243	+16
Loudon	24,300	40	28,600	47	+18
Morgan	13,600	10	16,600	12	+22
Roane	38,900	43	48,400	53	+24
City					
Knoxville	174,900	-	175,000	-	+ 0.1
Oak Ridge	28,400	-	27,700	-	- 2.5

†¹ U.S. Bureau of the Census (1970a).

†² U.S. Bureau of the Census (1980a).

3.3.6.2 Economy

The local economy is dominated by the manufacturing industry, which accounts for about 33% of all employment. The wholesale and retail trades/ services and government sector account for 20% and 19% of all employment, respectively, but the mining and government sectors are more important to the region than to the entire state (U.S. Dep. Energy 1982c). For example, much of the manufacturing employment in Anderson and Roane counties derives from government-related contract work. Because Knoxville is the center of commerce for the region, Knox County has the largest proportional employment in all economic sectors except mining.

3.3.6.3 Public Facilities

There are 21 schools with an estimated 1980 enrollment of 11,000 students in the communities located within 16 km (10 mi) of the Oak Ridge Reservation (U.S. Dep. Energy 1979). Facilities for law enforcement, health care, and fire protection in the counties surrounding the site had been considered more than adequate to meet the needs of the area (U.S. Dep. Energy 1982c). However, local government representatives have recently questioned the adequacy of health and emergency services (Peele 1984).

The National Register of Historic Places lists 23 sites in the five-county area (Anderson, Knox, Loudon, Morgan, and Roane), four of which exist within about a 16-km (10-mi) radius of the site (U.S. Dep. Energy 1979). Additionally, there are 45 sites of archaeological significance near the Oak Ridge Reservation, most of which are distributed along the Clinch River mainstream. The American

Museum of Science and Energy is located in Oak Ridge about 14 km (9 mi) northeast of the Reservation. There are no known historical, architectural, or archaeological properties located on the Pine Ridge Knolls site that possess the qualities required for eligibility to the National Register (Tenn. Hist. Comm. 1977, 1983).

Although there are no hunting areas, wildlife preserves, or sanctuaries in the immediate vicinity of the site, a waterfowl refuge is located on the Tennessee River about 16 km (10 mi) west-northwest of the site. About 69 ha (170 acres) of the Reservation is also used as a natural study area for ecological observation and experimentation. Information on recreational areas located near the Pine Ridge Knolls site may be found in other publications (U.S. Dep. Energy 1979--p. 4-4; Proj. Manage. Corp. and Tenn. Val. Auth. 1975).

3.3.7 Existing Radiological Environment

Radioactive wastes have been generated at the various research and production facilities on the Oak Ridge Reservation since 1943. The major facilities include the Gaseous Diffusion Plant (enriched uranium production), the Y-12 Plant (nuclear weapons production), and the Oak Ridge National Laboratory (research). The inventory of solid radioactive wastes, as of 1982, included: about 6,200 m³ of solid transuranic wastes and 12,000 to 1,600,000 m³ of transuranic-contaminated soils having a total radioactivity of 2,100 Ci; 1,000 m³ (28,000 Ci) of defense wastes stored in buildings and lined holes in the ground; and 330,000 m³ (600,000 Ci) of low-level wastes, including fissile materials, trash, and contaminated equipment (U.S. Dep. Energy 1982f--Tables 3.3, 3.4, and 4.9, Figure 4.1).

The Oak Ridge facilities and the radioactive waste disposal areas contribute radioactive emissions to the atmosphere, water, and land. Radioactivity in these media has been monitored for several years (Union Carbide Corp. 1981, 1982). A whole-body dose from direct radiation to a "hypothetical maximally exposed individual" at the boundary of the Reservation was calculated to be 6.1 mrem/yr and the cumulative whole-body dose to the population within an 80-km radius of the Oak Ridge facilities from 1980-1981 effluents averaged 20.2 person-rem (Union Carbide Corp. 1981, 1982). The individual dose from natural background radiation sources (cosmic and terrestrial sources) in Tennessee is approximately 100 mrem/yr (Natl. Counc. Radiat. Prot. Measure. 1975).

3.4 OCEAN DISPOSAL SITE

The 106-Mile Ocean Waste Disposal Site (Site 106) is a designated ocean waste-disposal site. The site is managed by the U.S. Environmental Protection Agency, who prepared a detailed description of the site in 1980 as part of the Final Environmental Impact Statement for designating the disposal site (U.S. Environ. Prot. Agency 1980--Appendix A and B). Environmental characterization studies are performed by the National Oceanic and Atmospheric Administration (1975, 1977a, 1977b, 1977c), who has research and monitoring responsibilities for dumpsites under authority of Title II of the Marine Protection, Research and Sanctuaries Act. Site 106 is 1640 km² (478 nmi²) of ocean surface over the lower edge of the Continental Slope and the upper edge of the Continental Rise where water depths are 1400 m (4600 ft) to 2750 m (9020 ft) (Figure 2.12). It is used for disposal of a variety of industrial and municipal wastes (U.S. Environ. Prot. Agency 1980). These wastes are dumped in bulk into the surface waters of the site where they are dispersed by oceanic mixing processes. Containerized or packaged wastes are not dumped at Site 106. For purposes of analysis in this EIS, this site is being considered as a potential site for ocean disposal of NFSS wastes.

3.4.1 Climate

Weather at Site 106 has been characterized by Brower (1977). Stable summer and early autumn weather conditions are dominated by the Bermuda High, although occasional tropical storms and hurricanes occur during late summer and fall. In winter, extreme weather is produced by storm fronts from the northeast and south. The frequency of high winds and waves is greatest for the months of November through March when winds greater than 17 m/s (34 knots) occur more than 5% of the time and waves higher than 2.5 m occur 25% of the time or more. During the proposed action period (May through October), the frequencies of high winds and waves are less (a frequency range of 0.2% in June to 2.9% in October for winds greater than 17 m/s; a frequency range of less than 3% in August to 20% in October for waves greater than 2.5 m in height).

3.4.2 Open-Water Environment

Site 106 lies in an area of complex oceanographic character between the Continental Shelf and the Gulf Stream (Figure 2.12). Although the surface waters of the site are often characteristic of the Continental Slope, regional atmosphere/ocean dynamics can drive Continental Shelf waters over the surface of the site. Occasionally, loops of the Gulf Stream pinch off to become large warm-core rings (approximately 56 km [30 nmi] in diameter) that move southwestward through the site toward Cape Hatteras. Warm-core rings are expected to occupy the dumpsite an average of 70 days per year (Bisagni 1976).

Open-water biota are characteristic of the different water types that may occupy Site 106. Surface biota may be either colder, shallower-water species from Shelf water; warmer oceanic forms

from Gulf Stream water in warm-core rings; or species from Slope water. Midwater biota include small fish that are day/night vertical migrants as well as squid, octopus, and jellyfish. Large fish such as tunas, swordfish, and sharks are seasonal migrants to the area. Three of five sea turtles from the area (hawksbill, leatherback, and green) are pelagic in habit and may pass through the site (U.S. Environ. Prot. Agency 1980). The leatherback is an endangered species and the green is a threatened species. Whales and dolphins could occasionally pass through the disposal site vicinity either as temporary residents or during migration, based on their ranges (Leatherwood et al. 1976). There are no records of sightings of marine mammals or sea turtles in the dumpsite.

3.4.3 Sea Floor Environment

Site 106 is located at the lower edge of the Continental Slope and the upper edge of the Continental Rise (Figure 2.12). Sediments are composed of silts and sandy silts deposited under tranquil (Slope) or shifting (Rise) conditions (U.S. Environ. Prot. Agency 1980). Concentrations of suspended particulates just above the sediment surface are less than 50 to 100 $\mu\text{g/L}$, approximately the same order of magnitude as concentrations at the surface ($<100 \mu\text{g/L}$). The total quantity of suspended particulates in a 30-m layer above the bottom is <10 to $200 \mu\text{g/cm}^2$ (Biscaye and Olsen 1976).

Water movements at the sediment surface appear to be very slow based on photographs of the bottom that do not show features associated with bottom currents (Heezen 1975, 1977). A net water velocity of 2 cm/s has been measured 180 km (110 mi) northeast of Site 106. The sediment surface shows evidence of mixing due to activities of animals living in the sediment (infauna). These organisms are primarily worms and various burrowing clams. Crawling animals such as brittle stars, anemones, sea urchins, and sea cucumbers live on the sediment surface (epifauna). Larger bottom-dwelling (benthic) swimming animals include 55 species of fish--the most common being eels, rattails, halosaurus, and lizard fish. Maximum densities of dominant benthic faunal components are epifauna, $2.5/\text{m}^2$; infauna, $1180/\text{m}^2$; and bottom-dwelling fish, 0.01 to $2.2/\text{m}^2$ (U.S. Environ. Prot. Agency 1980).

3.4.4 Resource Use

The U.S. Environmental Protection Agency (1980) concluded that few other resource activities occurred at Site 106 before its designation as a disposal site. The site is not within oil or gas lease areas, no shipping lanes cross it, and no mineral resources are known to occur there. Commercial fish or shellfish species inhabiting the site include (1) swordfish, sharks, and tunas, (2) red crab (larvae and adults), which are caught by trawler on the Continental Shelf, and (3) grey sole (juveniles), which occur as adults on the Grand Banks farther north off the coast of Canada. The only fishing actively known to occur in the Slope waters within 80 km (50 mi) of the site is longline fishing for sharks, swordfish, and tunas (Casey and Hoenig 1977).

3.4.5 Natural Abundance of Radioactive and Nonradioactive Materials

Uranium and thorium radionuclides and their decay products are naturally occurring components of the ocean environment that enter the sea from erosion of the land masses. The decay series of the predominant uranium isotope uranium-238 (and its decay product, uranium-234) includes the longer-lived thorium-230 isotope, which is scavenged by particles and deposited on the sea floor. Thorium-230 decay produces radium-226, which is mobilized into the pore water of the sediments and enriches the bottom of the overlying water column. The variations in abundance of naturally occurring radionuclides depends upon variations in oceanic sedimentation rates, water mass mixing, and major ocean circulation (Cochran 1982). Deep sea sediments are enriched in radium-226 ($\sim 20 \text{ pCi/g}$) whereas the sediment concentrations of the Continental Shelf and Slope are similar to typical inland soil concentrations of 1 pCi/g . Site 106 sediments for which data are not available, are more likely of the latter concentration. Open water concentrations of radium-226 in ocean surface waters are 0.1 pCi/L (Goldberg et al. 1972; Cochran 1982).

Since 1961, Site 106 has been used for disposal of industrial wastes containing elevated concentrations of trace metals including manganese, copper, zinc, cadmium, and lead. Based on monitoring studies for biota, sediments, and water of the site (Natl. Oceanic Atmos. Admin. 1975; Greig and Wenzloff 1977), the ranges of sediment concentrations (ppm dry weight) for selected trace metals are: cadmium, 1.2-1.8 ppm; chromium, 16.8-28.6 ppm; copper, 13.4-37.2 ppm; nickel, 12.6-33.6 ppm; lead, 16.0-38.8 ppm; and zinc, 33.2-65.0 ppm.

3.5 TRANSPORTATION ROUTES

The preferred truck transportation routes for alternatives involving offsite transportation of the NFSS wastes and/or residues (Alternatives 3a, 3b, 4a, 4b, 4c, and 4d) are described in this section. Route selection criteria and alternative routes are discussed in Appendix D. For purposes of analysis, it is assumed that interstate highways will be used, where possible, and that the most direct U.S. or state highways will be used where interstates are not available. A preferred route is the one that has the fewest people living near it (Section D.4). Preferred and alternative routes are shown in Figure 3.17. The three transportation routes for offsite disposal scenarios are compared in Table 3.14.

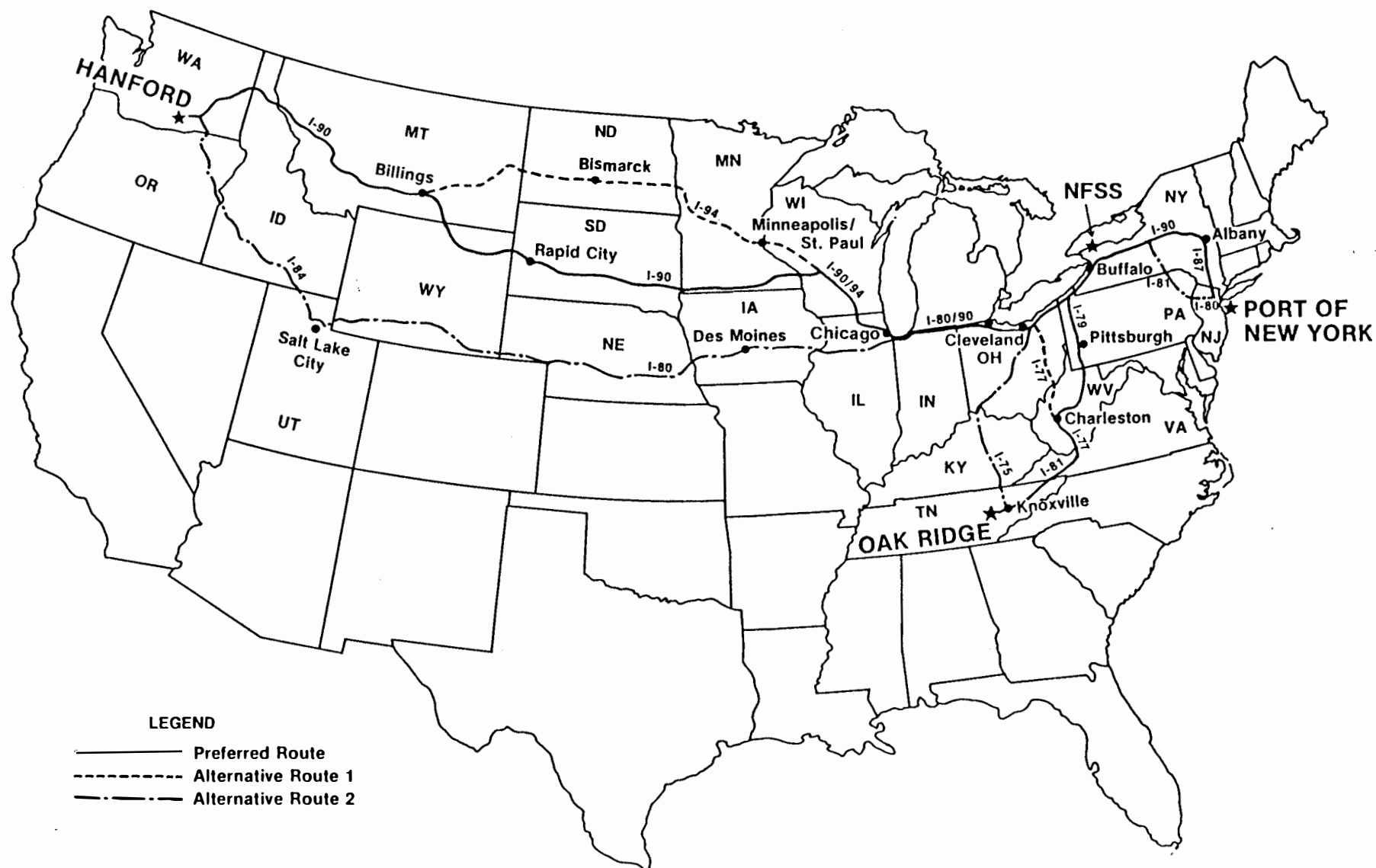


Figure 3.17. Preferred and Alternative Truck Transportation Routes.

Table 3.14. Three Transportation Routes Used to Transport the Radioactive Wastes from NFSS to the Final Deposition Site

Alternative	Local Roads Near NFSS	Interstate	Near Final Disposal Site	Total One-Way Distance
To Hanford (3a, 4a, and 4b)	12 km of local roads and highways in semirural area	3900 km crossing 12 states	140 km of local roads and highways in semirural/rural area	4100 km
To Oak Ridge (3b, 4c, and 4d)	12 km of local roads and highways in semirural area	1300 km crossing 5 states	10 km of local roads and highways in semirural/rural area	1300 km
To Harbor (4b and 4d)	12 km of local roads and highways in semirural area	710 km within New York and possibly within New Jersey	50-180 km (depending on final port selected) of interstates, major highways, and local roads in dense urban area	770-900 km

For purposes of analysis in this EIS, it is assumed that the NFSS residues will be transported to the final disposal destination in steel containers on either shielded vans or flat-bed, semitrailer trucks (depending on the radioactivity of the material). The lower-activity NFSS wastes will be transported by 15-m³ (20-yd³) dump trucks (each truck containing only 12.3 m³ [16 yd³] due to weight limitations). Details regarding packaging and transport vehicles are given in Appendix D.

3.5.1 Local Route from NFSS to Interstate System and Intersection with I-90 East of Buffalo

The wastes and/or residues will leave NFSS via the same route for all offsite alternatives (Figure 3.18). From the NFSS main gate off Pletcher Road, the trucks will proceed west on Pletcher Road, south on Route 18 (Creek Road), and west and south on U.S. Route 104. From this point, interstate highways will be taken: southeast on I-190 around Buffalo, and then east and south on I-290 to the east side of Buffalo (Figure 3.19). Beyond this point, the routes vary to the three alternative sites (Hanford, Oak Ridge, and Harbor).

3.5.2 Route to Hanford

From the Intersection of I-290 and I-90 just east of Buffalo, the routing is as follows: south around Buffalo on I-90; southwest on I-90 along the Lake Erie coastline through Pennsylvania and Ohio to Cleveland; south on I-271 to I-80/90; west through northern Indiana to Chicago; around Chicago on I-294 to I-90; northwest on I-90 into Wisconsin; southern Minnesota, central South Dakota, north-eastern Wyoming, and southern Montana; west from Billings, Montana, on I-90/94 through northern Idaho and Washington to Ritzville; southwest on U.S. 395 to Highway 240 to Richland; and north on Route 2 onto the Hanford Reservation. Route 4 and other onsite roads will be used to transport the wastes the remaining 8 km to the 200-West Area (Figure 3.20). The local and interstate routes to Hanford are summarized in Table 3.14.

3.5.3 Route to Oak Ridge

From the intersection of I-290 and I-90 just east of Buffalo, the route to Oak Ridge is as follows: south on I-290 around Buffalo and southwest on I-90 along the Lake Erie coastline to Erie, Pennsylvania; south on I-79 through Pennsylvania to Charleston, West Virginia; south on I-77 to Wytheville, Virginia; southwest on I-81 to its junction with I-40 at Dandridge, Tennessee; on I-40 to Knoxville, Tennessee; around Knoxville on I-40; west on I-40 to State Highway 95 (White Wing Road); north 7 km over the Clinch River; west on Bear Creek Road for about 1-2 km to the Pine Ridge Knolls site. The route to Oak Ridge is summarized in Table 3.14; the local route is illustrated in Figure 3.21.

3.5.4 Route to Harbor

From the intersection of I-290 and I-90 just east of Buffalo, the route to the Harbor (Port of New York) is as follows: I-90 to Albany (using interstates circumventing Syracuse and Utica) and south on I-87 through Newburgh to I-87/287 near the New York/New Jersey border. At this point, the route depends upon the final location of the barge dock to be used. The Harbor area is saturated with interconnecting interstates and major four-lane roads (Figure 3.22). These areas are also densely populated. The route to the Harbor is summarized in Table 3.14.

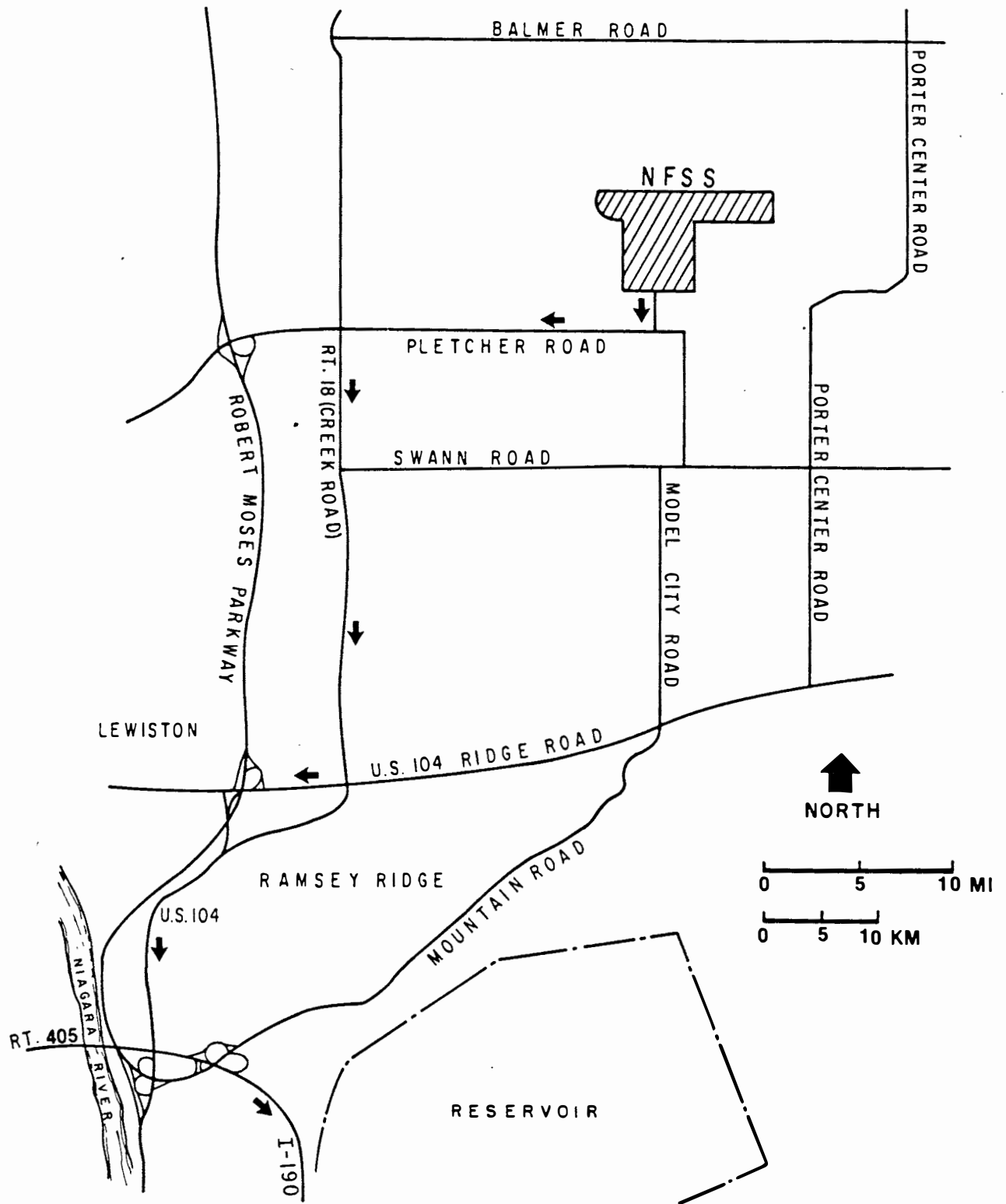


Figure 3.18. Local Route from NFSS to Interstate 190.

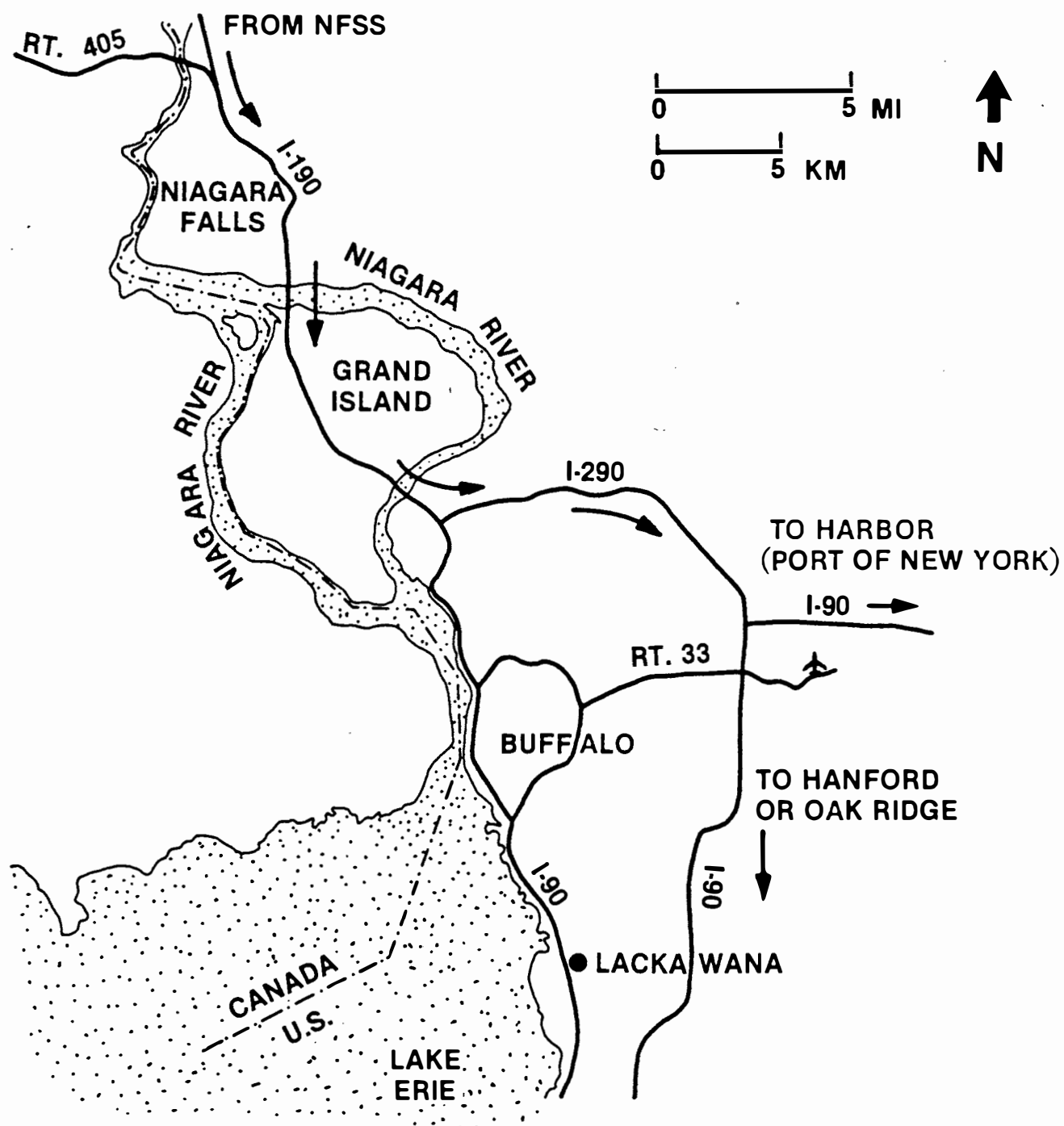


Figure 3.19. Route from I-190 to Intersection with I-90 East of Buffalo.

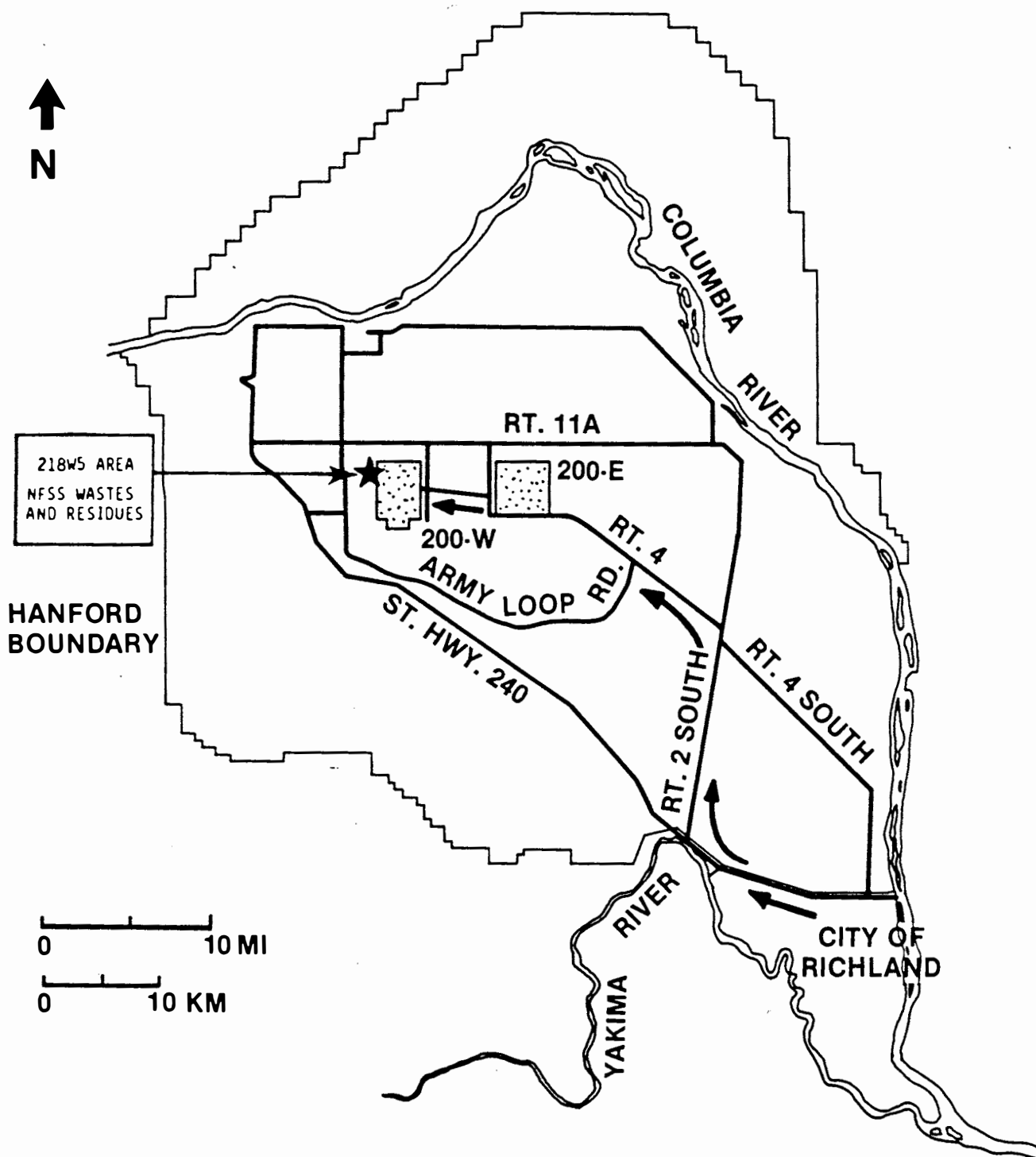


Figure 3.20. Local Route to Hanford Site.

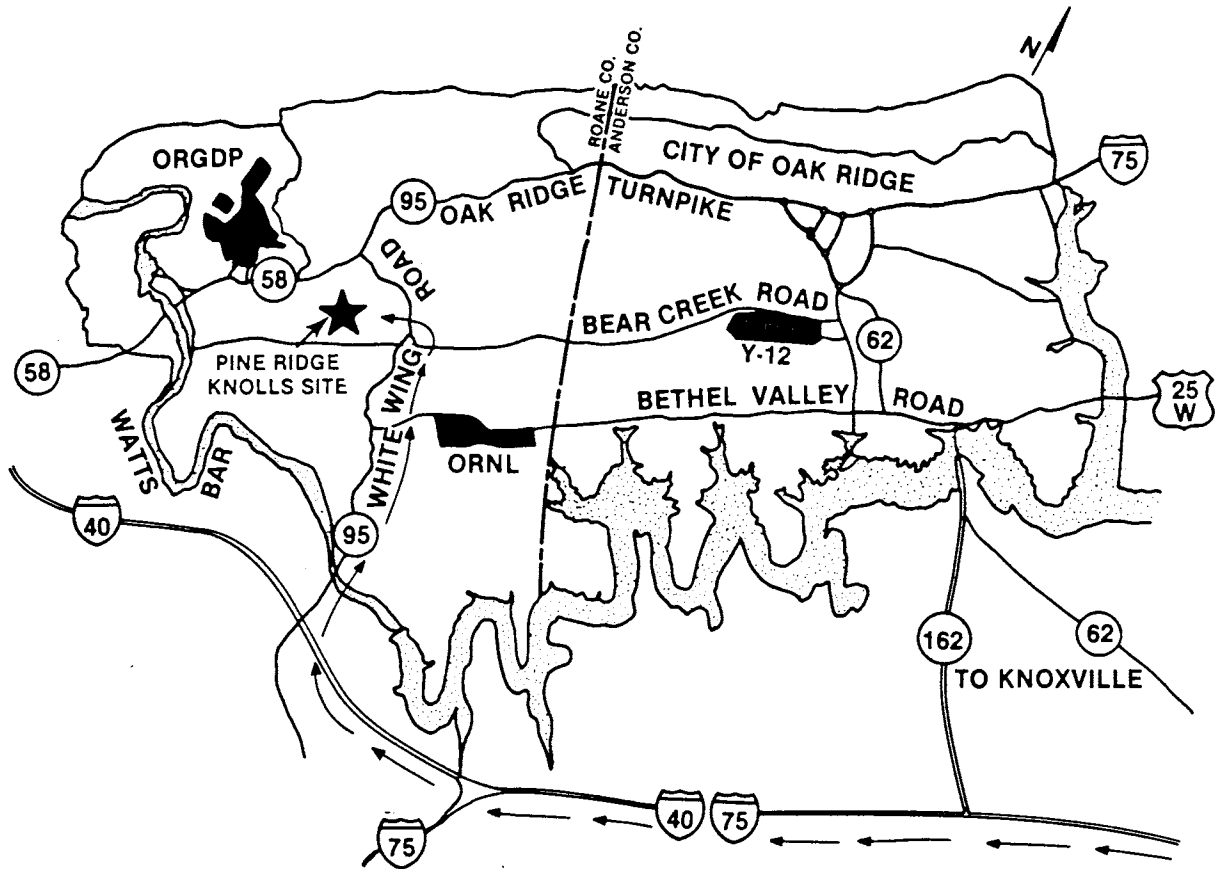


Figure 3.21. Local Route to Oak Ridge Site.

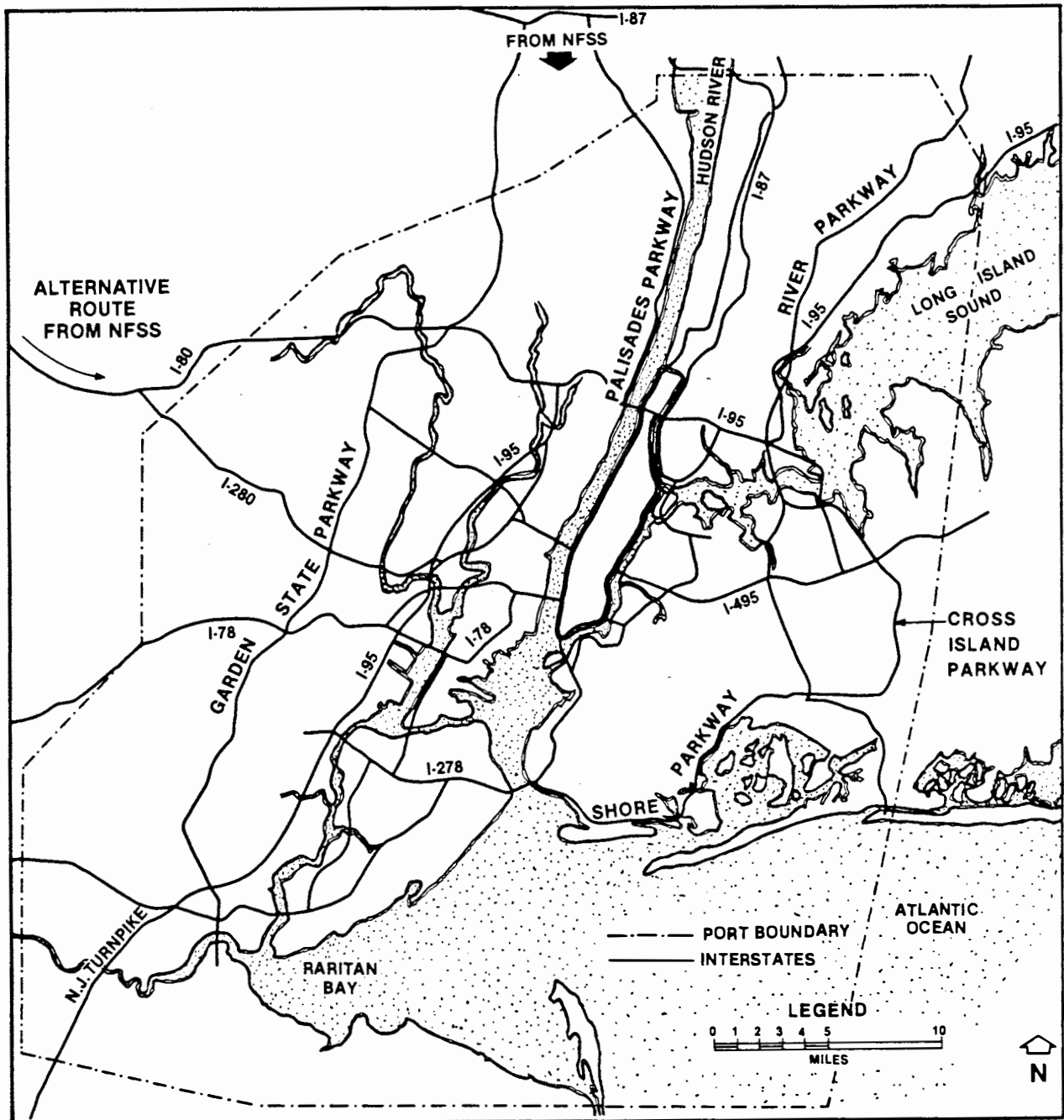


Figure 3.22. Roadways to Deliver NFSS Wastes to the Harbor (Port of New York).

REFERENCES (Chapter 3)

- Acres American Incorporated. 1981. Hydrologic and Geologic Characterization of the DOE-Niagara Falls Storage Site. Prepared for NLO, Incorporated, Fernald, OH, by Acres American Incorporated, Buffalo, NY. September 30, 1981.
- Aerospace Corporation. 1982. Background and Resurvey Recommendations for the Atomic Energy Commission Portion of the Lake Ontario Ordnance Works. Aerospace Report No. ATR-82 (7963-04)-1. Prepared for the U.S. Department of Energy.
- Anderson, T.L., J.F. Dettorre, D.R. Jackson, and B.S. Ausmus. 1981. A Comprehensive Characterization and Hazard Assessment of the DOE-Niagara Falls Storage Site. BMI-2074 (Revised). Prepared for the U.S. Department of Energy, Remedial Action Program, by Battelle Columbus Laboratories, Columbus, OH. June 1981. 3 v.
- Bechtel National, Inc. 1984a. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. DOE/OR/20722-1. Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. January 1984.
- Bechtel National, Inc. 1984b. Geologic Report, Niagara Falls Storage Site, Lewiston, New York. DOE/OR/20722-8. Prepared for U.S. Department of Energy. June 1984.
- Bisagni, J.J. 1976. Passage of Anticyclonic Gulf Stream Eddies Through Deepwater Dumpsite 106 During 1974 and 1975. NOAA Dumpsite Eval. Rep. 76-1. Prepared for National Oceanic and Atmospheric Administration by National Marine Fisheries Service, Narragansett, RI.
- Biscaye, P.E., and C.R. Olsen. 1976. Suspended particulate concentrations and compositions in the New York Bight, pp. 124-137. In M.G. Gross (ed.), Middle Atlantic Continental Shelf and the New York Bight. Proceedings of the Symposium, American Museum of Natural History, New York City, November 3-5, 1975. Special Symposia, Volume 2. American Society of Limnology and Oceanography, Inc., Lawrence, KS.
- Bowen, H.J.M. 1979. Environmental Chemistry of the Elements. Academic Press, New York. pp. 59-61.
- Boyle, J.W., R. Blumberg, S.J. Cotter, G.S. Hill, C.R. Kerley, R.H. Ketelle, R.L. Kroodsmas, D.W. Lee, R.C. Martin, R.D. Roop, D.N. Secora, W.P. Staub, and R.E. Thoma. 1982. Environmental Analysis of the Operation of Oak Ridge National Laboratory (X-10 Site). ORNL-5870. Prepared for U.S. Department of Energy by Oak Ridge National Laboratory, Oak Ridge, TN. November 1982.
- Brado, M.B. 1982. Personal communication (Town Clerk, Town of Lewiston, NY) to Bechtel National, Inc.
- Braun, E.L. 1972. Deciduous Forests of Eastern North America. Hafner Publishing Company, New York. 596 pp. (Facsimile of 1950 edition).
- Brower, Jr., W.A. 1977. Climatic study of New York Bight, pp. 117-218. In Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Vol. I, Physical Characteristics. NOAA Dumpsite Eval. Rep. 77-1. National Oceanic and Atmospheric Administration, Rockville, MD.
- Brown, D.J., and Isaacson, R.E. 1977. The Hanford Environment as Related to Radioactive Waste Burial Grounds and Transuranium Waste Storage Facilities. ARH-ST-155. Prepared by Atlantic Richfield Hanford Company, Richland, WA, for the U.S. Energy Research and Development Administration.
- Casey J.G., and J.M. Hoenig. 1977. Apex Predators in Deepwater Dumpsite 106, pp 309-376. In Baseline Environmental Report of Environmental Conditions in Deepwater Dumpsite 106. Volume II. Biological Characteristics. National Oceanic and Atmospheric Administration. June 1977.
- Cochran, J.K. 1982. The use of naturally occurring radionuclides as tracers for biologically related processes in deep-sea sediments, pp. 55-72. In W.G. Ernst and J.G. Morin (eds.), The Environment of the Deep Sea. Rubey Volume II. Prentice-Hall, Inc., Englewood Cliffs, NJ.
- Committee for Tennessee Rare Plants. 1978. The rare vascular plants of Tennessee. J. Tenn. Acad. Sci. 53:128-133.
- Eardley, A.J. 1962. Structural Geology of North America. Harper and Row, New York.
- East Tennessee Development District. 1979. Land Use Plan, 1979-2000. Knoxville, TN. [As cited by U.S. Department of Energy (1982e).]
- Economic Consultants Organization, Inc. 1982. Population Disaggregations for Transportation Purposes 1982. Final Report.

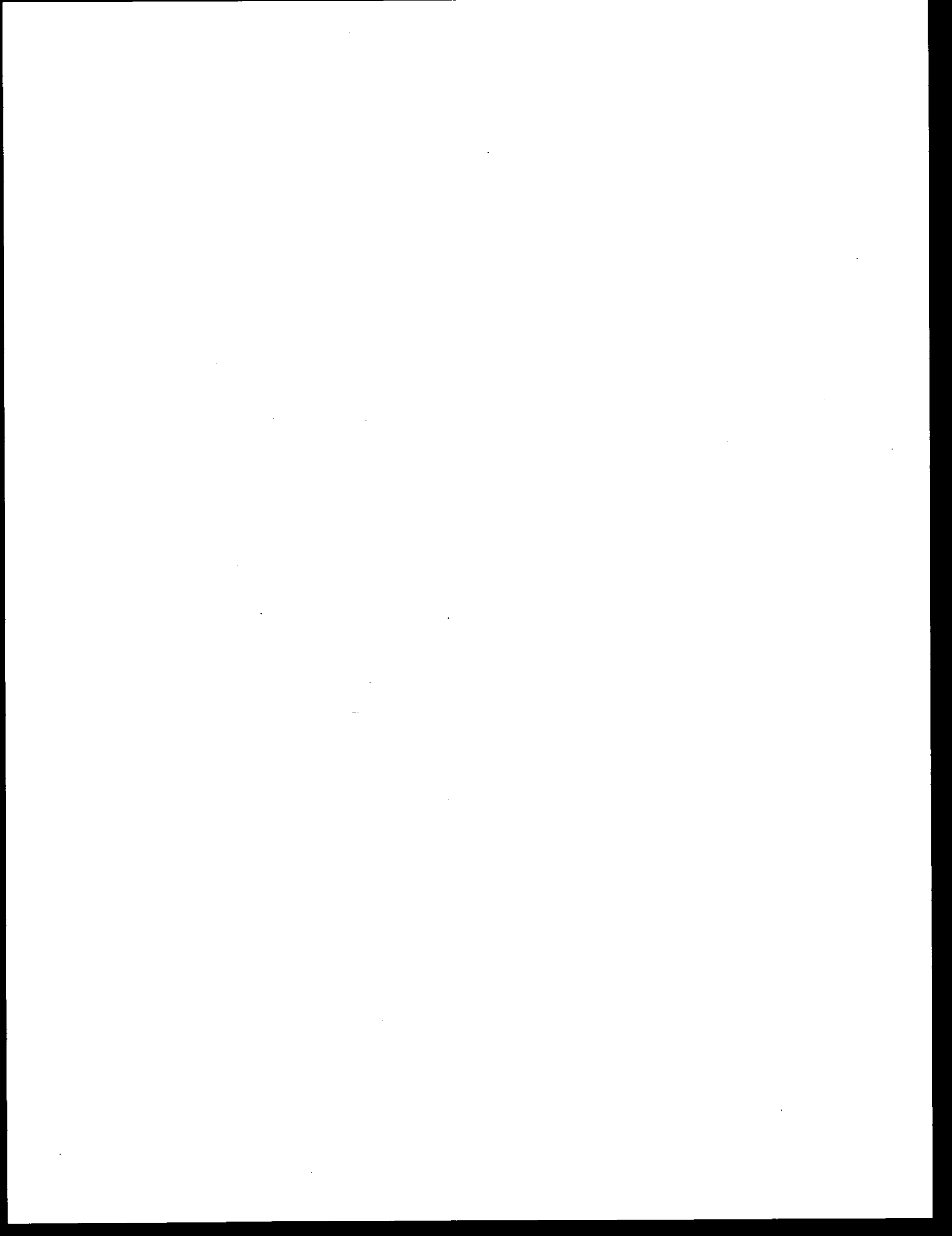
- Environmental Quality Advisory Board. 1983. Memorandum dated September 31, 1983, to Honorable Mayor and Members of City Council regarding "Long-Term Management of Radioactive Wastes from Niagara Falls on the Oak Ridge Reservation." 5 pp.
- Erie and Niagara Counties Regional Planning Board. 1978a. 208 Water Quality Management Program. Report No. 4, Environmental Inventory. Amherst, NY.
- Erie and Niagara Counties Regional Planning Board. 1978b. Ground Water Problems/Analysis. Report 13. Water Quality Management Program.
- Exxon Nuclear Company, Inc. 1977. Nuclear Fuel Recovery and Recycling Center. XN-FR-33. Environmental Report, Docket No. 50-564. Vol. 1 and 3.
- Fox, F.L. 1970. Seismic geology of the eastern United States. Bull. Assoc. Eng. Geol. 7(1&2):21-43.
- Garrison, G.A., A.J. Bjugstad, D.A. Duncan, M.E. Lewis, and D.R. Smith. 1977. Vegetation and Environmental Features of Forest and Range Ecosystems. U.S. Forest Service Agricultural Handbook No. 475.
- Gephart, R.E., et al. 1979. Stratigraphy and Tectonics of East Umtanum Ridge, South Central Washington. Abstract, EOS (Transactions). American Geophysical Union, Vol. 58.
- Goldberg, E.D., W.S. Broecker, M.G. Gross, and K.K. Turekian. 1972. Marine Chemistry, pp 137-146. In Radioactivity in the Marine Environment. National Academy of Sciences.
- Greig, R., and D. Wenzloff. 1977. Final Report on Heavy Metals in Small Pelagic Finfish, Euphausiid Crustaceans, and Apex Predators, Including Sharks, As well As on Heavy Metals and Hydrocarbons (C₁₅) in Sediments Collected at Stations in and near Deepwater Dumpsite 106, pp 547-564. In Baseline Report of the Environmental Conditions in Deepwater Dumpsite 106. Volume III: Containment Inputs and Chemical Characteristics - Appendix. National Oceanic and Atmospheric Administration. June 1977.
- Hadley, J.B., and J.F. Devine. 1974. Seismotectonic Map of the Eastern United States. Miscellaneous Field Study 620. U.S. Geological Survey.
- Hamilton, P.P. 1983. Letter (U.S. Fish and Wildlife Service) to L.F. Campbell (U.S. Department of Energy, Oak Ridge Operations), February 28, 1983.
- Hatcher, R.M. Undated. Endangered or Extinct. The Difference Could Be You. Tennessee Wildlife Resources Agency, Nashville, TN.
- Haywood, F. 1983. Results of Analysis of Three (3) NFSS Central Ditch Samples for EPA Priority Pollutants. Memorandum from F. Haywood (Eberline Instrument Corporation) to E. Walker (Bechtel National, Inc.), March 3, 1983.
- Heezen, B.C. 1975. Photographic reconnaissance of continental slope and upper continental rise, pp. 27-103. In May 1974 Baseline Investigation of Deepwater Dumpsite 106. NOAA Dumpsite Eval. Rep. 75-1. Prepared by National Oceanic and Atmospheric Administration, Rockville, MD. Published by U.S. Department of Commerce and Environmental Protection Agency.
- Heezen, B.C. 1977. Six dives to the lower continental slope and upper continental rise southwest of Hudson Canyon, pp. 9-28. In Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Vol. I, Physical Characteristics. NOAA Dumpsite Eval. Rep. 77-1. National Oceanic and Atmospheric Administration, Rockville, MD.
- Higgins, B.A., P.S. Puglia, R.P. Leonard, T.D. Yoakum, and W.A. Wietz. 1972. Soil Survey of Niagara County, New York. U.S. Soil Conservation Service and Cornell University Agricultural Experimental Station. Washington, DC.
- Howell, J.C. and P.B. Dunaway. 1959. Long-Term Ecological Study of the Oak Ridge Area: II. Observations on the Mammals with Special Reference to Melton Valley. ORNL Files 59-10-126 (unpublished document). Oak Ridge National Laboratory, Oak Ridge, TN. 24 pp.
- Howell, J.C., and M.B. Monroe. 1957. The birds of Knox County, Tennessee. J. Tenn. Acad. Sci. 32(4):247-322.
- Interstate Commerce Commission. 1981. Supplemental Draft Environmental Impact Statement, Finance Docket No. 29255, Somerset Railroad Corporation--Construction, Acquisition and Operation--of Line of Railroad in Niagara County, New York. Prepared by Interstate Commerce Commission, Office of Policy and Analysis, Energy and Environmental Branch; and Tera Corporation. October 1981.

- Johnston, R.H. 1964. Groundwater in the Niagara Falls Area, New York. N.Y. Water Resources Comm. Bull. GW-53.
- Kitchings, T., and L.K. Mann. 1976. A Description of the Terrestrial Ecology of the Oak Ridge Environmental Research Park. ORNL/TM-5073. Oak Ridge National Laboratory, Oak Ridge, TN.
- Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, Dolphins, and Porpoises of the Western North Atlantic - A Guide to Their Identification. NOAA Tech. Rep. NMFS Circ-396. National Oceanic and Atmospheric Administration, Seattle, WA.
- Litz, J.E. 1974. Treatment of Pitchblende Residues for Recovery of Metal Values. HRI Project No. 1373. Prepared by Hazen Research, Inc., Golden, CO, for Cotter Corporation, Canon City, CO. May 1974.
- Marshall, E. 1983. The "lost" mercury at Oak Ridge. Science 221:130-132.
- Mathiason, G.L. 1981. 1980 Census of Population, Final Counts, Niagara County. Niagara County Affiliate Data Center. Table 2-1.
- McMaster, W.M. 1967. Hydrologic Data for the Oak Ridge Area, Tennessee. U.S. Geol. Surv. Water-Supply Pap. 1839-N. 60 pp.
- Mellinger, M.V., and S.J. McNaughton. 1975. Structure and function of successional vascular plant communities in central New York. Ecol. Monogr. 45:161-182.
- Merritt, R. 1983. Nuclear wastes--little or no hazard, benefits. The Oak Ridger, November 1, 1983.
- National Council on Radiation Protection and Measurements. 1975. Natural Background Radiation in the U.S. NCRP Report No. 45. Washington, DC.
- National Oceanic and Atmospheric Administration. 1973. Local Climatological Data, Annual Summary with Comparative Data, Oak Ridge, Tennessee. U.S. Department of Commerce, Environmental Data Service.
- National Oceanic and Atmospheric Administration. 1975. Baseline Investigation of Deepwater Dumpsite 106 (May 1974). NOAA Dumpsite Eval. Rep. 75-1. Published by U.S. Department of Commerce and Environmental Protection Agency. Rockville, MD. December 1975.
- National Oceanic and Atmospheric Administration. 1977a. Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Vol. I, Physical Characteristics. NOAA Dumpsite Eval. Rep. 77-1. Rockville, MD.
- National Oceanic and Atmospheric Administration. 1977b. Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Vol. II, Biological Characteristics. NOAA Dumpsite Eval. Rep. 77-1. Rockville, MD.
- National Oceanic and Atmospheric Administration. 1977c. Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Vol. III, Contaminant Inputs and Chemical Characteristics; Appendix. NOAA Dumpsite Eval. Rep. 77-1. Rockville, MD.
- Nelson, T.C., and W.M. Zillgitt. 1969. A Forest Atlas of the South. U.S. Forest Service, Southern Forest Experimental Station, New Orleans, LA. 27 pp.
- New York State Department of Environmental Conservation. 1975. Water Quality Management Plan for Planning Area 03-01 Lake Ontario West.
- New York State Department of Environmental Conservation. 1981. Fish Stocking List (Region 9).
- New York State Department of Labor. 1982. Annual Planning Information for Manpower Planners, Buffalo SMSA in New York State, Fiscal Year 1983. BLMI Report No. 36, FY 1982. Bureau of Labor Market Information, Division of Research and Statistics, Albany, NY.
- New York State Department of Transportation. 1982. 1981 Traffic Volume Report, Planning Division, State Campus, Albany, NY.
- Peele, R. 1984. Remarks given at a public hearing held by the U.S. Department of Energy at the American Museum of Science and Industry, Oak Ridge, TN, September 20, 1984.
- Peele, R., and J.A. Church. 1941. Mining Engineers' Handbook. 3rd ed. John Wiley & Sons, Inc., New York.

- Project Management Corporation and Tennessee Valley Authority. 1975. Clinch River Breeder Reactor Project, Environmental Report, Construction Permit Stage. Docket 50-537.
- Rice, D. 1968. Archaeological Reconnaissance, Hanford Atomic Works. U.S. Atomic Energy Commission, National Park Service, and Washington State University.
- Shelford, V.E. 1974. The Ecology of North America. University of Illinois Press, Urbana, IL. 610 pp.
- Statistics Canada Ottawa. 1983. Personal communication to J. Olshansky (Argonne National Laboratory), July 1983.
- Sula, M.J., and P.J. Blumer. 1981. Environmental Surveillance at Hanford for CY-1980. PNL-3728. Prepared by Pacific Northwest Laboratory, Richland, WA, for the U.S. Department of Energy.
- Sula, M.J., W.D. McCormack, R.L. Dirkes, K.R. Price, and P.A. Eddy. 1982. Environmental Surveillance at Hanford for CY-1981. PNL-4211. Prepared by Pacific Northwest Laboratory, Richland, WA, for the U.S. Department of Energy.
- Swann, M.E., W. Roberts, E.H. Hubbard, and H.C. Porter. 1942. Soil Survey, Roane County, Tennessee. U.S. Department of Agriculture, Washington, DC. 125 pp.
- Tennessee Historical Commission. 1977. Letter (H.L. Harper, Nashville, TN) dated October 6, 1977, to D.A. Brodnick (Argonne National Laboratory, Argonne, IL).
- Tennessee Historical Commission. 1983. Letter (H.L. Harper, Executive Director, Nashville, TN) dated September 23, 1983, to L. Campbell (U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN).
- Union Carbide Corporation, Nuclear Division. 1981. Environmental Monitoring Report. United States Department of Energy, Oak Ridge Facilities, Calendar Year 1980. Y/UB-15.
- Union Carbide Corporation, Nuclear Division. 1982. Environmental Monitoring Report. United States Department of Energy, Oak Ridge Facilities, Calendar Year 1981. Y/UB-16.
- Urban Decisions, Inc. 1983. Computer printout of demographic data in the environs of two sites in New York.
- Urbanczyk, D. 1983. Letters to Bert Zimtrich (Bechtel National, Inc., Oak Ridge, Tennessee), dated September 13 and 22, 1983.
- Uresk, D.W., R.E. Fitzner, L.E. Rogers, and W.H. Rickard. 1977. Biotic components. In L.E. Rogers and W.H. Rickard (eds), Ecology of the 200 Area Plateau Waste Management Environs: A Status Report. PNL-2253. Prepared by Battelle Pacific Northwest Laboratories for the U.S. Department of Energy.
- U.S. Army Corps of Engineers. 1969. Lower Columbia River Standard Project Flood and Probable Maximum Flood. North Pacific Division, Portland, OR.
- U.S. Atomic Energy Commission. 1972. Environmental Statement Related to the Proposed Hanford Number Two Nuclear Power Plant, Washington Public Power Supply System. Docket No. 50-397.
- U.S. Bureau of the Census. 1970a. Characteristics of the Population, 1970 Census of Population. Volume 1, Part 44, Tennessee.
- U.S. Bureau of the Census. 1970b. Characteristics of the Population, 1970 Census of Population. Volume 1, Part 49, Washington.
- U.S. Bureau of the Census. 1977. City and County Data Book 1977. p. 330.
- U.S. Bureau of the Census. 1980a. Characteristics of the Population, 1980 Census of Population, Tennessee. Data collected by phone from the Census Bureau.
- U.S. Bureau of the Census. 1980b. Characteristics of the Population, 1980 Census of Population, Washington. Data collected by phone from the Census Bureau.
- U.S. Bureau of the Census. 1982. Number of Inhabitants, New York. U.S. Census of Population, PC 80-1-A 34.
- U.S. Department of Energy. 1979. Environmental Assessment of the Oak Ridge Gaseous Diffusion Plant Site. DOE/EA-0106. Oak Ridge, TN.

- U.S. Department of Energy. 1980. Oak Ridge Reservation Land-Use Plan. DOE/ORO-748 (Rev. 1). Prepared by Oak Ridge Operations.
- U.S. Department of Energy. 1982a. Action Description Memorandum, Proposed 1982 Interim Remedial Action (R-10 Pile Stabilization). Final, April 14, 1982.
- U.S. Department of Energy. 1982b. Action Description Memorandum, Proposed Interim Remedial Action for Buildings 413 and 414. Final, April 14, 1982.
- U.S. Department of Energy. 1982c. Draft Environmental Impact Statement. Sale of Segment 0 of the Oak Ridge Reservation to the City of Oak Ridge, Tennessee (Proposed Site for Tennessee Synfuels Associates Coal-to-Gasoline Facility). DOE/EIS-0094D.
- U.S. Department of Energy. 1982d. Engineering and Environmental Analysis Report for Disposal of Hanford High-Level and Transuranic Wastes, Hanford Site, Washington. Draft Working Papers, Document 1. December 1982.
- U.S. Department of Energy. 1982e. Environmental Assessment, Y-12 Plant Site, Oak Ridge, Tennessee. DOE/EA-0182. Office of Military Application. December.
- U.S. Department of Energy. 1982f. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics. DOE/NE-0017-1. Office of Nuclear Energy.
- U.S. Department of Energy. 1983a. Action Description Memorandum, Proposed Interim Remedial Actions for FY 1983. Final, February 14, 1983.
- U.S. Department of Energy. 1983b. Action Description Memorandum, Proposed Interim Remedial Actions for FY 1983-85 Accelerated Program. Final, June 20, 1983.
- U.S. Department of Energy. 1983c. Niagara Falls Storage Site (NFSS) Environmental Monitoring Report, Calendar Year 1981. 10-05-202-002. Oak Ridge Operations, Oak Ridge, TN. May 1983.
- U.S. Department of Energy. 1983d. Niagara Falls Storage Site (NFSS) Environmental Monitoring Report, Calendar Year 1982. 10-05-202-002. Oak Ridge Operations, Oak Ridge, TN. May 1983.
- U.S. Department of Energy. 1984. Niagara Falls Storage Site (NFSS) Environmental Monitoring Report, Calendar Year 1983. DOE/OR/20722-18. Oak Ridge Operations, Oak Ridge, TN. July 1984 (in preparation).
- U.S. Department of Housing and Urban Development. 1980. National Flood Insurance Program, Firm Flood Insurance Rate Map, Town of Lewiston, New York, Niagara County. Community-Panel No. 360502-0005-B, Panel 5 of 10. June 18, 1980.
- U.S. Department of the Interior. 1980. National Register of Historic Places. Fed. Regist. 45(54): 17446-17519 (March 18, 1980).
- U.S. Department of the Interior. 1983. National Register of Historic Places. Fed. Regist. 48(41): 8626-8679 (March 1, 1983).
- U.S. Energy Research and Development Administration. 1975. Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, WA. ERDA-1538. Washington, DC. 2 v.
- U.S. Energy Research and Development Administration. 1977. Final Environmental Impact Statement - High Performance Fuel Laboratory, Hanford Reservation, Richland, WA. ERDA-1550. Washington, DC. September.
- U.S. Environmental Protection Agency. 1980. Final Environmental Impact Statement (EIS) for 106-Mile Ocean Waste Disposal Site Designation. Oil and Special Materials Control Division, Marine Protection Branch, Washington, DC. February 1980.
- U.S. Fish and Wildlife Service. 1980. Federally Listed Endangered and Threatened Species in New York. Region 5 Office, May 1980 (mimeograph).
- U.S. Fish and Wildlife Service. 1983. Letter (V.G. Henry, Endangered Species Field Office, Asheville, NC) dated September 28, 1983, to L.F. Campbell (U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN).
- U.S. Nuclear Regulatory Commission. 1977. Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant, Docket No. 50-537. NUREG-0139. February.
- U.S. Nuclear Regulatory Commission. 1981. Final Environmental Statement Related to the Operation of WPPSS Nuclear Project No. 2, Docket No. 50-397. NUREG-0812. Office of Nuclear Reactor Regulation. December 1981.

- U.S. Nuclear Regulatory Commission. 1982. Supplement to Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant, Docket No. 50-537. NUREG-0139. Supplement No. 1, Vol. 1.
- VanKat, J.L. 1979. The Natural Vegetation of North America: An Introduction. John Wiley and Sons, Inc., New York. 261 pp.
- Washington Office of Archaeology and Historic Preservation. 1983. Letter (R.G. Whitman, Archaeologist, Olympia, WA) dated September 29, 1983, to L.F. Campbell (Oak Ridge Operations, Oak Ridge, TN).
- Wehran Engineering Corporation. 1979. Engineering Report, Modern Landfill, Inc., Sanitary Landfill, Lewiston, Niagara County, New York.
- Wilson, D.R. 1982. Memo entitled "Traffic Counts" from D.R. Wilson (Deputy Commissioner, Division of Public Works-Highways) to J.R. O'Grady (Deputy Commissioner, Division of Public Works-Engineering), September 13, 1982.



4. ENVIRONMENTAL CONSEQUENCES AND RISK

The radioactivity in the NFSS residues and wastes is due to naturally occurring radionuclides, principally those resulting from radioactive decay of uranium-238. The decay chain presented in Figure 4.1 indicates the relationship between the various radionuclides in the NFSS residues and wastes. The radioactive materials at NFSS result from extraction of uranium (i.e., uranium-238, uranium-235, and uranium-234) from uranium-bearing ores. Thus, the amount of uranium remaining in the residues and wastes is quite low.* However, there are significant quantities of thorium-230, radium-226, and all resultant decay products in these materials. For analysis of radiological impacts, it is assumed that all radionuclide from thorium-230 through polonium-210 are present and in secular equilibrium (lead-206 is stable). The impacts of radionuclides above thorium-230 in this decay chain will be negligible.

The rate at which the radionuclides in the NFSS residues and wastes will decay depends on the half-life of thorium-230. In this EIS, all radionuclides are assumed to remain in secular equilibrium with thorium-230. The concentration of these radionuclides (in pCi/g) through time, assuming that no dispersion occurs, is illustrated in Figure 4.2.

Because of the nature of the NFSS radioactive wastes and residues--i.e., the long-lived, naturally occurring radionuclides (e.g., radium-226 has a 1,600-year half-life and thorium-230 has a 77,000-year half-life)--it is necessary to evaluate alternatives over long time periods. The following time periods are used for analysis of all alternatives:

- Action Period (approximately 10 years): The period during which physical actions such as transportation, stabilization, ocean dumping, etc., will take place.
- Maintenance and Monitoring Period (200 years): For the alternatives involving management on land, the period during which the wastes and residues will continue to be managed.** Containment structures will be maintained, radioactive releases to the environment will be monitored, and periodic corrective remedial actions will be taken, as necessary.*** Human access to the waste-management areas will be limited and the federal government will continue to own the sites and use them solely for waste-management purposes.
- Long-Term (200 to 1000 years): Two cases, involving different degrees of loss of control, are assessed:

Case A: Loss of Monitoring, Maintenance, and Corrective Actions. Monitoring, maintenance, and corrective actions will cease,**** but access will continue to be limited and the federal government will continue to own and use the sites solely for waste-management purposes. The effects of natural processes on waste containment and the gradual release of radionuclides to the environment are assessed.

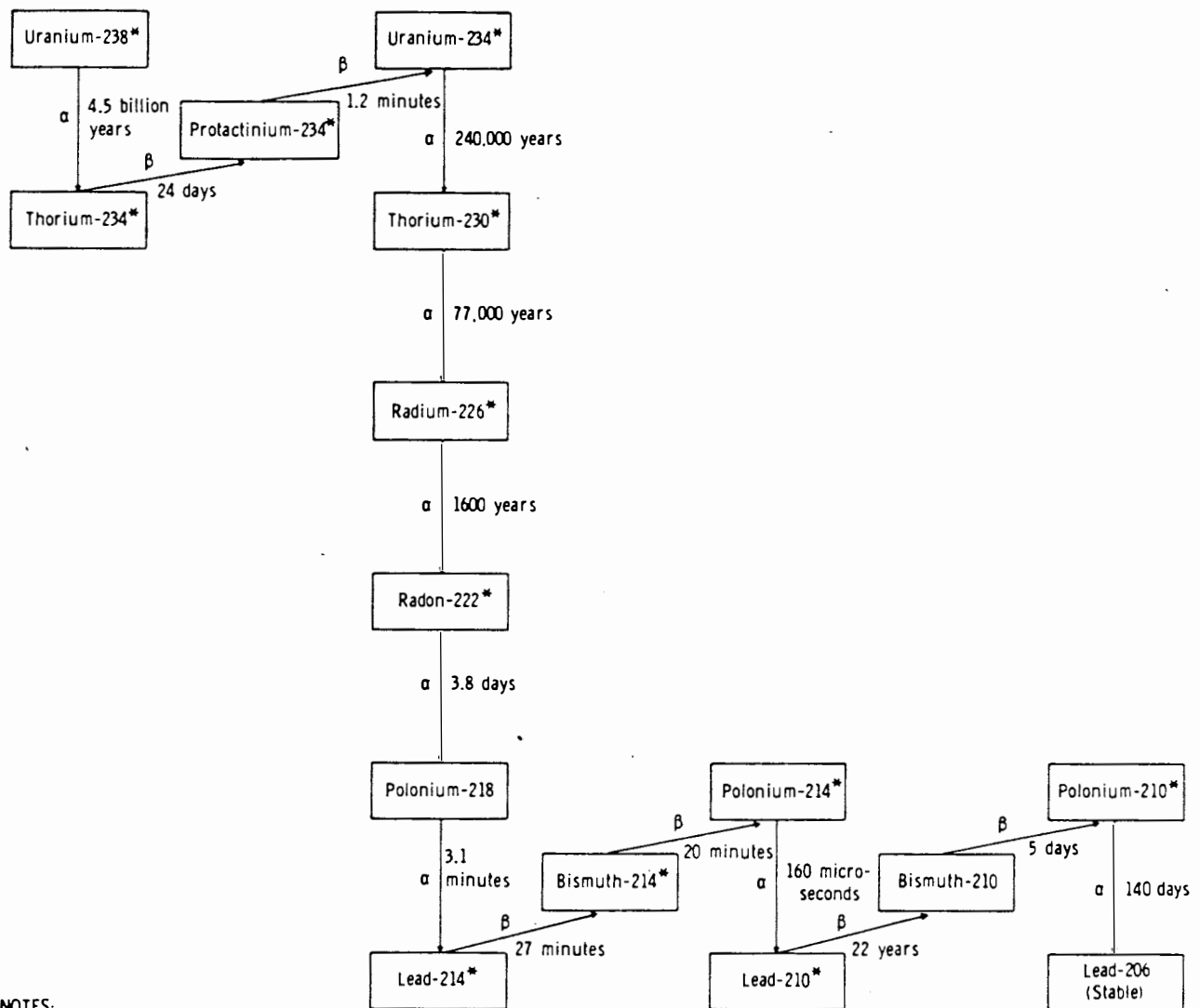
Case B: Loss of All Controls. Not only will monitoring, maintenance, and corrective actions cease, but access, land-use, and ownership controls be lost as well.**** Human intrusion into the wastes is assumed to occur.

*The radium-226 content of the residues is about 870 Ci, whereas the uranium content (uranium-238, -235, and -234) is less than 30 Ci. The radium-226 content of the wastes is about 7.8 Ci, whereas the uranium content is less than 1 Ci. See Section 3.1.7 for details.

**The federal government plans to take perpetual care of the NFSS wastes and residues. However, because it is unreasonable to assume that maintenance and monitoring will continue for the duration of the time that the wastes and residues will remain radioactively hazardous (hundreds of thousands of years), the 200-year maintenance and monitoring period is used as a reasonable reference point for purposes of analysis in this EIS. If maintenance and monitoring continues longer than 200 years, costs will be higher (Appendix F), but impacts due to failure of the containment system will be delayed.

***Although there could be physical failures of engineered containment structures during this period, as well as temporary failures of access controls, it is assumed that such failures will be detected and impact limited because corrective remedial actions will be taken.

****The reasons for cessation of controls can range from radical changes in society to gradual loss of concern for potential hazards due to lack of funds.



NOTES:

Only the dominant decay mode is shown.
 The times shown are half-lives.
 The symbols α and β indicate alpha and beta decay.
 An asterisk indicates that the isotope is also a gamma emitter.

Figure 4.1. Uranium-238 Decay Series.

The 200- and 1000-year time frames are selected to be consistent with the time frames identified in regulations of the U.S. Environmental Protection Agency (EPA) for management of inactive uranium mill tailings (40 CFR 192) (U.S. Environ. Prot. Agency 1983). The NFSS wastes and residues contain the same naturally occurring radionuclides as are found in uranium mill tailings. EPA considered "the single most important goal of control to be effective isolation and stabilization of tailings for as long a time period as is reasonably feasible, because tailings will remain hazardous for hundreds of thousands of years." Furthermore, "the longevity of control is governed by the possibility of intrusion by man and erosion by natural forces." After considering several time periods for control, EPA required that "control measures be carried out in a manner that provides reasonable assurance they will last, to the extent reasonably achievable, up to 1000 years, and, in any case, for a minimum of 200 years." Uncertainties increase significantly beyond 1000 years and it would not be reasonable to require assurances of control for longer time periods. Because the 200- and 1000-year time periods have been deemed to be a reasonable basis for EPA's decisions regarding inactive uranium mill tailings, DOE considers the same time periods to be reasonable reference points for purposes of analysis of environmental impacts in this EIS supporting DOE's decision on long-term management of the NFSS wastes and

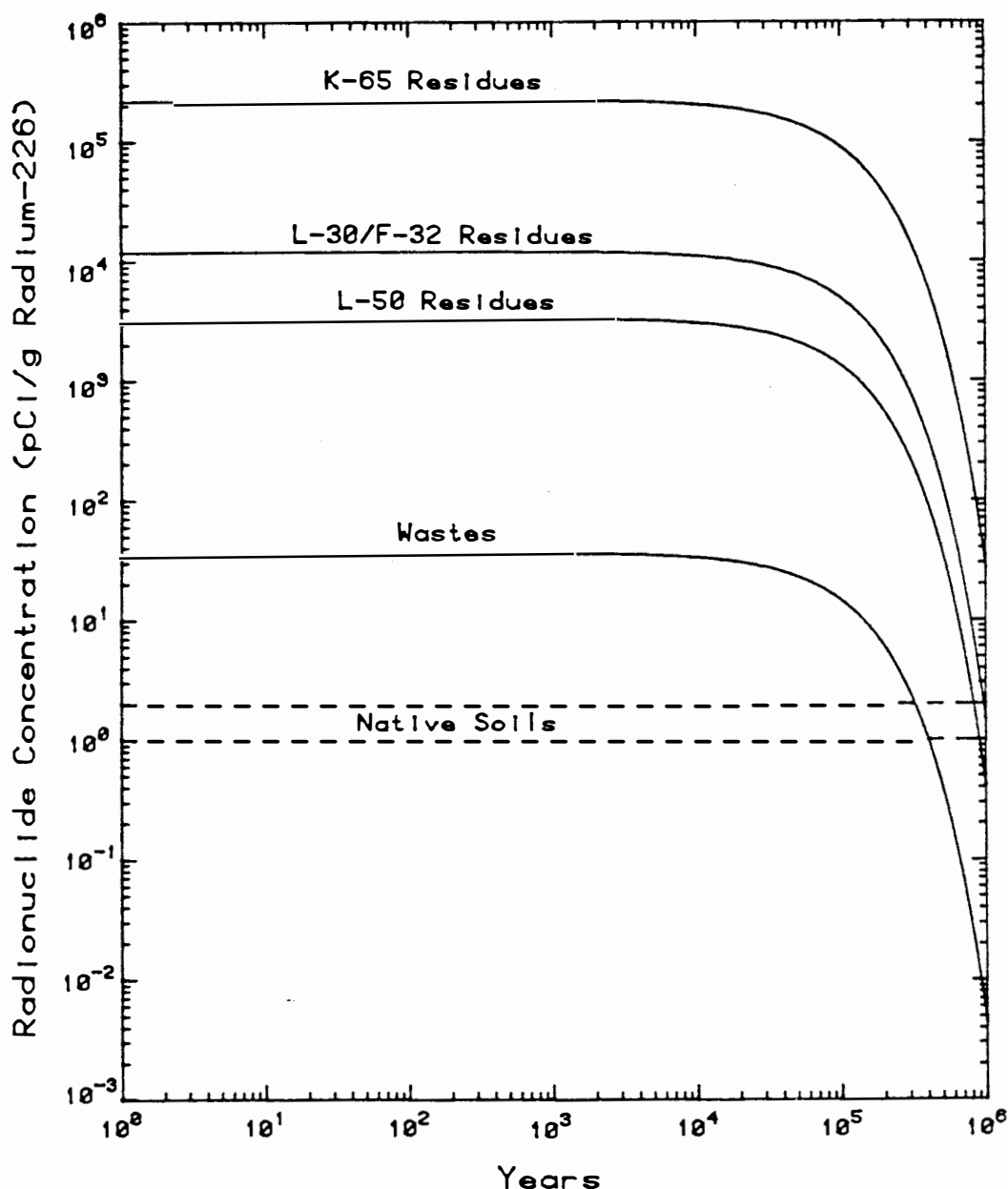


Figure 4.2. Concentration of Radionuclides in the NFSS Wastes and Residues, Assuming No Dispersion.

residues. The longevity of the various containment systems is estimated with respect to both surface erosion and migration of contaminants into groundwater. The exposure to an intruder living on the site (if such intrusion occurs) is assessed.

4.1 RADIOLOGICAL IMPACTS

4.1.1 Summary of Radiological Impacts

4.1.1.1 General Public

The estimated radiation doses to the general public for each alternative during the action period (0-10 years) and the maintenance and monitoring period (10-200 years) are given in Table 4.1. Doses to the general public at year 1000 are summarized in Table 4.2. The action-period doses include doses at NFSS, at the alternative sites (Hanford, Oak Ridge, and Harbor), and along transportation routes. The adverse health effects that are expected as a result of these organ doses are summarized in Table 4.3.

Table 4.1. Summary of Estimated Doses to the General Public During the Action Period (0-10 years) and During the Maintenance and Monitoring Period (10-200 years)

Alternative	Description	Cumulative Doses to the General Public (person- or organ-rem) ^{†1}			
		Whole Body	Bone	Lung	Bronchial Epithelium ^{†2}
1	No action	<0.001/<0.001	<0.001/<0.001	<0.001/<0.001	<0.001/0.0032
2a	Long-term management at NFSS: modified containment	<0.001/<0.001	<0.001/<0.001	<0.001/<0.001	<0.001/<0.001
2b	Long-term management at NFSS: modified containment plus modified form	18/<0.001	100/<0.001	91/<0.001	110/<0.001
3a	Long-term management at Hanford	120/2.5	480/13	440/2.0	260/140
3b	Long-term management at Oak Ridge	69/<0.001	370/<0.001	380/<0.001	290/<0.001
4a	Long-term management of residues at Hanford, wastes at NFSS	62/23	160/120	270/19	310/1300
4b	Long-term management of residues at Hanford; ocean dispersal of wastes	470/23	460/120	1300/19	330/1300
4c	Long-term management of residues at Oak Ridge, wastes at NFSS	43/<0.001	180/<0.001	200/<0.001	290/<0.001
4d	Long-term management of residues at Oak Ridge; ocean dispersal of wastes	450/<0.001	490/<0.001	1200/<0.001	310/<0.001

^{†1} All doses given to two significant figures, unless preceded by a less than (<) symbol. First number is dose during action period and second number is dose during maintenance and monitoring period. All values are cumulative over the 10 years of the action period or 190 years of the maintenance and monitoring period and are reported as the 100-year environmental dose commitment. Cumulative doses to the general public below 0.001 person- or organ-rem are not given because doses this small are immeasurable and meaningless with regard to predicting detrimental health effects.

^{†2} Dose resulting from inhalation of short-lived radon-222 decay products.

Table 4.2. Summary of Estimated Doses to the General Public
at Year 1000 (Loss of All Controls)

Alternative	Description	Cumulative Doses to the General Public (rem/yr/million persons) ^{†1}			
		Whole Body	Bone	Lung	Bronchial Epithelium ^{†2}
1	No action	0.065	1.9	1.7	1.6
2a	Long-term management at NFSS: modified containment	<0.001	<0.001	<0.001	<0.001
2b	Long-term management at NFSS: modified containment plus modified form	<0.001	<0.001	<0.001	<0.001
3a	Long-term management at Hanford	0.39	1.7	0.33	28
3b	Long-term management at Oak Ridge	<0.001	<0.001	<0.001	<0.001
4a	Long-term management of residues at Hanford, wastes at NFSS	3.3	14	2.8	230
4b	Long-term management of residues at Hanford; ocean dispersal of wastes	3.3	14	2.8	230
4c	Long-term management of residues at Oak Ridge, wastes at NFSS	<0.001	<0.001	<0.001	0.0020
4d	Long-term management of residues at Oak Ridge; ocean dispersal of wastes	<0.001	<0.001	<0.001	0.0020

^{†1} All doses given to two significant figures, unless preceded by a less than (<) symbol. It is assumed that the million persons are evenly distributed within an 80-km radius of the waste management site. Cumulative doses to the general public below 0.001 person- or organ-rem are not given because doses this small are immeasurable and meaningless with regard to predicting detrimental health effects.

^{†2} Dose resulting from inhalation of short-lived radon-222 decay products.

Table 4.3. Summary of Additional Health Effects in the General Public

Alternative	Description	Expected Number of Adverse Health Effects from Doses Incurred During† ¹ :		
		Action Period (total)† ²	Maintenance and Monitoring Period (total)† ³	Year 1000 (per million persons per year)
1	No action	<0.0000005	<0.0000005	0.00021
2a	Long-term management at NFSS: modified containment	<0.0000005	<0.0000005	<0.0000005
2b	Long-term management at NFSS: modified containment plus modified form	0.017	<0.0000005	<0.0000005
3a	Long-term management at Hanford	0.090	0.0039	0.00074
3b	Long-term management at Oak Ridge	0.066	<0.0000005	<0.0000005
4a	Long-term management of residues at Hanford, wastes at NFSS	0.054	0.036	0.0061
4b	Long-term management of residues at Hanford; ocean dispersal of wastes	0.30	0.036	0.0061
4c	Long-term management of residues at Oak Ridge, wastes at NFSS	0.040	<0.0000005	<0.0000005
4d	Long-term management of residues at Oak Ridge; ocean dispersal of wastes	0.28	<0.0000005	<0.0000005

†¹ Includes fatal cancers plus genetic defects (see Section 4.1.4).

†² Total from doses incurred during 10 years.

†³ Total from doses incurred during 190 years.

During the action period, whole-body and lung doses will be highest for Alternatives 4b and 4d, primarily as a result of transport of the wastes through the densely populated New York metropolitan area to the ocean. Bone doses will be highest for Alternatives 3a, 4b, and 4d, primarily because of transport of the wastes to Hanford or to the ocean. Bronchial epithelium doses, on the other hand, will be comparable for Alternatives 3a, 3b, 4a, 4b, 4c, and 4d, primarily because radon-222 gas releases associated with excavation, transport, and reburial of the residues at Hanford or Oak Ridge will be similar for these alternatives.

During the maintenance and monitoring period, doses to all critical organs will be highest under any of the Hanford alternatives (Table 4.1), primarily because of the greater diffusion of radon-222 gas out of the residues in the arid climate.

At the year 1000, assuming that controls cease, population doses per million persons per year will be highest at Hanford (Alternatives 3a, 4a, and 4b) and at NFSS under Alternative 1. The larger doses at Hanford will result primarily from greater radon-222 gas releases in the arid climate. The dose at NFSS under Alternative 1 will result from the predicted erosion of the cap and exposure of the wastes. It should be kept in mind that the doses and resultant health effects for year 1000, given in Tables 4.2 and 4.3, assume cessation of all controls at year 200 and development of erosive land uses until year 1000. Less erosive land uses and/or continuance of controls (with associated dollar costs) would result in lower radiological impacts.

For all time periods and all alternatives, the doses to the general public will be insignificant in terms of increased risk of adverse health effects (fatal cancers plus genetic defects). Doses incurred during the action period will result in the greatest risk, which is estimated to be 0.30 health effects for the worst case (Alternative 4b); this is less than one adverse health effect in a population of several million people.

4.1.1.2 Resident-Intruder

If controls cease, there is potential--wherever the residues are buried--for a resident-intruder to inhabit the site (a person residing in a house built in the contaminated residues and/or wastes). The resident-intruder will incur a very large dose to his/her bronchial epithelium from inhaling radon-222 gas diffusing out of the residues. Doses associated with other pathways, such as eating contaminated food grown in a garden on the waste area or drinking contaminated groundwater are very small in comparison.

The dose to the resident-intruder's bronchial epithelium will result in death within a few years (excluding other causes of death) in the worst cases (Alternatives 1 and 2a at NFSS). This adverse impact can be prevented if controls are maintained for hundreds of thousands of years to prevent people from building a house in the contaminated area or if a different method of long-term management (e.g., greater confinement) is implemented (see Appendix C, Section C.3).

4.1.1.3 Impacts Beyond 1000 Years

Because the NFSS wastes and residues will remain radioactive for hundreds of thousands of years, it is expected that eventually--on a geologic time scale--these materials will be eroded from the land. Prediction of when and how this will occur is beyond current predictive capabilities. Even within the 1000-year time frame, the predicted rates of erosion of the cover materials (assuming cessation of all controls at 200 years) range from several hundred years to over two million years, depending on the use of the land surface (Section 4.2). With increasing time, the uncertainties relative to degree of controls, locations of populations, environmental conditions, etc., become so great as to make any predictions only speculation. Given these uncertainties, no reasonable distinction can be made between the various alternatives for long-term management of the NFSS wastes and residues for time periods beyond 1000 years.

4.1.1.4 Workers

The estimated radiation doses to the work force for each alternative during the action period (0-10 years) are given in Table 4.4. These doses will be incurred during implementation of the various alternatives and include activities at NFSS, along transportation routes, and at alternative long-term management sites. The whole-body, bone, and lung doses are highest for Alternative 3a, primarily due to the doses to truck drivers transporting the residues and wastes to Hanford. The occupational doses to these organs for other activities will be comparable for all alternatives requiring retrieval of the residues, i.e., all except Alternatives 1 and 2a. Similarly, the bronchial epithelium doses are comparable for all alternatives requiring retrieval of the residues. The adverse health effects that are expected as a result of these organ doses are summarized in Table 4.5. The likelihood of an adverse health effect (fatal cancer or genetic defect) to workers is comparable for all alternatives requiring retrieval of the residues, i.e., all except Alternatives 1 and 2a. Alternative 3a has the largest estimated likelihood of a health effect. It is estimated that implementation of this alternative will result in 0.24 health effects to the work force.

Table 4.4. Summary of Estimated Doses to Workers During the Action Period†¹

Alternative	Description	Cumulative Occupational Doses (person- or organ-rem)† ¹			
		Whole Body	Bone	Lung	Bronchial Epithelium† ²
1	No action	2.6	3.4	3.5	1.9
2a	Long-term management at NFSS: modified containment	10	14	14	7.4
2b	Long-term management at NFSS: modified containment plus modified form	140	410	450	360
3a	Long-term management at Hanford	440	690	720	340
3b	Long-term management at Oak Ridge	250	490	530	340
4a	Long-term management of residues at Hanford, wastes at NFSS	330	560	590	310
4b	Long-term management of residues at Hanford; ocean dispersal of wastes	360	590	630	320
4c	Long-term management of residues at Oak Ridge, wastes at NFSS	190	420	450	310
4d	Long-term management of residues at Oak Ridge; ocean dispersal of wastes	220	460	490	320

†¹ All doses given to two significant figures.†² Dose resulting from inhalation of short-lived radon-222 decay products.

Table 4.5. Summary of Additional Health Effects
to Workers During the Action Period

Alternative	Description	Expected Number of Adverse Health Effects† ¹
1	No action	0.0013
2a	Long-term management at NFSS: modified containment	0.0051
2b	Long-term management at NFSS: modified containment plus modified form	0.10
3a	Long-term management at Hanford	0.24
3b	Long-term management at Oak Ridge	0.15
4a	Long-term management of residues at Hanford, wastes at NFSS	0.18
4b	Long-term management of residues at Hanford; ocean dispersal of wastes	0.20
4c	Long-term management of residues at Oak Ridge, wastes at NFSS	0.12
4d	Long-term management of residues at Oak Ridge; ocean dispersal of wastes	0.13

†¹ Includes fatal cancers plus genetic defects (see Section 4.1.4).

There will be no significant doses to workers during the monitoring and maintenance period (up to 200 years) at all sites except Hanford. Due to the much higher releases of radon-222 gas at this site, workers will likely incur significant bronchial epithelium doses, amounting to a cumulative dose of 290 organ-rem to the bronchial epithelium over the 190-year maintenance and monitoring period. This cumulative dose would be expected to result in 0.032 adverse health effects.

There will be no occupational doses or health effects during the long term (200-1000 years) if no monitoring and maintenance activities occur after 200 years.

4.1.2 Doses to the General Public

4.1.2.1 Action Period (0 to 10 years)

During the action period, radiological impacts to members of the general public will occur: (1) at NFSS and the alternative sites (Hanford, Oak Ridge, Harbor), (2) along transportation routes, and (3) at the ocean disposal site.

At NFSS and the Alternative Sites. Excavation, transfer, and reburial activities will result in releases of radon-222 gas and radioactively contaminated particulates to the atmosphere. For this analysis, radon-222 releases are separated into two categories: (1) the "steady" or continuous releases from exposed residue and waste surfaces and (2) the "puff" or temporary releases associated with disturbance of these materials.

Estimated steady radon-222 releases as well as the assumptions and values for the various parameters used in this analysis are given in Table 4.6. The radon fluxes are estimated using a one-dimensional diffusion equation (U.S. Nucl. Reg. Comm. 1983a). The total releases are the product of the fluxes (rate per unit area) times the area covered by the contaminated materials. The higher rates of steady radon-222 releases at Hanford and Oak Ridge are primarily due to the greater surface areas associated with reburial at these sites. (Radon-222 releases will be markedly reduced after the NFSS wastes and residues are reburied. See later discussion.)

When the residues and wastes are disturbed and exposed to the air (e.g., when they are excavated or unloaded at the alternative sites), radon-222 gas that has built up in the wastes and residues may be released in "puffs". Most of the radon-222 gas will be trapped inside individual particles and clumps of residues and wastes. This radon-222 gas will not be available for release but will decay to solid decay products before it can escape to the air. For this analysis, it is assumed that 20% of the total amount of radon-222 gas in the wastes and residues could be released in puffs. This value is commonly used for analyzing radon-222 releases from uranium mill tailings and is referred to as the emanating power (U.S. Nucl. Reg. Comm. 1980a). After the wastes and residues are again covered with clay, soil, etc., radon-222 releases will be markedly reduced.

A summary of the estimated radon-222 releases associated with various activities during the action period is given in Table 4.7. These releases are almost entirely associated with disturbance and exposure of the residues. The releases at Hanford are significantly larger than the releases at NFSS because of the much higher releases following reburial of the residues. The releases at Oak Ridge are slightly higher than, but comparable to, those at NFSS. When the residues are reburied at the alternative sites, it is assumed that the packages will be opened briefly so that the void spaces in the packages above the residues can be filled to reduce the potential for future slumping of the earthen caps over the residues.

There will also be releases of radioactive particulates during the action period. These releases will be associated with activities involving movement of the contaminated materials as well as with exposed residue and waste surfaces. It is assumed that control methods (such as periodic watering and minimization of exposed surfaces) will be used at all sites. To estimate yearly particulate release rates from exposed waste and residue surfaces at NFSS, a release rate of 0.27 kg/m²/mo (1.2 tons/acre/mo)--which is based on experience with earth-moving activities (U.S. Environ. Prot. Agency 1977a; Argonne Natl. Lab. 1982)--is multiplied by the exposed areas (Table 4.6) and the assumed six months of exposure each year. It is assumed that the contaminated materials will be covered (with the permanent cap) during the winter months at Hanford or Oak Ridge and that the remaining contaminated materials at NFSS will also be covered (with a temporary EPDM cover) each winter. As for radon-222 releases, almost all the particulate releases (in curies [Ci]) will be associated with the residues (Table 4.7). The area covered by the residues will be larger at Hanford and Oak Ridge, but the residues will be left in the packages and exposed only briefly while the lids are removed and the void spaces above the residues are filled with wastes or other earthen material.* Therefore, it is assumed that the

*The void space must be filled in order to avoid future subsidence problems. It may be possible to use containers that allow very little void space and the lids would not have to be removed. Radioactive releases and occupational doses could, therefore, be reduced.

Table 4.6. Estimated Steady Radon-222 Releases from Exposed Residue and
and Waste Surfaces During the Action Period (0 to 10 years)

Site/ Alternative	Material	Radium-226 Conc. (pCi/g)	Depth of Material (m)	Surface Radon Flux† ¹ (pCi/m ² /s)	Exposed Area† ² (m ²)	Duration per Year (mo)	Average Radon Release Rate† ¹ (Ci/yr)
<u>NFSS</u>							
2b, 3a, 3b 4a, 4b, 4c	Residues	67,000	2.0	3,900	170	6	10
3a	Wastes	36	6.0	2.1	600	6	0.020
3b, 4c, 4d	Wastes	36	6.0	2.1	1,500	6	0.050

<u>HANFORD</u>							
3a, 4a, 4b	Residues	67,000	0.8	3,900	700	6	43
3a	Wastes	36	2.4	2.1	1,600	6	0.053

<u>OAK RIDGE</u>							
3b, 4c, 4d	Residues	67,000	0.8	3,900	700	6	43
3b	Wastes	36	3.0	2.1	3,100	6	0.10

<u>HARBOR</u>							
4b, 4d	Wastes	36	3.0	2.1	250	6	0.0083

†¹ Above background. Assumes that the radon-222 diffusion coefficient for wastes and residues during the action period will be 0.0016 pCi/m²/s at all sites, i.e., that the wastes and residues will not dry out appreciably during the few days it will take to excavate, transport, and reburly the wastes and residues. All releases are given to two significant figures.

†² Assumes that the average exposed area equals 10% of the area covered by wastes or residues (Table 4.16) divided by the number of years to complete the activity.

Table 4.7. Estimated Radon-222 and Particulate Release Rates--Above Background--at the Various Sites During the Action Period (0 to 10 years)

Site/ Alternative	Activity	Duration of Activity (yr)	Release Rate-- Above Background (Ci/yr)		Total Releases--Above Background--During Action Period (Ci)		Average Release Rates-- Above Background-- During Action Period (Ci/yr)	
			Radon-222	Particulates† ¹	Radon-222	Particulates† ¹	Radon-222	Particulates† ¹
NFSS								
1	Interim storage	10	3 × 10 ⁻⁵ † ²	Negligible	3 × 10 ⁻⁴	Negligible	3 × 10 ⁻⁵	Negligible
2a	Construct long-term cap	2	1 × 10 ⁻⁸ † ²	Negligible	1 × 10 ⁻⁷	Negligible	1 × 10 ⁻⁸	Negligible
	Long-term management	8						
2b	Solidify residues	2	87 (puffs)† ³ 10 (steady)† ⁵	0.022† ⁴	190	0.044	19	0.0044
	Construct long-term cap	2	1 × 10 ⁻⁸ † ²	Negligible				
	Long-term management	6						
3a	Excavate residues	2	87 (puffs)† ³ 10 (steady)† ⁵	0.022† ⁴	200	0.044	20	0.0044
	Excavate wastes	5	0.31 (puffs)† ⁶ 0.020 (steady)† ⁵	1 × 10 ⁻⁵ † ⁴				
	Restore site	1	Negligible	Negligible				
	Release site for other use	4						
3b	Excavate residues and wastes	2	88 (puffs)† ⁷ 10 (steady)† ⁵	0.022† ⁴	200	0.044	20	0.0044
	Restore site	1	Negligible	Negligible				
	Release site for other use	7						

Table 4.7. Continued

Site/ Alternative	Activity	Duration of Activity (yr)	Release Rate-- Above Background (Ci/yr)		Total Releases--Above Background--During Action Period (Ci)		Average Release Rates-- Above Background-- During Action Period (Ci/yr)	
			Radon-222	Particulates† ¹	Radon-222	Particulates† ¹	Radon-222	Particulates† ¹
<u>NFSS</u>								
4a, 4c	Excavate residues	2	87 (puffs)† ³ 10 (steady)† ⁵	0.022† ⁴	200	0.044	20	0.0044
	Construct long-term cap	1	1 × 10 ⁻⁸ † ²	Negligible				
	Long-term management	7						
4b, 4d	Excavate residues and wastes	2	88 (puffs)† ⁷ 10 (steady)† ⁵	0.022† ⁴	200	0.044	20	0.0044
	Restore site	1	Negligible	Negligible				
	Release site for other use	7						

<u>HANFORD</u>								
3a	Bury residues	2	87 (puffs)† ³ 43 (steady)† ⁵	0.022† ⁸	370	0.044	37	0.0044
	Bury wastes	5	0.31 (puffs)† ⁶ 0.053 (steady)† ⁵	1 × 10 ⁻⁵ † ⁴				
	Cap in place over residues	8	14† ²	Negligible				
4a, 4b	Bury residues	2	87 (puffs)† ³ 43 (steady)† ⁵	0.022† ⁸	1,300	0.044	130	0.0044
	Cap in place over residues	8	130† ²	Negligible				

Table 4.7. Continued

Site/ Alternative	Activity	Duration of Activity (yr)	Release Rate-- Above Background (Ci/yr)		Total Releases--Above Background--During Action Period (Ci)		Average Release Rates-- Above Background-- During Action Period (Ci/yr)	
			Radon-222	Particulates† ¹	Radon-222	Particulates† ¹	Radon-222	Particulates† ¹
<u>OAK RIDGE</u>								
3b	Bury residues	2	87 (puffs)† ³ 43 (steady)† ⁵	0.022† ⁸	260	0.044	26	0.0044
	Bury wastes	2	0.78 (puffs)† ⁹ 0.10 (steady)† ⁵	1 × 10 ⁻⁵ † ⁴				
	Cap in place over residues	8	1 × 10 ⁻⁸ † ²	Negligible				
4c, 4d	Bury residues	2	87 (puffs)† ³ 43 (steady)† ⁵	0.022† ⁸	260	0.044	26	0.0044
	Cap in place over residues	8	1 × 10 ⁻⁶ † ²	Negligible				
<u>HARBOR</u>								
4b, 4d	Transfer wastes to barges	2	0.78 (puffs)† ⁹ 0.0083 (steady)† ⁵	1 × 10 ⁻⁵ † ⁴	1.6	1 × 10 ⁻⁴	0.16	1 × 10 ⁻⁵
	Restore dock area	1	Negligible	Negligible				
	Other uses	7						

†¹ Release rates for thorium-230, radium-226, and all subsequent decay products (except radon-222 gas), which are assumed to be in secular equilibrium (see Section 3.1.7 for radiological description of NFSS residues and wastes).

†² Release rates for long-term management activities are given in Table 4.19.

†³ $871 \text{ Ci} \div 2 \text{ yr} \times 20\% = 87 \text{ Ci/yr}$.

†⁴ Assuming exposed areas as given in Table 4.6 and particulate emission factor of $0.27 \text{ kg/m}^3/\text{mo}$ (1.2 tons/acre/mo) (U.S. Environ. Prot. Agency 1977a; Argonne Natl. Lab. 1982).

†⁵ Steady radon-222 releases from exposed residue and waste surfaces during the action period are given in Table 4.6.

†⁶ $7.8 \text{ Ci} \div 5 \text{ yr} \times 20\% = 0.31 \text{ Ci/yr}$.

†⁷ $879 \text{ Ci} \div 2 \text{ yr} \times 20\% = 88 \text{ Ci/yr}$.

†⁸ Although the exposed areas will be larger at Hanford and Oak Ridge, the residues--which account for 99% of the curie content--will be left in the packages and exposed only briefly after the lids are removed and the void spaces above the residues are filled with wastes or soils. These two factors tend to offset each other, so it is assumed that total particulate releases (Ci/yr) will be about the same as at NFSS.

†⁹ $7.8 \text{ Ci} \div 2 \text{ yr} \times 20\% = 0.78 \text{ Ci/yr}$.

particulate releases at Hanford and Oak Ridge will be about the same as at NFSS. Actual releases could be higher or lower, but because of the uncertainties regarding control methods (such as watering exposed surfaces) and weather conditions during operations, no quantitative differences in particulate releases between NFSS and the alternative sites can be predicted. Actual releases could be lower if the above-mentioned control measures are effective.

There will be no significant radiological impacts to the general public during the action period as a result of releases to groundwaters or surface waters. At all four sites, there is no mechanism for groundwater contamination beyond site boundaries during the action period (see Section 4.2, Geology and Hydrology). With respect to surface waters, there are no potential surface water users at Hanford (where discharge is to dry creekbed far from surface water) or the Harbor (where discharge is to brackish or salt water). In the Niagara Falls region, public water supplies are primarily from surface waters upstream of NFSS and the remainder are from deep aquifers (Section 3.1). At Oak Ridge, releases will occur for only two summers and potential surface water users downstream are sufficiently far away that dilution of releases from the Oak Ridge site will result in no distinguishable increases above natural concentrations in surface waters or sediments. Furthermore, it is assumed that water treatment systems, similar to the filtration/ion-exchange system used at NFSS during interim actions (U.S. Dep. Energy 1983c), will be used at all sites to keep releases as low as reasonably achievable below DOE operating orders for discharges to uncontrolled areas (e.g., maximum of 30 pCi/L for soluble radium-226). To meet the EPA federal drinking water standard of 5 pCi/L for soluble radium (applies to Washington and Tennessee), only a six-fold dilution is required. To meet the New York State standard of 3 pCi/L, a ten-fold dilution is required. At both NFSS and Oak Ridge, these dilutions will be attained before the creeks discharge into public surface water supplies (Lake Ontario at NFSS and Clinch River at Oak Ridge).

DOE operating orders permit discharges containing up to 30,000 pCi/L of insoluble radium-226 (see Section 4.7.1). During the operational periods, these radium-bearing solids could collect in depositional areas immediately downstream of NFSS and Oak Ridge. Therefore, after discharges have ceased, the downstream sediments will be surveyed and any contaminated sediments will be cleaned up to conform with DOE cleanup guidelines (Appendix H). Effective implementation of erosion, runoff, and sedimentation controls can mitigate this impact.

The potential radiological doses to the general public and to nearby individual members of the public during the action period are calculated based on the estimated radon-222 and particulate releases given in Table 4.7. For all radiological analyses, the current site-specific population distributions and meteorological conditions* are used. The locations of nearby persons assumed for this analysis are given in Table 4.8. The methods used to estimate these doses are described by Momeni et al. (1979). Results are summarized in Tables 4.9 and 4.10.

The doses to the general public are reported in terms of the 100-year environmental dose commitment, which includes both the doses received during the actual releases plus the doses associated with the lingering traces of contamination in the environment. The environmental dose commitment (EDC) is defined by EPA as the sum of all doses to individuals over the entire time period that the materials persist in the environment in a state available for interaction with humans. A 100-year integrating period, rather than some longer time interval, is used because: (1) the major exposure pathways are dominated by doses resulting from airborne activity concentrations that decrease rapidly when the source vanishes (the resuspension factor has a half-life of about 50 days); and (2) for a radionuclide in soil, a minimum of 75% of the infinite time integral of concentration occurs within the first 100 years. More than 75% of the 100-year EDC for each year's releases occurs within the first 15 years, with exposure over the next 85 years contributing less than 25%. The 100-year EDCs computed are within about 10% of those that would have otherwise been computed based on an infinite integrating period.

*In order to have several years of record for air stability data (as well as wind speed and direction), the STAR (Stability Array) data from the National Weather Service station closest to each site are used--i.e., Buffalo data for NFSS, Yakima data for Hanford, Knoxville data for Oak Ridge, and Newark data for the Harbor.

It was suggested during the EIS scoping process that site-specific meteorological conditions, such as lake-effect inversions at NFSS and valley inversions at Oak Ridge, may affect dispersion of radionuclides and result in population doses different from those predicted in this analysis. Such inversions will tend to retard the dispersion of radon-222 gas and particulates, thus leading to higher doses to individuals near the sites but lower doses to individuals farther away. Thus, the major population centers within the areas of analysis (within 80 km) may receive smaller doses than the more sparsely populated areas near the site. Overall, total population doses may be less. A large degree of conservatism has been built into the analysis in that it is assumed that exposed individuals are outdoors whereas, in reality, people spend much of their time indoors where exposure to the released NFSS radionuclides will be less. In the absence of several years of site-specific meteorological data for these sites, the use of data from the nearest National Weather Service stations is considered to be appropriate for comparison of alternatives.

Table 4.8. Nearby Persons at the Various Sites†¹

Site	Description	Distance (km)	Direction
NFSS	KOA campground	0.7	SSW
	Lewiston-Porter Schools	2.4	W
	Trailer park	2.6	NW
	SCA worker	1.2	NNE
	Potential residence	0.2	W
Hanford	Hanford facilities	10.4	N
	200-West burial area	1.0	E
	Richland potential residence	38.0	SE
Oak Ridge	Oak Ridge National Laboratory	3.2	SE
	Gaseous Diffusion Plant	2.7	NW
	Potential residence	4.0	SSW
Harbor	Barge/dock area	Onsite	Onsite
	Potential residence - East	1.0	E
	Potential residence - South	1.0	S
	Potential residence - West	1.0	W
	Potential residence - North	1.0	N

†¹ Persons are assumed to be present and exposed to radiation and/or radioactive substances released from the respective sites.

Table 4.9. Radiological Doses to General Public During the Action Period (0 to 10 years)

Site/Alternative	Cumulative Doses to the General Public† ¹ (person- or organ-rem)			
	Whole Body	Bone	Lung	Bronchial Epithelium† ²
<u>NFSS</u>				
1, 2a	<0.001	<0.001	<0.001	<0.001
2b, 3a, 3b, 4a, 4b, 4c, 4d	18	100	91	110

<u>HANFORD</u>				
3a	0.64	3.7	3.2	20
4a, 4b	0.64	3.7	3.2	69

<u>OAK RIDGE</u>				
3b, 4c, 4d	11	62	55	140

<u>HARBOR</u>				
4b, 4d	1.1	6.5	5.7	11

†¹ All doses given to two significant figures unless preceded by a less than (<) symbol. Doses are reported as the 100-year environmental dose commitment. Cumulative doses to the general public below 0.001 person- or organ-rem are not given because doses this small are immeasurable and meaningless with regard to predicting detrimental health effects.

†² Dose resulting from inhalation of short-lived radon-222 decay products.

Table 4.10. Radiological Doses to Nearby Individuals During the Action Period

	Dose (mrem) ^{†1}			
	Whole Body	Bone	Lung	Bronchial Epithelium ^{†2}
<u>NFSS^{†3}</u>				
KOA campground	0.62	17	15	10
School	0.081	2.1	1.9	1.3
Trailers	0.045	1.1	1.0	0.89
SCA	0.74	20	18	11
Residence	5.1	140	130	62

<u>HANFORD</u>				
Facilities	0.016	0.099	0.075	1.0 ^{†4}
200-W	1.9	46	42	200 ^{†4}
Richland	0.014	0.086	0.041	0.076 ^{†4}

<u>OAK RIDGE</u>				
National lab	0.040	1.0	0.78	1.3
Diffusion plant	0.050	0.93	0.83	2.4
Residence	0.077	1.7	1.5	2.4

<u>HARBOR</u>				
Barge	0.093	2.6	2.3	2.6
East	0.0014	0.037	0.033	0.053
South	0.0012	0.032	0.029	0.040
West	0.0049	0.015	0.014	0.022
North	0.0016	0.042	0.038	0.061

^{†1} All doses given to two significant figures.

^{†2} Dose resulting from inhalation of short-lived radon-222 decay products.

^{†3} Doses shown are for Alternatives 2b, 3a, 3b, 4a, 4b, 4c, and 4d. Doses for Alternatives 1 and 2a will be <0.001 mrem/yr.

^{†4} These bronchial epithelium doses are for Alternatives 4a and 4b. The bronchial epithelium doses for Alternative 3a will be about 30% of these values.

Fifty-year internal dose commitments--i.e., the entire dose insult received over a period of 50 years following intake into the body--are used to calculate doses resulting from inhalation of radon-222 gas and particulates.

Potential doses to the general public during the action period (Table 4.9) will be low at all three sites. The doses at NFSS under the no-action and modified-containment alternatives (1 and 2a) will be the lowest (the contaminated materials will not be exposed). The doses associated with removing the materials at NFSS will be about the same as reburying them at Oak Ridge, primarily because of a combination of somewhat similar release rates, populations, and meteorological conditions at the two sites. Although the release rates at Hanford will be higher (see previous discussion), the doses will be lower than at NFSS because of the markedly smaller and more distant population. At the Harbor, the release rates will be much lower than at NFSS, but there is a much larger and closer population, thus bringing the doses to the general public during the action period up to the level generally expected at Hanford.

The largest dose to the general public (at NFSS under Alternatives 2b, 3a, 3b, 4a, 4b, 4c, and 4d) is extremely small compared to the doses that the same 3.8 million persons will receive over the same 10-year period from natural background sources of radiation (Table 4.11). For example, the predicted whole-body doses are similar in magnitude to having each member of that population spend the same period of time (10 years) at 3.5-cm (1.4-in.) higher elevation (Argonne Natl. Lab 1982).

Table 4.11. Comparison of Doses to the General Public at NFSS (Alternatives 2b, 3a, 3b, 4a, 4b, 4c, and 4d) to Doses from Natural Background Sources (During Action Period)

Cumulative Population Dose at NFSS During Action Period ^{†1} (person- or organ-rem)	Dose to Same Population ^{†2} from Natural Background Radiation for 10 years (person- or organ-rem)
18 (whole body)	3,000,000 ^{†3}
100 (bone)	4,600,000 ^{†3}
91 (lung)	6,800,000 ^{†3}
110 (bronchial epithelium)	12,000,000 - 23,000,000 ^{†4}

^{†1} All doses are given to two significant figures. Doses are reported as the 100-year environmental dose commitment.

^{†2} Population of 3.8 million persons.

^{†3} Conversion factors are given in a report of the National Council on Radiation Protection and Measurements (1975).

^{†4} Based on 320 to 600 mrem/yr, assuming an outdoor radon-222 concentration of 0.3 pCi/L (Moses et al. 1963), an indoor concentration of 1 pCi/L (U.N. Sci. Comm. At. Radiat. 1977), and dose conversion factors for radon-222 of 1000 mrem/yr per pCi/L for outdoor background conditions (infinite source) and 625 mrem/yr per pCi/L for indoor conditions (50% equilibrium of radon-222 decay products) (U.S. Nucl. Reg. Comm. 1980a).

The doses to the general public during the action period are smaller than the doses resulting from other DOE activities at the Hanford and Oak Ridge reservations. At Hanford, the 1.2-rem whole-body dose compares with the 40-rem dose over the same 10-year period for other DOE nuclear-related activities on the Hanford Reservation (Section 3.2.7). At Oak Ridge, the 16-rem whole-body dose compares with the 200-rem dose associated with other DOE activities over the same 10-year period (Section 3.3.7).

The predicted doses to nearby individuals is also very small compared to background and other sources (Table 4.12). During the year of maximum exposure, the potential resident next to NFSS will receive a whole-body dose that is similar to spending 9 hours on a jet plane or spending the same year at 160-m (530-ft) higher altitude.

For any of the alternatives involving movement of the residues and wastes (Alternatives 2b, 3a, 3b, 4a, 4b, 4c, and 4d), there will be potential for spills at the various sites and along transportation routes. The population doses associated with transportation spills are analyzed in the next subsection; worker doses are analyzed in Section 4.1.3. Doses to the general public associated with onsite spills are not explicitly analyzed. The amount of material exposed as a result of a spill will be small compared to the amount assumed to be routinely exposed during the action period (see previous discussion). Thus, the incremental amount of radon-222 and particulate releases from spilled materials will be insignificant compared to the releases from the routinely exposed material. The worker doses associated with onsite spills are discussed in Section 4.1.3.2.

If Alternative 2b is implemented, there will be a dose to the general public associated with use of the materials extracted from the residues. One of the major potential limitations to implementation of this alternative is the need to determine an acceptable level of residual contamination in these materials and whether or not a specific extraction process can be reasonably designed to meet the requirements (see Section 2.3.1 and Appendix C). Criteria do exist for release to the general

Table 4.12. Comparison of Doses to Nearest Permanent Residents at NFSS During the Action Period to Doses from Other Sources

Dose During Action Period (mrem/10 yr)	Dose to Same Individual During 10-Year Period from Other Sources
5.1 (whole body)	Equal to dose from riding 17 hours in a jet plane at 10,000 m (33,000 ft) because of increase in cosmic radiation with altitude, ^{†1} or Equal to dose from spending the 10 years at 30 m (100-ft) higher altitude ^{†1}
140 (bone)	1200 mrem received from natural sources (background) ^{†1}
130 (lung)	1800 mrem received from natural sources (background) ^{†1}
62 (bronchial epithelium)	3200 to 6000 mrem received from natural sources (background) ^{†2}

^{†1} Conversion factors are given in reports of Argonne National Laboratory (1982) and National Council on Radiation Protection and Measurements (1975).

^{†2} Assuming an outdoor radon-222 concentration of 0.3 pCi/L (Moses et al. 1963), an indoor concentration of 1 pCi/L (U.N. Sci. Comm. At. Radiat. 1977), and dose conversion factors for radon-222 of 1000 mrem/yr per pCi/L for outdoor background conditions (infinite source) and 625 mrem/yr per pCi/L for indoor conditions (50% equilibrium of radon-222 decay products) (U.S. Nucl. Reg. Comm. 1980a).

public of equipment and materials contaminated with surface radioactivity (i.e., Regulatory Guide 1.86, proposed ANSI N13.12); however, there are no generally accepted criteria for release to the general public for unrestricted use of materials containing low levels of radioactivity distributed throughout their volume. The potential doses associated with use of such products will be a function of the level of contamination and type of use. In all probability, if the residual contamination level is questionable, the products will be restricted to DOE use. In any case, the doses to the general public associated with use of those extracted materials will be low compared to the doses associated with the excavation and extraction processes due to the low level of residual contamination, the limited number of people exposed, and the limited duration of exposure. Given these uncertainties, detailed analysis of doses to the general public associated with use of the extracted products is not warranted at this time. Such analysis would be appropriate if use of the products was actually proposed.

Along Transportation Routes. Transport of the NFSS residues and wastes will result in members of the general public being exposed to radiation. Radiation doses will be incurred: (1) as a result of direct exposure to gamma radiation emanating from radionuclides in the residues and wastes, and (2) as a result of release of radon-222 gas and particulates from moving trucks. The radioactive materials released from moving trucks can be absorbed by plants, animals, etc., and enter the food chain. Thus, two different radiation doses from transportation of the residues and wastes are estimated: (1) the external radiation dose resulting from gamma radiation from passing trucks, and (2) the 100-year environmental dose commitment resulting from release of radionuclides from trucks into the environment.

Models developed to estimate the radiological impact of transporting uranium mill tailings are modified and used for this analysis (Chen et al. 1981; Yuan and Chee 1982). The Chen et al. (1981) model is used to estimate external radiation doses, whereas the Yuan and Chee (1982) model is used to estimate doses resulting from dispersion of radon-222 gas and particulates from the transported residues and wastes. Waste packaging and shielding, trip distances and durations, as well as other pertinent input parameters are discussed in detail in Appendix D. A summary of the parameters used for estimating radiation doses to the public from truck transportation of NFSS residues and wastes is given in Table 4.13.

Persons exposed to external radiation can be divided into three categories: (1) persons surrounding the transportation route while the shipment is moving, (2) persons surrounding locations at which the shipment is stationary, and (3) passengers in vehicles sharing the transportation route (traveling both in the same and in opposite directions). The external radiation doses for the alternatives requiring transport of residues and wastes are given in Table 4.14. Even though there will be ten times more shipments of wastes than residues and some of the residue shipments will have additional shielding, the external radiation doses will result primarily from transport of the residues. The wastes will not be classified as radioactive for transportation purposes (see Appendix D).

Table 4.13. Summary of Major Input Parameters for Estimating Radiation Doses to the General Public Resulting from Truck Transportation of NFSS Residues and Wastes

Site/Alternative	Material Transported	Average Radium-226 Concentration (pCi/g)	Radium-226 Inventory per Shipment (Ci)	Method of Transport	Total Number of Shipments	One-Way Time (d)	Stop Time per Shipment (h)	One-Way Distance (km)	Average Population Density (persons/km ²)
<u>HANFORD</u>									
3a, 4a, 4b	Residues† ¹	67,000	1.6 (K-65) 0.1 (L-30/F-32) 0.043 (L-50)	Packaged	1,600	6	15	4,100	110
3a	Wastes	36	0.00052	Bulk	15,000	6	15	4,100	110

<u>OAK RIDGE</u>									
3b, 4c, 4d	Residues† ¹	67,000	1.6 (K-65) 0.1 (L-30/F-32) 0.043 (L-50)	Packaged	1,600	2.5	5	1,300	100
3b	Wastes	36	0.00052	Bulk	15,000	2.5	5	1,300	100

<u>HARBOR</u>									
4b, 4d	Wastes	36	0.00052	Bulk	15,000	1.25	0	1,000	2,300

†¹ Extra shielding may be needed on the vans transporting the K-65 and L-30/F-32 residues (see Appendix D).

Table 4.14. Estimated Radiation Doses to the General Public
Resulting from Transport of NFSS Residues and Wastes^{†1}

Site/Alternative	Material Transported	Source of Dose† ²	Cumulative Doses to the General Public† ¹ (person- or organ-rem)			
			Whole Body	Bone	Lung	Bronchial Epithelium† ³
<u>HANFORD</u>						
3a	Residues and wastes	External radiation	43	43	43	-
		Radioactive releases	<u>57</u>	<u>340</u>	<u>310</u>	<u>130</u>
		Total	100	380	350	130
4a, 4b	Residues	External radiation	41	41	41	-
		Radioactive releases	<u>2.3</u>	<u>13</u>	<u>140</u>	<u>130</u>
		Total	43	54	180	130

<u>OAK RIDGE</u>						
3b	Residues and wastes	External radiation	13	13	13	-
		Radioactive releases	<u>27</u>	<u>200</u>	<u>220</u>	<u>39</u>
		Total	40	210	230	39
4c, 4d	Residues	External radiation	13	13	13	-
		Radioactive releases	<u>0.65</u>	<u>3.9</u>	<u>41</u>	<u>39</u>
		Total	14	17	54	39

<u>HARBOR</u>						
4b, 4d	Wastes	External radiation	1.9	1.9	1.9	-
		Radioactive releases	<u>410</u>	<u>300</u>	<u>1000</u>	<u>5.6</u>
		Total	410	300	1000	5.6

^{†1} All doses given to two significant figures.

^{†2} It is assumed that the external radiation dose to bone and lung is approximately equal to the whole-body dose. Doses associated with radioactive releases (e.g., radon-222 gas and particulates) are reported in terms of the 100-year environmental dose commitment.

^{†3} Dose resulting from inhalation of short-lived radon-222 decay products.

Doses to the general public associated with radioactive releases to the environment during transport are also shown in Table 4.14. It is assumed that radon-222 gas will escape from both the packaged residues and the wastes; however, particulates are assumed to be released only from the unpackaged wastes. The amount of radon-222 gas released is assumed to be 50% of that available for release* in the initial (pre-excavation) amount plus all of the radon-222 generated and available for release* during transport as a result of radioactive decay of radium-226. The radon-222 gas that escapes will decay to solid decay products and will be deposited on the ground. The doses associated with these deposits are included in this analysis.

*As noted previously, it is assumed that only 20% is available for release.

It is also conservatively assumed that 1%* of the wastes will be released as particulates during transport to Hanford. For the other alternatives, the amount released is assumed to be proportional to the lesser distance traveled--i.e., for transport to Oak Ridge and the Harbor, 0.32% and 0.24% will be released, respectively.* These particulates are assumed to be dispersed from the transportation route and result in human exposure and entry into the food chain.

The largest whole-body and lung doses to the general public will be associated with transport of the wastes to the Harbor, primarily because of the release of particulates into the densely populated area. The largest bronchial epithelium and bone doses, however, will be associated with transport of the residues and wastes to Hanford, primarily because of the radon-222 and particulate releases and the longer distance involved. Doses associated with transport to Oak Ridge will be about one-third of the doses to Hanford because the average population densities are approximately the same and the distance to Oak Ridge is about one-third of the distance to Hanford.

The maximum exposed individual is assumed to be an individual who spends 2 hours about 3 meters (10 feet) away from a truck transporting the K-65 residues. This individual will incur an external whole-body dose of about 10 mrem.

During transport of the waste and residues, it is possible for an accident to occur that could result in the release of radioactive materials. The accident rate for trucks transporting radioactive materials is given as 1.06×10^{-6} accidents per vehicle-kilometer in a report of the U.S. Nuclear Regulatory Commission (1977b). Not all of these accidents would be expected to result in release of radioactive material. Because the residues are packaged, the likelihood of a release occurring during an accident would be lower for the residues than for the wastes. In this analysis, it is conservatively assumed that 20% of the accidents involving transport of the residues would result in a release of radioactive material and 50% of the accidents involving transport of the wastes would result in a release. Using these rates and the total distance traveled for the various alternatives, the expected number of accidents involving a release of radioactive materials is shown in Table 4.15.

Table 4.15. Projected Number of Transportation Accidents Involving Release of Radioactive Material†¹

Site/Alternative	Material Transported	Total Number of Shipments	One-Way Distance (km)	Total Distance (One-Way) Traveled (km)	Potential Number of Accidents Involving Release of Radioactive Material† ²
<u>HANFORD</u>					
3a, 4a, 4b	Residues	1,600	4,100	6.6×10^6	1.4
3a	Wastes	15,000	4,100	6.2×10^7	31

<u>OAK RIDGE</u>					
3b, 4c, 4d	Residues	1,600	1,300	2.1×10^6	0.45
3b	Wastes	15,000	1,300	2.0×10^7	10

<u>HARBOR</u>					
4b, 4d	Wastes	15,000	1,000	1.5×10^7	7.5

†¹ All estimates are given to two significant figures.

†² Based on the following assumptions: (1) accidents occur at the rate of 1.06×10^{-6} per vehicle-kilometer and (2) 20% of the accidents involving residues and 50% of the accidents involving wastes result in release of radioactive material.

During transport of the residues, about one accident is projected to occur that would result in release of radioactive material (Table 4.15). If an accident involving loss of contaminated materials

*No data are available regarding actual releases during bulk transport of soil materials (such as the NFSS wastes). Adjusting for distance traveled, it has been assumed that 0.5% of coal is lost during transport over similar distance (Szabo 1978). Allowing for the smaller average particle sizes in the NFSS wastes relative to chunks of coal mixed with coal dust, it is assumed that releases during transport to Hanford will be 1%. If the covers over the wastes are kept secure, actual releases should be substantially less.

occurs, efforts will be taken to minimize doses to the surrounding population. Access to the affected area will be controlled, and the contaminated material will be cleaned up as quickly as possible. The cumulative radiation doses to the general population from such accidents would be small in comparison to that incurred from normal transport. For this reason, radiation doses to the general population from transportation accidents are not analyzed explicitly in this EIS. However, it is possible for one or a few individuals to incur a measurable dose from such an accident. A person standing 1 meter (3 feet) from a ruptured K-65 bin for 10 minutes will receive a dose of about 20 mrem.

It is projected (Table 4.15) that several accidents could occur during shipment of the wastes with subsequent release of radioactive material. However, the consequences will be much lower for an accident involving the wastes than for one involving the residues. A person standing for 10 minutes at 1 meter (3 feet) from a spill of these materials will receive a dose of only 0.007 mrem. (Worker doses associated with transportation accidents are discussed in Section 4.1.3).

From Ocean Disposal. Site 106 is located on the lower edge of the Continental Slope and the upper edge of the Continental Rise. It is isolated from human habitation and is not hydrologically connected to any human water supply. The dumpsite is located in an area of tranquil deposition of sediments; wastes deposited on the sediments will remain there. Clumps and aggregates of NFSS wastes are expected to be deposited within the dumpsite, 1.6 km or less from the dump location (Appendix E, Section E.4.2).

Commercial fishing operations for bottomfish are limited to the Continental Shelf and are therefore not present within the dumpsite boundaries (U.S. Environ. Prot. Agency 1980a). Bottomfish abundance is low and any desirable species are more accessible to commercial exploitation in other areas of the dumpsite region. Both the red crab and the grey sole (or witch flounder) are known to occur at the dumpsite, and juveniles of the grey sole have been abundant in some trawl samples in the vicinity of the site (Musick et al. 1975). Juveniles of this species are most likely to be found on the lower and upper Continental Slope (approximately 160 m to 1400 m). Adults have not been captured at Site 106; they are more common at depths of 90 to 330 m near Site 106. The juveniles have a greater tendency toward seasonal migration than the adults (Martin and Drewry 1978), and Musick et al. (1975) suggest that the juveniles on the Continental Slope are later found as adults on the Continental Shelf.

Because commercial fishing is not practiced within the dumpsite or vicinity, no dose to the general public is expected. It is possible, although very unlikely, that an individual might eat fish from either a bottom-dwelling or a surface-dwelling fish that had been exposed to elevated concentrations of naturally occurring radionuclides resulting from disposal of the NFSS wastes. Therefore, both cases are analyzed and the dose to such an individual in the worst of the two cases is estimated.

It is possible that a bottom-dwelling grey sole juvenile living near the waste deposits at the dumpsite bottom could migrate to the lower Continental Shelf, there to be caught and consumed when an adult. If so, a person might purchase and consume a filet of that fish (1-2 kg) through a commercial fish dealer. Because grey sole juveniles living in the dumpsite are a very small part of a mobile and widely distributed species, it is unlikely that the same individual would eat a filet of fish from Site 106 more than once in his/her lifetime. The radium-226 content of an adult grey sole that spent a portion of its life near the wastes at Site 106 would depend upon the radium-226 concentration of water to which the fish was exposed and the rate of removal of radium-226 from the fish's flesh after it left the dumpsite. Analysis of movement of radium-226 from wastes deposited on the sediments of the dumpsite (Appendix E) suggests that dissolved radium-226 concentrations in water in the vicinity of the sediments will be only 0.002 pCi/L above the ambient concentration of radium-226 in seawater (0.1 pCi/L). The IAEA (Templeton 1979) recommends a concentration factor of 100 for radium-226 (i.e., 100 radium-226 atoms in fish for every atom in seawater). Therefore, the radium-226 content of the grey sole living on or near the wastes would be increased by 0.0002 pCi/g. Because ocean fish naturally contain an average of 0.0016 pCi/g of radium-226, the average radium-226 concentration of contaminated bottomfish would be 0.0018 pCi/g.

It also may be possible for a person to consume a surface-dwelling fish that had been in contact with the NFSS wastes within the surface waters of Site 106. Highly mobile, large open-water fish such as swordfish, sharks, and tuna are present in the dumpsite area and are caught by commercial longline fishing in adjacent Continental Shelf waters. Such a fish might swim throughout the dumpsite and at a later time swim into an area of longline fishing. A person might obtain the flesh of these fish as filets (1-2 kg) from a commercial dealer.

For brief periods following the dumping action, until the wastes are dispersed and diluted (Appendix E), the concentrations of the naturally occurring radionuclides found in the NFSS wastes are expected to be elevated above background in the surface waters. It is conservatively assumed that the concentration of radium-226 in a surface-dwelling fish comes into equilibrium with radium-226 in the contaminated water by the time the water leaves the dumpsite (4 days). By this time, the concentration of wastes in seawater is expected to be less than 100 mg/L (Section 4.5.2). Because the radium-226 content of the wastes is 36 pCi/g, the total radium-226 concentration in the waste-contaminated seawater will be less than 3.6 pCi/L. Because the concentration factor for radium-226 in

sediments is 500 (i.e., 500 radium-226 atoms in sediments to every atom in seawater), the dissolved radium-226 concentration in the waste-contaminated seawater will be less than 0.007 pCi/L. Using the previously mentioned concentration factor of 100 for fish, the radium-226 concentration of fish will be increased by 0.0007 pCi/g. Thus, the fish that naturally contains 0.0016 pCi/g radium-226 will contain 0.0023 pCi/g radium-226.

It is unlikely that anyone will ever consume a fish in which the radium-226 concentration is elevated above natural concentrations because commercial fishing in the dumpsite area is not frequent or habitual and the dumping episodes will occur only 3-5 times per month over a 2-year period. However, if an individual adult human consumed 2 kg of fish filet having 0.0007 pCi/g radium-226 above the normal 0.0016 pCi/g, he/she would incur an incremental dose of 0.0072 mrem to the whole body and 0.084 mrem to the bone. Doses to other organs would be even lower. These doses are estimated using ingestion dose conversion factors reported in Streng and Bander (1981). This conservatively high dose is insignificant compared to the dose a person normally receives from natural background radiation.

In conclusion, no significant radiological impact to the general public, either during the action period or during subsequent periods, is expected due to ocean disposal of the NFSS wastes. This conclusion is based on the fact that: (1) the NFSS wastes are expected to disperse in the ocean at Site 106, (2) Site 106 is not now or will ever likely be used for any extensive commercial fishing, and (3) the major radionuclide of potential concern (radium-226) is already present in the ocean and decreases in concentration from wastes to water.

4.1.2.2 Maintenance and Monitoring Period (10 to 200 years)

Maintenance, monitoring, and corrective remedial actions (as necessary) are assumed for 10 to 200 years. The wastes and residues will be covered during this period at all three sites. Therefore, the primary source of radiation exposure will be via the inhalation of radon-222 gas and its short-lived decay products.

There will be no significant population dose via the water pathway at any of the sites. At all three sites, maintenance of the layered cover system will prevent erosion of the contained wastes and residues into surface waters. Also, groundwater contamination will not be a significant pathway for several reasons. As discussed in Sections 3.1.2 and 4.2.2, most of the public water supply in the region of NFSS is from surface waters upstream of the site and the rest is from a deep aquifer that does not underlie NFSS. The shallow near-surface aquifer at NFSS can yield limited quantities of groundwater (i.e., a large sand lens yielding water for single-family use). Because leachate may contaminate the near-surface aquifer, it is assumed that the monitoring program will include identification of any new wells and monitoring to detect any contamination from NFSS. A mitigative measure that could also be applied is to ensure that zoning ordinances prohibit such shallow wells near hazardous waste facilities such as NFSS and SCA. The potential radiological impact to a theoretical individual drinking contaminated well water is discussed in Section 4.1.2.3 (long-term period, when all controls are lost).

At Hanford and Oak Ridge, groundwater contamination will not occur during the 10- to 200-year time period (see Section 4.2.2).

Calculation of doses for the maintenance and monitoring period is done in the same manner as for the action period. The current meteorological patterns and population distributions are used. It is also assumed that the relative differences in population sizes and distributions between the three sites will be the same in 200 years. The locations of selected nearby individuals are also assumed to be the same as for the action period.

To calculate radon-222 releases from the covered residues and wastes, it is necessary to make several assumptions about the depths, areas, and nature of the wastes, residues, and various layers of cover materials. The depths of the various materials at each of the sites for each of the alternatives are illustrated in Figures 4.3 through 4.6 (see Section 2 for description of conceptual designs for each alternative).^{*} The areas covered by the residues and wastes are shown in Table 4.16.^{**}

The radon-222 gas will diffuse through the various layers at different rates (e.g., it will diffuse faster through dry sand than wet clay). The radon-222 diffusion coefficients that are assumed for the different materials are given in Table 4.17. Of the several physical properties of the

^{*}Although the depths of the residue slag in Alternative 2b will be less than for the unmodified residues in Alternative 2a, it is assumed for purposes of this analysis that the depths are the same for both alternatives. Any difference due to depth is assumed to be accounted for in the assumption that the diffusion coefficient for the slag is one-tenth of that for the unprocessed residues.

^{**}The exact placement of the residues in Building 411 differs from that assumed for the analyses in this EIS. However, this does not significantly change the prediction of impacts as given in this EIS.

NFSS

Alternative 1 (no action)

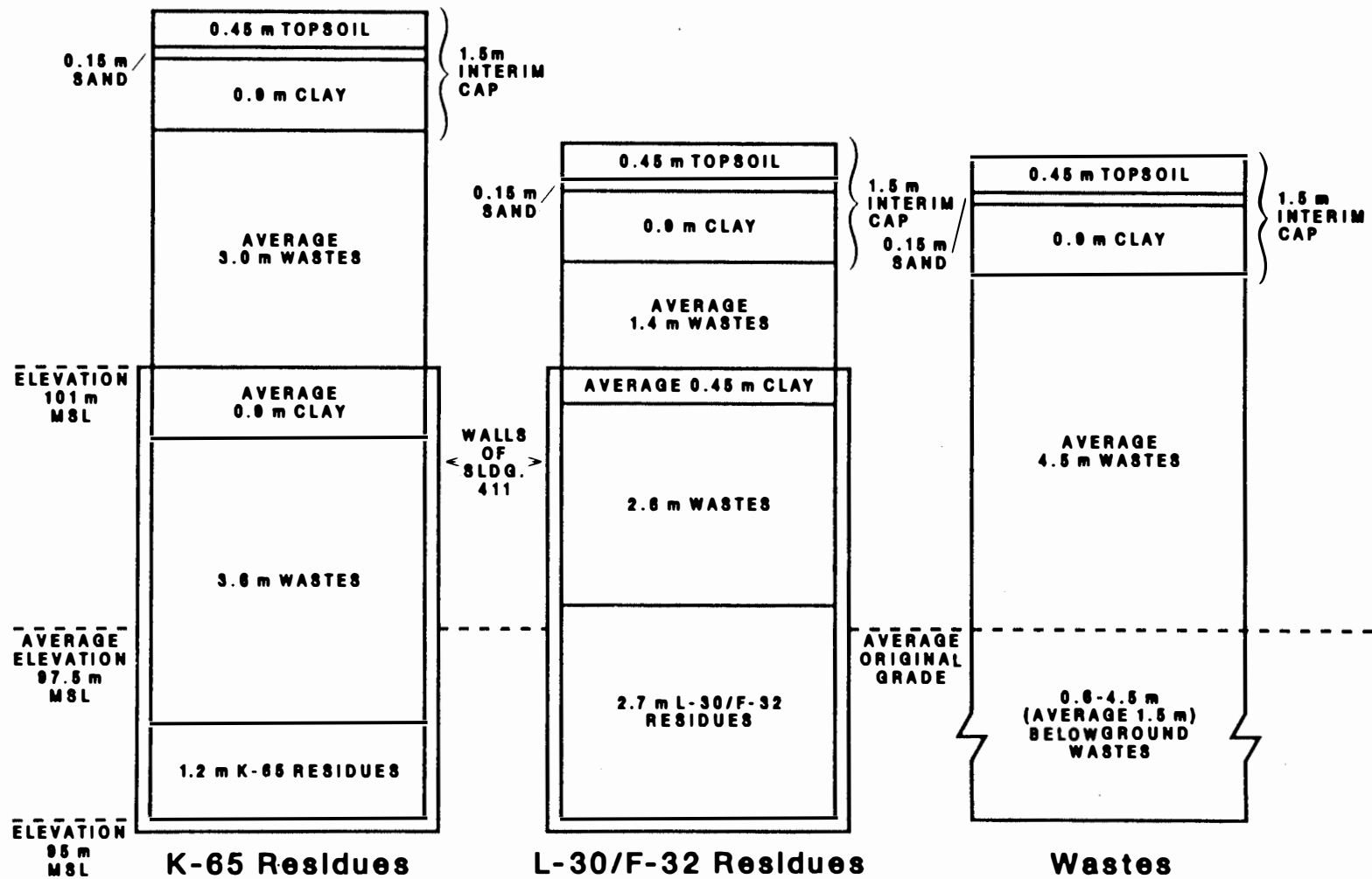


Figure 4.3. Initial Depths of Various Materials at NFSS, Alternative 1. NOTE: The exact placement of the residues in Building 411 differs from that depicted in this figure. However, this does not significantly change the prediction of impacts as given in this EIS.

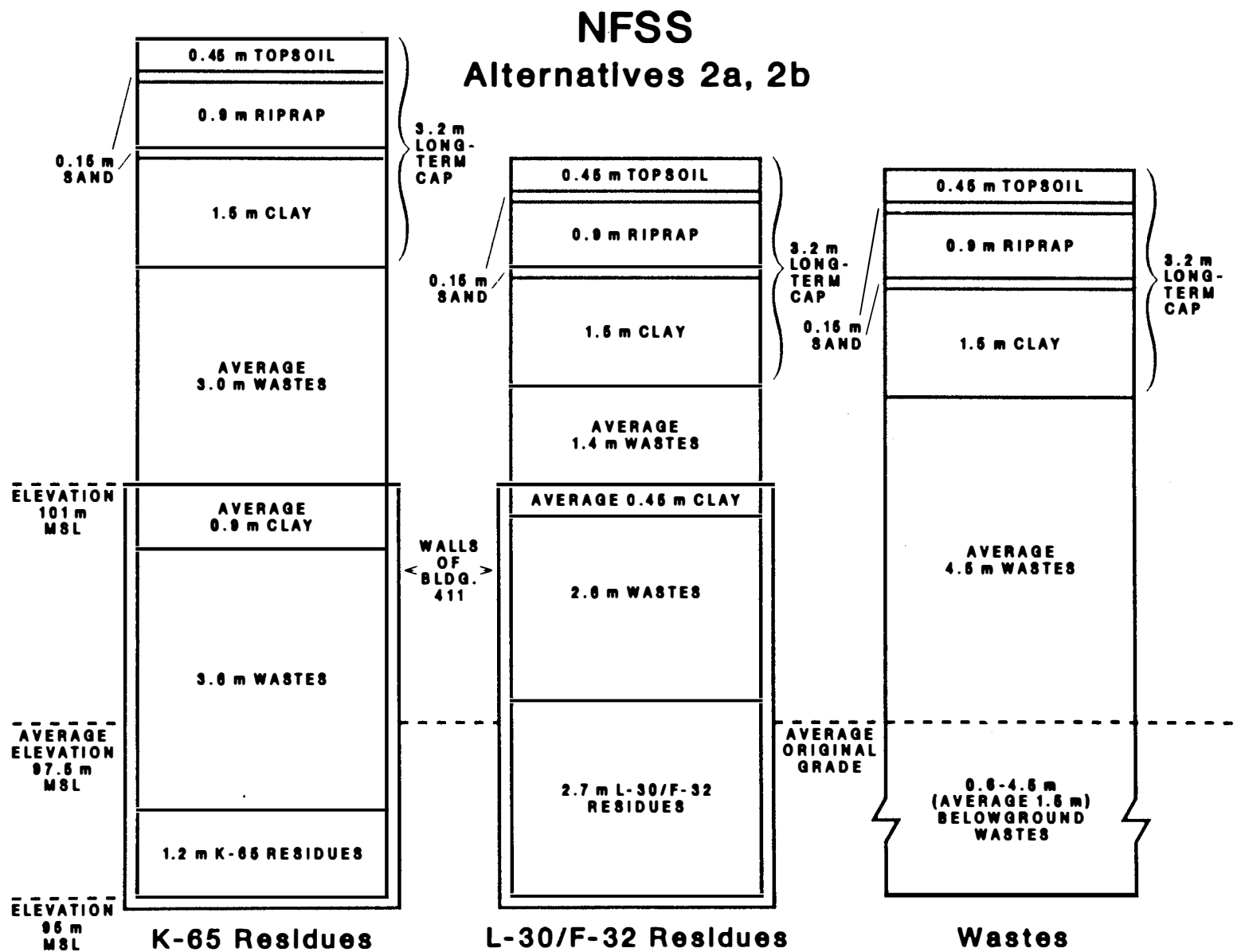


Figure 4.4. Initial Depths of Various Materials at NFSS, Alternatives 2a and 2b. NOTE: The exact placement of the residues in Building 411 differs from that depicted in this figure. However, this does not significantly change the prediction of impacts as given in this EIS.

NFSS

Alternatives 4a, 4c

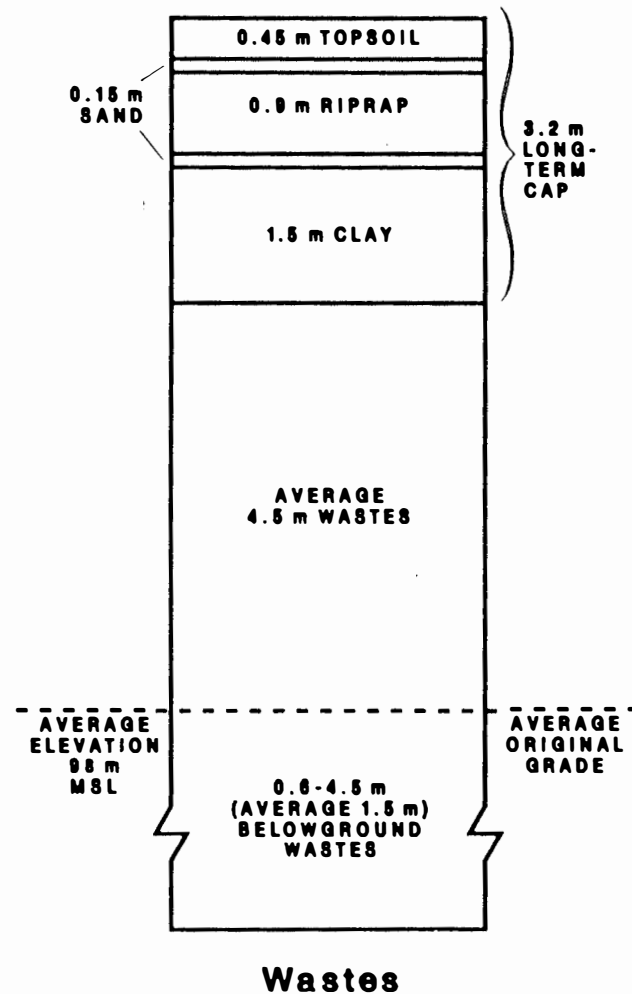


Figure 4.5. Initial Depths of Various Materials at NFSS, Alternatives 4a and 4c.

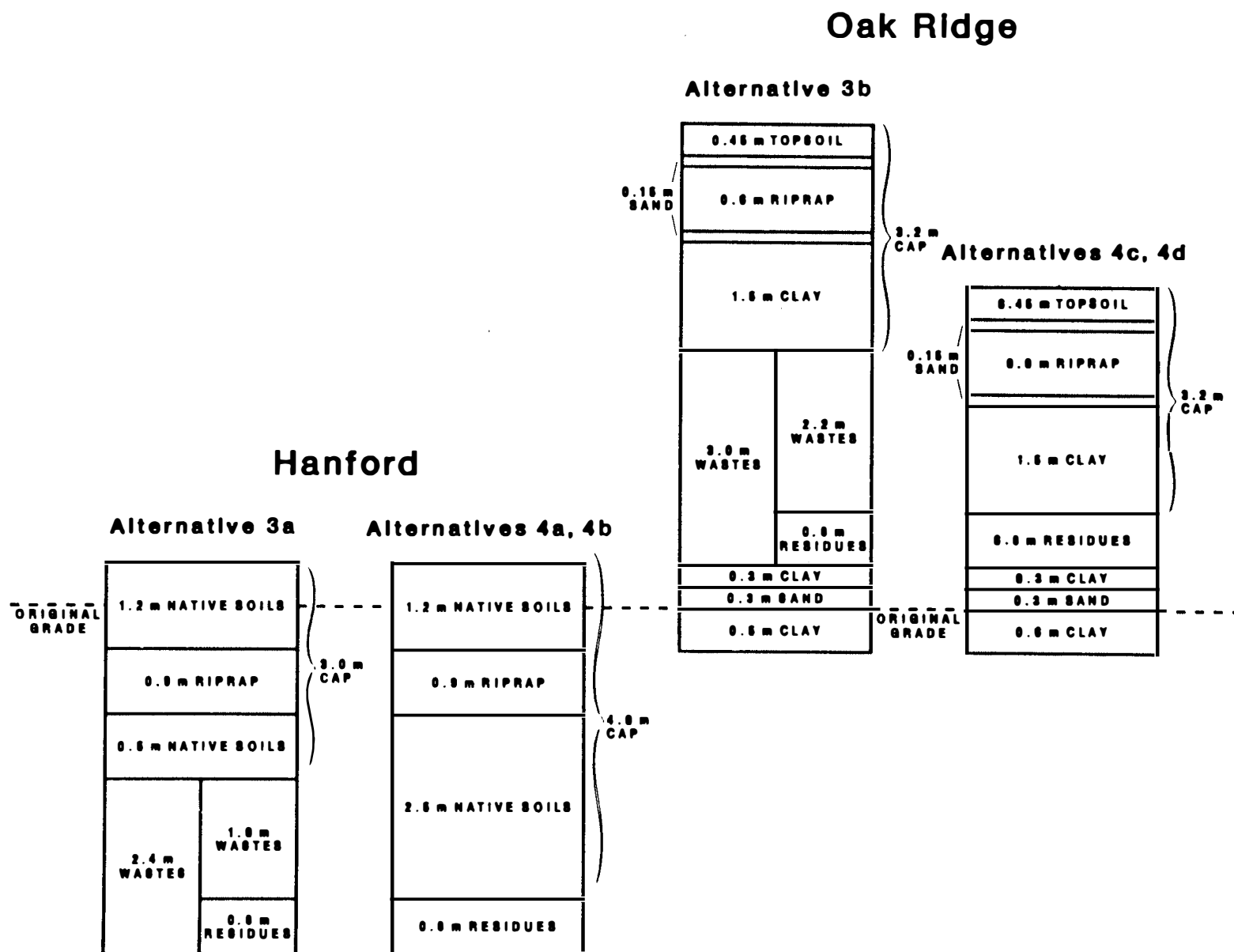


Figure 4.6. Initial Depths of Various Materials at Hanford--Alternatives 3a, 4a, and 4b-- and Oak Ridge--Alternatives 3b, 4c, and 4d.

Table 4.16. Areas Covered by Residues and Wastes

Site/Alternative	Residues and/or Wastes	Area† ¹	
		m ²	acres
<u>NFSS</u>			
1, 2a, 2b	K-65 residues and overlying wastes	1,700† ²	0.4
	L-30/F-32 residues and overlying wastes	1,700† ²	0.4
	Wastes only	<u>29,000</u>	<u>7.2</u>
	Total	32,000	8.0
4a, 4c	Wastes only	32,000	8.0

<u>HANFORD</u>			
3a	Residues and overlying wastes	14,000	3.4
	Wastes only	<u>81,000</u>	<u>20</u>
	Total	95,000	23
4a, 4b	Residues	14,000	3.4

<u>OAK RIDGE</u>			
3b	Residues and overlying wastes	14,000	3.4
	Wastes only	<u>62,000</u>	<u>15</u>
	Total	76,000	18
4c, 4d	Residues	14,000	3.4

†¹ Does not include areas covered by dikes and caps, areas between trenches, areas between residue packages, or buffer zones, service areas, etc. See Section 4.6 for total areas at each site. All data given to two significant figures.

†² The exact placement of the residues in Building 411 differs from that assumed for the analyses in this EIS. However, this does not significantly change the prediction of impacts as given in this EIS.

Table 4.17. Assumed Radon-222 Diffusion Coefficients for Various Materials

Material	Representative % Moisture	Radon-222 Diffusion Coefficient† ¹ (cm ² /s)
Riprap (air)	0	0.1
Sand		
Native soils at Hanford	6	0.022
Stoney soils at Hanford		
Topsoil at NFSS or Oak Ridge		
Stoney soils at NFSS or Oak Ridge	13	0.0036
Drier NFSS residues and wastes at Hanford		
Stoney wastes at NFSS		
Damp clay at NFSS or Oak Ridge		
Damp NFSS residues and wastes at NFSS or Oak Ridge	25	0.00016

†¹ Calculated using formula given in a report of the U.S. Nuclear Regulatory Commission (1980a--Appendix P).

residues, wastes, and cover materials that influence radon diffusion coefficients, the moisture content is the most important. The moisture content of these materials will vary not only throughout the year (particularly the materials near the surface) but also over time as the properties of materials (particularly the cap) are changed by natural physical and biological forces (Sections 4.2 and 4.3). These variations over hundreds of years cannot be predicted with certainty. Therefore, for purposes of analysis of the conceptual designs and comparisons of the alternatives in this EIS, the materials are grouped into four categories and "representative" moisture contents are used to determine radon diffusion coefficients.

The moisture content of the materials near the bottom will fluctuate the least. The residues at the bottom are expected to be saturated at about 30% moisture upon completion of the slurry/dewatering operations during the interim remedial actions (base case for analysis in this EIS). Therefore, the assumed 25% moisture content is conservatively low (i.e., results in a higher than expected diffusion coefficient) for the residues at NFSS and Oak Ridge. When the residues are taken to the arid Hanford site, they will also be buried under several feet of wastes and cap, but it is conservatively assumed that they will dry out to about 13% moisture content in the arid climate.

The wastes are essentially the native clayey soils excavated from the NFSS area and they will be covered with the layered caps at NFSS and Oak Ridge. Therefore, they are not expected to appreciably change in moisture content, and the 25% value is within the range from hygroscopic (dry) to field capacity (saturated) (Brady 1974). When the wastes are taken to Hanford, they are assumed to dry out to about 13%. Likewise, the clay layer at NFSS and Oak Ridge will be protected by the riprap/sand/topsoil and on the average is assumed to have about a 25% moisture content.

The representative moisture content of the next two groups of materials are also within the ranges reported in the literature. The riprap layer at all sites is conservatively assumed to retard radon no more than air. The radon flux from the residue slag (modified form) is simply assumed to be one-tenth of that of the unmodified residues (the physical properties of the slag are not well known--see Appendix C).

The radon fluxes are calculated according to the method of analysis given in a report of the U.S. Nuclear Regulatory Commission (1983a). The resulting calculated fluxes (Table 4.18) are several orders of magnitude smaller for the humid eastern sites than for the arid western site. Differences between the two eastern sites are well within the uncertainties due to changes in the materials over hundreds of years. The total radon-222 release rates associated with these fluxes and the resultant doses to the general public are given in Table 4.19.

The releases at NFSS result primarily from the presence of the wastes. The residues are buried so deeply that the radon-222 gas diffusing from the residues decays to solid decay products before it has a chance to escape from the containment system (hence, modification of the residue form does not affect fluxes at the top of the containment area). Only the radon-222 from the wastes on top of the residues can escape through the cap. Even so, the release rates are extremely low. At Oak Ridge, the release rates are also extremely low. At Hanford, the release rates are several orders of magnitude higher, primarily because the diffusion rates will be higher in the drier materials at that site.

At NFSS and Oak Ridge, the rates of radon-222 release are expected to be well below the DOE regulatory limit of 20 pCi/m²/s (see Appendix H). At Hanford, however, the radon-222 fluxes are expected to be slightly above criteria for Alternative 3a (29 pCi/m²/s) and 15 times above criteria for Alternatives 4a and 4b (300 pCi/m²/s). The flux is much higher for Alternatives 4a and 4b than for Alternative 3a because the NFSS wastes will not be moved to Hanford and placed over the residues in Alternatives 4a and 4b. The wastes, even though they will be much drier at Hanford than at NFSS and Oak Ridge, are still a better radon-222 barrier than the dry native sandy soils at Hanford. To bring the radon-222 fluxes at Hanford for Alternatives 4a and 4b down to the 20 pCi/m²/s criteria level, the trenches would have to be about 7.5-m (25-ft) deep. To reduce the radon-222 flux to the same low levels as predicted for the alternatives at NFSS and Oak Ridge, the trenches at Hanford would have to be about 30-m (97-ft) deep (assuming backfill with the native sandy soils). An alternative to deeper trenches is the use of backfill material that has a lower radon-222 diffusion coefficient (e.g., clay), but such material is not readily available in large quantities near Hanford. If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

The surface radon-222 fluxes will be higher at year 1000 due to the gradual loss of cover under erosive land uses (see Section 4.1.2.3). Again, the only site that will exceed the DOE limit of 20 pCi/m²/s is Hanford. At Hanford, the surface radon-222 flux will be 110 pCi/m²/s for Alternative 3a and 1100 pCi/m²/s for Alternatives 4a and 4b at year 1000.

Table 4.18. Estimated Surface Radon-222 Flux
for the Various Alternatives

Site/Alternative	Buried Radioactive Material	Surface Radon Flux† ¹ (pCi/m ² /s)	
		Until Year 201	At Year 1000
<u>NFSS</u>			
1	Wastes and underlying K-65 residues	2.9 × 10 ⁻⁵	9.6† ²
	Wastes and underlying L-30/F-32 residues	2.9 × 10 ⁻⁵	9.6† ²
	Wastes only	2.9 × 10 ⁻⁵	9.6† ²
2a, 2b† ²	Wastes and underlying K-65 residues	1.1 × 10 ⁻⁸	2.1 × 10 ⁻³
	Wastes and underlying L-30/F-32 residues	1.1 × 10 ⁻⁸	2.1 × 10 ⁻³
	Wastes only	1.2 × 10 ⁻⁸	2.1 × 10 ⁻³
4a, 4c	Wastes only	1.2 × 10 ⁻⁸	2.1 × 10 ⁻³

<u>HANFORD</u>			
3a	Wastes and underlying residues	29	110
	Wastes only	3.5 × 10 ⁻¹	3.5
4a, 4b	Residues only	300	1,100

<u>OAK RIDGE</u>			
3b	Wastes and underlying residues	7.9 × 10 ⁻⁹	2.2 × 10 ⁻⁸
	Wastes only	7.8 × 10 ⁻⁹	2.2 × 10 ⁻⁸
4c, 4d	Residues only	1.5 × 10 ⁻⁵	1.3 × 10 ⁻²

†¹ Assumes maintenance and monitoring efforts until year 201 and erosive land use (Section 4.2.1) from the year 201 through the year 1000.

†² Cap is predicted to be completely eroded away and the wastes exposed at the surface by the year 1000. The predicted surface radon flux is, therefore, from the surface of the exposed wastes.

Doses to the general public during the maintenance and monitoring period are calculated assuming that the average radon-222 release rates will be the same each year. In reality, there will be periodic increases in diffusion through the cap prior to any maintenance actions. The cumulative doses to the general public resulting from the radon-222 releases for 190 years are shown in Table 4.19. The maximum individual organ doses to permanent residents near the sites will be less than 0.001 mrem per year for all alternatives at all sites.

The doses to the general public at Hanford are clearly higher than at NFSS or Oak Ridge. However, these doses are still insignificant relative to the dose that the population near Hanford will receive over the same period of time from natural background sources of radioactivity in the environment (Table 4.20).

Table 4.19. Radon-222 Release Rates and Doses to the General Public
During the Maintenance and Monitoring Period (10 to 200 years)

Site/Alternative	Radon-222 Release Rate (Ci/yr)† ¹	Cumulative Doses to the General Public (person- or organ-rem)† ²			
		Whole Body	Bone	Lung	Bronchial Epithelium† ³
<u>NFSS</u>					
1	3 × 10 ⁻⁵	<0.001	<0.001	<0.001	0.0032
2a	1 × 10 ⁻⁸	<0.001	<0.001	<0.001	<0.001
2b	1 × 10 ⁻⁸				
4a, 4c	1 × 10 ⁻⁸				

<u>HANFORD</u>					
3a	14	2.5	13	2.0	140
4a, 4b	130	23	120	19	1300

<u>OAK RIDGE</u>					
3b	2 × 10 ⁻⁸	<0.001	<0.001	<0.001	<0.001
4c, 4d	7 × 10 ⁻⁶				

^{†1} Incremental release above background. Based on areas given in Table 4.16 and fluxes given in Table 4.18.

^{†2} All doses are given to two significant figures unless preceded by a less than (<) symbol. Doses are reported as the cumulative 100-year environmental dose commitment over 190 years. Cumulative doses to the general public below 0.001 person- or organ-rem are not given because doses this small are immeasurable and meaningless with regard to predicting detrimental health effects.

^{†3} Dose resulting from inhalation of short-lived radon-222 decay products.

Table 4.20. Comparison of Doses to the General Public at Hanford
(Alternatives 4a and 4b) to Doses from Natural Background
Sources (During Maintenance and Monitoring Period)

Cumulative Population Dose at Hanford During Maintenance and Monitoring Period ^{†1} (person- or organ-rem)	Dose to Same Population ^{†2} from Natural Background Radiation for 190 years (person- or organ-rem)
23 (whole body)	3,900,000 ^{†3}
120 (bone)	5,900,000 ^{†3}
19 (lung)	8,800,000 ^{†3}
1300 (bronchial epithelium)	16,000,000 - 29,000,000 ^{†4}

^{†1} All doses are given to two significant figures. Doses are reported as the cumulative 100-year environmental dose commitment over 190 years.

^{†2} Population of 258,000 persons.

^{†3} Conversion factors are given in a report of the National Council on Radiation Protection and Measurements (1975).

^{†4} Based on 320 to 600 mrem/yr, assuming an outdoor radon-222 concentration of 0.3 pCi/L (Moses et al. 1963), an indoor concentration of 1 pCi/L (U.N. Sci. Comm. At. Radiat. 1977), and dose conversion factors for radon-222 of 1000 mrem/yr per pCi/L for outdoor background conditions (infinite source) and 625 mrem/yr per pCi/L for indoor conditions (50% equilibrium of radon-222 decay products) (U.S. Nucl. Reg. Comm. 1980a).

In summary, control and maintenance of the NFSS wastes and residues in an earthen mound at NFSS (preferred alternative) is predicted to result in doses to nearby members of the general public that are extremely small compared to doses that occur in everyday life because of natural radioactivity in the environment. For example, the predicted maximum individual dose of less than 0.001 mrem/yr (whole body) compares with approximately 2.0 rem/yr that the same individual would receive just by moving to Buffalo, New York, because of the increase in cosmic radiation at the 117-m (385-ft) higher altitude in Buffalo. The same individual would receive 3.0 mrem from riding 10 hours cross country in a jet plane at 10,000 m (30,000 ft) altitude. Likewise, the predicted doses of less than 0.001 mrem/yr to other organs compare with the following yearly doses from natural sources (background radiation such as naturally occurring radionuclides in the soil, water, and body tissues; and cosmic radiation from outer space): 120 mrem/yr (bone), 180 mrem/yr (lung), and 320-600 mrem/yr (bronchial epithelium).

4.1.2.3 Long-Term Period (200 to 1000 years)

During the long-term period (200 to 1000 years), the primary pathway to the general public will again be via inhalation of radon-222 gas and its decay products. It is assumed, for purposes of analysis, that the covers will no longer be maintained and that they will gradually erode. Under Case A (land-use controls still in effect), the rates of erosion from land covered with natural vegetation will be slow (Section 4.2.1). In all alternatives, the residues will not be exposed. The covers will continue to inhibit radon-222 diffusion out of and water infiltration into the wastes (although not as well as during the maintenance and monitoring period--see Section 4.3 for discussion of biointrusion). Although the cap thicknesses will be decreasing slightly, the rates of radon-222 release are not expected to be significantly different than during the maintenance and monitoring period.

For Case B (no controls), the erosion rates under intensive use of the land (i.e., agriculture at NFSS and Oak Ridge and overgrazed range at Hanford--Section 4.2.1) will be much greater. Only under Alternative 1 will the cap be eroded away within 1000 years. Doses under Case B are estimated for the general public and for an individual called the "resident-intruder". Following are discussions of the assumptions, methodology, and results of the analysis of doses to the general public and a hypothetical resident-intruder at each site.

General Public. The water pathway to the general public is not significant for the long-term period (to 1000 years) because of the same considerations discussed for the maintenance and monitoring period. For estimating doses via airborne releases, it is assumed that there will be one million people evenly distributed within 80 km of each site, thus focusing on the site-specific physical features (geology, hydrology, meteorology, containment system, etc.). This assumption is reasonable because, over such a long time period, relative population differences between sites could completely change (e.g., the population near the Hanford site could become larger than at the other sites). Therefore, for purposes of analysis, it is assumed that the populations near each site are identical and the doses to the general public are reported in terms of dose per million persons.

It is also assumed that the meteorological conditions will be the same as current conditions. Although there may be some climatic changes over 1000 years, it is expected that the relative differences between sites will remain the same, i.e., the climate at Hanford will continue to be arid and the climates at Oak Ridge and NFSS will continue to be humid.

At year 201, radon-222 releases will be the same as during the maintenance and monitoring period (Table 4.21). At year 1000, the materials covering the waste and residues will be less thick and have different radon-222 diffusion coefficients due to the natural process of erosion (Section 4.2.1) and soil formation (Section 4.3). Therefore, radon-222 release rates at the year 1000 (Table 4.21) are calculated based on the depths of the various materials as given in Table 4.22 and the radon-222 diffusion coefficients as given in Table 4.17. In addition to radon-222 releases, for Alternative 1 there will be particulate releases because the cap will be completely eroded away, thus exposing the wastes.

At year 201 and at year 1000, the highest doses to the general public (per million persons) will be at the Hanford site for Alternatives 4a and 4b. As during the maintenance and monitoring period, the arid climate at Hanford results in higher rates of radon-222 release with consequent higher doses to the general public. Exposure of the wastes at NFSS under Alternative 1 will result in population doses to the whole body, bone, and lung comparable to those at Hanford. The relatively large organ doses at NFSS for Alternative 1 are a result of particulate releases. Once the caps eventually erode at all sites, the population doses to the whole body, bone, and lung at all three sites will be comparable, assuming equal population distributions, because the major contributor to these doses will be from particulate releases. The bronchial epithelium doses will be larger at Hanford due to the drier climate which results in drier wastes, residues, and cover materials.

Although the doses at Hanford will be significantly larger during the long term than at the other sites under any of the action alternatives (the doses at NFSS under the no-action Alternative 1 will be comparable to the doses at Hanford), the doses will still be insignificant relative to the doses that the populations will receive from natural background sources of radioactivity (Table 4.23).

Table 4.21. Radon-222 Release Rates and Doses to the General Public
at the Year 201 and the Year 1000

Site/ Alternative	At Year 201					At Year 1000				
	Radon-222 Release Rate (Ci/yr)† ¹	Dose to the General Public† ^{2,†3} (organ-rem/year/million persons)				Radon-222 Release Rate (Ci/yr)† ⁵	Dose to the General Public† ^{2,†3} (organ-rem/year/million persons)			
		Whole Body	Bone	Lung	Bronchial Epithelium† ⁴		Whole Body	Bone	Lung	Bronchial Epithelium† ⁴
NFSS										
1	3 × 10 ⁻⁵	<0.001	<0.001	<0.001	<0.001	9.8† ⁶	0.065	1.9	1.7	1.6
2a, 2b, 4a, 4c	1 × 10 ⁻⁸	<0.001	<0.001	<0.001	<0.001	2 × 10 ⁻³	<0.001	<0.001	<0.001	<0.001

HANFORD										
3a	14	0.092	0.39	0.078	6.5	59	0.39	1.7	0.33	28
4a, 4b	130	0.86	3.7	0.73	61	500	3.3	14	2.8	230

OAK RIDGE										
3b	2 × 10 ⁻⁸	<0.001	<0.001	<0.001	<0.001	5 × 10 ⁻⁸	<0.001	<0.001	<0.001	<0.001
4c, 4d	7 × 10 ⁻⁶	<0.001	<0.001	<0.001	<0.001	6 × 10 ⁻³	<0.001	<0.001	<0.001	0.0020

^{†1} Incremental release above background. Same as during maintenance and monitoring period (see Section 4.1.2.2).

^{†2} Assumed populations of one million persons evenly distributed within 80 km of each site.

^{†3} All doses given to two significant figures, unless preceded by a less than (<) symbol. Cumulative doses to the general public below 0.001 person- or organ-rem are not given because doses this small are immeasurable and meaningless with regard to predicting detrimental health effects.

^{†4} Dose resulting from inhalation of short-lived radon-222 decay products.

^{†5} Incremental release above background. Based on depths of materials as shown in Table 4.22.

^{†6} In addition to radon-222 releases, there will be particulate releases (3×10^{-3} Ci/yr for thorium-230, radium-226, and all subsequent decay products except radon-222 gas) from the exposed residues (the cap will have eroded away).

Table 4.22. Thickness of Various Materials at Year 1000
(Case B, No Controls)

Site/ Alternative	K-65 Residues		L-30/F-32 Residues		Wastes	
	Material† ¹	Thickness† ² (m)	Material† ¹	Thickness† ² (m)	Material† ¹	Thickness† ² (m)
<u>NFSS</u>						
1	Stoney wastes	0.7	Stoney wastes	0.7	Stoney wastes	0.7
	Wastes	1.9	Wastes	0.3	Wastes	4.9
	Clay	0.9	Clay	0.45		
	Wastes	3.6	Wastes	2.6		
	K-65 residues	1.2	L-30/F-32 residues	2.7		
2a, 2b	Stoney soil	0.7	Stoney soil	0.7	Stoney soil	0.7
	Clay	0.5	Clay	0.5	Clay	0.5
	Wastes	3.0	Wastes	1.4	Wastes	6.0
	Clay	0.9	Clay	0.45		
	Wastes	3.6	Wastes	2.6		
	K-65 residues† ³	1.2	L-30/F-32 residues† ³	2.7		
4a, 4c	Not applicable		Not applicable		Stoney soil	0.7
					Clay	0.5
					Wastes	6.0

Site/ Alternative	Residues		Wastes			
	Material† ¹	Thickness† ² (m)	Material† ¹	Thickness† ² (m)		
<u>HANFORD</u>						
3a	Stoney soil	1.4	Stoney soil	1.4		
	Wastes	1.6	Wastes	2.4		
	Residues	0.8				
4a, 4b	Stoney soil	3.0	Not applicable			
	Residues	0.8				

<u>OAK RIDGE</u>						
3b	Stoney soil	0.7	Stoney soil	0.7		
	Clay	1.5	Clay	1.5		
	Wastes	2.2	Wastes	3.0		
	Residues	0.8				
4c, 4d	Stoney soil	0.7	Not applicable			
	Clay	1.0				
	Residues	0.8				

†¹ Radon-222 diffusion coefficients of various materials are given in Table 4.17.†² Thickness of various materials based on erosion rates given in Section 4.2.1 for intensive land uses.†³ Radon-222 diffusion coefficients of K-65 and L-30/F-32 residues reduced by a factor of 10 for Alternative 2b (residues processed and resulting solidified slag is reburied).

Table 4.23. Comparison of Doses to the General Public at Hanford (Alternatives 4a and 4b) to Doses from Natural Background Sources at Year 1000

Annual Population Dose at Year 1000† ^{1,†2} (person- or organ-rem/yr)	Annual Dose to Same Population† ² from Natural Background Radiation (person- or organ-rem/yr)
0.065 (whole body)	80,000† ³
1.9 (bone)	120,000† ³
1.7 (lung)	180,000† ³
1.6 (bronchial epithelium)	320,000 - 600,000† ⁴

†¹ All doses are given to two significant figures.

†² Population is assumed to be 1 million persons evenly distributed within an 80-km radius.

†³ Conversion factors are given in a report of the National Council on Radiation Protection and Measurements (1975).

†⁴ Assuming an outdoor radon-222 concentration of 0.3 pCi/L (Moses et al. 1963), an indoor concentration of 1 pCi/L (U.N. Sci. Comm. At. Radiat. 1977), and dose conversion factors for radon-222 of 1000 mrem/yr per pCi/L for outdoor background conditions (infinite source) and 625 mrem/yr per pCi/L for indoor conditions (50% equilibrium of radon-222 decay products) (U.S. Nucl. Reg. Comm. 1980a).

Resident-Intruder. The basic assumptions of the resident-intruder scenario are based on known and probable patterns of human activity. In this scenario, a resident-intruder--unaware of the presence of the wastes and/or residues--lives in a house constructed into the contaminated materials at a future date when the cover systems have completely eroded or been removed.* It is assumed that the resident-intruder (1) lives in a two-story house in which the basement is built into 1.5 m of wastes and residues, (2) consumes produce from a vegetable garden located in the contaminated area, and (3) obtains drinking water from a well located on the edge of the contaminated area in the direction of groundwater flow.

The two-story house has a full basement--10 m × 10 m in area and 8 m from basement floor to roof--with ceiling heights of 2.5 m for each floor. It is assumed that the structure provides a shielding factor of 0.7 for radiation from sources outside the house (U.S. Nucl. Reg. Comm. 1977a); no credit is taken for shielding by internal partitions. The house is ideally represented in the scenario as an 800-m³ volume shielded by the external walls. It is assumed that concrete is used for the foundation and basement floor. Attenuation factors for radon-222 gas migration through concrete can range from 0.08 to 0.5 (Healy and Rogers 1978); a value of 0.3 is used for this study for both basement floor and below-grade walls (U.S. Nucl. Reg. Comm. 1980a).

It is further assumed that the time spent by the resident-intruder inside the house is distributed between the basement, first floor, and second floor in the proportion 0.1/0.3/0.6. He/she is expected to spend 500 hours cultivating the garden and 500 hours in the yard annually. The produce from the garden is expected to account for approximately 50% of the resident-intruder's plant diet, and he/she is assumed to drink 730 liters of contaminated well water per year.

The methods of Gilbert et al. (1983) are applied to this resident-intruder scenario to obtain source/dose conversion factors for the various pathways. Although the wastes and residues will be exposed at different times for the various alternatives (depending on when the caps are removed or eroded), the year 1000 is used as a base. Under Case B (no controls), the resident-intruder scenario could actually occur as early as 200 years or as late as several thousand years. For Alternative 2b, the effective source concentrations of the residues are reduced by a factor of 10 to allow for the modified form.

There are several pathways by which the resident-intruder will receive radiation doses. By far the most important pathway, both in terms of dose and in terms of health effects, is the inhalation of

*It is not possible to predict when the resident-intruder scenario will occur at the three sites, nor the relative probabilities of intrusion, because there are too many major uncertainties with respect to cessation of controls and the behavior of containment systems in the long term (see Sections 4.1.1.3, 4.2, and 4.3).

radon-222 gas and its decay products with resulting dose to the bronchial epithelium (U.S. Dep. Energy 1983a; see also Table 4.30). The expected doses to the resident-intruder's bronchial epithelium are given in Table 4.24.

The effective source concentration (radium-226) for estimating doses to the bronchial epithelium via inhalation of radon-222 gas and its short-lived decay products is based on the assumption that the house could be built in the residues ("hot spot") at NFSS, whereas at the other sites there will be no "hot spot" because of the method of reburial (residues in packages dispersed among the wastes). The radon-222 diffusion into the house at Hanford is adjusted for the drier materials in the arid environment. The average diffusion coefficient for radon-222 in the sandy soils and wastes/residues at Hanford is assumed to be 5×10^{-2} cm²/s; that in the loamy soils and wastes/residues at NFSS and Oak Ridge is assumed to be 8×10^{-3} cm²/s.

As can be seen in Table 4.24, as long as the residues are located near the surface--no matter what form they are in--the radon-222 working levels (WL) in the resident-intruder's house will be extremely high (the working level in a house normally ranges from about 0.001 to 0.067 WL [George and Breslin 1980]). As a result, the resident-intruder will receive a very large dose to his/her bronchial epithelium. Leaving the residues concentrated in a "hot spot" at NFSS will result in the highest doses. The dose to the resident-intruder will be less if (1) the form of the residues is

Table 4.24. Dose to the Resident-Intruder's Bronchial Epithelium†¹

Site/Alternative	Effective Source (Dry Weight) Concentration (pCi/g)† ²	Working Level (WL)	Bronchial Epithelium Dose† ³ (mrem/yr)
<u>NFSS</u>			
1	67,000 (residues)† ⁴	110† ⁵	8,000,000† ⁶
2a	67,000 (residues)† ⁴	110† ⁵	8,000,000† ⁶
2b	6,700 (modified residues)† ⁴	11† ⁵	800,000† ⁶
4a, 4c	36 (wastes)† ⁴	0.058† ⁵	4,300† ⁶
<u>HANFORD</u>			
3a	1,300 (wastes and residues)† ⁷	5.2† ⁸	400,000† ⁹
4a, 4b	5,200 (residues)† ⁷	21† ⁸	1,600,000† ⁹
<u>OAK RIDGE</u>			
3b	4,000 (wastes and residues)† ⁷	6.4† ⁵	480,000† ⁶
4c, 4d	18,000 (residues)† ⁷	29† ⁵	2,200,000† ⁶

†¹ All values given to two significant figures.

†² The concentration of radium-226 will not decrease appreciably in 1000 years because it is assumed that radium-226 is in secular equilibrium with its parent radionuclide, thorium-230, and there will be ingrowth of radium-226 due to decay of the thorium-230.

†³ Dose resulting from inhalation of short-lived radon-222 decay products.

†⁴ At NFSS, the effective source concentrations for estimating doses to the bronchial epithelium via inhalation of radon-222 and its short-lived decay products is based on the assumption that the house is built in the residues ("hot spot") under Alternatives 1, 2a, and 2b. The effective concentration for 2b is lower by a factor of ten because the residues will be modified and radon-222 will not diffuse as readily out of the residues.

†⁵ Based on 0.0016 WL (in the house) per pCi/g (in the source) (U.S. Dep. Energy 1983a--Table 3.6).

†⁶ Based on dose/source conversion factor of 120 mrem/yr per pCi/g (U.S. Dep. Energy 1983a).

†⁷ The effective source concentrations for Hanford and Oak Ridge are calculated based on the assumption that the contaminated materials are 1.5 m deep over the entire waste containment area (as given in Table 4.58).

†⁸ Based on 0.004 WL per pCi/g, adjusting for the higher diffusion rates in the drier residues in the arid climate at Hanford (U.S. Dep. Energy 1983a).

†⁹ Based on 300 mrem/yr per pCi/g, adjusting for the higher diffusion rates and higher WL in the house in the arid environment.

modified, (2) small packages of residues are spread among the wastes at Oak Ridge or Hanford, or (3) the residues are spread over a large area at Oak Ridge or Hanford. This conclusion is very sensitive, however, to the assumptions that are made about the nature and durability of the modified residues and about the geometry and effective dilution of the residues at the alternative sites. Only under Alternatives 4a and 4c will the dose to the resident-intruder at NFSS be significantly reduced. However, under the same alternatives, the resident-intruder at either of the other two alternative sites will receive a very large dose.

The NFSS wastes and residues are both in the same category of "wastes contaminated with naturally occurring radionuclides" under Section IV of DOE Order 5820.2. For management of these materials, DOE is using the EPA uranium mill tailings regulations (40 CFR 192) as guidance (see introduction to Section 4). It is explicitly stated in the preamble to these regulations that "institutional oversight is an essential backup to passive controls," that "it would not be safe to build habitable structures on the disposal sites," and that "Federal ownership of the site is assumed to preclude such inappropriate uses" (U.S. Environ. Prot. Agency 1983). DOE has explicitly stated in the introduction to Section 2 (p. 2-1) that it intends to take perpetual care of whatever site is used for long-term management of the NFSS wastes and residues.

If controls are effective, the resident-intruder scenario will not occur. Even if controls cease, the intrusion barrier (riprap layer) incorporated into the long-term cap of preferred Alternative 2 is intended to deter the intruder and make the resident-intruder scenario unlikely to occur. However, to assess potential environmental impacts so that the DOE decision-maker has full knowledge of the potential consequences of the long-term management decision, the analysis includes the potential impacts that could occur if maintenance, monitoring, and controls were to cease. The resident-intruder scenario for the preferred Alternative 2 is based on several conservative assumptions, including: (1) both the 3-m (10 ft) earthen cap (which includes a 0.9-m [3-ft] riprap intrusion barrier) and the approximately 3-m (10-ft) layer of wastes overlying the residues are either completely eroded or have been removed, and (2) the intruder's house is constructed exactly over the uncovered residues. It is unlikely that an intruder would build a house on the exact spot on the mound of wastes/residues where the residues are buried.

Because of the very high doses that are predicted and because of the many other potential long-term impacts associated with the presence of the residues, DOE also identified possible modifications to the near-surface containment designs as well as optional design concepts (Section C.3)--some of which would reduce the likelihood of the resident-intruder scenario or reduce the impact to such an intruder (Tables C.3 and C.4).

As a result of further discussions with EPA and New York officials, DOE has given consideration to an additional intruder barrier over the residues (in addition to the riprap layer in the cap). The engineering aspects and costs of several options have been investigated (Bechtel Natl. 1985). In order to install the additional barrier, the cap and wastes overlying Building 411 would have to be excavated and stored. A barrier could be constructed of reinforced concrete, asphalt, cement-stabilized sand, cement-stabilized fly ash, or stone. Reinforced concrete would provide the only practical means to tie the barrier into the building walls and would provide the most positive means of deterring an inadvertent intruder. Construction of such a barrier is estimated to cost an additional \$1.3 million (Bechtel Natl. 1985).

Using the same methodology and parameter values given in Section 4.1.2.2, radon emissions at the top of Building 411 are estimated to be at background levels--with or without a concrete barrier--primarily because of the intervening layer of approximately 4 m (12 ft) of damp wastes (mostly native clayey soils) and clay on top of the residues. This layer retards the radon emitted from the residues long enough for the radon to decay to solid decay products. Thus, if an intruder only intruded as far as the top of Building 411, he/she would not incur the very high radiation doses calculated for the case in which the residues are assumed to be uncovered.

Summary. In summary, during the long-term period, even the largest doses to the general public at Hanford would be small relative to doses the same population would receive from natural background sources. Moreover, severe erosion of the cap at NFSS would not lead to a significant dose to the general public. If a person intruded into the highly radioactive residues, he/she would incur a very high radiation dose. However, if the intended perpetual care of the site is effective, if the intruder is stopped by the layer of riprap in the cap of preferred Alternative 2, or if the intruder does not happen to construct a house immediately on top of the residues, the calculated doses would not be incurred and there would be no significant impact to individuals in the long term.

4.1.3 Doses to Workers

Implementation of any of these alternatives will require that workers be exposed to radiation and radioactive materials and thus incur radiation doses. The doses to workers (occupational doses) are given separately from the doses to the general public in this EIS because the occupational doses are basically voluntary whereas those to the general public are involuntary.

At NFSS and Oak Ridge, the only time period during which significant occupational doses will occur is the action period (0-10 years). Doses during the action period are discussed in detail in Sections 4.1.3.1 through 4.1.3.4. During the maintenance and monitoring period, doses to workers at NFSS and Oak Ridge are expected to be negligible. Workers will periodically be onsite to collect air and water samples, to inspect the condition of the containment system, to maintain the fences and mow the grass, to patrol the site for security purposes, and to perform other routine maintenance and monitoring activities. Occasionally, workers may be onsite to take remedial actions such as repairing any failures in the containment system. During the maintenance and monitoring period, workers are not expected to be directly exposed to the radioactive wastes or residues. Radioactive emanations, including radon-222 gas, from the deeply buried residues and from the slightly contaminated wastes are expected to be negligible at the surface of the earthen containment caps (see expected radon-222 release rates in Section 4.1.2.2). Also, workers are expected to be onsite only for brief periods of time. Because of all these factors, occupational doses at NFSS and Oak Ridge during the maintenance and monitoring period are expected to be negligible, probably less than a total of a few rem to the whole body or critical organs (principally the bronchial epithelium) over the entire period.

At Hanford, there will be significant occupational doses during both the action period and the maintenance and monitoring period. During the action period, doses are estimated in the same manner as doses at NFSS and Oak Ridge and are detailed in Sections 4.1.3.1 through 4.1.3.4. During the maintenance and monitoring period, workers will be onsite only briefly and will also not be directly exposed to the contaminated materials. However, the radon-222 gas releases from the buried materials at Hanford will be much higher than at NFSS or Oak Ridge (Section 4.1.2.2). Workers at Hanford will therefore be exposed to significantly elevated levels of radon-222 gas and its short-lived decay products and will incur significant bronchial epithelium doses. Thus, worker doses at Hanford during the maintenance and monitoring period are estimated separately (see Section 4.1.3.5 for details).

At all sites, there will be no occupational doses in the long-term period because it is assumed that there will be no monitoring or maintenance activities occurring after 200 years.

4.1.3.1 General Assumptions and Methodology

Occupational doses during the action period are estimated for (1) activities at NFSS, (2) transportation activities, and (3) activities at alternative long-term management sites and the Harbor. There are three major sources of radioactivity that could lead to occupational doses from these activities: (1) direct gamma exposure, (2) release of radioactively contaminated particulates, and (3) release of radon-222 gas. The first source results in an external whole-body dose whereas the second and third sources result in doses to internal organs via inhalation of radionuclides. The contribution from other pathways (e.g., ingestion of contaminated water and foodstuffs) will have a relatively small effect on occupational doses to internal organs. All three sources are not applicable to each alternative or component of the alternatives, e.g., the second and third sources do not apply to transportation (see Section 4.1.3.3).

The occupational doses for direct gamma exposures resulting from activities associated with processing and handling the radioactive materials are calculated separately for the residues and the wastes. Only the workers in the immediate vicinity of the wastes or residues will receive significant exposures because direct gamma radiation decreases rapidly with distance from the wastes or residues. The occupational doses associated with inhalation of particulates and radon-222 gas (and its short-lived decay products) are also calculated separately for activities associated with the processing and handling of the residues and wastes.

External whole-body doses are calculated by multiplying the length of time workers spend in various radiation fields by the radiation field strength and summing over the number of workers involved. Internal doses are calculated in a similar manner using the estimated concentrations of airborne radionuclides in the work environment and average rates of inhalation. Fifty-year internal dose commitments--i.e., the entire dose insult received over a period of 50 years following intake into the body--are used in this EIS.

Direct Gamma Exposure. Activities involving the residues will be the major source of occupational doses via direct gamma exposure due to the high concentration of radium-226 and its decay products. Workers directly involved in handling the residues are assumed to be exposed to an average radiation field of 1 mrem/h. This dose rate is used to estimate the dose to the whole body, bone, and lung from exposure to external gamma radiation. The radiation field for certain of the residues may be much higher than this value--i.e., the K-65 residues may have contact exposure rates up to 300 mR/h or higher (Bechtel Natl. 1984a). Thus, some workers may be exposed to higher radiation fields during activities involving processing and handling of the K-65 residues. (The exposure rates for the other residues will be significantly lower because they have a much lower concentration of radium-226--see Table 3.5). However, efforts will be taken to keep the length of such exposures to a minimum to be in compliance with DOE's "as low as reasonably achievable" (ALARA) philosophy. When necessary, shielding and remote handling equipment will be used to reduce exposure rates. The 1 mrem/h average radiation field is appropriate for estimating occupational doses considering the radium-226 concentration in the residues, the assumed engineering procedures for the various alternatives, and compliance with ALARA.

Workers involved in handling the wastes are assumed to be exposed to an average radiation field of 0.04 mrem/h. This dose rate is used to estimate the dose to the whole body, bone, and lung from exposure to external gamma radiation. This average radiation field assumes handling of the wastes by machinery without the use of additional shielding or remote handling equipment. The 0.04 mrem/h average radiation field strength is based on an average radium-226 concentration of 36 pCi/g (see Table 3.5) and taking credit for a small amount of shielding afforded by construction equipment.

Inhalation of Radioactive Particulates. Inhalation of radioactively contaminated dust will result in workers incurring an internal radiation dose. Dust concentrations will generally be quite low; however, use of respiratory-protection equipment may occasionally be necessary to ensure that the ALARA principle is maintained. In this analysis, it is assumed that respirators are not used but masks will be used for activities involving excavation and packaging of the residues. The masks are assumed to reduce the amount of particulates inhaled by a factor of 10.

The amount of dust in the vicinity of earth-moving activities has been estimated by NRC to be about 0.01 g/m³, with 10% being in the respirable particle-size range, i.e., <10 µm in diameter (U.S. Nucl. Reg. Comm. 1980b). Thus, the amount of respirable dust will be about 0.001 g/m³. Wetting would be expected to reduce this by at least a factor of two, so the respirable dust load is assumed to be 0.0005 g/m³ for this analysis. The workers exposed to this airborne contamination will include machinery operators, laborers, and supervisory and monitoring personnel. This average concentration of 0.0005 g/m³ is used for internal dose estimates for all workers at NFSS and at the various alternative management sites and the Harbor. A respiration rate of 20 L/min is assumed in calculating the amount of dust that would be inhaled by workers (Int. Comm. Radiol. Prot. 1966).

The average concentration of radium-226 is about 67,000 pCi/g in the residues and about 36 pCi/g in the wastes. In this EIS, it is assumed that the concentration of thorium-230 is equal to that of radium-226. Therefore, for every person-hour associated with handling the residues until they are packaged, workers will inhale about 4 pCi of thorium-230, radium-226, and all of its decay products (excluding radon-222 gas and its short-lived decay products, which are calculated separately). This estimate is obtained by multiplying the average concentration of radionuclides in the residues by the average inhalation rate, taking into account the reduction in particulates inhaled through use of air-filtering masks assumed to be used by the workers.

For every person-hour associated with handling the wastes, it is estimated that workers will inhale about 0.022 pCi of thorium-230, radium-226, and all subsequent decay products (excluding radon-222 gas). This estimate is obtained in a manner similar to that obtained for the residues, i.e., multiplying the average concentration of radionuclides in the residues by the average inhalation rate.

The dose conversion factors for critical organs (i.e., whole body, bone, and lung) are given as follows:

<u>Organ</u>	<u>Dose Conversion Factor</u> (mrem/pCi inhaled)
Whole Body	0.020
Bone	0.57
Lung	0.65

These conversion factors were obtained from Appendix G of the U.S. Nuclear Regulatory Commission (1980a) report, using an average particle size of 5 µm. Thus, the internal occupational dose associated with handling the NFSS residues and wastes, per worker-hour of exposure, is given as follows:

<u>Organ</u>	<u>Occupational Dose</u> (mrem/worker-hour)	
	<u>Residues</u>	<u>Wastes</u>
Whole body	0.080	0.00044
Bone	2.3	0.013
Lung	2.6	0.014

Inhalation of Radon-222 Gas and Its Short-Lived Decay Products. Radon-222 gas will emanate from the residues and wastes, and part of it will escape into the atmosphere. As a result, the concentration of radon-222 gas and its short-lived decay products will be elevated in the ambient air. Construction workers and maintenance personnel will, therefore, be exposed while on the job. The only internal organ that will receive a significant dose from radon-222 gas and its short-lived decay products is the bronchial epithelium. Average radon-222 concentrations above contaminated surfaces that emit radon-222 gas are extremely variable. It is difficult to correlate radon-222 concentrations in air with radon-222 flux from the surface or with the radium-226 concentration in the contaminated materials (even in the relatively rare cases when the radium-226 distribution is homogeneous). Thus, it is necessary to make simplifying assumptions to estimate this component of the occupational dose.

The bronchial epithelium dose for handling the residues and wastes is estimated as follows. The average occupational exposure to radon-222 and its short-lived decay products at uranium mills was reported to be 0.05 working level (WL) in a report of the U.S. Nuclear Regulatory Commission (1980a). Because the residues have a higher concentration of radium-226 than uranium mill tailings, the average occupational exposure to workers handling the residues is assumed to be 0.1 WL. The average occupational exposure to workers handling the wastes is assumed to be 0.001 WL due to the much lower concentration of radium-226 in the wastes. Certain workers may be exposed to higher concentrations of radon-222 gas and its short-lived decay products for short periods of time. If necessary, procedures such as use of supplied air or ventilation will be implemented to keep doses ALARA. The occupational doses to the bronchial epithelium from inhalation of radon-222 gas and its short-lived decay products, per worker-hour of exposure, are given as follows based on the assumed working level for residues and wastes and a conversion factor of 5 rem to the bronchial epithelium per working level month (one month of exposure is approximately equal to 170 hours):

<u>Organ</u>	<u>Occupational Dose (mrem/worker-hour)</u>	
	<u>Residues</u>	<u>Wastes</u>
Bronchial epithelium	2.9	0.029

4.1.3.2 Occupational Doses at Various Sites During the Action Period

The occupational doses for activities at the various locations during the action period are given in this section utilizing the methodology described in Section 4.1.3.1 and the work force requirements given in Section 4.6.4 for the various sites. The occupational doses for transportation are given in Section 4.1.3.3. The total occupational doses for the action period for the various alternatives are given in Section 4.1.3.4.

Occupational Doses at NFSS. Occupational doses at NFSS during the action period for the various alternatives are given in Table 4.25. These estimates are obtained using the work force estimates given in Section 4.6.4 and the dose conversion factors described in Section 4.1.3.1. Many of the activities at NFSS do not directly involve handling of the wastes and residues (e.g., site preparation, field supervision). If there is a potential for radiation exposure from these activities, the unit dose factors given for the wastes are used to estimate occupational doses because the residues are initially covered beneath at least 6 m of material and, hence, radiation exposure for initial activities will be largely from the wastes. In addition, most of the activities will occur in much closer proximity to the wastes than the residues.

The largest component of occupational doses for activities at NFSS is from the excavation, packaging, and loading of the residues. Alternatives that do not require retrieval of the residues (i.e., Alternatives 1 and 2a) have much lower occupational doses. The external whole-body doses result from direct gamma exposure; the internal organ doses result from inhalation of radioactive particulates and radon-222 gas. Procedures that would eliminate the need for workers to be exposed to the residues (i.e., remote retrieval and processing) could result in much lower internal organ doses.

Occupational Doses at Hanford. Occupational doses at Hanford associated with receipt and disposal of the residues (Alternatives 3a, 4a, and 4b) and wastes (Alternative 3a) are given in Table 4.26. When the packaged residues are received, they will be removed from the trucks and placed into trenches for burial. The covers of the bins will be removed, and wastes or other earthen materials will be placed on top of the exposed residues prior to backfilling the trenches. The purpose of this procedure is to fill the bins and thus minimize the likelihood of trench subsidence in the future.* Workers will be exposed to radon-222 gas and particulates from the exposed residues during these activities (Alternatives 3a, 4a, and 4b) and thus will incur internal radiation doses. Workers will also be exposed to external radiation and radioactive radon-222 gas and particulates from disposal of the wastes in Alternative 3a. The wastes are assumed to be emplaced in the trenches using standard earth-moving equipment. The occupational doses at Hanford are significantly lower than those at NFSS due to the much lower work force requirements associated with disposal activities. Alternatives 4a and 4b, involving receipt and disposal of only the residues, have a lower occupational dose commitment than Alternative 3a in which all of the NFSS residues and wastes are disposed at Hanford.

Occupational Doses at Oak Ridge. Occupational doses at Oak Ridge associated with receipt and disposal of the residues (Alternatives 3b, 4c, and 4d) and wastes (Alternative 3b) are given in Table 4.26. Although the concept for long-term management of the NFSS residues and wastes is significantly different at Oak Ridge than at Hanford (i.e., above-ground versus below-ground disposal), the activities associated with emplacement of the residues and waste into the containment system will be similar. As at Hanford, the covers of the bins containing the residues will be removed and the bins filled with wastes or other earthen material prior to emplacement of an earthen cap. The wastes are

*It may be possible to use containers that allow very little void space and the lids would not have to be removed. Radioactive releases and occupational doses could, therefore, be reduced.

Table 4.25. Occupational Doses at NFSS During the Action Period

Alternative	Occupational Doses (person- or organ-rem) ^{†1}			
	Whole Body	Bone	Lung	Bronchial Epithelium ^{†2}
1	2.6	3.4	3.5	1.9
2a	10	14	14	7.4
2b	140	410	450	360
3a	110	300	320	250
3b	110	290	320	250
4a	100	280	300	240
4b	110	290	320	250
4c	100	280	300	240
4d	110	290	320	250

^{†1} All doses given to two significant figures.

^{†2} Dose resulting from inhalation of short-lived radon-222 decay products.

Table 4.26. Occupational Doses at Hanford, Oak Ridge, and the Harbor During the Action Period

Alternative	Occupational Doses (person- or organ-rem) ^{†1}			
	Whole Body	Bone	Lung	Bronchial Epithelium ^{†2}
<u>Hanford</u>				
3a	51	110	120	88
4a	26	79	86	70
4b	26	79	86	70
<u>Oak Ridge</u>				
3b	51	110	120	88
4c	26	79	86	70
4d	26	79	86	70
<u>Harbor</u>				
4b	2.7	3.5	3.6	1.9
4d	2.7	3.5	3.6	1.9

^{†1} All doses given to two significant figures.

^{†2} Dose resulting from inhalation of short-lived radon-222 decay products.

assumed to be handled with standard earth-moving equipment. Thus, the occupational doses at Oak Ridge will be comparable to those at Hanford.

Occupational Doses at the Harbor. In Alternatives 4b and 4d, the wastes will be brought to the Harbor for loading onto a barge with subsequent disposal in the ocean. The occupational doses for activities at the Harbor are given in Table 4.26. These doses are significantly lower than those at Hanford or Oak Ridge because only the wastes are involved. There will be no significant doses associated with disposal of the wastes once the barge has left the Harbor because the barge will be towed by a tugboat that will be several hundred meters away.

The maximum exposed individual for these various sites will be a worker involved in the retrieval, packaging, and loading of the residues at NFSS for all alternatives except 1 and 2a in which the residues are not retrieved. The dose to the maximally exposed worker at alternative long-term management sites will be significantly lower. The dose to the maximally exposed individual at NFSS is estimated by assuming exposure to the residues for 100 of the 120 working days in a construction season. The annual whole-body and critical-organ doses received by this worker are: whole-body dose, 0.86 rem; bone, 1.8 organ-rem; lung, 2.1 organ-rem; and bronchial epithelium, 2.3 organ-rem. These doses are below limits established by DOE for protection of workers, as given in DOE Order 5480.1A. The maximum individual doses for alternatives not involving excavation of the residues (i.e., Alternatives 1 and 2a) will be much lower--doses to the whole body and critical organs are expected to be less than 100 mrem.

If an accident occurs during retrieval of the residue or wastes, workers will incur an incremental radiation dose. The cumulative dose to the work force would not change appreciably with such an accident. However, it is possible that one, or perhaps several, workers may incur radiation doses that are significantly larger than the average dose. Precautions will be taken to minimize radiation doses to the workers, e.g., use of breathing apparatus and minimization of the time spent in the immediate vicinity of the radioactive materials. The major source of radiation exposure will be from external gamma radiation because any radon-222 gas released will quickly disperse and workers will use breathing apparatus to minimize intake of particulates. The external whole-body dose to a worker from an accident associated with retrieval of the K-65 residues is estimated to be about 30 mrem, assuming that this worker spends 10 minutes in a 100 mrem/h field, 50 minutes in a 10 mrem/h field, and 1 hour in a 5 mrem/h field. Occupational doses associated with an accident involving a spill of wastes will be much lower. The dose to a worker will be less than 1 mrem, even assuming that such a worker spends several hours in the direct vicinity of such wastes.

4.1.3.3 Occupational Doses to Drivers Transporting NFSS Residues and Wastes

The principal pathway by which drivers will be exposed to radiation is from direct external exposure to gamma rays emanating from the radioactively contaminated residues and wastes. Doses from exposure to contaminated particulates and radon-222 gas will be negligible and are not considered further. Shielding may be required between the drivers and the residues to meet the regulatory exposure limit of 2 mrem/h (see Appendix D). It is assumed that sufficient shielding of the residues is used to reduce the dose rate to an average of 1 mrem/h; the dose to the drivers transporting the unshielded NFSS wastes is estimated to average 0.04 mrem/h (assuming an average radium-226 concentration of 36 pCi/g and allowing for the shielding afforded by the truck body and cab). Other assumptions used in calculating driver doses are a one-way trip length as listed in Table 4.13 and use of two drivers alternating driving shifts and continuously occupying the cab while the truck is moving from NFSS to its destination. The drivers are assumed to be in the trucks for 64 hours enroute to Hanford, 20 hours to Oak Ridge, and 16 hours to the Harbor. The greatest dose to a driver on a single trip is 64 mrem/person during transport of a load of residues to Hanford (Alternatives 3a, 4a, and 4b). The cumulative doses to drivers are listed in Table 4.27. The annual external whole-body dose to the maximally exposed driver is estimated to be 0.64 rem for Alternatives 3a, 4a, and 4b for transport of residues to Hanford and 0.48 rem for Alternatives 3b, 4c, and 4d for transport of residues to Oak Ridge. These estimates are based on a 120-day construction season and the transport times given in Table 4.13.

If an accident occurs during transport of the residues and wastes, it will be necessary for workers to clean up any materials that are spilled. (The two basic types of potential accidents are described in Section 4.1.2.1.) The dose to workers will be much greater for cleaning up spilled K-65 residues than spilled wastes because the much higher concentration of radium-226 in the K-65 residues will result in much higher external radiation exposures. It is assumed that it will take two workers 4 hours each to clean up any spilled K-65 residues and that each worker will spend about 10 minutes in a 50 mrem/h field, 50 minutes in a 10 mrem/h field, and 3 hours in a 5 mrem/h field. Each worker will receive an external whole-body dose of about 30 mrem; the total external whole-body worker dose for this cleanup will therefore be about 60 mrem.

Because there will be many more shipments of wastes than of residues, the probability of an accident involving the wastes is much higher. Also, because the wastes will not be packaged, the probability and magnitude of a spill of wastes is greater. However, the radium-226 content of the wastes is much lower than that of the residues, so the doses to workers will be much less for cleaning

Table 4.27. Doses to Drivers Transporting NFSS Residues and Wastes

Alternative	Cumulative Dose to Drivers† ¹ (person- or organ-rem)			
	Whole Body	Bone	Lung	Bronchial Epithelium† ²
3a	280	280	280	-
3b	88	88	88	-
4a	200	200	200	-
4b	220	220	220	-
4c	64	64	64	-
4d	83	83	83	-

†¹ All doses given to two significant figures. It is assumed that the external radiation dose to each organ is approximately equal to the whole-body dose.

†² Dose resulting from inhalation of short-lived radon-222 decay product.

up spilled wastes than spilled residues. Assuming that it will take two workers 10 hours each to clean up spilled wastes and that each worker will receive an external whole-body dose rate of about 0.04 mrem/h (the same as the truck driver), the external whole-body dose to each worker will be 0.4 mrem and the total external whole-body worker dose will be 0.8 mrem.

4.1.3.4 Occupational Doses for the Various Alternatives

Estimates of the occupational doses for the various alternatives considered in this EIS are given in Table 4.28. These total doses are obtained by summing the doses for the various components of the alternatives given in the preceding two sections. The occupational doses are lowest for Alternatives 1 and 2a, which do not involve retrieval of the wastes and residues. Implementation of any of the other alternatives will result in significant radiation doses to the work force that are of the same order of magnitude as the cumulative doses to the general public during the action period.

4.1.3.5 Occupational Doses at Hanford during the Maintenance and Monitoring Period

Because of the relatively high releases of radon-222 gas from the burial area at Hanford during the maintenance and monitoring period, it is likely that workers on the Hanford site will incur significant doses to the bronchial epithelium. The estimated radon-222 fluxes at Hanford are similar to the fluxes measured at uranium mill tailings sites. Therefore, it is assumed that the average worker exposure to radon-222 and its short-lived decay products at Hanford will be similar to those at uranium mills, i.e., about 0.05 WL (U.S. Nucl. Reg. Comm. 1980a). At 0.05 WL, a worker will receive a dose of about 1.5 organ-mrem to the bronchial epithelium per hour of exposure. Assuming an average of 250 worker-days per year for maintenance and monitoring activities at the Hanford site, and assuming that about half of this is spent onsite (or about 130 worker-days), the cumulative bronchial epithelium dose to the workers will be about 1.5 organ-rem/yr, or a total of 290 organ-rem over the assumed 190-year maintenance and monitoring period. If maintenance and monitoring continues longer, the annual worker dose will continue and the total dose will increase.

4.1.4 Estimation of Health Effects

The significance of the estimated doses for the various alternatives may be placed in perspective by estimating their effects on human health. The potential health effects from exposure to low levels of radiation may include a small (unmeasurable) increase in the occurrence of cancer, depending on what particular organ is irradiated, and possible genetic effects that may occur in future generations. With respect to NFSS, implementation of any one of the alternatives is not expected to result in exposures to radiation that are large enough to produce either immediately observable health effects in any individual or long-term effects that could be identified by statistical methods in the exposed population (the only exception being the inadvertent resident-intruder--see later discussion).

The probability that a unit dose of radiation will produce a deleterious effect on an individual (or effects on a population) is commonly referred to as a risk factor or risk estimator. Estimates of risk factors from exposure to radiation, for both individuals and populations, are available in a

Table 4.28. Occupational Doses for the Action Period

Alternative	Occupational Doses (person- or organ-rem) ^{†1}			
	Whole Body	Bone	Lung	Bronchial Epithelium ^{†2}
1	2.6	3.4	3.5	1.9
2a	10	14	14	7.4
2b	140	410	450	360
3a	440	690	720	340
3b	250	490	530	340
4a	330	560	590	310
4b	360	590	630	320
4c	190	420	450	310
4d	220	460	490	320

^{†1} All doses given to two significant figures.

^{†2} Dose resulting from inhalation of short-lived radon-222 decay products.

number of publications. The National Academy of Sciences issued a report in 1960 from the Advisory Committee on Biological Effects of Atomic Radiation called the BEAR Report (Nat'l. Acad. Sci. 1960). In 1972, the National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation issued a report commonly referred to as "BEIR I" (Nat'l. Acad. Sci. 1972). The committee was subsequently asked to review the risk estimators, and the results of that review were issued in the 1980 report referred to as "BEIR III" (Nat'l. Acad. Sci. 1980). Other groups of experts also have published risk estimators for radiation exposure; for example, the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) have both studied radiation effects. The ICRP issued Publication 26 in 1977 (Int. Comm. Radiol. Prot. 1977). In the same year, a United Nations study group (U.N. Scientific Committee on the Effects of Atomic Radiation, or UNSCEAR) published an extensive report that included estimates of risks of cancer from ionizing radiation (U.N. Sci. Comm. Effects Atom. Radiat. 1977).

4.1.4.1 Cancers

The cancer risk estimates developed by various professional organizations are presented in Table 4.29. The values represent the estimated range of added cancer mortality (above the normal mortality from such cancers) per 0.5 rem of radiation to a population of one million people continuously exposed to external gamma radiation. Comparison of the values in Table 4.29 indicates that there is general agreement among the estimates developed by the three studies. In application of

Table 4.29. Estimated Cancer Mortality from Exposure to Low-Level Radiation

Source	Number of Additional ^{†1} Fatal Cancers Estimated to Result from Continuous Exposure of One Million People to 0.5 rem of External Gamma Radiation
National Academy of Sciences (1980)--BEIR III	33-85
International Commission on Radiological Protection (1977)	50
United Nations Scientific Committee on the Effects of Atomic Radiation (1977)	38-88

^{†1} Additional means above the normal cancer mortality.

Source: U.S. Department of Energy (1983b).

these estimates, care must be taken to identify the limitations of each study. The UNSCEAR and ICRP approach provides average lifetime risk factors. The UNSCEAR report discusses absolute risk, or the number of expected cancer cases that will result from exposure of a given population. The BEIR III report considers both absolute and relative risk. Relative risk is the ratio of incidence of cancer in an exposed population to the incidence in a control population.

The American Cancer Society (1978) indicates that about half of all cancer cases are fatal. Thus, the numbers in Table 4.29 can be multiplied by 2 to estimate total incidence (not just fatalities, but also injury and illness). These cancers would be in addition to those normally expected in a population. According to the American Cancer Society, the individual risk of getting cancer for any member in the population is 1 chance in 4. The cure rate for these cancers ranges from 90% to 5%, depending on the type of cancer.

The values given in Table 4.29 are considered by many radiation protection specialists to be the best estimates that can be provided. Press releases have publicized radiation-effects studies in which the authors have indicated that the risk is much higher. For example, recent epidemiological studies on workers from the Portsmouth Naval Shipyards and the Hanford Reservation indicate that a greater risk may exist from radiation exposure than has been reported in the past. The Committee on the Biological Effects of Ionizing Radiation (Natl. Acad. Sci. 1980) reviewed these studies and took the results into consideration in making its recommendations in the BEIR III report.

There have been no direct measurements of increased cancer for low-level radiation exposures; data exist only for higher-level exposures. Risks at lower doses have been estimated by assuming that the same dose/health-effects relationship applies to low doses as to high doses and then extrapolating from data taken at higher dose levels.

Organ-risk estimators have been presented in the UNSCEAR and National Academy of Sciences reports for radiation exposure of organs in which radionuclides deposit selectively. Risk estimators given in BEIR III (Natl. Acad. Sci. 1980) for irradiation of selected organs are summarized in a report prepared by the U.S. Department of Energy (1983b). These risk estimators are used to estimate the likelihood of incurring a fatal cancer (fatal plus nonfatal) as a result of radiation exposure. These risk estimators are given in Table 4.30 for the four critical organs considered in this analysis.

Table 4.30. Estimated Cancer Mortality
Relative to Selected Organs

Organ	Risk Estimator† ¹ (Lifetime risk of cancer mortality per person-rem)
Whole body	120×10^{-6}
Bone	2×10^{-6}
Lung	90×10^{-6}
Bronchial epithelium	$20 \times 10^{-6} \dagger^2$

†¹ Source: U.S. Department of Energy (1983b).

†² Obtained using a value of 100 additional fatal lung cancers per 1 million persons each exposed to 1 working-level month (WLM) of radon decay products (U.S. Dep. Energy 1983b). A conversion factor of 5 person-rem/person-WLM is used to convert to a risk estimator per person-rem of exposure. (U.S. Nucl. Reg. Comm. 1980a).

4.1.4.2 Genetic Effects

Genetic effects in subsequent generations may be estimated as a result of exposure of the parents to a given radiation level. The risk factor used to estimate the total of all genetic effects as given in BEIR III to range from 60 to 1100 total cases of genetic disorders* per one million live-born

*Includes disorders and traits that cause serious handicaps at some time during lifetime.

offspring for each 1 rem per generation from low-LET* radiation (X-rays, gamma rays, and beta particles), and from 180 to 3300 total cases of genetic disorders per one million live-born offspring for each 1 rem per generation of high-LET radiation (alpha particles and neutrons). The dose involved here is the gamete dose--which is calculated from the gonadal dose of the exposed individuals, their age and sex distribution, the probabilities of their having children, and adjustment factors of 0.82 and 0.18 for male and female exposures, respectively, to account for spermatogonia and oocyte mutational sensitivities. Because the major component of the gonadal dose for these alternatives is from low-LET radiation, the appropriate risk estimator for estimating genetic effects is 60×10^{-6} to 1100×10^{-6} genetic effects per person-rem of whole-body exposure. (The gonadal dose is approximately equal to the whole-body dose). A value of 250×10^{-6} (the geometric mean of the two limits) is used in this document.

4.1.4.3 Risk of Adverse Health Effects for Each Alternative

Health Effects to the General Public. Estimates of increased risks of adverse health effects to the general public as a result of doses incurred during the action period and the maintenance and monitoring period are shown in Tables 4.31 and 4.32, respectively. The risks to the general population per million persons per year at the year 1000 and the yearly risks to the resident-intruder are shown in Table 4.33. Adverse health effects are estimated based on the various doses to the critical organs multiplied by the corresponding risk estimators discussed previously. Fatal cancers and genetic defects are included in the total health effects.

Doses incurred during the action period will result in the lowest health effects for Alternatives 1 and 2a, primarily because the NFSS wastes and residues will not be exposed in these two alternatives. Implementation of Alternatives 4b and 4d, wherein the residues are shipped either to Hanford or Oak Ridge and the wastes are shipped to the ocean, is expected to result in the highest number of adverse health effects--primarily because of transportation of the wastes through the densely populated New York metropolitan area. However, the risk is less than one health effect in a population of several million people (total at the various sites and along transportation routes), and is therefore considered to be insignificant.

During the maintenance and monitoring period, the risk of increased adverse health effects is highest for Alternatives 3a, 4a, and 4b (long-term management at Hanford); however, this risk is still insignificant, i.e., less than one health effect over a 190-year period in a population of 258,000 persons.

At the year 1000, if no one intrudes into the waste-management areas, the population dose per million persons per year will be highest at Hanford under Alternatives 4a and 4b** and at NFSS under Alternative 1. However, the risk is still insignificant (0.019 and 0.0010 health effects at Hanford and NFSS, respectively).

If there is a resident-intruder (Section 4.1.2.3), it is expected that such a person will have adverse health effects as a result of exposure to the NFSS radioactive materials. The highest risk will be for the resident-intruder at NFSS under Alternatives 1 and 2a wherein 0.88 health effects (fatal cancers) are expected for each year of bronchial epithelium dose resulting from inhalation of radon-222 gas and its decay products. The number of expected health effects is lowest at Hanford and Oak Ridge under Alternatives 3a and 3b because the residues are assumed to be spread out among the wastes, thus lowering the concentration of radon-222 in the house. Excluding other causes of death, the resident-intruder in Alternatives 1 and 2a would be expected to die within a few years as a result of exposure to the NFSS radioactive materials.

Health Effects to the Work Force. Estimates of increased risk of adverse health effects to workers as a result of doses incurred during the action period are given in Table 4.34. The lowest estimates of health effects are for Alternatives 1 and 2a in which the residues and wastes are not exposed. The estimates of adverse health effects for the remaining alternatives (2b, 3a, 3b, 4a, 4b, 4c, and 4d) are about the same because retrieval, handling, and reburial of the residues are common to all these alternatives and doses associated with these activities are the largest components of the occupational doses. The alternative with the highest estimated adverse health effects for workers is

*LET = Linear energy transfer, the amount of energy transferred from the radiation to tissue per unit path length.

**If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

Table 4.31. Estimated Additional Health Effects in the General Public As a Result of Doses Incurred During the Action Period

Alternative	Number of Potential Adverse Health Effects† ¹				
	Fatal Cancers Associated With				Total Health Effects† ⁵
	Whole-Body Doses† ²	Bone Doses† ²	Lung Doses† ^{2,†3}	Genetic Defects† ⁴	
1	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$
2a	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$
2b	2.2×10^{-3}	2.0×10^{-4}	1.0×10^{-2}	4.5×10^{-3}	1.7×10^{-2}
3a† ⁶	1.4×10^{-2}	9.6×10^{-4}	4.5×10^{-2}	3.0×10^{-2}	9.0×10^{-2}
3b	8.3×10^{-3}	7.4×10^{-4}	4.0×10^{-2}	1.7×10^{-2}	6.6×10^{-2}
4a† ⁶	7.4×10^{-3}	3.2×10^{-4}	3.1×10^{-2}	1.6×10^{-2}	5.4×10^{-2}
4b† ⁶	5.6×10^{-2}	9.2×10^{-4}	1.2×10^{-1}	1.2×10^{-1}	3.0×10^{-1}
4c	5.2×10^{-3}	3.6×10^{-4}	2.4×10^{-2}	1.1×10^{-2}	4.0×10^{-2}
4d	5.4×10^{-2}	9.8×10^{-4}	1.1×10^{-1}	1.1×10^{-1}	2.8×10^{-1}

†¹ All values given to two significant figures unless preceded by a less than (<) symbol. Based on doses to the general public given in Table 4.1.

†² Based on fatal cancer rates for doses to various organs as given in Table 4.30.

†³ Includes fatal cancers associated with lung doses plus those associated with bronchial epithelium doses.

†⁴ Based on the assumption that the dose to the gonads (reproductive organs) is approximately the same as the whole-body dose and that the genetic defect rate is 250×10^{-6} /organ-rem.

†⁵ Total adverse health effects resulting from doses to the critical organs.

†⁶ If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

Table 4.32. Estimated Additional Health Effects in the General Public As a Result of Doses Incurred During the Maintenance and Monitoring Period

Alternative	Number of Potential Adverse Health Effects† ¹				
	Fatal Cancers† ² Associated With				Total Health Effects† ⁵
	Whole-Body Doses† ²	Bone Doses† ²	Lung Doses† ^{2,†3}	Genetic Defects† ⁴	
1	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<2 \times 10^{-7}$	$<3 \times 10^{-7}$	$<6 \times 10^{-7}$
2a	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$
2b	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$
3a† ⁶	3.0×10^{-4}	2.6×10^{-5}	3.0×10^{-3}	6.3×10^{-4}	3.9×10^{-3}
3b	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$
4a† ⁶	2.7×10^{-3}	2.4×10^{-4}	2.7×10^{-2}	5.8×10^{-3}	3.6×10^{-2}
4b† ⁶	2.7×10^{-3}	2.4×10^{-4}	2.7×10^{-2}	5.8×10^{-3}	3.6×10^{-2}
4c	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$
4d	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$

†¹ All values given to two significant figures unless preceded by a less than (<) symbol. Based on doses to the general public over 190 years, as given in Table 4.1.

†² - †⁶ Same as Table 4.31.

Table 4.33. Estimated Adverse Health Effects As a Result of Doses Incurred During the Year 1000

Alternative	General Public (health effects/million persons/year) ^{†1}					Resident-Intruder ^{†2} (health effects/year)
	Fatal Cancers Associated With					Fatal Cancers Associated With Bronchial Epithelium Dose ^{†3}
	Whole-Body Doses ^{†3}	Bone Doses ^{†3}	Lung Doses ^{†3,†4}	Genetic Defects ^{†5}	Total ^{†6}	
1	7.8×10^{-6}	3.8×10^{-6}	1.9×10^{-4}	1.6×10^{-5}	2.1×10^{-4}	0.16
2a	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$	0.16
2b	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$	0.016
3a ^{†7}	4.7×10^{-5}	3.4×10^{-6}	5.9×10^{-4}	9.8×10^{-5}	7.4×10^{-4}	0.0080
3b	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$	0.0096
4a ^{†7}	4.0×10^{-4}	2.8×10^{-5}	4.9×10^{-3}	8.3×10^{-4}	6.1×10^{-3}	0.032
4b ^{†7}	4.0×10^{-4}	2.8×10^{-5}	4.9×10^{-3}	8.3×10^{-4}	6.1×10^{-3}	0.032
4c	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$	0.044
4d	$<1 \times 10^{-7}$	$<2 \times 10^{-9}$	$<1 \times 10^{-7}$	$<3 \times 10^{-7}$	$<5 \times 10^{-7}$	0.044

^{†1} All values given to two significant figures unless preceded by a less than (<) symbol. Based on doses given in Table 4.2.

^{†2} Based on doses given in Table 4.24.

^{†3} Based on fatal cancer rates for doses to various organs as given in Table 4.30.

^{†4} Includes fatal cancers associated with lung doses plus cancers associated with bronchial epithelium doses.

^{†5} Based on the assumption that the dose to the gonads (reproductive organs) is approximately the same as the whole body dose and that the genetic defect rate is 250×10^{-6} /organ-rem.

^{†6} Total adverse health effects resulting from doses to the critical organs.

^{†7} If DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission guideline. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release. However, the total dose to the general public would still be several orders of magnitude higher than for any of the alternatives involving long-term management of the wastes and residues in a humid environment (at NFSS or Oak Ridge).

Table 4.34. Estimated Additional Health Effects to Workers
As a Result of Doses Incurred During the Action Period

Alternative	Number of Potential Adverse Health Effects† ¹				
	Fatal Cancers Associated With			Genetic Defects† ⁴	Total Health Effects† ⁵
	Whole-Body Doses† ²	Bone Doses† ²	Lung Doses† ^{2,†3}		
1	3.1×10^{-4}	6.8×10^{-6}	3.5×10^{-4}	6.5×10^{-4}	1.3×10^{-3}
2a	1.2×10^{-3}	2.8×10^{-5}	1.4×10^{-3}	2.5×10^{-3}	5.1×10^{-3}
2b	1.7×10^{-2}	8.2×10^{-4}	4.8×10^{-2}	3.5×10^{-2}	1.0×10^{-1}
3a	5.3×10^{-2}	1.4×10^{-3}	7.2×10^{-2}	1.1×10^{-1}	2.4×10^{-1}
3b	3.0×10^{-2}	9.8×10^{-4}	5.5×10^{-2}	6.3×10^{-2}	1.5×10^{-1}
4a	4.0×10^{-2}	1.1×10^{-3}	5.9×10^{-2}	8.3×10^{-2}	1.8×10^{-1}
4b	4.3×10^{-2}	1.2×10^{-3}	6.3×10^{-2}	9.0×10^{-2}	2.0×10^{-1}
4c	2.3×10^{-2}	8.4×10^{-4}	4.7×10^{-2}	4.8×10^{-2}	1.2×10^{-1}
4d	2.6×10^{-2}	9.2×10^{-4}	5.1×10^{-2}	5.5×10^{-2}	1.3×10^{-1}

†¹ All values given to two significant figures unless preceded by a less than (<) symbol. Based on doses to the general public given in Table 4.4.

†² Based on fatal cancer rates for doses to various organs as given in Table 4.30.

†³ Includes fatal cancers associated with lung doses plus those associated with bronchial epithelium doses.

†⁴ Based on the assumption that the dose to the gonads (reproductive organs) is approximately the same as the whole-body dose and that the genetic defect rate is 250×10^{-6} /organ-rem.

†⁵ Total adverse health effects resulting from doses to the critical organs.

Alternative 3a (0.26 health effects). For all alternatives, the expected number of health effects is less than one. Given the conservative assumptions used in making these estimates, it is highly unlikely that any individual worker will incur an adverse health effect strictly as a result of work activities for this program.

There will be no significant doses or health effects to workers during the maintenance and monitoring period at all sites except Hanford (Alternatives 3a, 4a, and 4b). There is a likelihood for significant bronchial epithelium doses at Hanford during this time period due to the relatively high radon-222 flux from the buried materials. Maintenance and monitoring workers at Hanford are predicted to incur a cumulative dose of 290 organ-rem to the bronchial epithelium during the 190-year maintenance and monitoring period. This cumulative dose would be expected to result in 0.032 adverse health effects (fatal cancers). The occupational doses at NFSS at Oak Ridge are expected to be negligible during this time period, probably less than a total of a few rem to the whole body or critical organs (principally the bronchial epithelium) over the entire 190 years. Thus, it is highly unlikely that any individual worker will incur an adverse health effect as a result of monitoring and maintenance activities.

There will be no adverse health effects to the work force during the long-term period (200-1000 years) because it is assumed that there will be no monitoring and maintenance activities occurring after 200 years. If such activities continue beyond 200 years, the impacts to workers will continue.

4.1.5 Mitigation of Radiological Impacts

The radiological impacts previously discussed were estimated based on several assumptions regarding engineering design, construction practices, health-physics safety procedures, compliance with existing regulations, and the degree of physical and institutional control for each time period. Following are additional measures that could be taken to mitigate the predicted radiological impacts.

4.1.5.1 Action Period

During the action period, radiation doses to the general public near NFSS and the alternative sites are primarily the result of releases of radon-222 gas and particulates from the NFSS wastes and residues. These releases could be reduced by: (1) minimizing the amount of exposed residue and waste

surfaces--e.g., limiting the excavation area, (2) minimizing the amount of time the wastes and residues are exposed--e.g., use of temporary coverings, construction of new permanent caps at alternative sites as quickly as possible, (3) minimizing disturbance of exposed surfaces--e.g., limiting equipment speeds, (4) wetting exposed surfaces to minimize dust, and (5) ceasing operations during adverse weather conditions.

Radiation doses to the general public along transportation routes could be reduced by: (1) using extra shielding around residue packages, (2) packaging the wastes to reduce the amount of material lost during transport, and (3) minimizing public contact with the shipment--e.g., avoiding use of heavily traveled roads, routing around densely populated areas, selection of another harbor for the ocean disposal alternative so as to avoid the densely populated New York metropolitan area.

Impacts to workers will be minimized by implementing an effective health-physics program consistent with the "as low as reasonably achievable" (ALARA) philosophy. Specific measures to reduce occupational doses include: (1) minimizing the time spent in proximity of the wastes and residues, (2) encouraging attention to personal hygiene, (3) using protective clothing and respirators, particularly around the residues, and (4) using extra shielding between the workers and the residues.

4.1.5.2 Maintenance and Monitoring Period

During the maintenance and monitoring period, corrective actions will be taken, as necessary, to restore the containment system and to return any dispersed contaminated materials to the long-term management site. One mitigative measure would be the implementation of an intensive and extensive environmental monitoring system and frequent monitoring of the condition of the containment system. Another mitigative measure would be the construction of a containment system that is less likely to fail.

4.1.5.3 Long-Term Period

During the long-term period, the most effective mitigative measure would be to continue maintenance, monitoring, and corrective actions. Another measure would be to minimize the potential for human intrusion into the wastes and residues by (1) institutional controls for land use that are more strict than are currently in place (better record controls, use of physical site markers, stricter legal constraints), and (2) modified containment design (additional physical barriers on top of the wastes and residues, burying the materials deeper, etc.). Doses to the general public could also be reduced by constructing modified caps that would reduce the radon-222 emissions. (Several engineering options are discussed in Appendix C.)

4.2 GEOLOGY AND HYDROLOGY

4.2.1 Site Integrity

Following is a discussion of the physical processes affecting site integrity. Biotic processes are discussed in Section 4.3.

4.2.1.1 Erosion

Soil erosion, by the action of wind or water, could prove to be a major impact at NFSS and the alternative long-term management sites. The soil erosion process can degrade the stability of the protective cap, and the gradual loss and degradation of the barriers placed over the wastes will eventually allow penetration of the wastes by plant roots. The subsequent uptake, translocation, and accumulation of waste constituents by plants could serve to transport these materials into food chains and the surrounding environment. With complete erosion of the cap (or portions thereof), contaminated wastes and residues could also be eroded and transported into the surrounding environment. To evaluate the effects of soil erosion on the integrity of the waste-containment design, potential soil loss is estimated for each alternative site.

NFSS and Oak Ridge Sites. Water erosion is the principal cause of soil loss in the humid eastern United States (Brady 1974). In this analysis, the average annual or long-term average seasonal erosion for NFSS and Oak Ridge (eastern U.S. sites) are estimated using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978) according to the approach and assumptions detailed by Knight (1983a). The USLE yields good estimates of long-term average erosion rates on uniform slopes such as those at a waste-burial site (Foster 1979). It is an erosion model that can be used to estimate the sediment generated and displaced from a given area by sheet and rill erosion over time, but it does not estimate soil loss due to gully erosion. There are no accepted methods for quantifying gully erosion over hundreds of years.

Soil loss (per unit area per year) due to water erosion is computed as the product of five major factors:

$$\text{Soil Loss} = R \times K \times LS \times C \times P$$

where: R = rainfall and runoff, K = erodibility, LS = topographic, C = cover, and P = support practice.

The damage of the cap caused by water erosion is evaluated only for the long-term period (200 to 1000 years) (or a total of 800 years). During the initial 200-year period, it is assumed that there will be no net loss of soil from the cap because site maintenance activities will include addition of soil material to the cap to replace any materials lost.

Vegetation management (i.e., land use) is the single most important determinant of the rate of water erosion at a waste-burial site (Knight 1983a). Thus, the range of soil loss that can be expected at NFSS and Oak Ridge is estimated by assuming that erosive and nonerosive land uses (agriculture and natural succession to forest, respectively) represent the extreme bounds of possible uses affecting long-term erosion. (The diked burial at NFSS and the mounded burial at Oak Ridge are not expected to be particularly well suited to either use, and the probable uses are expected to fall somewhere in between these two extremes--see Section 4.3.)

The erosive land use assumes that the sites are used for 4-year crop-rotation agriculture. For purposes of analysis, it is assumed that the vegetative cover (C) factor for agriculture at NFSS and Oak Ridge corresponds to that of a midwestern 4-year crop rotation of wheat, meadow, and corn (grown in two successive years) using good soil management practices (e.g., contour plantings) (Wischmeier and Smith 1978).

The nonerosive land use is assumed to be local climax vegetation. The development of local climax vegetation through natural succession will result in a vegetation cover on the site that will protect the soil cap and minimize water erosion. For purposes of analysis, therefore, it is assumed that the sites will be managed as grassland during the 200-year maintenance and monitoring period and that natural succession begins at the end of this 200-year period. At NFSS, natural succession will lead to the establishment of a mature beech-maple forest; due to the elevation of the burial site above surrounding grade, it is thought that the site will be drier than its vicinity, and thus succession will tend towards the beech-maple forest which occurs on well-drained, fairly dry sites of that area rather than the mesophytic maple-oak forest type that originally occurred on site. At the Oak Ridge site, a mature oak-hickory forest will eventually develop (Whittaker 1975). The various successional stages involved in the development of mature forests on these sites will influence the values of the vegetative cover (C) factor. Using information presented in Wischmeier and Smith (1978), appropriate C factors are determined for each successional stage. The successional stages used in this analysis are presented in Table 4.35.

The topsoil at NFSS is assumed to be Madalin silt loam (Anderson et al. 1981), whereas that at the Oak Ridge site (Pine Ridge Knolls) is assumed to be Lehigh loam (Luxmoore et al. 1981). It is also assumed that as layers of soil are removed from the cap by water erosion, the natural process of soil genesis (Brady 1974) alters the underlying material into a form resembling the native soils of that site (Section 4.3.2). Given the long period of analysis (1000 years) and the uncertainties about climatic fluctuations, land use, etc., it is not possible to predict whether or not the rate of soil erosion will exceed the rate at which the containment materials are broken down into soil. Therefore, it is simply assumed that the rates of erosion at all sites will be similar to the rates for native soils. (See Section 4.3 for discussion of long-term biotic effects on integrity of containment systems.)

The presence of the riprap (rock) layer is not taken into account in these estimates of long-term cap erosion. The ability of such layers to withstand 1000 years of weathering is highly uncertain (Lindsey et al. 1982). Although such a layer will probably inhibit initial erosion rates after the overlying soil is eroded, the effectiveness of riprap over hundreds of years cannot be ensured. Riprap will eventually be broken down into soil by physical and biological forces. The rate of soil genesis layer will depend on climatic conditions, physical rock properties, as well as the biotic community that develops on the cap (Section 4.3.2). Furthermore, the riprap may be an attractive resource and might be removed for construction materials when institutional controls are no longer in effect. Given such uncertainties at this conceptual design stage of the decision-making process, the surface material of the cap at any given point in time is therefore assumed to be native soil, as discussed above. Specifications of more durable rock types (igneous rock such as rhyolites and granites, or metamorphic rocks, such as quartzites or granitic gneiss [Lindsey et al. 1982]) and consideration of site-specific physical and biological factors may allow specific cap designs that will have long-term erosion rates that are less than those estimated in this analysis.

During construction of the cap, the site and cap soils will be compacted to varying extents by trucks and heavy earth-moving equipment. Such compaction will drastically alter the physical characteristics of the soil such as bulk density, thereby altering the soil erodibility factor (K). However, it is assumed that the physical characteristics of the surface soils will gradually return to a state similar to that of undisturbed native soils of the same classification due to the action of (1) plant roots penetrating the cap surface (Section 4.3) and (2) frost heave and soil desiccation.

The average annual soil losses from NFSS and the Oak Ridge site are calculated using the parameters described in Table 4.35. The long-term soil losses from these sites are derived by extrapolation of the average annual soil loss estimates and are presented in Table 4.36. Such estimates are

Table 4.35. Land Use, Stage of Success, and Universal Soil Loss Equation (USLE) Factors Used in Estimating Water Erosion from the Eastern Long-Term Waste Management Sites

Site/Alternative	Land Use (Vegetation)	Stage of Natural Succession† ²	Length of Stage (years)	USLE Factor† ²				
				R	K	LS	C	P
NFSS								
1 (no action)	Agriculture (4-yr crop rotation)	-	800	75	0.37	2.6	0.35	0.5
		Old field/meadow	50	75	0.37	2.6	0.011	1
	Natural succession (beech-maple forest)	Shrub/young trees	250	75	0.37	2.6	0.012	1
		Early forest development	200	75	0.37	2.6	0.011	1
		Mature forest	300	75	0.37	2.6	0.0001	1
2a, 2b, 4a, 4c	Agriculture (4-yr crop rotation)	-	800	75	0.37	1.8	0.35	0.5
		Old field/meadow	50	75	0.37	1.8	0.011	1
	Natural succession (beech-maple forest)	Shrub/young trees	250	75	0.37	1.8	0.012	1
		Early forest development	200	75	0.37	1.8	0.011	1
		Mature forest	300	75	0.37	1.8	0.0001	1
OAK RIDGE								
3b	Agriculture (4-yr crop rotation)	-	800	210	0.28	0.8	0.35	0.5
		Old field/meadow	50	210	0.28	0.8	0.011	1
	Natural succession (Oak-hickory forest)	Shrub	250	210	0.28	0.8	0.04	1
		Early forest development	200	210	0.28	0.8	0.011	1
		Mature forest	300	210	0.28	0.8	0.001	1
4c, 4d	Agriculture (4-yr crop rotation)	-	800	210	0.28	1.1	0.35	0.5
		Old field/meadow	50	210	0.28	1.1	0.011	1
	Natural succession (Oak-hickory forest)	Shrub	250	210	0.28	1.1	0.04	1
		Early forest development	200	210	0.28	1.1	0.011	1
		Mature forest	300	210	0.28	1.1	0.001	1

†¹ General successional patterns developed from information in Daubenmire (1968), Whittaker (1975), and VanKat (1979).

†² R = rainfall and runoff factors; K = erodibility factors; LS = topographic factors; C = cover factors; P = support practice factors. All data from Wischmeier and Smith (1978), except K factors obtained from state soil conservation services for Madalin silt loam (NFSS) and Lehigh loam (Pine Ridge Knolls) and LS factors estimated using Wischmeier and Smith (1978) and information describing burial site dimensions and structural details presented in Section 2.

Table 4.36. Estimates of Long-Term Erosion of Earthen Covers (Caps) at Alternative Burial Sites†¹

Site/Alternative	Material	Primary Erosive Force† ²	Land Use (Vegetation)	Cap Thickness (m)		Cap Loss at 1000 Years		Total Years to Erode Cap
				200 Years	1000 Years	Meters	Percent	
NFSS								
1 (no action)	Wastes and residues	Water	Natural succession (beech-maple forest)	1.5	1.42	0.08	5	1,100,000
			Agriculture		-0.4	1.9	>100	650
2a, 2b	Wastes and residues	Water	Natural succession (beech-maple forest)	3.2	3.12	0.08	3	2,200,000
			Agriculture		1.2	2.0	63	1,300
4a, 4c	Wastes only	Water	Natural succession (beech-maple forest)	3.2	3.12	0.08	1	2,200,000
			Agriculture		1.2	2.0	63	1,300

HANFORD								
3a	Wastes and residues	Wind	Natural succession (sagebrush)	3	1.6	1.4	47	1,800
			Rangeland, overgrazed (shrubs/annual grasses)		1.4	1.6	53	1,500
4a, 4b	Residues only	Wind	Natural succession (sagebrush)	4.6	3.2	1.4	30	2,800
			Rangeland, overgrazed (shrubs/annual grasses)		3.0	1.6	35	2,300

OAK RIDGE								
3b	Wastes and residues	Water	Natural succession (oak-hickory forest)	3.2	3.1	0.10	3	420,000
			Agriculture		2.2	1.0	31	2,400
4c, 4d	Residues only	Water	Natural succession (oak-hickory forest)	3.2	3.06	0.14	4	310,000
			Agriculture		1.7	1.5	47	1,800

†¹ Estimates are used to compare the relative potential for loss of containment, not the actual longevity of containment.†² Water estimates based on Universal Soil Loss Equation; wind estimates based on Wind Erosion Equation.

used to compare the relative potential for loss of containment under different scenarios and are not intended to predict the actual longevity of the containment system. It should be noted that the USLE predicted "soil loss" represents the average soil thickness removed from a sloping surface. In reality, it is likely that soil erosion will not be uniform across the surface of the containment caps. Soil eroded from the cap will be redeposited further downslope, and, as a result, there will be a continual change in the slope parameter (LS) with time as a result of the decrease in slope steepness and increase in slope length. Because the USLE equation cannot be used with any validity for slopes in excess of 18% (the out-slopes of the containment caps at NFSS are 40% and 20% and the out-slope at Oak Ridge is 20%), and because of the continuous change in the slope parameter with time, the average slopes of the disposal sites are used in this analysis. Use of the average slope results in underestimation of the initial out-slope erosion and overestimation of the initial erosion of the tops of the piles. However, the average slopes more closely approximate the shape of the piles in the long-term period (e.g., with the side slopes longer and less steep because of deposition of eroded material from the top of the pile at the base of the slope).

Changes in environmental factors, such as climate or topographic relief, that will undoubtedly occur during this period will subsequently alter the composition and structure of plant communities on the waste-management sites. Changes in these factors will, in turn, alter the rate of soil erosion. Unfortunately, current state-of-the-art modeling is not capable of predicting such changes.

Although the constraints of the USLE (Foster 1979) limit the accuracy of soil erosion estimates for NFSS and the Oak Ridge site, a number of general conclusions can be made. First, there is a large range in the number of years it might take for the containment cap to erode. Thus, the interim cap at NFSS might erode as early as 650 years under agricultural use or as late as 1.1 million years under natural succession to forest. Erosion of the long-term cap might be as early as 1,300 years or as late as 2.2 million years. At Oak Ridge, the cap might be eroded by 1,800 years or as late as 420,000 years. Given such great ranges because of uncertainties in future land uses, there is no significant difference between the two humid sites of NFSS and Oak Ridge with respect to eventual erosion of the caps.

For all alternatives, cap erosion will occur much more rapidly under crop-rotation agriculture than under natural succession (Table 4.36). The principal effect of water erosion under agricultural land use will be a reduction in the thickness of the protective caps placed over the wastes. Complete erosion of the NFSS Alternative 1 cap will occur within the 200- to 1000-year period under crop-rotation agriculture. This will not only increase radon emanation from the site, but will also increase the potential for plant root and burrowing animal intrusion of the wastes which will, in turn, allow for the subsequent uptake and translocation of radionuclides in the wastes by plants and the ingestion and inhalation of the wastes themselves by animals. In addition, the penetration of the cap by burrowing animals or plant roots will jeopardize the integrity and stability of the cover system. Biologic effects on the long-term stability of the cap are discussed further in Section 4.3. The impacts associated with the dispersion of the wastes into surface water supplies are discussed in Sections 4.1, 4.2.2, and 4.4.

Hanford Site. In analyzing the amount of erosional losses at the arid Hanford site, the effects of both wind and water erosion are examined. Soil losses at Hanford due to water erosion are calculated as for the NFSS and Oak Ridge sites using the USLE. Soil losses at Hanford due to wind erosion are computed according to the Wind Erosion Equation (WEE) (Woodruff and Siddoway 1965; Skidmore and Woodruff 1968; Skidmore 1983). Because soil losses at Hanford due to wind erosion are computed (using the WEE) to be 100 to 200 times greater than soil losses due to water erosion (using the USLE), the wind erosion losses are reported here. (As noted previously, the USLE equation cannot be used to estimate soil losses as a result of severe flooding events or gully erosion, which can be the dominant geomorphic force in arid climates. The possibility of such severe water erosion losses occurring at Hanford are discussed in Section 4.2.1.2.)

Soil loss (per unit area per year) due to wind erosion is computed as the product of five major factors:

$$\text{Soil Loss} = f (I' K' C' L' V)$$

where: I' = erodibility, K' = surface roughness, C' = climatic, L' = open-field length, and V = vegetative cover. The functional aspects of the variables of the WEE are not discussed here because resolution of the equation entails the use of numerous tables, figures, and equations. A detailed explanation of the WEE is given by Woodruff and Siddoway (1965) and Skidmore and Woodruff (1968).

Several of the assumptions made to use the USLE for estimating water erosion loss at NFSS and the Oak Ridge site are also made to use the WEE for estimating wind erosion loss at the Hanford site. The parameters used to compute average wind erosional soil loss are presented in Table 4.37. As with the eastern sites, land use is the primary factor affecting erosion rates. Therefore, erosion is estimated using both an erosive and nonerosive land use. The erosive land use is assumed to be overgrazed rangeland and the nonerosive land use is assumed to be native, undisturbed vegetation (i.e., sagebrush community). Also, as was the case for the eastern sites, the assumed land uses represent two extremes in that the burial trenches at Hanford are not expected to provide particularly good habitat for

Table 4.37. Land Uses, Stage of Community Development, and Wind Erosion Equation (WEE) Factors Employed in Estimating Wind Erosion from the Arid Long-Term Waste Management Site (Hanford)

Land Use	Stage of Community Development	Length of Stage (years)	WEE Factorst ¹				
			I'	K'	C'	L'	V
Sagebrush used for rangeland	Overgrazed	800	98	1.0	18.9%	1000	732
Native sagebrush community	Developing	30	98	1.0	18.9%	1000	732
	Mature	770	98	1.0	18.9%	1000	1742

†¹ I' = Erodibility factor. Computed assuming 20% of the soil particles of the site's soil is greater than 0.84 mm in diameter.

K' = Surface roughness factor. Assumes the top of the burial trench is smooth.

C' = Climatic factor. Calculated according to Woodruff and Siddoway (1965).

L' = Open-field length. Assumes prevailing wind is along the length of the trench.

V = Vegetative cover factor. Assumes productivity of developing and overgrazed community to be 41 g/m²/yr, mature community to be 80 g/m²/yr (from Uresk et al. 1977).

native vegetation or rangeland. Because successional patterns are poorly understood in arid western ecosystems, it is assumed that 30 years is required to develop a sagebrush community (it is assumed that during the maintenance and monitoring period, deep-rooted plants such as sagebrush are prohibited from growing in the waste management area through use of herbicides or other control methods).

It is assumed that the cap placed over the wastes at Hanford is intact at the end of the maintenance and monitoring period (200 years). Wind erosion is then estimated for the long-term period (200-1000 years). The soil at the Hanford site is assumed to be a sandy loam (Uresk et al. 1977) with an undisturbed bulk density of 1.5 g/cm³. As with the erosion estimates for the two humid sites, the riprap layer at Hanford is assumed to be changed into soil by physical and biological weathering processes. As noted previously, careful selection of rock material during detailed engineering design may lead to erosion rates that are slower than those predicted--if the riprap layer is not removed after institutional controls cease. Also, as is the case for the water erosion calculations, wind erosion losses are calculated assuming uniform losses. In reality, losses will not be uniform. The predicted erosion rates are used only for comparison of the relative potential for loss of the caps and are not intended to precisely predict the actual longevity of the cap. Furthermore, at Hanford, there could even be deposition of material on top of the trenches (as is the case with dune formation), thereby increasing the length of time to waste/residue exposure.

The soil-loss estimates computed using the WEE are converted to trench-cap loss estimates following the procedure outlined in the previous subsection and are presented in Table 4.36. If controls cease in 200 years, the cover over the NFSS wastes and residues at Hanford may be eroded in as little as 1,800 years or as many as 420,000 years, depending primarily on land use.

Mitigative Measures. During the initial 200-year maintenance and monitoring period, any loss of soil from the cap at any site will be replaced and cap failures will be repaired. Grass over the cap will help to stabilize the cap and minimize soil erosion losses during this period (see Section 4.3 for detailed discussion of vegetation management). Regression of the sites to native climax vegetation or use of known farming practices conducive to soil conservation will significantly reduce erosion losses in the long-term period.

4.2.1.2 Flooding

In addition to the average or everyday forces acting upon the storage site, severe events occurring within the 1000-year period of analysis are likely to stress the integrity of the containment systems.

At NFSS, the potential for flooding could increase without proper maintenance and dredging of the existing drainage ditches or with future modifications to the drainage system both upstream or downstream from NFSS. For example, rerouting of water into the NFSS drainage system from offsite areas could increase the potential for floods at the site--especially if there is no attendant modification of the carrying capacity of downstream culverts and ditches. Flooding could lead to saturation of the contaminated materials, thereby increasing the concentrations of contaminants in groundwater and surface water in the vicinity of the site. During the maintenance and monitoring period, all site drainage systems will be maintained to ensure proper drainage. Such maintenance will include dredging

of local ditches, culvert cleaning and repair, and control of drainage flow patterns both upstream and downstream from NFSS.

During the long-term period, the NFSS drainage ditches will fill with sediments and the NFSS could become as poorly drained as it was prior to the construction of the drainage ditches. As a result, groundwater flow patterns may be altered. With ponding of water on the site, saturation of the wastes and residues is likely. Increased saturation of the waste/residue pile may also trigger slope failures at the outer slope of the pile (see Section 4.2.1.4 for further discussion).

The containment area in the Oak Ridge alternatives will not be subject to severe flooding because of its location on the knolls. The 218W5 site for the Hanford alternatives is above the floodplain of the Columbia River, and severe flooding will not be a problem on the plateau area.

4.2.1.3 Severe Erosion Events and Droughts

Seasonally heavy rains could trigger gully erosion at both the NFSS and Oak Ridge sites. Gully erosion will be most likely to occur during the construction period and prior to the establishment of a stable vegetative cover over the piles. During the maintenance and monitoring period, gully erosion is assumed to be detected and repaired. Drainage control measures such as drainage swales to collect runoff from the pile and riprapped channels down the side slopes can be used to minimize gully development.

Without maintenance, the effectiveness of drainage control measures will decrease during the long-term period. In addition, drought or fire could damage the vegetative cover. Without effective drainage controls and a vegetative cover, the steep outer slopes of the piles will be extremely vulnerable to gully erosion. This will be particularly true on the very steep outer slopes on the interim cap at NFSS. The long-term cap at NFSS and the cap at Oak Ridge will have less steep slopes, but they will be steep enough to create a good potential for gully erosion. Unchecked, gully erosion will seriously jeopardize the integrity of the waste/residue pile. No quantitative methods are available for estimating the extent of gully erosion over the long term.

Seasonal droughts at the NFSS and Oak Ridge sites could result in the formation of dessication cracks in the surface of the clay layer. During the maintenance and monitoring period and while the overlying layers of riprap/ sand/soil remain intact during the long-term period, such cracking should be minimal. During the wetter seasons, infiltrating water will moisten the clay and the cracks will tend to close up. As the surface layers erode during the long-term period or if there is a prolonged drought, the cracks will be more extensive. Radon emissions will tend to increase with cracking of the clay layer. However, it should be pointed out that underneath the clay layer will be the clayey NFSS wastes which will still serve to retard the radon emanating from the major source--the residues buried even deeper underneath the wastes.

In arid climates, water erosion can be the dominant geomorphic factor. Sudden, heavy rains ("flash floods") may be responsible for substantial sheet erosion and possibly gully erosion of the trench covers. However, the flat topography of the plateau, the low relief of the trench covers, and the distance of the disposal site from major surface drainage systems should minimize the potential for gully erosion at the Hanford alternative site.

However, a severe drought or fire at Hanford could destroy the vegetative cover over the trenches and subsequent high winds could increase the rate of soil loss. The presence of the 0.9-m riprap layer may serve to reduce such losses by acting like "desert pavement" (a stone-covered surface resistant to wind erosion that is naturally present in deserts).

4.2.1.4 Slope and Cover Failure

Because of the relative steepness of the outer slopes of the caps at NFSS and Oak Ridge (40% in Alternative 1 and 20% in Alternatives 2a, 2b, 3b, 4a, 4b, 4c, and 4d), the protective cap covering the wastes will likely eventually slump, inducing gully erosion and increased erosion. Although measures such as careful compaction of the wastes, scarification of transition surfaces (e.g., clay to sand), and gradual gradation of materials (e.g., clay to sand to pea gravel), can initially reduce the potential for slumping, they will probably not eliminate the problem on such steep slopes over hundreds of years. Any slope failure occurring within the initial 200 years of maintenance and monitoring will be repaired. If controls cease, slope failure will result in earlier exposure and dispersion of the contaminated wastes/residues. Slope failure is likely to occur in the diked and mounded containment structures in the humid climates at NFSS and Oak Ridge. Slope failures are not expected on the low-relief trench covers at Hanford. If one of the alternatives at NFSS or Oak Ridge is selected, a rigorous analysis of potential slope failure will be appropriate at the detailed engineering design stage of the decision-making process.

The presence of karst features (sink holes, underground caves, etc.) in the Oak Ridge area are indications of solution cavities that have developed in the limestone bedrock. Although there are no surface manifestations of such solutioning on the Pine Ridge Knolls, solutioning is known to occur in some units of the Conasauga Group that underlies the knolls (Section 3.3.1). Development of solution

cavities in the bedrock underneath the knolls could jeopardize the integrity of the piles. Subsidence of the piles into such a cavity would result in: (1) failure of the caps with consequent increase in water infiltration into the wastes and residues, (2) increase in gully erosion of the cover system with consequent earlier dispersion of the contaminated materials into the environment, and (3) decrease in the effectiveness of the cap in retarding radon and consequent increase in radon emissions. The probability of such an event occurring on the Pine Ridge Knolls site is less than in other parts of the Oak Ridge Reservation that are underlain by different kinds of bedrock that are more prone to solutioning.

4.2.1.5 Seismic Activity

The possible effects of the maximum probable seismic event during the 10-year and 10- to 200-year time frames as well as the effect of the maximum potential seismic event for the 200- to 1000-year time frame on the integrity of the containment structures at the Niagara Falls, Oak Ridge, and Hanford sites are presented in Table 4.38. Based on historic seismic records, all sites may experience very strong earthquakes of at least a modified Mercalli (MM) intensity of VII (see Sections 3.1, 3.2,

Table 4.38. Potential Effects of Seismic Activity on Containment Structures

Site/ Alternative	Potential Impacts Associated with Three Time Frames† ¹		
	Action Period (10 years)	Maintenance and Monitoring Period (10-200 years)	Long-Term Period (200-1000 years)
<u>NFSS</u>			
1, 2a, 2b, 4a, 4c	Possible cracking of cap and failure along cap slopes after maximum probable seismic event-- will be repaired Subsurface clay cutoff wall may be damaged--will be repaired only if damage detected	Possible cracking of cap and failure along cap slopes after maximum probable seismic event-- will be repaired Subsurface clay cutoff wall may be damaged--will be repaired only if damage detected	Cracking of cap and failure along cap slopes after maximum potential seismic event Damage to cutoff wall

<u>HANFORD</u>			
3a, 4a, 4b	Maximum probable seismic event may cause slight ground cracking in trenches--will be repaired Possible subsidence of cap into voids between packaged wastes--will be repaired	Maximum probable seismic event may cause slight ground cracking in trenches--will be repaired Possible subsidence of cap into voids between packaged wastes--will be repaired	Maximum potential seismic event may cause slight ground cracking in trenches Subsidence of cap into voids between packaged wastes

<u>OAK RIDGE</u>			
3b, 4c, 4d	Possible damage to cap and failure of cap slopes after maximum probable seismic event--will be repaired Possible subsidence of cap into voids between packaged wastes--will be repaired	Possible damage to cap and failure of cap slopes after maximum probable seismic event--will be repaired Possible subsidence of cap into voids between packaged wastes--will be repaired	Damage to cap and failure of cap slopes after maximum potential seismic event Subsidence of cap into voids between packaged wastes

†¹ Maximum probable seismic event assumed to be MM VI to VII for all sites, based on historical records (see Sections 3.1.1, 3.2.1 and 3.3.1). Maximum potential seismic event assumed to be one level higher than historic record, or MM VIII for all sites.

and 3.3).* Ground cracking or slope failure may occur but should be minimal in extent at all sites for the maximum probable quake unless saturated soil conditions exist. With saturated conditions, slope failure may occur at NFSS and the Oak Ridge site especially along the sand/clay interfaces. Such slope failures may result in the exposure and erosion of the wastes at these two sites. No such slope failure is expected at the Hanford site due to the use of burial trenches. Such seismic events may also facilitate settling of the material used to fill the spaces between the waste containers and thereby cause limited subsidence and possible cracking of the cover material at Hanford and Oak Ridge. Subsidence at these sites would increase radon releases until the cracks caused by subsidence are filled by natural erosion processes or by active maintenance.

Although possible damage to the site structures may occur during the 200-year period, it is assumed that all structures or features known to have been damaged will be promptly repaired, thereby minimizing impacts resulting from the failure. This assumption applies primarily to repair of the cap because damage to the cap will be most noticeable. Damage to the subsurface clay cutoff wall at NFSS may not be noticed unless monitoring wells are fortuitously located to detect a breach in the wall and any subsequent migration of contaminants. The slow lateral migration of groundwater at NFSS (see Section 3.1.2), however, lessens the importance of this impact in the short term (0 to 200 years). Because no studies have been conducted to demonstrate and predict the long-term durability of a cutoff wall (Harris et al. 1982), the effectiveness of this structure over 1000 years cannot be relied upon to restrict contaminant migration via groundwater. The analysis of groundwater contamination is presented in Section 4.2.2, and the impacts resulting from groundwater migration of contaminants are addressed in Sections 4.1 and 4.4.

The potential for cap subsidence at Oak Ridge and Hanford may be substantially lessened by the orderly arrangement of containerized waste and backfilling between the residue containers with fine sand or grout. With cap subsidence, infiltration of precipitation through the wastes and residues will increase and gully erosion of the cap may be accelerated. It is assumed that such damage will be repaired during the maintenance and monitoring period.

As the time frame for analyses increases, so does the potential for more severe earthquakes for each area. Prediction of the severity of quakes that may occur within the 200- to 1000-year time frame, however, is limited by the relatively short period of record for seismic events in the North American Continent. For purposes of analysis, therefore, the maximum potential earthquake possible for the 200- to 1000-year time frame is assumed to be greater than the predictions for the maximum probable earthquake based on the historic records. The resulting impacts will be more severe and are assumed to not be repaired in the long-term period. In addition, it can be assumed that due to site design differences (e.g., trenches vs. waste pile), loss of containment during severe seismic events within the 200- to 1000-year time frame will be less likely to occur at the Hanford site than at either NFSS or Oak Ridge.

4.2.2 Groundwater Impacts

4.2.2.1 General Model Description

Both radiological and nonradiological substances will be leached out of the NFSS wastes and residues by infiltrating water and carried into the groundwater. An individual could consume contaminated water from a well (assumed to be located onsite next to the waste/residue area), and a population could consume contaminated water from a stream or other surface-water body that receives contaminated groundwater discharge. In this section, the C/S ratios (concentration of the contaminant in the groundwater divided by the concentration in the source [wastes and/or residues]) are determined for both the onsite well and the point where groundwater discharges to surface water. The impacts associated with releases of radiological and nonradiological contaminants to surface waters and groundwaters are discussed in Sections 4.1, 4.2, and 4.4.

The rate of release of contaminants from the waste/residue area can be estimated by means of the ion-exchange model or diffusion model (U.S. Dep. Energy 1983a). In this study, the ion-exchange model is used because it gives a more conservative (higher) estimate. The geometry and time variation of the groundwater contamination are shown schematically in Figure 4.7. Precipitation striking the residue/waste area (waste field) infiltrates through the wastes and transports contaminants down into the aquifer. The waste field is assumed to be a rectangular region with dimensions L_x , L_y , and L_z . The geometry of the contaminated layer is assumed to be constant during migration. After the contamination reaches the water table, it will be diluted in the groundwater and transported to the well and eventually to nearby surface waters. The well is assumed to be located at the center of the edge of the waste field downgradient in the groundwater flow.

Contaminant concentrations in the groundwater at various times and places may be determined by solving a three-dimensional mass transport equation that includes the effects of convective transport, molecular diffusion, hydraulic dispersion, chemical sorption, and radioactive decay (Bear 1972; Yeh

*No information is available to perform probabilistic earthquake risk analysis for the soils upon which the containment systems will be founded at all three sites. Possible modes of failure are discussed.

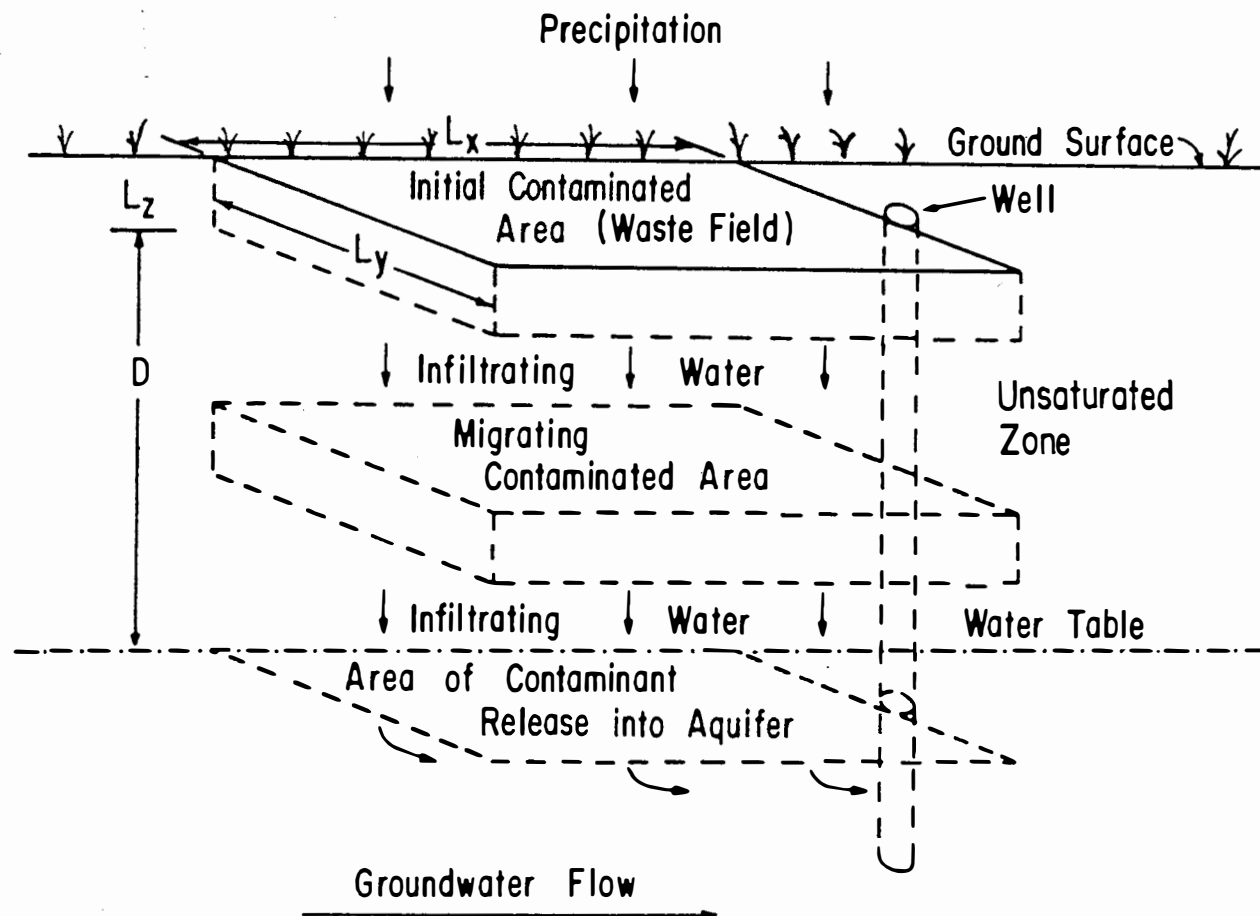


Figure 4.7. Schematic Diagram of Model for Estimating Concentrations of Contaminants in Groundwater. Modified from Gilbert et al. (1983)

1981). It is assumed that the aquifer is homogeneous and isotropic and that the flow is uniform and in one direction. The effects of fractures and solution cavities on the flow and solute transport are taken into consideration in the selection of the values for the various hydrogeologic parameters. For example, the hydraulic conductivity at Oak Ridge is set at 0.03 cm/s, whereas at NFSS it is 0.000011 cm/s (Table 4.39). It is also assumed that water drawn into the onsite well will be mixed before it reaches the ground surface.

The solution of the mass transport equation is obtained with the aid of a computer program developed at Oak Ridge National Laboratory (Yeh 1981) and adapted for this study. The program is modified to take into account the delay time for the contaminants to migrate from the bottom of the waste field to the water table. The most sensitive parameters are hydraulic conductivity or distribution coefficient. The results of a sensitivity study of the concentrations predicted by the model to various input parameters have been reported by Gilbert et al. (1983).

Although more sophisticated groundwater models are available, the use of a more complex model is not warranted because of the uncertainties relative to hydrogeological conditions at the sites, the conceptual nature of the containment designs at this stage of the decision-making process, the uncertainties relative to the behavior of containment systems over hundreds of years, and the uncertainties relative to duration of maintenance and institutional controls. Use of a more complex model would require inclusion of even more assumptions and would not result in a more accurate prediction of impacts. For the model used, conservative assumptions are made regarding the "average" values for the various input parameters (see next section) and a relative comparison of alternatives is made. Use of a more complex model may be appropriate at a later stage in the decision-making process when one of the basic alternatives has been selected for implementation and further decisions must be made relative to specific detailed engineering designs.

Table 4.39. Parameters Used for the Calculation of Contaminant Concentrations in Groundwater†¹

Parameter	Symbol	Unit	NFSS	Hanford	Oak Ridge
Annual precipitation	P	m/yr	0.89	0.16	1.40
Surface runoff coefficient	C	-	0.20	0.20	0.15
Evapotranspiration rate	E_t	m/yr	0.60	0.10	0.89
Infiltration rate (w/o cover)	I	m/yr	0.11	0.03	0.30
Infiltration rate (with cover)	I	m/yr	0.04	0.01	0.10
Effective porosity	n_e	-	0.1	0.2	0.025
Bulk density of soil	ρ_s	kg/m ³	1,700	1,600	1,700
Hydraulic gradient	l	-	0.001	0.002	0.03
Hydraulic conductivity	K_h	cm/s	0.000011	0.19	0.03
Longitudinal dispersivity	α_L	m	1.0	3.0	1.0
Transverse dispersivity	α_T	m	0.1	0.3	0.1
Vertical dispersivity	α_V	m	0.1	0.3	0.1
Waste field dimensions	L_x	m	270	310	270
	L_y	m	120	310	270
	L_z	m	6.0	2.4	3.0
Distance from lower boundary of waste field to water table	D	m	0	65	4
Distance from water table to bottom of well	D_w	m	10	10	10

†¹ Distribution coefficients and radioactive decay constants are discussed in the text.

4.2.2.2 Hydrological Parameter Values

The various hydrological parameters used in the model are listed in Table 4.39. The hydrologic parameters such as precipitation and evapotranspiration are obtained either from site-specific reports (Acres American 1981; Bechtel Natl. 1984a, 1984b; U.S. Nucl. Reg. Comm. 1981; Brown and Isaacson 1977; Exxon Nucl. Co. 1977) or from the Water Atlas of the United States (Geraghty et al. 1973). The surface runoff coefficients are selected for "mild" grass cover (Chow 1968) and average waste-area slope conditions for the containment designs presented in Section 2. The waste-field dimensions are based on the conceptual designs described in Section 2.

The groundwater flow characteristics such as hydraulic gradient, hydraulic conductivity, and various dispersivities are obtained from site-specific reports (Acres American 1981; Bechtel Natl. 1984a, 1984b; Brown and Isaacson 1977; Exxon Nucl. Co. 1977). At NFSS, the average hydraulic conductivity of the near-surface brown sand aquifer is assumed for the entire site. (The effects of the intermittent sand lenses are discussed in Section 4.2.2.3.) Calculations by Bechtel Civil and Minerals, Inc. (1982), and Bechtel National (1984b) indicate that the migration of contaminants in groundwater could be slowed by the lower-permeability clay cutoff wall surrounding the waste/residue areas. However, several natural processes (e.g., tree root penetration, frost heaving, dessication, crack development, etc.) could seriously jeopardize the integrity and durability of the cutoff wall over the 200- to 1000-year period. Therefore, in this analysis it is assumed that over the time frame analyzed, the average properties of the cutoff wall are the same as for the wastes and surrounding soils. Likewise, the concrete foundations of the buildings containing the residues are assumed to offer no significant long-term barrier to contaminant migration.

Whereas site investigations at NFSS have established the presence of the groundwater table one or more meters (several feet) below the ground surface during the dry summer period, the fluctuation of the groundwater level throughout the year has not yet been determined. Knowledge of the saturated conditions at NFSS during spring snowmelt, the poor drainage of the site (Higgins et al. 1972), and the ponding of water on the site during snowmelt and heavy periods of precipitation suggest that zero depth to groundwater should be assumed during some periods of the year. This is also a reasonable assumption in light of the fact that some of the contaminated soils and residues are buried well below the ground surface (see Sections 2 and 3.1.7).

There is probably little potential for undetected underground piping to facilitate the migration of contaminated groundwater from the wastes/residues at NFSS. During construction of the subsurface clay cutoff wall during interim remedial actions, all known pipes were removed or grouted to inhibit groundwater communication along these pathways. Any remaining undetected pipes will have to be located so as to discharge into a sand lens bordering NFSS in order to facilitate rapid migration of wastes offsite through the lens. If such a pipe is not connected to a sand lens, only limited contaminant migration is expected to occur through the surrounding low-permeability clay material. Migration of the contaminated groundwater into a discontinuous sand lens adjacent to the site will pose a health risk only if the sand lens is tapped by a domestic well; the potential risks associated with such an event are presented in Section 4.1.2.3 under the resident-intruder scenario.

4.2.2.3 Estimates of Radium-226 in Groundwater

With respect to groundwater contamination, the radionuclide of most concern in the NFSS wastes and residues is radium-226 (Gilbert et al. 1983). Concentrations of radium-226 in groundwater are modeled for varying thicknesses of clay in the cover materials (Table 4.40), corresponding to the conceptual designs discussed in Section 2. The thickness of only clay is considered because the other layers of sand, gravel, etc., will not significantly inhibit water infiltration into the contaminated materials. For each site, an estimate is also made for the case in which there is no clay cover because, at all sites, the cover material will deteriorate and eventually be eroded (see Section 4.2.1). If the sand and riprap layers in the final cap at NFSS (Alternatives 2a and 2b) and in the cap at Oak Ridge remain intact, these layers--combined with the steepness of the cap slopes--should promote cap drainage and infiltration may be less than assumed (at least while the cap is maintained for 200 years).

Table 4.40. Radium-226 in Onsite Wells†¹

Site	Clay Cover Thickness (m)	C/S Ratio† ¹ at Year 1000 (pCi/L)/(pCi/g)	Maximum C/S Ratio† ² (pCi/L)/(pCi/g)	Time to Reach Maximum Concentration† ³ (yr)
NFSS:				
No cap	0	3.8	4.0	1,400
Interim cap	0.9	2.1	2.5	1,800
Long-term cap	1.5	1.0	1.2	3,600

Hanford:				
No cap	0† ⁴	0† ⁵	0.55	35,000

Oak Ridge:				
No cap	0	0† ⁵	0.23	2,500
Long-term cap	1.5	0† ⁵	0.083	7,000

†¹ Assumed to be located next to the waste/residue containment area.

†² C is the concentration of radium-226 in the well water, and S is the initial concentration of radium-226 in the wastes and/or residues.

†³ Includes the delay time for radium-226 to migrate from the bottom of the waste field to the water table (0 yr at NFSS, 35,000 yr at Hanford; and 230 yr [no clay] or 6,800 yr [1.5 m clay] at Oak Ridge).

†⁴ Native sandy soils will be used for the cover material at Hanford. A clay cover would dry out and become ineffective in the arid climate at Hanford. Therefore, only the no clay cap case is analyzed.

†⁵ Zero means that the waste front has not reached the specified location at t = year 1000.

For the sandy soil conditions at the Hanford site, the assumed K_d value (distribution coefficient) is $10 \text{ cm}^3/\text{g}$, which is ten times lower than the assumed value of $100 \text{ cm}^3/\text{g}^*$ for the clayey soils at both the Niagara Falls and Oak Ridge sites (Nucl. Saf. Assoc. 1980).

The C/S ratios for onsite wells and for groundwater at various locations downgradient from the waste/residue areas are presented in Tables 4.40 and 4.41, respectively. Following are discussions of predicted radium-226 contamination of groundwater of each site.

NFSS. The concentrations of radium-226 in onsite wells at year 1000 for the various NFSS alternatives are presented in Table 4.42. These concentrations are based on the C/S ratios given in Table 4.40. For Alternative 1, the C/S ratio is assumed to be 3.0, which is between the value for no clay and 0.9 m clay because the clay cover will gradually be eroded away under agricultural use of the site (Section 4.2.1). Furthermore, a multiplier of 0.1 is applied based on the assumption that a well drilled into a sand lens at the edge of the NFSS waste/residue area will draw 10% of its water from the contaminated area and 90% from the surrounding uncontaminated area in order to have sufficient yield to supply the water needs of the person using the well water. The C/S ratios, and thus the well-water concentrations, will be only slightly higher at the time of maximum concentration.

For all alternatives in which the residues would remain at NFSS (Alternatives 1, 2a, and 2b), the concentrations of radium-226 in the onsite wells are predicted to be greater than the current DOE standard of 30 pCi/L for soluble radium-226 in uncontrolled areas. For alternatives in which only the wastes would remain at NFSS (Alternatives 4a and 4c), the radium-226 concentrations are predicted to meet both the DOE standard of 30 pCi/L and the EPA drinking water standard of 5 pCi/L but to exceed the current New York state standard of 3 pCi/L.

No offsite contamination is predicted to occur at a theoretical well located at the site boundary northwest of the containment area within the 1000-year design life of the containment system (Table 4.2). Even after 32,000 years (the point at which the computer program was aborted), the groundwater contamination will not migrate very far from the waste/residue area (Tables 4.40 and 4.41); thus, discharge of contaminated groundwater to surface water is not considered further in this analysis. Because of the characteristics of the NFSS site hydrology (e.g., hydraulic gradient and conductivity, depth to deeper confined aquifers, direction of groundwater flow), it is highly unlikely that radiological contamination of the deeper confined aquifers in the region would occur even in the long-term period.

When less conservative values are used for the most sensitive parameters (i.e., distribution coefficient for radium of $500 \text{ cm}^3/\text{g}$ and average hydraulic conductivity of 10^{-7} cm/s), it is predicted that again there will be no offsite contamination for the 1000-year design life of the containment system and that peak concentrations in the theoretical onsite well will decrease by a factor of about 5.

In summary, the clay of the interim cap (Alternative 1) and the additional clay in the preferred long-term cap (Alternatives 2a and 2b) are expected to reduce (but not eliminate) water infiltration into the buried wastes and residues. The existing clayey soils beneath the containment area are expected to retard (but not eliminate) migration of radionuclides from the wastes and residues. Because the clay layers (including the so-called "grey clay layer") are known to contain sand lenses, the average hydraulic properties of the underlying clayey materials are conservatively assumed to be between the properties of clay and sand. Furthermore, over the long term, it is conservatively assumed that the properties of the cutoff wall are the same as for the surrounding soils--i.e., that the cutoff wall offers no significant additional long-term barrier. Thus, the migration of contaminants may actually be slower than predicted in this analysis.

Groundwater is used very little in the NFSS area, and most of the groundwater that is used is obtained from a geologic formation located south of the Niagara Escarpment but not north of the escarpment at NFSS. However, individuals occasionally are able to find sand lenses in the near-surface unconsolidated glacial deposits (in the clayey soils) that yield enough water to supply the needs of about one family. Because sand lenses are known to occur in the NFSS containment area and because it cannot be ascertained whether or not there are large sand lenses next to the containment

*Radium-226 sorption tests have been performed on seven soil samples from NFSS (Kelmers and Seeley 1983). K_d values ranging from 1100 to 18,000 cm^3/g were reported. However, examination of the test results indicate that if initial concentrations in the groundwater are lower than the initial concentration of 100,000 pCi/mL used in the tests, then the K_d value could be significantly lower than the values reported. Because of this uncertainty, a conservatively low K_d value of $100 \text{ cm}^3/\text{g}$ was used for the soils at both NFSS and Oak Ridge. Thus, groundwater impacts are conservatively overestimated.

Table 4.41. Radium-226 in Groundwater at Various Locations
Downstream from the Waste/Residue Areas

Site	Distance From Site (m) ^{†1}	Clay Cover Thickness (m)	Maximum C/S Ratio ^{†2} (pCi/L)/(pCi/g)	Time to Reach Maximum Concentration ^{†3} (yr)
NFSS	4,000	0 and 1.5	- ^{†3}	>32,000 ^{†4}
	8,000 (at Lake Ontario)		- ^{†3}	>32,000 ^{†4}

Hanford	11,000	0	- ^{†3}	>32,000 ^{†4}
	22,000 (at Columbia River)		- ^{†3}	>32,000 ^{†4}

Oak Ridge	2,400	0	0.044	3,800
		1.5	0.016	8,400
	4,800 (at Clinch River)	0	0.017	4,800
		1.5	0.0047	10,000

^{†1} Contamination at 0 m (onsite well) is shown on Table 4.40.

^{†2} C is the concentration of radium-226 in the groundwater at the specified point, and S is the initial concentration of radium-226 in the contaminated materials.

^{†3} Includes the delay time for radium-226 to migrate from the bottom of the waste field to the water table (0 yr at NFSS; 35,000 yr at Hanford; and 230 yr [no clay] or 6,800 yr [1.5 m clay] at Oak Ridge).

^{†4} For NFSS and Hanford, there will be no contamination at the number of years indicated. The computer program was aborted when 32,000 years was reached and no contamination was yet indicated.

Table 4.42. Concentrations of Radium-226 in
Onsite Wells^{†1} at NFSS at Year 1000

Alternative	Initial Clay Cover Thickness ^{†2} (m)	Initial Waste/Residue Concentration (pCi/g)	Concentration in Onsite Well at Year 1000 ^{†2} (pCi/L)	Concentration in Site Boundary Well at Year 1000 (pCi/L)
1	0.9	3,800	1,100	0
2a	1.5	3,800	380	0
2b	1.5	420 ^{†3}	42	0
4a, 4c	1.5	36	3.6	0

^{†1} Well is assumed to be located next to the residue/waste containment area.

^{†2} See text for discussion of calculation and assumptions.

^{†3} For Alternative 2b, the effective concentration of the residues is decreased by a factor of 10 because they will be buried in a modified form (residue slag) that is less leachable.

area without digging up the entire site, it is assumed for analysis that there is a large sand lens immediately adjacent to the containment area and that leachate from the wastes and residues will migrate into such a sand lens. It is also assumed that a well is drilled into this lens, that the well has sufficient yield, and that groundwater from this well is used for drinking water. If the large sand lens does not exist, if no one accidentally locates a well and uses the water from such a lens, or if the perpetual controls that DOE intends to exert continue, then there will be no impact on humans through the drinking water pathway. If the average properties of the soils, wastes, residues, and cap over the containment area are better than those assumed in this analysis, then the migration of contaminants will be even slower.

Hanford. Despite the high permeability of the sandy soils at Hanford, there will be very slow migration of contaminants from the site because of the low annual precipitation. As a result of the slow migration of contaminants to the deep aquifers, contaminant concentrations in the groundwater will be very low. It is predicted that radium-226 will not even reach the water table until 35,000 years.

Although it is possible that eventually (hundreds of thousands of years) contaminated groundwater from the aquifer underlying the site could be tapped and used for irrigation and public or domestic water supplies, the slow migration of contaminants into this aquifer minimizes the potential concentration and consequent health risk associated with use of the slightly contaminated groundwater.

For Alternatives 4a and 4b in which only the residues will be buried at Hanford, the amounts of contaminants--and hence the calculated C/S ratios--will be about the same as for Alternative 3a in which both the wastes and residues are involved. This conclusion is based on the assumption that the residues will be buried in the same manner for all three Hanford alternatives.

Oak Ridge. The C/S ratios presented in Tables 4.40 and 4.41 are for Alternative 3b, in which all the NFSS residues and wastes will be buried at Oak Ridge. The maximum C/S ratios in the onsite well are smaller than the maximum C/S ratios at NFSS and Hanford because of the much larger groundwater flow, and consequent greater dilution, at Oak Ridge. Contaminants will also be transported downstream much faster at Oak Ridge. This reflects the effects of fractures and solution cavities at the Oak Ridge site. At year 1000, the 1.5 m of clay in the cover system will not yet be eroded (even under the most erosive land use, Section 4.2.1). With the clay cover intact, the radium-226 will not yet have reached the water table.

The C/S ratios for Alternatives 4c and 4d, in which only the NFSS residues will be buried at Oak Ridge, will be slightly lower. The smaller volume of the residues and greater average slope of the containment area (see Sections 2.8 and 4.2.1) will result in more surface runoff, less infiltration, and even lower concentrations of contaminants in the groundwater.

4.2.2.4 Estimates of Radium-226 in Surface Waters

Within 1000 years, if NFSS is used for agriculture, the cap will erode and the contaminated wastes will be exposed only under Alternative 1. In order to estimate potential radium-226 concentrations resulting from erosion and leaching of contaminated materials into surface waters, a scenario is evaluated wherein it is assumed that a farm pond is constructed immediately downstream of the waste-containment area, that the pile of contaminated materials is the entire watershed for the pond, that the cap has entirely eroded and the wastes are exposed but the deeply buried residues are not exposed, and that 100 mg/L of suspended solids in the pond originate from the contaminated waste materials. Because the average concentration of radium-226 in the wastes is 36 pCi/g, the concentration of suspended radium-226 in the farm pond will be 3.6 pCi/L. Using the natural analogue method of Gilbert et al. (1983), the concentration of dissolved radium-226 in the pond water is estimated to be 18 pCi/L. This is much less than the 1,100 pCi/L in the theoretical onsite well at the year 1000 (Section 4.2.2.3).

4.2.2.5 Nonradiological Elements in Groundwater

The general model and parameter values used for estimating the C/S ratios for nonradiological elements are similar to those used for calculating the radium-226 C/S ratios. However, the depletion constant (radioactive decay constant for radionuclides) is assumed to be zero. The predicted results are presented in Tables 4.43 through 4.46 for various clay cover conditions and for groundwater at different locations downgradient of the waste/residue areas. The concentrations for nonradiological elements are obtained for a representative range of K_d values, chosen by grouping all the K_d values for the nonradiological elements considered in this study (see Section 4.4 for detailed discussion of K_d values). For the sandy soil conditions at Hanford site, the K_d values are assumed to be 10 times lower than the K_d values selected for clayey subsoils at both NFSS and Oak Ridge (Nucl. Saf. Assoc. 1980).

Discussions of predicted concentrations of the various nonradiological elements in groundwater, and any resulting impacts, are presented in Section 4.4.

Table 4.43. Nonradiological Elements in Onsite Wellst¹ for Various Kd Values, Assuming No Clay Cover

Site	Distribution Coefficient, Kd (cm ³ /g)	Release Time† ² (yr)	C/S Ratio† ³ at Year 1000 (ppb)/(ppm)	Maximum C/S Ratio† ³ (ppb)/(ppm)	Time to Reach Maximum Concentration† ⁴ (yr)
NFSS	0	76	3.0	3.2	800
	3	230	0.9	1.0	1,000
	25	1,900	0.062	0.11	6,000
	50	3,800	0.022	0.05	6,400
	100	7,600	0.0075	0.025	9,500
	1,000	76,000	0.00020	0.0024	95,000
Hanford	0	13	0† ⁵	0.55	450
	0.3	53	0	0.018	1,500
	2.5	330	0	0.0025	9,200
	5	670	0	0.0011	12,000
	10	1,300	0	0.00068	36,000
	100	13,000	0	0.000067	350,000
Oak Ridge	0	15	0† ⁵	5.1	50
	3	45	0	0.20	110
	25	380	0	0.025	700
	50	750	0	0.013	1,300
	100	1,600	0	0.0072	2,600
	1,000	16,000	0	0.00071	26,000

NOTE: See Table 4.44 for footnotes.

Table 4.44. Nonradiological Elements in Onsite Wellst¹ for Various Kd Values, Assuming Clay Cover†⁶

Site	Distribution Coefficient, Kd (cm ³ /g)	Release Time† ² (yr)	C/S Ratio† ³ at Year 1000 (ppb)/(ppm)	Maximum C/S Ratio† ³ (ppb)/(ppm)	Time to Reach Maximum Concentration† ⁴ (yr)
NFSS	0	210	1.7	2.0	4,000
	3	630	0.50	0.69	6,000
	25	5,300	0.022	0.084	56,000
	50	10,500	0.0078	0.040	68,000
	100	20,900	0.0027	0.019	90,000
	1,000	209,000	0.000071	0.0019	900,000
Oak Ridge	0	45	0† ⁶	2.8	100
	3	130	0	0.067	280
	25	1,100	0	0.0085	2,300
	50	2,300	0	0.0044	4,100
	100	4,600	0	0.0025	8,000
	1,000	46,000	0	0.00025	80,000

†¹ Well is assumed to be located next to the residue/waste containment area.†² Release time is the time for all of the chemical with the specified Kd value to be released to the groundwater.†³ C is the concentration of the chemical in the well water, and S is the initial concentration of the chemical in the wastes and/or residues.†⁴ Includes the delay time for the chemical to migrate from the bottom of the waste field to the water table.†⁵ Zero means that the waste front has either passed or not yet reached the specified location at year 1000.†⁶ The clay covers are 1.5-m thick at NFSS and Oak Ridge. There will be no clay cover at Hanford.

Table 4.45. Nonradiological Elements in Groundwater at Various Locations Downstream from Waste/Residue Areas, Assuming No Clay Cover

Site	Distance from Site (m)	Distribution Coefficient, Kd (cm ³ /g)	Maximum C/S Ratio† ¹ (ppb)/(ppm)	Time to Reach Maximum Concentration (yr)
NFSS	4,000	0 - 1,000	-† ²	>32,000† ²
	8,000	0 - 1,000	-† ²	>32,000† ²
(at Lake Ontario)				
Hanford	11,000	0 - 100	-† ²	>32,000† ²
	22,000	0 - 100	-† ²	>32,000† ²
(at Columbia River)				
Oak Ridge	2,400	0	0.80	90
		3	0.12	160
		25	0.017	800
		50	0.0090	1,500
		100	0.0048	3,500
		1,000	0.00048	35,000
	4,800 (at Clinch River)	0	0.33	120
		3	0.091	250
		25	0.012	900
		50	0.0060	1,800
		100	0.0031	4,600
		1,000	0.00031	46,000

†¹ C is the concentration of the chemical in the groundwater and S is the initial concentration of the chemical in the wastes and/or residues.

†² For NFSS and Hanford, there will be no contamination for the number of years indicated.

Table 4.46. Nonradiological Elements in Groundwater at Various Locations Downstream from Waste/Residue Areas, Assuming Clay Cover†¹

Site	Distance from Site (m)	Distribution Coefficient, Kd (cm ³ /g)	Maximum C/S Ratio† ² (ppb)/(ppm)	Time to Reach Maximum Concentration (yr)
NFSS	4,000	0-1,000	-† ³	>32,000† ³
	8,000	0-1,000	-† ³	>32,000† ³
(at Lake Ontario)				
Oak Ridge	2,400	0	0.30	160
		3	0.052	350
		25	0.0041	2,500
		50	0.0032	4,400
		100	0.0014	9,200
		1,000	0.00014	92,000
	4,800 (at Clinch River)	0	0.089	200
		3	0.028	410
		25	0.0032	2,700
		50	0.0020	4,800
		100	0.00098	11,000
		1,000	0.000098	110,000

†¹ The clay covers are 1.5-m thick at NFSS and Oak Ridge. There will be no clay cover at Hanford.

†² C is the concentration of the chemical in the groundwater and S is the initial concentration of the chemical in the wastes and/or residues.

†³ For NFSS, there will be no contamination for the number of years indicated.

4.2.2.6 Mitigative Measures

In order to confirm the validity of the modeling results, continued site investigations of the chosen site will be necessary (including seasonal evaluation of groundwater characteristics, Kd determinations for the various soil units underlying the sites, field testing to determine the effects of secondary permeability features on infiltration rates, and hydraulic conductivity determinations). Direct monitoring of the chosen site may be useful in verifying model predictions. However, such monitoring is generally difficult to perform, especially in heterogeneous (NFSS) or fractured (Oak Ridge) conditions.

Measures to mitigate the migration of contaminants will be required only if contaminants are found to be migrating at an unacceptable rate and concentration from the site. Such mitigative measures may include reengineering/reconstruction of the waste-containment system. Monitoring will be continued through the 200-year maintenance and monitoring period. Any modifications specific to the chosen long-term alternative will be summarized in the DOE Record of Decision.

4.2.3 Impacts on Geologic and Hydrologic Resources

The quantities of gravel, sand, soil, and clay required for construction of cover systems for the various alternatives (see Appendix D, Table D.10) will generally be available locally at each site and will not strain the existing resource base. At Oak Ridge, however, limited supplies of sand and gravel may be available in Roane and Anderson counties (Swann et al. 1942; U.S. Dep. Agric. 1981). As such, sand and gravel requirements for the cover system at the Oak Ridge site may strain existing supplies or may compete with existing or future demands for these materials. Requirements for sand and gravel at Oak Ridge will be greatest under Alternative 3b.

No other known mineral or fuel resources will be impacted at any of the three sites.

Although local water supplies will be used during the construction operations to control fugitive emissions for vehicle decontamination and for sanitary purposes, the amounts to be used are small relative to the available resources and local demands at each site.

4.3 ECOLOGY

4.3.1 Impacts Associated with Development of Long-Term Waste-Management Site

Activities associated with the long-term management of wastes at NFSS are not expected to have adverse effects on the biota of the site. During the interim remedial actions (assumed to be completed as a baseline for analysis in this EIS), the plant and animal communities on the site will have been destroyed or extensively disturbed. Any further disturbance associated with long-term management activities will have no significant impact.

The development of long-term waste management sites at Hanford and Oak Ridge will result in the destruction of approximately 56 ha (140 acres) of Sagebrush community at the Hanford site under Alternative 3a, and approximately 24 ha (60 acres) of oak-hickory forest at the Oak Ridge site. However, large tracts of similar plant communities are located in the vicinity of both sites, and this loss is not considered significant. The destruction of the plant communities of these sites will also eliminate wildlife habitat. The clearing and development of these sites will destroy less mobile animals species; more mobile animal species will seek habitat in areas adjacent to the waste management site, but since these undisturbed areas are very likely at their carrying capacity, the total number of individuals of a given species will be reduced (Dvorak et al. 1978).

Before DOE would implement any of the Oak Ridge alternatives, surveys would be conducted to determine the presence or absence of threatened or endangered species possibly on the Pine Ridge Knolls site (Section 3.3.4). If present, DOE would take measures to avoid impacting those species. If, in cooperation with the U.S. Fish and Wildlife Service, it was determined that impacts to those species could not be mitigated or avoided, then DOE would not be able to implement any of the Oak Ridge alternatives. The possibility of endangered species being present on the Pine Ridge Knolls site is an uncertainty that will be considered in making a decision on the long-term management of the NFSS wastes and residues. No impacts to endangered or threatened species are expected to occur at the NFSS or Hanford site.

4.3.2 Biotic Effects on Long-Term Integrity of Containment Systems

Following is a discussion of the general effects of biota on the long-term integrity of containment systems. The various alternatives for management of the NFSS wastes and residues are then discussed and some mitigative measures are suggested.

4.3.2.1 General Effects

Biota can affect the long-term integrity of the proposed containment systems in a variety of ways that are both beneficial and adverse. Beneficial biotic effects on containment systems that have multilayered protective caps with vegetated soil as the outermost layer include: (1) soil stabilization and erosion control and (2) physical and chemical modification of cap soils to improve tilth and allow for potential productive land use of the cap surface. Adverse biotic effects include plant and animal intrusion into the stored wastes and residues followed by mobilization and dispersal of the contaminated materials via both physical and biological transport pathways.

Disturbance of the cap by burrowing animals, the creation of channels by plant roots, and the formation of soil aggregates by microorganisms all have the effect of decreasing soil bulk density and producing interconnected voids of various sizes. Such voids increase water infiltration and provide routes for radon to escape to the atmosphere before it can decay to solid decay products. Increased water infiltration into the cap can increase the likelihood of slippage or slumping of the cap materials, especially in the most steeply sloped (20%) perimeter areas.

Increased infiltration may also result in more water moving through the cap layers into the stored wastes where accelerated leaching and contamination of groundwater can occur (see Section 4.2.2). These effects can be balanced by the enhanced water storage capacity of soils modified by biological activity, as well as by the ability of vegetation to absorb and transpire large amounts of soil moisture back to the atmosphere. In the western United States, this can amount to nearly all of the annual precipitation (Hakonson et al. 1983).

Numerous examples of plant root intrusion into buried radioactive wastes have been reported (Cline and Uresk 1979; Fitzner et al. 1979; Breedlow et al. 1982; Yamamoto 1982). When the riprap and other layers of the containment caps over the NFSS waste and residues have been breached by deep-rooted plant species, the uptake of radioactive and other waste constituents may take place, with transport of some fraction of these constituents to above-ground or near-surface plant organs (Knight 1983b). Waste constituents can then be dispersed either directly to the atmosphere (as in the case of radon), to food webs via a variety of conventional herbivores (mammals, reptiles, insects, etc.), or via rather specialized pathways such as the soil water-plant nectar-honeybee-honey route (Hakonson et al. 1983). Physical dispersal of contaminated plant parts by wind and water can also occur.

Burrowing rodents, carnivores, ants, and termites have been reported as intruding into buried radioactive wastes (Fitzner et al. 1979). Tunneling activities of animals cause soil pulverization, transfer of materials between layers of the containment structure, and creation of voids as tunnels and nest chambers. Loose soil and/or waste materials brought to the surface by burrowing activity will be subject to accelerated erosion and dispersal in the environment. Contaminated animal biomass entering food webs is another route of waste constituent dissemination.

The NFSS containment alternatives and time periods are evaluated in terms of the biomodification and biointrusion considerations presented above. Because this is essentially an assessment of cap integrity under these biotic influences, it was possible to group the alternatives for assessment of ecological impacts--either because the differences between alternatives have no effect on the parameters being considered or because no meaningful differences could be ascertained between alternatives in light of the complex interactions characteristic of biological systems. There are three major groups of alternatives as follows:

Group 1--Alternative 1 at NFSS (1.5 m layered cap* consisting of 0.9 m clay, 0.15 m sand, and 0.45 m soil). This alternative is in a separate group because the cap design is distinctively different in that it lacks the layer of riprap and has less clay.

Group 2--Alternatives 2a, 2b, 4a, and 4c at NFSS and Alternatives 3b, 4c, and 4d at Oak Ridge (3.2 m layered cap* consisting of 1.5 m clay, 0.15 m sand, 0.9 m graded riprap, 0.15 m sand, and 0.45 m soil). These alternatives are grouped together because they have identical caps and are located at the two temperate, humid eastern sites of NFSS and Oak Ridge. The minor differences between the two humid sites do not permit meaningful distinctions in biotic effects.

Group 3--Alternatives 3a, 4a, and 4b at Hanford (3.0 m layered cap* consisting of 0.9 m or 2.5 m native soils, 0.9 m graded riprap, and 1.2 m soil). These alternatives are slight variations of the same trench cap design located at the arid western site.

4.3.2.2 Groups 1 and 2: Alternatives at NFSS and Oak Ridge

The Group 1 and 2 alternatives at the humid sites will have protective caps with an outermost soil layer 0.45 m thick underlain by 0.15 m of sand. In the Group 1 alternative, the sand will be

*Conceptual designs for the various alternatives are given in Section 2.

underlain by 0.9 m of clay and then the NFSS wastes (interim cap--Figure 2.1). In the Group 2 alternatives, the sand will be underlain by 0.9 m of graded riprap, another 0.15 m of sand, 1.5 m of clay, and then the wastes or residues (long-term caps--Figures 2.3, 2.8, 2.10, and 2.13).

Both the Group 1 and 2 caps will be invaded by plant roots and animals. Initially, the effective rooting zone will be only about 0.6 m (0.45 soil plus 0.15 m sand), which will preclude the development of most mature native trees (Spurr and Barnes 1973) and will be limiting to many other plants except grasses, forbs, and some shallow-rooted shrubs and small trees. Shrubs and trees will germinate and become established in this soil depth but their growth will slow when the roots encounter the clay or riprap interface. The local species that are adapted to heavy soils will continue to grow through the clay of the interim cap. Some woody species growing on the long-term cap (over riprap) may persist as stunted individuals and some may die.

Because the NFSS interim cap will contain no riprap layer, it will probably be breached first by plants whose roots are adapted to grow in heavy, clayey soils. As these initial intruding roots die and leave channels through the clay layer, other plant roots can follow. It is probable that this will occur early in the maintenance and monitoring period, perhaps even during the 10-year action period. Eventually, the long-term caps at NFSS and Oak Ridge will also be breached, probably during the maintenance and monitoring period, as soil settling and rock fragmentation fill the interstices between the riprap with particles and provide a soil pathway for plant roots (Hakonson et al. 1983).

The early cap communities will be slightly more susceptible to erosion and will have poorer wildlife habitat than the surrounding area. The initial plant community, and the later mature communities that develop on either type of cap, will be particularly susceptible to drought, during which many individual plants may die. Following severe drought, likely to occur several times during the maintenance and monitoring period and numerous times during the long-term period, large areas of bare ground may be produced that will be subject to accelerated erosion. The stressed plant communities on the caps will also be more susceptible to the adverse effects of herbivores (grazing animals and insects), disease, and fire than the surrounding plant communities growing on normal soils of the area.

The plant communities on the caps will undergo plant succession. However, the successional patterns are likely to be different than those in the surrounding plant communities on normal soils. During the first 200 years of maintenance, this succession will be regularly interrupted by maintenance activities aimed at precluding or destroying large, deep-rooted plants. During the long-term period, after maintenance ceases, cap communities may initially "stagnate" in a grass/forb/small shrub/small tree stage, with a few individuals of larger tree species usually present. These young trees will not reach maturity because they (and some of the other plants) will die out during periods of drought. When adequate moisture is restored, the cycle will begin again with new seedlings replacing the plants that have died. During the first 300 years of the long-term period, biological modification of the cap layers will continue and adapted plant species will colonize the cap. Eventually, deep-rooted mature trees will develop on all of the NFSS and Oak Ridge caps. Continued soil modification, development, and settling combined with vegetation succession may result in the establishment of a climax forest typical of each area. However, this community will continue to be more susceptible to drought than a similar one on normal soils of the area.

The clay liner of the NFSS interim cap and the additional barrier provided by the riprap layer in the long-term caps at NFSS and Oak Ridge will initially deter burrowing animals from intruding into the wastes and residues. However, as root growth modifies and disrupts these layers, mammals, ants, and other insects will intrude into the contaminated materials because the materials will be within the known tunneling depths of these organisms (Cline et al. 1982). As the thicknesses of the caps are reduced appreciably by erosion, the likelihood of animal intrusion will increase.

Potential agricultural use of the cap surfaces for pasture, grain, or row crops will be initially limited by the 0.45 m soil thickness because many crop plants such as corn, soybeans, alfalfa, and other legumes require considerably deeper rooting depths for optimal growth (Mitchell 1975). However, agricultural activities will not be allowed for 200 years, by which time the soil formation processes discussed previously may lead to a deeper rooting layer. During the long-term period, agricultural success will depend both on the depth of the rooting layer at the time agriculture begins and on the rate of soil erosion losses.

4.3.2.3 Group 3: Alternatives at Hanford

All of the Hanford alternatives will have protective caps with an outermost native soil layer 1.2-m thick, underlain by a graded riprap layer 0.9-m thick over 0.9 or 2.5 m of native soil. No clay layer is included in these caps (Figures 2.5 and 2.9). Native shrub-steppe grassland--consisting of grasses, forbs, and shrubs adapted to arid conditions--will be allowed to develop on the caps. These plants are mostly deep-rooted, with high levels of root growth activity when soil moisture is available (Fitzner et al. 1979). Most of the plant biomass in these species occurs underground. Typical root to shoot biomass ratios are 9:1 (Caldwell and Fernandez 1975).

The disturbed soil cover of the completed cap will probably be initially colonized by weedy annual plants such as Russian thistle, Kochia, and cheatgrass. The upper 1.2 m of soil will be adequate to support a nearly normal native plant community that will become reestablished early in the 190-year maintenance and monitoring period. Because the riprap layer will initially be a barrier to most root penetrations, the deep-rooted shrubs and forbs could experience moisture stress during periods of drought early in their development (Rickard 1983--personal communication). Soil settling, rock fragmentation, and the soil-pulverizing activities of burrowing animals and ants will eventually fill some of the interstices between the rocks of the riprap with soil particles and provide a pathway for root extension through the layer.

Once through the riprap layer, the plant roots will penetrate quickly through the 0.9 m or 2.5 m of native soil underlying the riprap and will intrude into the buried wastes and residues. Continued penetration of the riprap layer by new roots and the death of old roots will permit small rodents (mice and pocket gophers), ants, and other insects to gain access to the wastes via root channels because the deepest wastes are well within known tunneling depths of these organisms in the loose sandy soils at Hanford (Cline et al. 1982). These events are likely to occur early in the maintenance and monitoring period.

Periodically, the vegetation on the caps will be destroyed by wildfire. Wildfire is a fairly common and often natural (lightning-initiated) occurrence in the shrub-steppe communities of the Hanford site. Although fire helps to maintain the overall vigor of the ecosystem, burned areas are subject to increased wind erosion for at least one growing season following a fire (Hinds and Thorp 1970). If the fire is extensive, seed sources within effective dispersal distances are reduced and the erosion-prone period is increased.

Biointrusion and radionuclide dispersal (as described earlier) will gradually increase, with continued biomodification of the cap layers until a relative steady-state is reached that will be related to the biological carrying capacity of the cap ecosystem. Because of the sandy soils and the greater below-ground activity of both plant roots and burrowing animals at Hanford, biointrusion into the buried wastes and residues will probably occur sooner than at the two humid sites under the Group 2 alternatives. However, the presence of the riprap layer at Hanford will probably delay biointrusion longer than in the Group 1 alternative at NFSS (which has no riprap layer).

4.3.2.4 Mitigative Measures

Measures to mitigate biointrusion into the NFSS wastes and residues can be of two types: (1) correcting biointrusion after it occurs, and (2) delaying biointrusion.

Corrective Measures. During the maintenance and monitoring period, measures will be taken to restore cap integrity if radionuclide dispersal due to the activity of plants and animals reaches a level of concern. Such measures could include removal of large, deep-rooted plants, herbicide application to eliminate and prevent regrowth of such plants, trapping and/or poisoning of burrowing animals, insecticide application to control ants and other insects, and additions to and recompaction of the soil layer.

Delaying Measures. All the alternative caps will be affected by biomodification of the cap layers and biointrusion into the wastes and residues followed by dispersal of radionuclides to the environment. Although these events cannot be prevented, the cap designs could be modified to further delay biomodification and biointrusion. In particular, the outer soil layer could be eliminated, leaving only rock on the outer cap surface, or a chemical "biobarrier" could be built into the cap.

Rock Cover. At NFSS and Oak Ridge, the outer 0.6 m of soil and sand could be eliminated, leaving the 0.9 m of riprap outermost. At Hanford, the trenches could be backfilled almost entirely with soil and the 0.9 m of riprap could be placed on top. Furthermore, instead of having the riprap layer graded from small pea gravel to large cobbles and back to pea gravel, large cobbles could be placed outermost. Such rock armoring of the cap surface would provide adequate protection against water and wind erosion (Breedlow et al. 1982) and would greatly delay biointrusion. Within the 1000-year period, sediments may fill the riprap interstices and provide sites for some vegetation establishment. However, the resulting sparse community would have a much lower biomodification and biointrusion potential than the soil-covered cap. A rock-covered cap would also eliminate the increased soil erosion that will otherwise occur when vegetation on a soil-covered cap is reduced because of drought, disease, fire, herbivory, or agricultural use.

A rock-covered cap is feasible at all three alternative sites, but careful consideration would have to be given to several aspects of water management in such a modified cap. Such a modification would also eliminate the water storage capability of the soil cover and the transpiration potential of the vegetation. Both of these processes can prevent a large portion of infiltrated precipitation from being available for downward movement through the cap and into the wastes where leaching and ground-water contamination could occur (Hakanson 1983--personal communication). The vegetation transpiration consideration is especially important at the arid Hanford site. At the humid NFSS and Oak Ridge sites, water transport through the clay layer will be very slow, and most precipitation entering the cap will probably flow along the clay/sand interface and out of the cap at the periphery. For this

reason, a modified cap would have to be carefully constructed so that the clay, sand, and riprap layers toe out at ground level, and provision should be made for erosion control in these cap perimeter areas.

Chemical Biobarriers. Chemical biobarriers have been developed to prevent root intrusion through soil-covered, vegetated caps (Cline et al. 1982). The most effective barrier consists of polymer pellets impregnated with a herbicide that is released slowly into the soil. The pellets would be placed in a layer during cap construction (probably at the sand/clay interface in the NFSS and Oak Ridge caps or the upper soil/riprap interface in the Hanford cap) to kill plant roots (but not the entire plant) that penetrate to that depth. The estimated effective lifetime of the chemical bio-barrier is 100 years, which would help reduce maintenance costs during the maintenance and monitoring period but would not reduce biointrusion and biomodification impacts in the long-term period.

4.4 CHEMICAL

In addition to radionuclides, there are other chemical elements and compounds in the NFSS residues and wastes that could potentially contaminate the environment. Most of the elements occur naturally in soils and water but are in above-normal concentrations in the NFSS materials, especially the residues. Some elements are in concentrations sufficiently high to warrant further consideration regarding extraction and sale of some of these elements (Alternative 2b). The chemical nature of the NFSS wastes and residues is detailed in Section 3.1.8. Following are the results of analysis of potential chemical impacts associated with each alternative involving land disposal; chemical impacts associated with ocean disposal are discussed in Section 4.5. Because the potential impacts are closely linked to the various time periods and associated assumptions regarding control measures, the following discussion is divided into the three time periods (action period, maintenance and monitoring period, and long-term period). Other than the potential for elevated concentrations of a few elements, no significant chemical impacts to either surface waters or groundwaters are expected at NFSS, Oak Ridge, or Hanford.

4.4.1 Action Period (0 to 10 years)

4.4.1.1 NFSS

Under Alternative 1 (no action), there will be no disturbance of the contaminated materials at NFSS. Because the cover will be actively maintained, no erosion of the contaminated materials into the surface water will occur. A small amount of water may infiltrate through the cover and percolate through the residues into the groundwater. However, because the groundwater moves so slowly (Section 4.2.2), the leachate is not expected to move outside the diked area within the action period.

The contaminated materials may be exposed during the action period under all alternatives except Alternative 1. Under Alternatives 3a, 3b, 4a, 4b, 4c, and 4d, the residues--and in some cases the wastes as well--will be disturbed in order to transport them to other sites. Under Alternatives 2a and 2b, partial removal of the interim cover and construction of the long-term cover over the diked area may also result in inadvertent temporary exposure of some of the wastes; while the residues and wastes are exposed, they will be subject to water and wind erosion. As a result, there may be slight increases in sediment loading in the ditches and increased deposition of windborne material on nearby areas. However, as was the case for the interim actions at NFSS, it is assumed that control measures will be employed--such as limiting the amount of exposed wastes or residues, control and treatment of all water, and periodic watering to minimize dust. Impacts resulting from such dispersions are therefore expected to be negligible.

Under Alternative 2b, there is additional potential for release of chemical contaminants to surface waters. The residues will be slurried from the buildings in the diked containment area and processed to recover valuable elements. All aqueous and gaseous wastes generated by the recovery process will be treated to remove contaminants before release, and all solid wastes will be returned to the diked area for burial. Any wastewater produced must satisfy the New York State Pollution Discharge Elimination System (SPDES) requirements before being discharged.

4.4.1.2 Hanford and Oak Ridge

Under Alternatives 3a, 3b, 4a, 4b, 4c, and 4d, burial of the packaged residues at Hanford or Oak Ridge will result in negligible dispersion of chemically contaminated residues. Under Alternatives 3a and 3b, atmospheric dispersion and surface water runoff from the wastes will occur during unloading and burial operations. The concentrations of the majority of nonradioactive contaminants in these wastes will be similar to those of most natural soils with the exception of cobalt, nickel, copper, lead, and uranium for which the upper limits of concentrations found in NFSS waste materials exceed the upper limits in natural soils (Section 3.1.8). The geometrically averaged concentrations of these elements, however, do not greatly exceed the natural concentrations of these elements in natural soils. As a result, surface runoff will not carry suspended or dissolved elements of concern in concentrations greatly in excess of upper limits found in naturally occurring soils. At all sites, measures will be taken to minimize and control runoff from temporarily exposed waste surfaces.

Because of the arid climate and depth to groundwater at Hanford, no leachate from the wastes and/or residues is expected to reach the groundwater during the action period. At Oak Ridge, the rate of migration for any leachate that may be generated is too slow to reach the groundwater during this period.

4.4.2 Maintenance and Monitoring Period (10 to 200 years)

4.4.2.1 NFSS

For all alternatives at NFSS (1, 2a, 2b, 4a, and 4c), there will be no chemical impact on the surrounding areas. The residues and wastes will continue to lie under the maintained cover and thus will not be exposed to wind or water erosion. According to hydrologic modeling results, there will be no appreciable migration of chemical contaminants beyond the site boundary in 200 years (see Section 4.2.2).

4.4.2.2 Hanford and Oak Ridge

As at NFSS, maintenance and monitoring of the caps at Hanford and Oak Ridge will prevent dispersion of contaminated material. During this period there will continue to be no chemical contamination of groundwater at either Hanford or Oak Ridge (Section 4.2.2).

4.4.3 Long-Term Period (200 to 1000 years)

For all alternatives at all sites, there will be no chemical impacts in Case A (wherein maintenance and monitoring cease but land-use controls remain effective). Under these conditions, there will be no intensive use of the waste-management areas; thus, the caps will not erode very fast and the wastes and residues will not be exposed to wind and water erosion (Section 4.2.1). Water infiltration through the caps will increase only slightly and there will be no significant chemical contamination of groundwater (see Section 4.2.2).

However, in Case B, there may be some chemical impacts for some alternatives. The loss of all controls could lead to intensive use of the waste-management areas, which in turn will lead to accelerated erosion of the caps, accelerated infiltration of water into the caps, and leaching to groundwater. In addition, wells could be drilled into contaminated groundwater next to the waste areas. The geological and hydrological aspects are discussed in detail in Section 4.2. Following are discussions of potential chemical impacts for the various alternatives at each site.

4.4.3.1 NFSS

Surface Waters. Within 1000 years, if NFSS is used for agriculture, the cap will erode and the contaminated materials will be exposed only under Alternative 1. In order to estimate chemical impacts resulting from erosion and leaching of contaminated materials to surface waters, it is assumed that a farm pond is constructed immediately downstream of the waste-containment area. It is also assumed that the pile of contaminated materials is the entire watershed for the pond, that the cap has been entirely lost, and that 100 mg/L of suspended solids in the pond originate from the contaminated materials. At year 1000, only the NFSS wastes will be exposed (the residues are buried much deeper and will not be exposed until much later [Section 4.2]). Therefore, estimates of concentrations of various elements in the farm pond at year 1000 are based on the assumption that erosion and leaching from the wastes contribute to the concentrations in the pond. Eventually, however, the residues will be exposed. Therefore, concentrations in the pond are also estimated for the time at which both wastes and residues will be exposed.

Dissolved and suspended solids concentrations for various elements are given in Table 4.47. The concentration of total suspended solids is assumed to be 100 mg/L; the suspended solids concentration of each element is assumed to be proportional to its concentration in the wastes. The dissolved concentrations are based on the natural analogue method of Gilbert et al. (1983). This method uses ratios of natural concentrations in soils to concentrations in water to determine concentrations in water if the "soils" are the NFSS wastes or the residues plus wastes (see Section 3.1.8 for description of NFSS residues and wastes). The dissolved concentrations include contributions from both surface runoff and groundwater seepage into the pond.

For most, but not all of the elements, the main contribution to the total concentration is made by the suspended solids. Exceptions include fluorine, mercury, selenium, silver, strontium, and uranium. Also, even when the residues are exposed, the total concentration of most elements is below 0.1 ppm (100 ppb), which is at or below regulatory limits. Exceptions include lead, iron, manganese, and nickel. However, various sedimentation and precipitation effects may act to reduce these values.

The values predicted by the farm pond model could be larger or smaller by a factor of 10, and estimates are therefore given to only one significant figure. The current state of New York SPDES permit concentrations are given for comparative purposes (Table 4.47). It should be noted that farm pond waters are generally not used for drinking water and are usually subject to less stringent regulations or none at all. Also, farm ponds and other surface waters would generally have watersheds

Table 4.47. Concentrations of Elements of Concern in a Farm Pond

Element	Concentration (ppb)† ¹						Regulatory Limit† ² (ppb)
	At Year 1000			At Time Both Residues and Wastes are Exposed			
	Suspended	Dissolved	Total	Suspended	Dissolved	Total	
Arsenic	0.1	0.1	0.2	0.5	0.4	0.9	330
Barium	30	6	40	200	40	200	420
Cadmium	0.03	0.07	0.1	0.05	0.1	0.2	-
Cerium	0.6	0.02	0.6	20	0.6	20	100
Chromium	3	0.4	3	5	0.7	6	150
Cobalt	8	2	10	70	20	90	100
Copper	10	10	20	30	30	60	100
Fluorine	5	24	30	1.7	8	10	4,200
Iron	2,000	240	2,000	2,000	200	2,000	100
Lanthanum	1	0.03	1	20	0.4	20	100
Lead	4	4	8	300	300	600	100
Lithium	20	10	30	20	10	30	420
Manganese	40	4	40	400	30	400	100
Mercury	0.03	0.5	0.5	0.03	0.5	0.5	-
Nickel	20	2	20	200	20	200	100
Selenium	0.07	0.3	0.4	0.8	4	5	-
Silver	0.02	1	1	0.4	2	2	-
Strontium	10	30	40	10	40	50	420
Uranium	1	3	4	50	100	200	600† ³
Vanadium	10	0.5	10	40	2	40	400
Zinc	0.2	0.3	0.5	2	3	5	100
Zirconium	6	0.1	6	8	0.2	8	300

^{†1} Values given in parts per billion to one significant figure only. Estimates of dissolved elements are based on natural analogue method (Gilbert et al. 1983).

^{†2} New York SPDES permit concentrations; maximum allowed in receiving waters.

^{†3} The DOE regulatory concentration of 600 pCi/g for soluble natural uranium in uncontrolled areas (DOE Order 5480.1) would be the applicable regulatory limit.

that encompass much larger areas than just the NFSS waste/residue pile, thus affording dilution of runoff and leachate from the NFSS wastes and residues. The concentrations based on the farm pond model should be interpreted as a conservative upper limit of potential concentrations in surface waters.

Because of the small amounts of organic chemicals in the NFSS wastes (see Table 3.9), concentrations in the pond will be extremely low. If the wastes contribute 100 mg/L to the suspended sediments in the pond, organic suspended solids concentrations will be 0.01% of the average concentrations in the NFSS wastes. These are very low values. If the dissolved components are present at the same concentrations or less, the total concentrations will be low. For example, PCBs will be at concentrations less than 0.003 ppb, which is much lower than the regulatory limit of 0.1 ppb (see Table 4.53).

Groundwater. Leachate from the NFSS wastes and residues will eventually contaminate the groundwater. This contamination will occur sooner and reach higher levels if the caps are not maintained and infiltration of water through the cap and into the wastes and residues increases (Section 4.2). The concentrations of chemical contaminants in water from a well drilled next to the diked area at NFSS will be the sum of the natural background concentrations (from natural leaching of the chemicals from the ground) plus the contribution from leachate from the NFSS residues and wastes.

The contributions from NFSS wastes and residues are estimated using the source/water concentration ratios estimated in Section 4.2.2 (Groundwater Impacts). For Alternatives 1, 2a, 4a, and 4c, the source concentrations of each contaminant are given in Section 3.1.8. Under Alternative 2b, the residues will be processed to remove some valuable elements, and the resulting slag will be solidified and reburied in the diked area. To obtain the effective source concentrations for the various elements in this slag, the original concentrations in the residues (Section 3.1.8) are multiplied by a factor of 0.1 or 0.01. The factor 0.1 is used if the element of concern is not separated out by the resource recovery process. This accounts for the assumed 10-fold reduction in the leachability of the element from the residue slag relative to untreated residue.* The factor of 0.01 is used if the element of concern is separated out by the recovery process (assuming a 90% efficient process; the remaining 10% is contained in the slag wastes).

As discussed in Section 4.2.2, the concentrations in well water will also depend on the distribution coefficients (K_d) for each chemical. Literature values of the distribution coefficients are given in Table 4.48 for soils and clays and for sand. Geometric standard deviations, σ_g , are calculated for the K_d values in the table by use of literature data (Baes and Sharp 1983). The K_d values are uncertain by factors ranging from 1.8 for arsenic to 15 for manganese. Because there are many elements of concern and the K_d values have appreciable uncertainties, each element is assigned a representative K_d value and the hydrologic calculations are made for these representative values. This simplification is supported by the fact that for all the elements, the mean K_d values are within one geometric standard deviation of the assigned values.

The concentrations of various elements in water from a well adjacent to the diked area for Alternatives 1, 2a, and 2b are presented in Tables 4.49, 4.50, and 4.51. Estimates of contaminant concentrations in the well water are given for two times: (1) at year 1000 and (2) at the time at which leachate contributions to groundwater will reach a maximum. The elements of concern are taken here to be the trace elements listed either in the New York State Regulations regarding discharge to groundwater (N.Y. Department of Environmental Conservation, Title 6, Part 703, 1978) or in the SPDES discharge permit for the NFSS interim remedial actions (Eisman 1983a, 1983b). The elements of concern and the corresponding maximum allowable concentrations are given in Table 4.52. Uranium is also included because of concern expressed by Environment Canada regarding uranium chemical toxicity (Alexander 1983). The lowest regulatory values are reported for comparative purposes in Table 4.49.

For most elements of concern, the background well-water concentrations are larger than those contributed by leachate from NFSS contaminated materials under Alternatives 1, 2a, and 2b. Only in the case of lead in Alternatives 1 and 2a do the leachate concentrations make significant contributions to the total well-water concentrations. For Alternative 2b, the concentration contributions from the leachate are much less than the background concentrations for all elements of concern at both 1000 years and at the time of maximum concentration (Table 4.51). The total well-water concentrations are slightly smaller for Alternative 2a than for Alternative 1. These differences are due to the additional clay in the cap under Alternative 2a, which reduces the infiltration rate into and the leach rate out of the diked materials.

In Alternative 1, the total well-water concentrations of cadmium, manganese, mercury, strontium, and zinc are higher than the regulatory limits. The high values of cadmium and mercury may be due to the relative insensitivity of the background analyses; the real values are probably much lower than the upper limits given. The background concentrations for strontium, manganese, and zinc, which are real values and not upper limits, are much larger than the concentrations allowed in the receiving waters by the SPDES Discharge Permit (Table 4.52). The values for manganese and strontium are also larger than the maximum allowed in groundwater.

In general, for Alternatives 1, 2a, and 2b, the estimated impact of the diked materials at NFSS on concentrations of the various inorganic elements of concern in the well water is small. Because even these small impacts are primarily associated with the presence of the NFSS residues, the impacts associated with the NFSS wastes only (Alternatives 4a and 4c) will be even less and are therefore not specifically calculated. Furthermore, the contributions from the leachate are calculated using a simple ion-exchange model (Gilbert et al. 1983) that overestimates the concentrations in the well water. However, because the concentrations are already small, especially for the 1000-year period of concern, use of a more complex model (Gilbert et al. 1983) is not warranted.

In addition to the inorganic elements, contamination of the well water by organic chemicals (e.g., pesticides) leaching from the contaminated diked materials may also occur. The estimated concentrations of organic chemicals in the wastes are given in Section 3.1.8. The potential concentrations of these organics in the well water under Alternative 1 are given in Table 4.53. The values

*The hydrologic model used gives ratios of concentrations in the well water to those in the diked materials. These are multiplied by the average concentrations in the diked materials to obtain well-water concentrations. Reducing the ratio by a factor of 10 is equivalent to use of the original ratio and reducing the concentration by a factor of 10.

Table 4.48. Distribution Coefficients for the Elements of Concern

Element	Average Distribution Coefficient,† ¹ Kd (cm ³ /g)		Geometric Standard Deviation	Assigned Representative Distribution Coefficient, Kd (cm ³ /g)	
	Soils and Clays† ²	Sand† ^{2,†3}		Soils and Clays† ²	Sand† ^{2,†3}
Arsenic	3.3	0.33	1.8	3	0.3
Barium	50	5	--	50	5.0
Cadmium	6.7	0.67	2.4	3	0.3
Cerium	1,100	110	3.7	1,000	100
Chromium (+6)	3.7	3.7	9.0	25	2.5
Cobalt	1,000	100	--	1,000	100
Copper	22	2.2	3.0	25	2.5
Fluorine	0	0	--	0	0
Iron	1,000	100	--	1,000	100
Lanthanum	1,000	100	--	1,000	100
Lead	99	9.9	5.5	100	10
Lithium	500	50	--	1,000	100
Manganese	150	15	15	100	10
Mercury	100	10	--	100	10
Nickel	1,000	100	--	1,000	100
Selenium	2.7	0.27	1.9	3	0.3
Silver	110	11	3.7	100	10
Strontium	27	2.7	7.4	25	2.5
Uranium	45	4.5	3.6	50	5.0
Vanadium	1,000	100	--	1,000	100
Zinc	16	1.6	6.7	25	2.5
Zirconium	1,000	100	--	1,000	100

†¹ Data for arsenic, cadmium, cerium, chromium, cobalt, copper, lead, manganese, selenium, silver, strontium, uranium, and zinc from Baes and Sharp (1983); the values of Kd are the geometric means of the literature data (see also Gilbert et al. [1983--pp. 3-57 to 3-60]). Data for other elements from Nuclear Safety Associates (1980).

†² The values for soils and clays are used for assessment of impacts at NFSS and Oak Ridge, whereas the values for sand are used for Hanford.

†³ The values are taken to be 10% of the values of soils and clays (Nucl. Saf. Assoc. 1980).

Table 4.49. Concentrations of Various Inorganic Elements in a Well Adjacent to the Diked Materials, Alternative 1

Element	Average Concentration, Diked Material (ppm)	Contribution from Diked Material Leachate ^{†1}		Time to Reach Maximum Concentration (yr)	Background Concentration ^{†3} (ppb)	Total Concentration, Well Water		Lowest Regulatory Limit Concentration (ppb) ^{†4}
		Yr 1000 ^{†2} (ppb)	Maximum ^{†2} (ppb)			Yr 1000 ^{†2} (ppb)	Maximum ^{†2} (ppb)	
Arsenic	4.5	0.34	0.38	1,000	<6.7	<7	<7	25
Barium	2,200	3.4	9.9	6,400	220	220	230	420
Cadmium	0.5	0.035	0.042	1,000	<53	<53	<54	10
Cerium	160	0.0021	0.035	95,000	2.0	2.0	2.0	100
Chromium	48	0.20	0.45	6,000	28	28	28	50
Cobalt	670	0.0076	0.15	95,000	3.7	3.7	3.7	100
Copper	320	1.3	3.0	6,000	81	82	84	100
Fluorine	17	3.7	4.5	800	180	180	180	1,500
Iron	18,500	0.24	4.0	95,000	200	200	200	300
Lanthanum	150	0.0020	0.033	95,000	<4	<4	<4	100
Lead	2,900	1.5	6.4	9,500	13	15	19	25
Lithium	180	0.023	0.040	95,000	250	250	250	420
Manganese	4,200	2.1	9.2	9,500	1,200	1,200	1,200	100
Mercury	0.32	0.0002	0.0007	9,500	<270	<270	<270	2
Nickel	2,000	0.026	0.44	95,000	21	21	21	100
Selenium	8.5	0.60	0.72	1,000	<16	<17	<17	20
Silver	0.35	0.0002	0.0008	9,500	<3.3	<3.3	<3.3	50
Strontium	130	0.54	1.2	6,000	4,000	4,000	4,000	420
Uranium	510	0.76	1.1	6,400	8.7	9.4	9.8	600
Vanadium	380	0.049	0.083	95,000	<2.4	<2.4	<2.5	400
Zinc	18	0.076	0.17	6,000	2,600	2,600	2,600	100
Zirconium	76	0.0010	0.017	95,000	<6.6	<6.6	<6.6	300

^{†1} Concentration contributions were calculated by multiplying the average diked material concentrations by the average of the ratios of well-water concentration/source concentration given in Table 4.43 (without cover) and Table 4.44 (with cover) for each Kd value. This assumes that the average cover is equivalent to a complete cover for one-half the period and no cover for the remainder. The resulting concentrations are then multiplied by a factor of 0.1. This factor accounts for the fact that a well drilled into a sand lens at the edge of the diked area will draw most water (assumed to be 90% of the total) from surrounding uncontaminated areas (see Section 4.2.2).

^{†2} Yr 1000 = concentration at year 1000. Maximum = maximum concentration reached at the times noted.

^{†3} Values are averages of values given in Anderson et al. (1981--Table I-22, Appendix I) for wells N4W29, N10W17, and N10E10. These wells on the periphery of the site are chosen to be representative of background concentrations because the radium-226 concentration in these wells was low, ≤ 0.1 pCi/L, for all samples drawn from the wells. The symbol < denotes that values for all three wells are upper limits.

^{†4} See Table 4.52 for details on regulatory limits.

Table 4.50. Concentrations of Various Inorganic Elements in Water from a Well Adjacent to the Diked Materials, Alternative 2a

Element	Contribution from Diked Material Leachate† ¹		Time to Reach Maximum Concentration (yr)	Background Concentration† ³ (ppb)	Total Concentration, Well Water	
	Yr 1000† ² (ppb)	Maximum† ² (ppb)			Yr 1000† ² (ppb)	Maximum† ² (ppb)
Arsenic	0.23	0.31	6,000	<6.7	<6.7	<6.7
Barium	1.7	8.8	68,000	220	220	230
Cadmium	0.025	0.035	6,000	<53	<53	<53
Cerium	0.001	0.03	900,000	2.0	2.0	2.0
Chromium	0.11	0.4	56,000	28	28	28
Cobalt	0.005	0.13	900,000	3.7	3.7	3.7
Copper	0.7	2.7	56,000	81	82	84
Fluorine	2.9	3.4	4,000	180	180	180
Iron	0.13	3.5	900,000	200	200	200
Lanthanum	0.0011	0.03	900,000	<4	<4	<4
Lead	0.78	5.5	90,000	13	14	19
Lithium	0.001	0.034	900,000	250	250	250
Manganese	1.1	8.0	90,000	1,200	1,200	1,200
Mercury	0.00009	0.0006	90,000	<270	<270	<270
Nickel	0.014	0.38	900,000	21	21	21
Selenium	0.43	0.59	6,000	<16	<16	<17
Silver	0.00009	0.0007	90,000	<3.3	<3.3	<3.3
Strontium	0.28	1.1	56,000	4,000	4,000	4,000
Uranium	0.4	2.0	68,000	8.7	9.1	11
Vanadium	0.003	0.072	900,000	<2.4	<2.4	<2.5
Zinc	0.04	0.15	56,000	2,600	2,600	2,600
Zirconium	0.0005	0.014	900,000	<6.6	<6.6	<6.6

†¹ Calculated for a constant cap thickness of 1.9 m (1.5 m clay + 0.2 m sand + 0.2 m riprap). The concentration values have been multiplied by a factor of 0.1. This accounts for the fact that a well drilled into a sand lens at the edge of the diked area would draw most water (assumed to be 90% of the total) from surrounding uncontaminated areas.

†² Yr 1000 = concentration at year 1000. Maximum = maximum concentration reached at the times noted.

†³ See Table 4.49.

Table 4.51. Concentrations of Various Inorganic Elements in Water from a Well Adjacent to the Diked Materials, Alternative 2b

Element	Effective Average Concentration, Diked Materials (ppm)	Contribution from Well-Water Leachate† ¹		Time to Reach Maximum Concentration (yr)	Background Concentration† ³ (ppb)
		Yr 1000† ² (ppb)	Maximum† ² (ppb)		
Arsenic	2.0	0.1	0.14	6,000	<6.7
Barium	440	0.34	1.8	68,000	220
Cadmium	0.24	0.012	0.017	6,000	<53
Cerium	21	0.00015	0.0040	900,000	2.0
Chromium	26	0.057	0.22	56,000	28
Cobalt	71	0.00050	0.013	900,000	3.7
Copper	89	0.19	0.75	56,000	81
Fluorine	43	7.3	8.6	4,000	180
Iron	16,000	0.11	3.0	900,000	200
Lanthanum	24	0.0002	0.0045	900,000	<4
Lead	59	0.016	0.11	90,000	13
Lithium	160	0.0011	0.030	900,000	250
Manganese	780	0.21	1.48	90,000	1,200
Mercury	0.26	0.00007	0.0005	90,000	<270
Nickel	170	0.0012	0.032	900,000	21
Selenium	1.4	0.07	0.097	6,000	<16
Silver	0.17	0.00004	0.0003	90,000	<3.3
Strontium	92	0.2	0.77	56,000	4,000
Uranium	16	0.012	0.064	68,000	8.7
Vanadium	110	0.00078	0.020	900,000	<2.4
Zinc	5.9	0.013	0.050	56,000	2,600
Zirconium	59	0.00042	0.011	900,000	<6.6

†¹ Calculated for a constant cap thickness of 1.9 m (1.5 m clay + 0.2 m sand + 0.2 m riprap). The concentration values are multiplied by a factor of 0.1. This accounts for the fact that a well drilled into a sand lens at the edge of the diked area would draw most water (assumed to be 90% of the total) from surrounding uncontaminated areas (see Section 4.2.2).

†² Yr 1000 = concentration at year 1000. Maximum = maximum concentration reached at the times noted.

†³ See Table 4.49.

Table 4.52. Maximum Allowed Concentrations of Various Inorganic Elements†¹

Element	Maximum Allowed Concentrations (mg/L)		
	Groundwater		SPDES Discharge Permit† ³
	Discharge	Receiving Water† ²	
Arsenic	0.05	0.025	0.33
Barium	2.0	1.0	0.42
Cadmium	0.02	0.01	--
Cerium	--	--	0.10
Chromium	0.10† ⁴	0.05† ⁴	0.15
Cobalt	--	--	0.10
Copper	1.0	1.0	0.10
Fluorine	3.0	1.5	4.2
Iron	0.6† ⁵	0.3† ⁶	0.42† ⁷
Lanthanum	--	--	0.10
Lead	0.05	0.025	0.10
Lithium	--	--	0.42
Manganese	0.6† ⁵	0.3† ⁶	0.10
Mercury	0.004	0.002	--
Nickel	2.0	--	0.10
Selenium	0.04	0.02	--
Silver	0.1	0.05	--
Strontium	--	--	0.42† ⁷
Uranium	--	--	1.8† ⁸
Vanadium	--	--	0.40
Zinc	5.0	5.0	0.10
Zirconium	--	--	0.30

†¹ Source: New York Department of Environmental Conservation Groundwater Quality Standards, Title 6, Part 703; Eisman (1983a, 1983b).

†² Maximum allowable concentrations in groundwater unless exceeded by the natural environment.

†³ Maximum allowable concentrations in receiving water in the central drainage ditch under conditions of large water flow in the ditch.

†⁴ Applies to hexavalent chromium only.

†⁵ The combined concentrations of iron and manganese shall not exceed 1.0 mg/L.

†⁶ The combined concentrations of iron and manganese shall not exceed 0.5 mg/L.

†⁷ The New York SPDES Permit has recently been modified to a limit of 0.42 mg/L for total iron and 0.42 mg/L for strontium (Facility Permit No. NY-011-0469, Modification date: March 9, 1984).

†⁸ DOE Order 5480.1A Limit (Alexander 1983). 1% of 96-h LC₅₀ for fathead minnows in hardwater is 1.35 mg/L (U.S. Environ. Prot. Agency 1972).

Table 4.53. Well-Water Concentrations of Selected Organics Contributed by Leachate from NFSS Contaminated Materials, Alternative 1

Organics	Concentration in NFSS Wastes† ^{1,†2} (ppb)	Contribution to Well Water from NFSS Material (ppb)† ³				Regulatory Limit Concentration† ⁵ (ppb)
		Year 1000† ⁴		Maximum† ⁴		
		Kd = 0	Kd = 1000	Kd = 0	Kd = 1000	
PCBs	<26	<0.0057	<3 × 10 ⁻⁷	<0.0067	<5 × 10 ⁻⁶	0.1
Lindane, etc† ⁵	<10	<0.0022	<2 × 10 ⁻⁷	<0.0025	<2 × 10 ⁻⁶	ND
Toxaphene	13	<0.0028	<2 × 10 ⁻⁷	<0.0033	<2 × 10 ⁻⁶	ND
Heptachlor	<10	<0.0022	<2 × 10 ⁻⁷	<0.0025	<2 × 10 ⁻⁶	ND
Chlordane	<10	<0.0022	<2 × 10 ⁻⁷	<0.0025	<2 × 10 ⁻⁶	0.1
Dieldrin	<10	<0.0022	<2 × 10 ⁻⁷	<0.0025	<2 × 10 ⁻⁶	ND
Phenol	<10	<0.0022	<2 × 10 ⁻⁷	<0.0025	<2 × 10 ⁻⁶	1
Benzo(a)pyrene	<10	<0.0022	<2 × 10 ⁻⁷	<0.0025	<2 × 10 ⁻⁶	ND

^{†1} See Section 3.1.8 for details.

^{†2} The symbol < indicates that sample values are reported as upper limits.

^{†3} Concentration contributions are calculated by multiplying the average diked material concentrations by the average of the ratios of well-water concentration/source concentration given in Section 4.2.2 for clay cover and no clay cover for each Kd value. This assumes that the average cover is equivalent to a complete cover for one-half the period and no cover for the remainder. The resulting concentrations are then multiplied by a factor of 0.1. This factor accounts for the fact that a well drilled into a sand lens at the edge of the diked area would draw most water (assumed to be 90% of the total) from surrounding uncontaminated areas.

^{†4} Year 1000 = concentration at year 1000; Maximum = maximum concentration reached at any time; maximum for Kd = 0 and Kd = 1000 cm³/g is 800 and 95,000 years, respectively.

^{†5} New York Department of Environmental Conservation Groundwater Quality Standards, Title 6, Part 703, 9/1/78). ND = not detectable.

^{†6} Includes several isomers of benzene hexachloride. One sample value for one of the isomers was not an upper limit.

are calculated using the same hydrologic model and parameters as used for the inorganic elements of concern (Section 4.2.2). Because Kd values are not available, estimates of concentrations are calculated using 0 and 1000 cm³/g as the lowest and highest possible values for Kd (Table 4.48). Because of the increased cover thickness in Alternatives 2a, 2b, 4a, and 4c, leachate generation will be reduced relative to Alternative 1. As a result, concentrations of organics in the well water will be approximately 70-80% of the concentrations presented in Table 4.53 for the time of maximum concentration.

The organic concentrations are low and are well below the regulatory limits for the cases in which specific limiting concentrations are given. Although this indicates that the potential for organic chemical contamination is negligible, this conclusion is reached with the caveat that the concentrations in the NFSS waste are not well documented (based on limited sampling, some insensitive analyses, and a simple assumption that 2% of the wastes are contaminated with organic chemicals). Also, the estimated concentrations are sensitive to the Kd values assumed; without more accurate values of Kd, the values for Kd = 0 and Kd = 1000 are assumed to be upper and lower limits of a range of possible values. Finally, for these calculations, the organics are assumed to be completely persistent and to not decompose appreciably for periods of 1000 years and more. With decomposition, the estimated concentrations of organics in well water will be reduced further.

4.4.3.2 Hanford

The cover will not erode during the 200- to 1000-year time period for all alternatives at Hanford (3a, 4a, 4b), even under intensive use of the land for grazing animals. Therefore, there will be no release of wastes or residues to surface waters. There will be no impact of leachate from buried NFSS materials on water in a well drilled at the edge of the buried materials because the leachate will not reach the groundwater in this period. At later times after the leachate reaches the groundwater, the maximum contributions to well-water concentrations of both inorganic elements and organic chemicals

will be about 10% of the maximum values calculated for the well at NFSS. The maximum concentration of any element of concern in the well water at Hanford will be negligible (less than 1 ppb). The concentrations of nonradioactive contaminants in groundwater at the point of discharge to the Columbia River are expected to be essentially zero.

4.4.3.3 Oak Ridge

As at Hanford, there will be no releases to surface waters at Oak Ridge within 1000 years under all alternatives (3b, 4c, and 4d). With the exception of arsenic, cadmium, fluorine, and selenium, the well-water concentrations of all nonradioactive chemical contaminants will be essentially zero during the first 1000 years. Most of the contaminants require more than 1000 years to migrate from the bottom of the waste/residue pile to the water table. Arsenic, cadmium, fluorine, and selenium will be only slightly retarded by sorption-desorption effects and will therefore reach maximum concentrations in less than 1000 years (Tables 4.43 and 4.44). At 1000 years after waste emplacement, the concentrations of these four elements in the well water will be reduced to zero.

Maximum contributions of elements in the leachate to the groundwater at a well next to the burial site (Alternative 3b) and at a point of groundwater discharge to the Clinch River are given in Table 4.54. The times at which maximum concentrations will be reached are also presented. The maximum concentrations of elements of concern in the groundwater immediately under the site are expected to be

Table 4.54. Maximum Contribution to Concentrations of Elements of Concern in Groundwater at Different Oak Ridge Locations, Alternative 3b

Element	Maximum Contribution from Leachate (ppb)		Tennessee Water Quality Criteria ² (ppb)	Time to Reach Maximum Contribution (yr)	
	At Clinch River ¹	At Site Well		At Clinch River	At Site Well
Arsenic	0.12	0.30	50† ³	410	280
Barium	4.4	9.7	1,000† ³	4,800	4,100
Cadmium	0.014	0.033	10	410	280
Cerium	0.015	0.04	--	110,000	80,000
Chromium	0.15	0.41	50	2,700	2,300
Cobalt	0.065	0.17	--	110,000	80,000
Copper	1.0	2.7	1,000	2,700	2,300
Fluorine	1.5	4.8	--	200	100
Iron	1.8	4.6	--	110,000	80,000
Lanthanum	0.01	0.04	--	110,000	80,000
Lead	2.8	7.2	50	11,000	8,000
Lithium	0.02	0.04	--	110,000	80,000
Manganese	4.1	10	--	11,000	8,000
Mercury	0.0003	0.0008	0.05	11,000	8,000
Nickel	0.20	0.5	100	110,000	80,000
Selenium	0.24	0.57	10	410	280
Silver	0.0003	0.0009	50	11,000	8,000
Strontium	0.41	1.1	--	2,700	2,300
Uranium	1.0	2.2	--	4,800	4,100
Vanadium	0.04	0.1	--	110,000	80,000
Zinc	0.06	0.15	5,000	2,700	2,300
Zirconium	0.007	0.19	--	110,000	80,000

†¹ 4800 m from the burial site.

†² Source: Rules and Regulations of the State of Tennessee, Chapter 1200-4, Rule 3 as amended, October 22, 1982.

†³ National Interim Primary Drinking Water Standards (40 CFR 141).

well below the regulatory limits. As a result, the impact on the groundwater of concentrations of elements of concern resulting from burial of the NFSS wastes at Oak Ridge will be negligible at all times. Under Alternatives 4c and 4d, groundwater concentrations at the well and at Clinch River will be even lower than under Alternative 3b.

Similarly, toxic organics buried at Oak Ridge will have a negligible impact on groundwater. Those organics with $K_d > 3 \text{ cm}^3/\text{g}$ will not reach the water table in 1000 years, and the maximum values of the concentration contributions will be about 7% of the values for the NFSS well for Alternative 2a. For those organics with $K_d = 0$, maximum concentrations will be reached in 570 years and will be the same as those for the well water at NFSS for Alternative 2a.

4.5 MARINE

The consequences of dumping NFSS wastes in the ocean will depend upon the fate of the NFSS wastes in the ocean environment. The exposure of marine organisms to turbidity and trace elements, including radionuclides, will depend on the location and dilution of the waste constituents. The exposure of humans to radionuclides added to the dumpsite (Section 4.1.2.2) will depend on their use of the marine environment.

4.5.1 Disposal Site Selection

In order to estimate the relative impacts from ocean disposal as compared to onland disposal alternatives, it is necessary to identify a potential ocean-disposal site. Detailed analysis of optional ocean disposal sites is beyond the scope of this EIS. In this EIS, the site assumed for ocean disposal is the 106-Mile Ocean Waste Disposal Site (Site 106), which is dedicated to disposal of industrial and municipal wastes (see Appendix E for detailed descriptions). Site 106 is a deep-water site in an area with complex hydrodynamic features. The site is within a reasonable distance of the Port of New York, yet in an area with little other human use of the marine environment (U.S. Environ. Prot. Agency 1980a). Site 106 and adjacent areas of the Continental Slope and Rise are under study by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA). Site monitoring studies by NOAA have provided preliminary estimates of waste dispersion and the impact of past disposal activities. Using Site 106 as an example in this EIS enables the use of empirical data as well as theoretical calculations to estimate the impacts of the ocean disposal of NFSS wastes.

4.5.2 Waste-Fate Scenarios

Existing models of waste dispersion in the ocean have been developed for analysis of wastes that are either liquid or easily dispersed solids (industrial slurries, ash, liquid chemical wastes, drilling muds, sanitary wastes, and dredge spoils). In contrast, NFSS wastes are silty clays and will be wet, compacted, and very cohesive when they arrive at the dumpsite. Use of existing models without reservations will result in underestimating the impact to the ocean bottom because these models treat waste plumes as though they were liquids, so the models predict that the wastes disperse while still suspended in the upper layers of the ocean. In actuality, cloddy soils will probably be poorly mixed with seawater and only part of the wastes will act like a patch of turbid water. The contrary assumption is that all the NFSS soils will remain a solid mass and sink directly to the bottom. This assumption would result in underestimating the impact to the surface waters of the ocean and overestimating impacts to the bottom of the dumpsite because some muds may be washed from the soil mass during disposal operations and as the mass sinks. NFSS wastes are composed primarily of soils (Section 3.1.7) that have particle densities of about 2.5 to 10 g/cm³. Although some organic material will be present in the soil fraction of the wastes, the primary contaminated component of the soils will be clay particles. Because the density of particles in the wastes (density = 2.6 g/cm³) is more than twice the density of seawater (density = 1.026 g/cm³), accumulation of particles at the various zones of rapid density change in the seawater is not considered further. Colloidal suspensions of clay in seawater will also be more dense than seawater and will not be permanently trapped in zones of rapid density change.

Therefore, predictions of waste fate in this EIS are based on an analysis of two bounding scenarios (Figure 4.8): (1) all the wastes fall directly to the bottom without dilution, and (2) all the wastes are well mixed in the surface waters above the layer of permanent water stratification (pycnocline) (Appendix E, Section E.4.1). The actual impacts from NFSS wastes are expected to fall somewhere between these two extreme cases. The current state of the art on modeling dispersion of solid bulk wastes does not allow a more precise assessment than presented here. Cumulative impacts on surface waters (Scenario I) from repeated dumping are not expected because wastes from one dumping action will be diluted and carried beyond the dumpsite before the next dumping action (Appendix E). With respect to deposition of wastes on the ocean bottom (Scenario II), less than 0.1% of the dedicated waste-disposal site bottom will be affected by dumping of all the NFSS wastes (see Section 4.5.2.1).

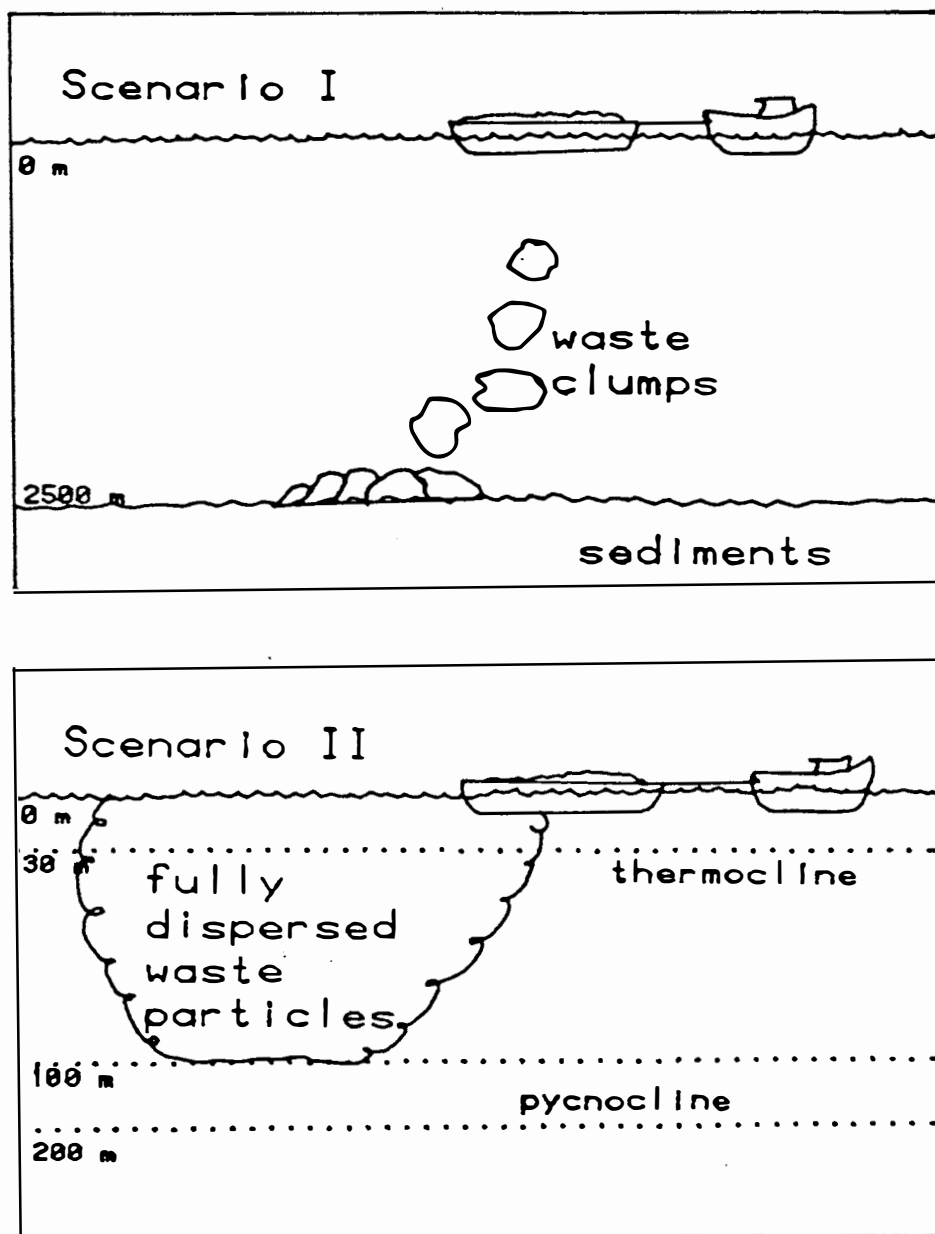


Figure 4.8. Schematic Diagram of Two Bounding Scenarios Used for Assessment of Impacts from Ocean Disposal of NFSS Wastes.

4.5.2.1 Scenario I: Waste Deposition to the Sediments

The highest rate of exposure of marine organisms to waste constituents over the longest period of time would occur if the wastes descended directly to the bottom of the dumpsite without dilution (Scenario I). Such behavior might be expected of wet, compacted, silty-clay soils--such as the NFSS wastes--which should reach the bottom within about 1.6 km of the dump location. During the dumping action, the falling wastes would probably smother animals (worms, etc.) living on the ocean floor. If all the NFSS wastes (180,000 m³) were deposited in layers or mounds at least 10-cm thick, no more than 1.7 km² of benthic surface (ocean bottom) would be covered. This is less than 0.1% of the dumpsite area.

Recolonization of waste deposits by benthic animals will be limited by their sensitivity to waste constituents that are dissolved in water in the pore space of the sediments. The composition of the

pore water in the wastes will be determined primarily by the trace-metal composition of the wastes and the distribution coefficients between sediments and water. The concentrations of trace metals in the wastes are compared with their concentrations in the Site 106 sediments in Table 4.55. Chromium, lead, and zinc concentrations in the wastes are not much greater than concentrations in the sediments; however, copper and nickel concentrations are higher. Estimates of the initial concentration of dissolved copper and nickel in pore waters in the NFSS wastes are calculated by dividing the NFSS waste concentrations by the representative distribution coefficients (from Table 4.48), yielding 4.0 ppm for copper and 0.17 ppm for nickel. These concentrations exceed criteria recommended for protection of marine life and, therefore, some animals may have difficulty recolonizing the waste soon after deposition. Although initial pore water concentrations for other trace metals are greater than the toxicity criteria, recolonization should not be inhibited by these metals because Site 106 sediments naturally contain even greater concentrations than the wastes. With time, trace-element concentrations should decrease as the elements in the pore waters diffuse into waters that move over the deposited wastes.

Table 4.55. Comparison of Trace Elements in Wastes and Site 106 Sediments

Element	Existing Site 106 Sediments ^{†1} (µg/g)	NFSS Wastes ^{†2} (µg/g)	Distribution Coefficients ^{†3}	Initial Pore Water Concentration in Wastes (mg/L)	Criteria Based on Toxicity (mg/L)
Cadmium	1.2-1.8	0.26	6.7	0.04	<0.0001
Chromium	16.8-28.6	28	37	0.8	0.2 ^{†4}
Copper	13.4-37.2	99	25	4.0	0.004 ^{†4}
Lead	16.0-38.8	34	99	0.3	0.02 ^{†5}
Nickel	12.6-33.6	170	1000	0.17	0.007 ^{†4}
Zinc	65.0	5.2	16	0.3	0.05 ^{†4}

^{†1} From Greig and Wenzloff (1977).

^{†2} Average from Table 3.8 of this document.

^{†3} From Table 4.48 of this document.

^{†4} 24-hour average, total recoverable (U.S. Environ. Prot. Agency 1980a).

^{†5} Reported level for chronic toxicity (U.S. Environ. Prot. Agency 1980a).

Caution should be used in applying data from freshwater and coastal species to deepwater species because the trace-metal tolerances of deepwater marine organisms are not known. Also, those organisms living in typical deep-sea sediments (130-570 ppm copper; 80-290 ppm nickel) or in areas of manganese nodules (3,920 ppm copper; 6340 ppm nickel) are exposed to much higher concentrations of trace metals than are present in NFSS wastes.

The addition of 7.8 Ci of radium-226 to Site 106 would be only a small addition to the inventory of naturally occurring radium-226 in the sediments of Site 106. It is estimated that the upper 10 cm of the Site 106 sediments contain approximately 200 to 400 Ci of radium-226, based on the assumption that the radium content of the Site 106 sediments is similar to soils of nearby areas of the continental United States (1-2 pCi/g). The radium content of the Site 106 sediments is not known, but much of these sediments is derived from continental erosion. Based on calculations using the highest flux of radium-226 known for the oceans (Appendix E, Section E.4.2), the addition of radium-226 to water overlying the wastes will be less than 0.002 pCi/L in wastes undiluted by natural sediments. This is less than 2% of the average concentration of radium in seawater, which is 0.1 pCi/L (Joseph et al. 1971).

4.5.2.2 Scenario II: Waste Dispersion in the Surface Waters

Wastes that are well mixed with surface waters during a disposal action will be dispersed in both vertical and horizontal directions due to the density of the soil particles, the descent of the waste-filled water, and the natural mixing action of ocean waters. Site 106 is a dedicated waste-disposal site; therefore, impacts to areas outside the site are estimated.

Vertical Mixing. Because the particles are more dense (approximately 2.5 g/cm³) than seawater (approximately 1.0 g/cm³), the particles will sink due to gravity--a tendency that will be resisted by

the viscosity of the water, water turbulence, and density gradients. A simple approximation for determining the sinking rate of particles that are far apart is Stokes' equation. When applied to NFSS wastes at Site 106, Stokes' equation predicts that sand particles will settle to the bottom within 1.5 days, but small silt and clay particles will sink very slowly and may not settle for many days (see Section E.4.2 for further discussion).

When waste particles are close together, such as in a turbid cloud, the waste and its associated water act like a dense fluid. The difference in density between the waste cloud and the surrounding water results in descent of the waste cloud, a process called convective descent. As the cloud descends, it captures surrounding water (entrainment) until its density decreases to that of the surrounding water. An estimate of convective descent for a large load of NFSS wastes indicates that the wastes will be carried through the seasonal thermocline* (approximately 26-30 m) but may or may not be carried below the permanent pycnocline** (100-200 m), depending on initial dilution and geometry of the waste mass (see Section E.4.2). In any case, convective descent is a mechanism by which the NFSS wastes would rapidly mix vertically in the surface water, even for very small soil particles with very slow sinking rates. Therefore, it is assumed that before the wastes are dispersed by oceanic turbulence, they are mixed to the top of the permanent pycnocline. Mixing the wastes from one dumping action into a volume of water that is 100 m in depth and 100 m in radius results in a dilution to approximately 2000 mg/L. Convective descent can result in large dilutions, even without the effects of horizontal dispersion.

Horizontal Dispersion. Horizontal dispersion of wastes is due to a variety of hydrodynamic processes that create currents and ocean turbulence. The average current in the surface waters of Site 106 is 11 cm/s in a south south-westerly direction, parallel to the Continental Shelf (Section E.2.3.4). Thus, wastes dumped at the center of Site 106 will be carried 37 km to the southern boundary of site within 93 hours (4 days); at this time, the center of the waste mass will be at the site boundary. All calculations of waste dilution and dispersion are predicted for the waste mass in this position. As the wastes move outside the site, they will continue to be diluted, reducing exposure of marine organisms to the wastes. Exposure is expected only during the action period.

The turbulence of the ocean from the motions of water ranges from as small as a few centimeters to tens of kilometers from large water motions associated with major ocean features, such as fronts between different water masses or large eddies 100 km or more across. Such turbulence (called eddy diffusion) will disperse and dilute the wastes to varying degrees, depending on the strength of the turbulence. The rates of dispersion expected for NFSS wastes are evaluated from theoretical formulations of dispersion applied to data on plume dispersion of experimental dumping activities at Site 106 (see Section E.4.3 for details). Data on experimental waste dumping are analyzed using three different dispersion relationships, which give a wide range of dispersion predictions. The lowest and highest estimates of dispersion are referred to as low mixing and high mixing in further discussions. The results of this analysis suggest that at the end of 4 days when the waste mass leaves Site 106, the patch is between 0.64 to 17 km wide and the average waste concentrations expected at these patch sizes range from 12,300 to 8,900,000 more dilute than initial waste concentrations. These dilutions result in waste concentrations of 100 mg/L to 0.1 mg/L, respectively (Table 4.56).

Paul et al. (1983) have analyzed waste dispersion at Site 106 based on dispersion coefficients derived from long term current records at Site D, located northwest of Site 106. Their analysis presents concentrations of wastes in a plume resulting from frequent (100 times per day) dumping at Site 106. The results show that dilutions of 6,000,000 times within the dumpsite are reached under high-mixing conditions. Under low-mixing conditions, a dilution of 2,000,000 is reached at the edge of a narrow plume extending tens of kilometers south of Site 106. This range of dilution is within that calculated by analysis of experimental dumps.

4.5.3 Impacts to Biota

Suspended sediment concentrations in the slope waters in the vicinity of Site 106 are characteristically very low, less than 0.1 mg/L. On initial contact with seawater, the waste mass will contain little water, but will be rapidly mixed with seawater due to convective descent. During the initial phases of dispersion, planktonic organisms that are incapable of escaping the waste mass could be killed or damaged by high turbidity. Further dilutions by horizontal dispersion would reduce average waste concentrations to between 0.1 and 100 mg/L by the time the waste cloud reaches the boundary of Site 106. Damage to marine organisms from turbidity is not expected at the lower end of this range where particulates are within the range of ambient concentrations.

*A thermocline is an area of sharp changes in water density due to changes in temperature that develops in the summer because of solar heating of the surface water; it disappears when the surface waters cool in fall and winter.

**The permanent pycnocline is an area of sharp changes in water density due to changes in salinity and/or temperature that prevent mixing of surface waters with deeper ocean waters.

Table 4.56. Waste Patch Width and Waste Dilution
Four Days After Waste Disposal

Conditions	Patch Width, 4xσ (km)	Waste Dilution† ¹	Average Concentration† ² (mg/L)
I. High Mixing			
A. Case I	2.0	120,000	10
B. Case II	3.4	350,000	4
C. Case III	17	8,900,000	0.1
II. Low Mixing			
A. Case I	0.64	12,300	100
B. Case II	1.1	36,500	40
C. Case III	1.6	77,300	20

†¹ Mixing depth = 100 m.†² Initial waste concentration = 1.3 g dry solids/cm³.

The effects of waste dilution by horizontal dispersion alone on trace-metal concentrations in the water are summarized in Table 4.57. After 4 days, two of the expected total concentrations of trace metals in the waste patch exceed the recommended criteria of 24-hour average concentrations for protection of marine life by factors of 2.5 (copper) and 2.4 (nickel). Dilution to the toxicity criteria would require a dilution of 32,000 times, which would occur in a waste patch 1.03-km wide. This level of dilution is accomplished within 4 days under all conditions except lowest mixing; under lowest-mixing conditions, such dilution would be reached within 7 days. This comparison is conservative because only part of the trace metals in the waste can be measured as "total recoverable" trace metal. In addition, it is highly unlikely that much of the waste will remain in the surface waters for more than 38 hours, when all soil aggregates and sand particles larger than 0.2 mm will have been deposited to the sediments due to the densities of the particles. Rapid settling will decrease the quantity of wastes upon which dispersion acts. For total concentrations of trace metals to be at or above toxicity criteria, 40% of the wastes would have to be completely mixed with water during the dumping operation. The energy necessary to mix such a high proportion of dry or damp soils into their colloidal clay constituents is unlikely in dispersal by gravity dump.

4.5.4 Mitigation, Measurement, and Monitoring

Additional studies of the cohesiveness of NFSS wastes are needed in order to use a verified simulation model to predict waste dispersion. These studies might include an experimental dumping of bulk soils because other studies of waste dispersion at Site 106 have used liquid or slurried wastes. Requirements for toxicity bioassay tests, monitoring, and mitigating impacts will be specified in the EPA Ocean Dumping Permit.

4.6 SOCIOECONOMIC IMPACTS

4.6.1 Introduction

For the alternatives being considered in this EIS, no large construction work force will be required, few new jobs will be created, and the major engineering actions will be brief. Therefore, no large-scale demographic changes beginning a chain of other changes in the social and economic environment are expected to occur. Rather, because of the radioactive nature of the NFSS wastes and residues, public attitudes and perceptions will be a major factor influencing the alternatives and their potential socioeconomic impacts (Argonne Natl. Lab 1982; Payne 1983). For example, potential impacts relative to land use and property values are a function of public perceptions regarding the potential health risks associated with the wastes and residues. Public perceptions will depend primarily on: (1) the sensitivity of the public to radioactive waste, hazardous waste, and environmental issues in general and (2) negative publicity (Nigg 1982; Argonne Natl. Lab. 1982; Payne 1983). It is expected that public sensitivity and the potential for negative publicity will generally decrease over time.

Table 4.57. Dilution of Trace Metals by Dispersion After 4 Days
(Based on Lowest Dispersion Estimate)

Element	Weighted Average Concentration in Wastest ¹ (µg/g)	Ambient Dissolved Concentration in Seawater† ² (µg/L)	Average Concentration in Waste Patches due to the Wastes (µg/L, total)	Criteria (24-h avg.) for Protection of Aquatic Marine Life† ³ (µg/L, total recoverable)
Arsenic	1.4	0.09	0.14	508
Cadmium	0.26	0.014	0.026	4.5
Chromium	28	0.07	2.8	18
Copper	99	0.17	9.9	4.0
Lead	34	0.005	3.4	25
Mercury	0.3	0.005	0.03	0.025
Nickel	170	0.2	17	7.1
Selenium	0.68	0.04	0.068	54
Vanadium	96	1.5	9.6	150† ⁴
Zinc	5.2	0.01	0.52	58

†¹ From Table 3.8 of this document.†² From Paul et al. (1983); 1 µg/L = 0.980 µg/kg.†³ From U.S. Environmental Protection Agency (1980b).†⁴ From U.S. Environmental Protection Agency (1977b).

4.6.2 Land Use and Property Values

4.6.2.1 Land Use

The land on which the NFSS wastes and residues are buried must be considered to be permanently (irreversibly and irretrievably) dedicated to waste management, with all other land uses permanently preempted. In order to contain the NFSS wastes and residues, the land above, under, and surrounding the containment area must remain undisturbed. Improper onsite surface or subsurface development could stress engineered barriers and allow for migration of the wastes offsite. Therefore, certain onsite human activities (e.g., excavation or agricultural activities) must be prevented. Offsite land uses must also be controlled because there is a potential for offsite uses to adversely affect the isolation of the NFSS wastes. For example, during the long term when controls have ceased, the construction of a dam near the waste site or failure to maintain drainage ditches could result in flooding of the waste site, thereby adversely affecting the integrity of the containment system. Therefore, some uses of nearby land may also be permanently preempted.

The amount of land dedicated to waste management will be small for all the alternatives (Table 4.58). The greatest amount of land will be dedicated at Hanford under Alternative 3a (56 ha [140 acres]) and at NFSS under Alternative 1 (69 ha [170 acres]). Most of the land at Hanford will be in the actual waste-containment area. This area is much larger at Hanford than at the other sites because the radioactive materials will be buried in trenches with strips of land in between the trenches, thus consuming more land than when placed in large piles as at NFSS and Oak Ridge. At NFSS under Alternative 1, most of the land is not used for waste management but it is assumed that DOE takes no action and retains ownership of the entire site. Under Alternatives 2a, 2b, 4a, and 4c, it is assumed that DOE will release the unused portions of the site for other uses. The actual waste-containment areas at the various sites range from 3.4 ha (8.3 acres) at NFSS under Alternative 1 to 38 ha (95 acres) at Hanford under Alternative 3a.

At NFSS, the land is already used for waste management, and implementation of Alternatives 2a, 2b, 4a, or 4c would simply commit the land to waste-management use. At Oak Ridge and Hanford, although the land use on the Reservations is currently restricted, development of the NFSS waste-management sites would permanently commit those particular parts of the Reservations to restricted use. At Hanford, this commitment does not appear to be a serious impact because the NFSS waste-management site is a very small addition to an existing waste-management site on the Reservation and waste-management sites are not scarce. At Oak Ridge, however, such commitment of a site that is also a prime potential industrial site may be significant. Local citizens and governments have objected to such commitment of potential industrial land during the EIS scoping process. The Pine Ridge Knolls

Table 4.58. Land Use at the Alternative Waste-Management Sites†¹

Alternative	Location	Waste Containment Area† ²		Buffer Area		Service Area		Total	
		ha	acres	ha	acres	ha	acres	ha	acres
1	NFSS	3.4	8.3† ³	66† ⁴	160† ⁴	† ⁴	† ⁴	69	170† ⁵
2a, 2b, 4a, 4c	NFSS	4.5	11† ⁶	3.2	8† ⁷	8.1	20	16	39† ⁸
3a	Hanford	38	95† ⁹	9.7	24† ⁷	8.1	20	56	140
4a, 4b	Hanford	9.3	23† ¹⁰	4.0	10† ⁷	8.1	20	21	53
3b	Oak Ridge	12	29† ¹¹	4.4	11† ⁷	8.1	20	24	60
4c, 4d	Oak Ridge	2.7	6.7† ¹²	2.4	5.8† ⁷	8.1	20	13	33

†¹ All numbers rounded to two significant figures.

†² Includes area between trenches and waste packages, dikes, underneath cover, etc. See Table 4.16 for areas covered by wastes and/or residues.

†³ Source: U.S. Department of Energy (1983d).

†⁴ Buffer zone and service area are combined.

†⁵ Area of current DOE site.

†⁶ Based on a 120-m × 270-m (400-ft × 900-ft) containment area in Alternative 1 plus an extra 15 m (50 ft) all around to allow for the long-term cap (extra 1.7 m [5.5 ft]) and a 20% outslope on the containment area.

†⁷ Assuming a 30-cm (100-ft) buffer strip at all sites for long-term management.

†⁸ Assumes that only the waste containment, buffer, and small service areas need be retained under DOE ownership for long-term management. After ongoing interim cleanup actions and construction of a long-term cap are completed, the rest of NFSS could be released for other use.

†⁹ Assuming 190,000 m³ (250,000 yd³) of NFSS wastes and residues buried in 42 trenches 300-m (1000-ft) long having dimensions and spacing as shown in Figure 2.5.

†¹⁰ Assuming NFSS residues packaged in 7360 bins 1.8 m × 1.5 m × 1.2 m (6 ft × 5 ft × 4 ft) and placed in 10 trenches having dimensions and spacing as shown in Figure 2.9.

†¹¹ Assuming 190,000 m³ (250,000 yd³) of NFSS wastes and residues piled 3-m (10-ft) deep (plus 20% contingency area) over a 0.6-m (2-ft) base of clay and sand/gravel, covered by a 3.2-m (10.5-ft) cap with a 20% outslope (see Figure 2.8 for conceptual design).

†¹² Assuming NFSS residues packaged in 5100 bins 1.8 m × 1.5 m × 1.2 m (6 ft × 5 ft × 4 ft) bins placed in a 77 × 96 array with 0.15 m (0.5 ft) spacing between bins--with base, cap, and outslope as described above (Figure 2.13).

site has been considered for private industrial development in the recent past (for the proposed Exxon project) and the scarcity of such sites in the hilly region has prompted local authorities to request that DOE release some of the Reservation land for private development. In addition to a scarcity of industrial sites, there is also a scarcity of waste-management sites in the region. The local cities have difficulty finding landfill sites and DOE needs sites to dispose of wastes from various ongoing DOE operations on the Reservation. Dedication of the Pine Ridge Knolls site to management of the NFSS contaminated materials will lessen the amount of land available for disposal of other wastes.

The designation of a site for long-term management of the NFSS wastes and residues may affect the types of surrounding land-use developments. Certain surrounding land uses and their associated human activities may be perceived by the public as compatible or incompatible with a waste site. For example, the existence of a waste site may be perceived by the public (and potential developers) as posing a significant health risk to the public. Therefore, land uses adjacent to the site may shift to industrial-type development or some form of recreational rather than residential use.

Land-use impacts that could occur for the various alternatives over the various time frames are presented in Table 4.59. The effects on land use pertain to restricted and unrestricted site use, impacts to surrounding land uses, and surrounding land uses impacting the integrity of the containment system.

Table 4.59. Land-Use Impacts

Alternative	Impacts Associated with Three Time Frames			
	Action Period (10 years)	Monitoring Maintenance, and Corrective Action (200 years)	Long Term (200-1000 years)	
			Case A† ¹	Case B† ²
1	• Restricted use of NFSS. • No significant impacts to surrounding land uses are anticipated. • Surrounding land uses should not adversely affect the integrity of the wastes.	• Restricted use of NFSS. • No significant impacts to surrounding land uses are anticipated. • Surrounding land uses should not adversely affect the integrity of the wastes.	• Restricted use of NFSS. • Surrounding land uses could be adversely impacted as waste containment measures fail. • Potential for surrounding land uses to adversely affect the integrity of the wastes.	• Unrestricted use of NFSS resulting in the potential for human intrusion into the wastes. • Surrounding land uses could be adversely impacted due to waste containment failure or inadvertent human intrusion into the wastes. • Potential for surrounding land uses to adversely affect the integrity of the wastes.
2a, 2b	• Same as Alternative 1, except improved containment measures should reduce the potential for adverse impacts.	• Same as Alternative 1, except improved containment measures should reduce the potential for adverse impacts.	• Same as Alternative 1.	• Same as Alternative 1.
3a	• Unrestricted use of NFSS upon completion of removal of wastes. • Continued restricted use of Hanford site. • No significant impacts to surrounding land uses at Hanford are anticipated. • Surrounding land uses should not adversely affect the integrity of the Hanford site.	• Restricted use of Hanford site. • No significant impacts to surrounding land uses at Hanford site are anticipated. • Surrounding land uses should not adversely affect the integrity of the Hanford site. • Land use on NFSS potentially affected if residual contamination causes restricted land use.	• Restricted use of Hanford site. • Surrounding land uses at Hanford could be adversely impacted as waste containment measures fail. • Potential for surrounding land uses to adversely affect the integrity of the Hanford site.	• Unrestricted use at the Hanford site resulting in the potential for human intrusion into the wastes. • Surrounding land uses at Hanford could be adversely impacted due to containment failure or inadvertent human intrusion into the wastes. • Potential for surrounding land uses to adversely affect the integrity of the Hanford site.
3b	• Same as Alternative 3a (except effects will be to Oak Ridge area rather than Hanford area).	• Same as Alternative 3a (except effects will be to Oak Ridge area rather than Hanford area).	• Same as Alternative 3a (except effects will be to Oak Ridge area rather than Hanford area).	• Same as Alternative 3a (except effects will be to Oak Ridge area rather than Hanford area).

Table 4.59. Continued

Alternative	Impacts Associated with Three Time Frames			
	Action Period (10 years)	Monitoring Maintenance, and Corrective Action (200 years)	Long Term (200-1000 years)	
			Case A† ¹	Case B† ²
4a (4c)	• Restricted use of NFSS and Hanford (Oak Ridge). • No significant impacts to surrounding land uses at Hanford (Oak Ridge) or NFSS are anticipated. • Surrounding land uses should not adversely affect the integrity of NFSS or Hanford (Oak Ridge).	• Restricted use of NFSS and Hanford (Oak Ridge). • No significant impacts to surrounding land uses at NFSS or Hanford (Oak Ridge) are anticipated. • Surrounding land uses at NFSS and Hanford (Oak Ridge) should not adversely affect the integrity of the wastes.	• Restricted use of NFSS and Hanford (Oak Ridge). • Potential for surrounding land uses to adversely affect the integrity of the wastes at NFSS and Hanford (Oak Ridge). • Surrounding land uses at the Hanford (Oak Ridge) site could be adversely impacted as waste containment measures fail. • Although the magnitude of the impact would be reduced, surrounding land uses at NFSS could be adversely impacted as waste containment measures fail.	• Unrestricted use of NFSS and Hanford (Oak Ridge) resulting in the potential for human intrusion into the wastes. • Potential for surrounding land uses to adversely affect the integrity of NFSS and Hanford (Oak Ridge). • Surrounding land uses at the Hanford (Oak Ridge) site could be adversely impacted due to containment failure or inadvertent human intrusion into the wastes. • Although the magnitude of the impact would be reduced, surrounding land uses at NFSS could be impacted as waste containment measures fail.
4b (4d)	• Unrestricted use of NFSS upon completion of removal of NFSS wastes. • Short-term restricted use of designated dock site. • Continued restricted use at Hanford (Oak Ridge) site. • No significant impacts to surrounding land uses at Hanford (Oak Ridge) are anticipated. • Surrounding land uses should not adversely affect the integrity of the Hanford (Oak Ridge) site.	• Same as Alternative 3a, except residual contamination is only potential land use consideration at NFSS.	• Same as Alternative 3a, except no land use impacts at NFSS.	• Same as Alternative 3a, except no land use impacts at NFSS.

†¹ Assumes loss of monitoring, maintenance, and corrective action.

†² Assumes loss of monitoring, maintenance, corrective action, and institutional controls.

For all the alternatives, the potential for significant land-use impacts is minimal during the action period and the maintenance and monitoring period (up to 200 years). However, if land-use controls cease during the long-term period (200-1000 years), surrounding land uses could be adversely affected as the waste-containment system begins to fail. Over time, the potential also exists for surrounding land uses to stress engineered barriers and allow for migration of the wastes offsite. If the waste site becomes unrestricted in use, the potential exists for direct human intrusion into the wastes (see Section 4.1.2.3). Surrounding land uses are currently controlled on the Oak Ridge and Hanford reservations. However, it is possible that the current buffer zones between the various DOE facilities could be released to other owners for other uses in the future. Because of the uncertainty of the types of land uses surrounding the waste sites over the long term, long-term land-use impacts can be discussed only in general terms. It should be noted that in order to maintain land-use controls for longer periods, dollar costs will increase. Furthermore, it is not reasonable to expect land-use controls to remain in effect for the hundreds of thousands of years that the NFSS wastes and residues will remain radioactive (see beginning of Section 4).

Under Alternatives 1, 2a, and 2b, the wastes will remain at NFSS and land use will be restricted. The site area is currently zoned industrial and is bordered to the north by a hazardous waste facility and to the east by a landfill. Surrounding land-use patterns are well established and are not likely to be significantly affected by officially designating the site as a long-term (rather than "interim") waste-management site. As long as use of the site remains restricted and the wastes are maintained and monitored, no significant impacts to surrounding land uses are anticipated. During the action period and maintenance and monitoring period at NFSS in Alternatives 2a and 2b, the potential for adverse land-use impacts will be further reduced because of the lowered potential for loss of containment and resultant negative publicity.

At NFSS in the short term, it may be more difficult to maintain active land use controls than at the Oak Ridge or Hanford Reservations. This is because NFSS is an isolated piece of federally owned property, and there will be no ongoing active federal projects after one of the alternatives is implemented. At the DOE Reservations, active and passive controls over the small areas containing the NFSS wastes and residues would be part of the larger controlled and actively managed federal Reservation. It should be stressed, however, that the possible control advantages of locating the NFSS wastes and residues on a large federal Reservation are contingent upon federal ownership and active use of the Reservation. If the government sells or transfers "unused" portions of the Reservations to private or other institutional owners and only the actual waste-management sites on the DOE reservations remain under government control, the long-term advantage of having the NFSS wastes and residues on a Reservation will be lost.

Under Alternatives 3a, 3b, 4b and 4d--in which all wastes and residues will be removed from NFSS--land-use impacts at NFSS will occur primarily during the action period (10 years). These impacts will be temporary and associated with construction and excavation activities at the site. Upon completion of these activities, NFSS will be released for other uses. Depending on the degree of decontamination, other uses of the site may be restricted or unrestricted. Even if the site is released for unrestricted use, however, potential controversy over what constitutes acceptable levels of residual contamination may lead to reimposition of land-use restrictions by state or local authorities. This has happened in the past at NFSS and other sites. Also, local zoning authorities may restrict uses of the site to those considered compatible with the existing use of the surrounding land for other waste-management activities.

During the action period at Hanford and Oak Ridge, location of the NFSS waste-management sites well within the boundaries of the Reservations is expected to preclude land-use impacts associated with construction activities under Alternatives 3a, 3b, 4a, 4b, 4c, and 4d.

Management of the NFSS wastes and residues at Hanford (Alternatives 3a, 4a, and 4b) should not adversely affect the surrounding land uses through the maintenance and monitoring period. Both nuclear power generation facilities and radioactive waste-storage sites are located on the Hanford Reservation, and these sites are committed to restricted use for the foreseeable future. As long as the federal government retains ownership and control of the Reservation and because of the remoteness of the Hanford waste-management site and restricted-use buffer zone, impacts to land uses surrounding the Reservation are not anticipated. However, if the federal government sells or releases portions of the reservation to other governmental or private entities in the future, much of the existing buffer zone area could be lost and result in conflictive land uses adjacent to the site where the NFSS wastes and residues are buried.

The land-use impacts at Oak Ridge (Alternative 3b, 4c, and 4d) will be similar to those at Hanford. However, because the Oak Ridge site is not as remote as the Hanford Reservation, the potential for impacts to surrounding land uses is greater.

During the action period at the Harbor, it is expected that the dock will be restricted to use for the transfer of the NFSS wastes to the barges. After the wastes have all been disposed at the ocean dumping site and the dock area has been decontaminated, no future land-use restrictions are anticipated.

4.6.2.2 Property Values

Impacts on residential property values may occur because the public may perceive the activities associated with long-term management of the NFSS wastes and residues as being hazardous and detrimental to public health and safety. Property values of commercial or industrial properties, such as the adjacent hazardous waste facility at NFSS, are not expected to be affected. Residential property value impacts may be measured in terms of variations in number of days on the market or differences in asking versus selling price between properties near the waste-management site and properties farther away.

During the scoping process at NFSS, a local real estate agent (Collins 1983) argued that the property values near NFSS have been adversely influenced by negative publicity about the NFSS and other waste sites in the area. However, a second local real estate agent (Baldwin 1983) pointed out that a cause-effect relationship between proximity to NFSS and residential property values cannot be documented because of: (1) the difficulty in separating out the influence of other nearby hazardous waste sites, (2) the spillover of negative publicity from other recent local environmental issues, (3) the difficulty in separating out the influence of national trends in the economy and housing market, and (4) the fact that a pattern of property value decline would be difficult to determine from the very small number of homes that have changed hands in the NFSS area in recent years. It is also important to point out that, in general, patterns of property values are a function of several historical forces, including proximity to urban areas, transportation system development, and proximity to other developments (residential, commercial, industrial, etc.). It should be kept in mind that property-value impacts associated with management of the NFSS wastes and residues may be insignificant compared to all these other factors.

Although there is no clear evidence to confirm or deny any past influence of NFSS on property values, it has been shown that there is a correlation between perceived radiological hazards and short-term property value impacts (Gamble and Downing 1981). If all or some of the wastes and residues remain at NFSS (Alternatives 1, 2a, 2b, 4a, and 4c), there is a potential for a short-term (6 months to 1 year), negative impact on property values. The removal of all the wastes and residues from NFSS (Alternatives 3a, 3b, 4b, and 4d) may have some positive short-term impacts on property values in the communities surrounding NFSS, after which property-value impacts associated with NFSS will be negligible. Concurrently, the import of the wastes and residues to the Oak Ridge or Hanford sites may produce negative impacts on property values in those areas, particularly if the potential negative publicity is realized. It should be kept in mind, however, that private residences are located much farther away from the waste-management sites at Oak Ridge and Hanford than at NFSS, thereby decreasing the potential for property-value impacts relative to NFSS. Disposal of the NFSS wastes in the ocean is not expected to have an impact on property values in the Harbor area.

In addition to potential negative property values impacts (e.g., greater number of days on the market and much lower selling price than asking price), there can be possible economic benefits. The negative impacts could occur for those residents attempting to sell or rent their homes, but these impacts may occur only while it is common knowledge that there is a nearby radioactive waste-management site. For those who buy at lower prices, on the other hand, their property may gain in value when the presence of the radioactive waste site is no longer widely publicized. Residents who intend to stay in the area may experience a positive impact if the assessed value of their property is lowered, with attendant reduction in property taxes. Residents near NFSS, for example, have claimed that their property values are lower because of proximity to the waste area and therefore should have lowered property tax assessments.

4.6.3 Transportation

4.6.3.1 Traffic Congestion and Road Deterioration

Implementation of some of the alternatives may result in increased traffic congestion and road deterioration. For Alternative 1, there will be no such impact. For Alternatives 2a and 2b, only fill materials will be transported; for the other alternatives, both contaminated and fill materials will be transported. Estimated peak traffic volumes are shown in Table 4.60.

The greatest potential for adverse impact is at Oak Ridge under Alternative 3b in which there will be about one truck every minute during two summers. About one-fourth of the trucks will be hauling or returning for contaminated materials while the remainder will be hauling or returning for fill materials. White Wing Road (Rt. 95) and Bear Creek Road will bear most of the traffic (Figure 3.21). Trucks hauling contaminated materials will arrive from the south via White Wing Road and travel west on Bear Creek road to the Pine Ridge Knolls site. The trucks hauling fill material could arrive from any direction, depending on what suppliers are awarded contracts for the fill material. White Wing Road is a state highway. Most of Bear Creek Road within the Oak Ridge Reservation is the responsibility of DOE (the western portion through an industrial area near the Clinch River has been turned over to the city of Oak Ridge).

In addition to the NFSS-associated traffic, these roads are used by workers commuting to various Oak Ridge facilities. They are also used to transport materials for other projects. For example,

Table 4.60. Truck Traffic at the Various Sites†¹

Activity/Rate of Trucks Arriving and Departing	NFSS									HANFORD			OAK RIDGE			HARBOR	
	1	2a	2b	3a	3b	4a	4b	4c	4d	3a	4a	4b	3b	4c	4d	4b	4d
Hauling contaminated residues:																	
trucks/day	0	0	0	13	13	13	13	13	13	13	13	13	13	13	13	0	0
trucks/hour	0	0	0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0	0
Hauling contaminated wastes:																	
trucks/day	0	0	0	50	120	0	120	0	120	50	0	0	120	0	0	120	120
trucks/hour	0	0	0	6.2	15	0	15	0	15	6.2	0	0	15	0	0	15	15
Hauling fill materials:																	
trucks/day	0	150	150	28	28	170	28	170	28	44	10	10	360	82	82	0	0
trucks/hour	0	19	19	3.5	3.5	21	3.5	21	3.5	6	1.3	1.3	45	10	10	0	0
Peak traffic:																	
trucks/day	0	150	150	63	133	170	133	170	133	107	23	23	510	95	95	120	120
trucks/hour	0	19	19	7.8	17	21	17	21	17	14	2.9	2.9	62	12	12	15	15
Duration of peak traffic:																	
number of years	NA	1	1	5	2	1	2	1	2	2	2	2	2	2	2	2	2
months/year	NA	6	6	6	6	6	6	6	6	4	4	4	4	4	4	6	6

Abbreviations: NA = not applicable.

†¹ Based on numbers given in Appendix D.

there have been recent traffic problems on Bear Creek Road because trucks hauling crushed rock from the eastern side of the Reservation to the former breeder reactor project on the western side of the Reservation cause congestion and potential accident situations during shift changes at the Y-12 complex. Although this project has been cancelled, there is a potential for overlap with another project--the proposed central waste facility on West Chestnut Ridge across the street south of the Pine Ridge Knolls site (U.S. Dep. Energy 1983e). Traffic from the other facilities on the Oak Ridge Reservation also use White Wing and Bear Creek roads, particularly during the morning and evening rush hours. The cumulative impacts associated with the heavy truck traffic from implementing NFSS Alternative 3b, especially if combined with heavy traffic associated with other projects, will be increased traffic congestion, increased accidents, and accelerated deterioration of the roads. These impacts might be mitigated to some extent (see Section 4.6.7).

At NFSS, Hanford, and the Harbor, NFSS-associated traffic will be much less than at Oak Ridge (Table 4.60), and the potential for adverse impacts is correspondingly less. This is somewhat dependent on the degree of overlap with other traffic, and the need for similar mitigative measures will have to be determined for the time an alternative is actually implemented.

4.6.3.2 Deaths and Injuries Resulting from Transportation Accidents

Transportation of contaminated and fill materials will increase the risk of human injury and death because of the potential for transportation accidents. Based on accident statistics for the United States (rural and urban areas), the injury rate for truck accidents is 5.1×10^{-7} injuries per kilometer and the fatality rate is 3.0×10^{-8} per kilometer (Gay 1979). Available data do not separate the occupational (driver) and public components. The estimated transportation-related deaths and injuries associated with implementation of each alternative for management of the NFSS wastes and residues are given in Table 4.61.

There will be no transportation-related deaths or injuries for Alternative 1 (no action). The risks of transportation-related death and injury under Alternatives 2a and 2b are insignificant (Table 4.61). For the remaining alternatives, all of which involve transport of all or part of the NFSS wastes and residues to other sites, several injuries and deaths are projected to occur. Alternative 3a (transport of all wastes and residues to Hanford) will have the greatest risk, with an estimated 4 deaths and 66 injuries. Transport of all the wastes and residues to Oak Ridge entails about one-third as much risk because of the lesser distance involved. Almost all the potential risk is associated with transport of the contaminated materials because of the greater total distances involved. Even doubling of the average transportation distance for fill materials from 20 to 40 km will not significantly increase the relative risk associated with hauling of fill materials. Also, most of the risk is associated with transport of the slightly contaminated, but large, bulk wastes. Removal of only the residues from NFSS (Alternatives 4a and 4c) will result in only one-tenth of the risk incurred by removing all contaminated materials from NFSS.

These risk estimates are based on general U.S. truck-accident death and injury rates. Local conditions and mitigative measures could increase or decrease the actual rates. For example, if mitigative measures are not implemented or are not effective, the injuries and deaths associated with transportation at Oak Ridge (see previous discussion about traffic congestion) could be greater. On the other hand, extra precautions taken because of the radioactive materials may lead to accident rates that are generally lower than the average rates. However, although the absolute numbers may be slightly different, the relative risks between alternatives are expected to be about the same.

4.6.3.3 Air Pollution

Transportation of the contaminated and fill materials will lead to increased levels of combustion pollutants in the atmosphere. In a study about potential impacts associated with a clean-up activity involving about 20 trucks/hour (plus some construction equipment) (Argonne Natl. Lab 1982), it has been reported that vehicle emissions can be major contributors to local air quality degradation. This is especially true for rural areas where the background emissions are about one-tenth of those for urban areas.

As discussed in Section 4.6.3.1, peak traffic will be greatest at Oak Ridge under Alternative 3b (over 60 trucks/hour). Not only will emissions be greater than those analyzed in the Argonne study (Argonne Natl. Lab 1982), but also the roads at Oak Ridge are located in valleys where the air is often very stable--thus delaying dispersion of air pollutants. Depending on the amount of existing traffic (Section 4.6.3.1), the emissions associated with NFSS traffic could be a significant contributor to air quality degradation during peak traffic periods. Even if the NFSS contribution is only a minor contribution in comparison to existing traffic contributions, it will exacerbate air quality problems during rush hours on days when there are weather inversions. Impacts can be reduced to some extent if the mitigative measures discussed in Section 4.6.7 are employed.

The peak traffic, and thus the potential air pollution impacts, are less for the other alternatives. Implementation of Alternative 1, 2a, or 2b will cause little or no impact. The impact at Hanford (Alternatives 3a, 4a, and 4b) is expected to be less not only because the peak traffic will be less but also because local meteorological conditions will cause pollutants to be more readily

Table 4.61. Estimated Number of Transportation-Related Deaths and Injuries†¹

Alternative/ Type of Material Transported	Total Distance Traveled† ² (km)	Number of Deaths† ³	Number of Injuries† ⁴
<u>Alternative 1</u>			
None	0	0	0
<u>Alternative 2a</u>			
Contaminated	0	0	0
Fill	<u>370,000</u>	<u>0.11</u>	<u>0.19</u>
Total	370,000	0.11	0.19
<u>Alternative 2b</u>			
Contaminated	0	0	0
Fill	<u>370,000</u>	<u>0.11</u>	<u>0.19</u>
Total	370,000	0.11	0.19
<u>Alternative 3a</u>			
Contaminated	130,000,000	3.9	66
Fill	<u>580,000</u>	<u>0.018</u>	<u>0.3</u>
Total	130,000,000	3.9	66
<u>Alternative 3b</u>			
Contaminated	42,000,000	1.3	21
Fill	<u>1,800,000</u>	<u>0.054</u>	<u>0.92</u>
Total	44,000,000	1.4	22
<u>Alternative 4a</u>			
Contaminated	13,000,000	0.39	6.6
Fill	<u>520,000</u>	<u>0.016</u>	<u>0.27</u>
Total	14,000,000	0.44	6.9
<u>Alternative 4b</u>			
Contaminated	43,000,000	1.3	22
Fill	<u>190,000</u>	<u>0.0058</u>	<u>0.098</u>
Total	43,000,000	1.3	22
<u>Alternative 4c</u>			
Contaminated	4,200,000	0.13	2.1
Fill	<u>790,000</u>	<u>0.024</u>	<u>0.40</u>
Total	5,000,000	0.15	2.5
<u>Alternative 4d</u>			
Contaminated	34,000,000	1.0	17
Fill	<u>460,000</u>	<u>0.014</u>	<u>0.23</u>
Total	34,000,000	1.0	17

†¹ All values rounded to two significant figures.†² Taken from tables in Appendix D.†³ Based on truck-accident fatality rate of 3.0×10^{-8} /km, (includes drivers and the public).†⁴ Based on truck-accident injury rate of 5.1×10^{-7} /km, (includes drivers and the public).

dispersed. Implementation of any of the Hanford alternatives will, however, result in a greater net contribution to general air quality degradation in the United States because total emissions will be greater as a result of the greater distance involved. NFSS vehicle emissions in the Harbor area will be insignificant relative to the existing emissions in the New York metropolitan area.

4.6.3.4 Demands on State and Local Emergency Preparedness Services

State and local authorities charged with independently safeguarding the public may have to provide emergency preparedness services with respect to transport of the NFSS wastes and residues, particularly the residues that will be classified as "radioactive" under federal regulations (see Appendix D.2). Although not legally applicable to DOE shipments, the state of New York and some local municipalities have enacted numerous laws in the past several years regarding the transportation of radioactive materials (U.S. Nucl. Reg. Comm. 1983b). For example, one of the latest is New York's proposed Radioactive Materials Transportation Act. For the protection of public health and safety in the event of an accident during the transportation of radioactive materials, this Act requires the preparation of emergency response procedures and the training of public safety officials ..., the costs of which should be borne by the carriers of radioactive materials." Some of the key provisions include:

1. Permits for the transport of radioactive waste must be obtained from the state, the cost of which will be \$1,000 plus \$100 per truckload (4-b).
2. An additional \$1,000 will be added to each shipment containing spent fuel or radioactive materials (4-c).
3. Financial responsibility in case of an accident must be met by the carrier (4-d).
4. All fees collected in accordance with RMTA shall be used for the planning, training, and equipment needed for emergency preparedness for accidents that may occur during the transport of radioactive materials (6a-c).

Thus, for New York, as well as other states having similar provisions for support of emergency preparedness efforts through fees on radioactive waste shipments, there will be an economic loss in that they will have to provide a service and will not receive payments for the DOE-exempt shipments.

4.6.4 Occupational Injuries and Deaths (Excluding Transportation)

Implementation of each of the action alternatives will require workers to conduct activities that have risk of injury and death (Argonne Natl. Lab. 1982). Accidental injuries and death usually arise from improper use or maintenance of equipment or failure to take proper precautions particularly in high-risk situations.

Preliminary estimates of the manpower requirements for three major worker categories are given in Table 4.62. The estimated injuries and deaths for each alternative are listed in Table 4.63, based on the manpower requirements and injury and fatality rates for these classes of workers.

In general, alternatives involving the most activities relative to construction and material handling and processing will have the greatest risk of worker injuries and deaths. For example, implementation of Alternative 3a is projected to result in 100 worker injuries. This is more injuries than are projected for the transportation activities associated with implementation of this alternative (66 injuries--Table 4.61). There is great uncertainty, however, regarding the amount of future remedial action that may be needed if containment systems fail during the 200 years of maintenance and monitoring. In reality, the number of worker injuries and deaths may be highest for those alternatives that have a greater probability of failure, especially Alternative 1 (see Sections 4.2 and 4.3 for detailed discussions of the integrity of containment systems).

4.6.5 Population, Economy, Public Facilities, and Public Services

4.6.5.1 Population

Estimates of the work force required under the various alternatives (see Section 4.6.4) are extremely small relative to the current populations at the four sites. The impact of the estimated labor force on population growth and density is therefore considered to be negligible.

4.6.5.2 Economy

To determine the potential impacts of each alternative on the economy, there are two major issues that need to be considered: (1) the relationship between public perceptions and the economy, and (2) how the various alternatives may influence the tax base of the affected communities.

The current economic climate at NFSS, Hanford, and Oak Ridge is a reflection of historical changes in the economy and the relative dependence of each community on the various economic sectors (industry,

Table 4.62. Estimated Work Force Requirements of the Various Sites
During the Action Period†¹

Activity/Site	Work Force Requirement (worker-days) for Each Alternative								
	1	2a	2b	3a	3b	4a	4b	4c	4d
FIELD SUPERVISION, ENVIRONMENTAL MONITORING:									
NFSS	8,000	11,000	12,000	13,000	13,000	11,000	13,000	11,000	13,000
Hanford† ²	NA	NA	NA	13,000	NA	11,000	13,000	NA	NA
Oak Ridge† ²	NA	NA	NA	NA	13,000	NA	NA	11,000	13,000
Subtotal	8,000	11,000	12,000	26,000	26,000	22,000	26,000	22,000	26,000
SITE PREPARATION:									
NFSS† ³	NA	8,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Hanford† ⁴	NA	NA	NA	20,000	NA	10,000	10,000	NA	NA
Oak Ridge† ⁵	NA	NA	NA	NA	30,000	NA	NA	20,000	20,000
Subtotal	NA	8,000	10,000	30,000	40,000	20,000	20,000	30,000	30,000
RESIDUE RETRIEVAL/PACKAGING/LOADING, OR RETRIEVAL/PROCESSING/DISPOSAL, OR UNLOADING/DISPOSAL:									
NFSS	NA	NA	15,000	10,000	10,000	10,000	10,000	10,000	10,000
Hanford† ⁶	NA	NA	NA	3,000	NA	3,000	3,000	NA	NA
Oak Ridge† ⁶	NA	NA	NA	NA	3,000	NA	NA	3,000	3,000
Subtotal	NA	NA	15,000	13,000	13,000	13,000	13,000	13,000	13,000
WASTE RETRIEVAL/LOADING, OR UNLOADING/DISPOSAL:									
NFSS	NA	NA	500	40,000† ⁷	30,000	NA	30,000	NA	30,000
Hanford† ⁸	NA	NA	NA	15,000	NA	NA	NA	NA	NA
Oak Ridge† ⁸	NA	NA	NA	NA	15,000	NA	NA	NA	NA
Subtotal	NA	NA	500	55,000	45,000	NA	30,000	NA	30,000
DEMOLITION OF BUILDING FOUNDATIONS:									
NFSS	NA	NA	NA	2,000	2,000	NA	2,000	NA	2,000
Hanford	NA	NA	NA	NA	NA	NA	NA	NA	NA
Oak Ridge	NA	NA	NA	NA	NA	NA	NA	NA	NA
Subtotal	NA	NA	NA	2,000	2,000	NA	2,000	NA	2,000
RADIOLOGICAL SUPPORT:									
NFSS	NA	4,000	6,000	11,000	11,000	6,000	11,000	6,000	11,000
Hanford† ⁹	NA	NA	NA	6,000	NA	3,000	6,000	NA	NA
Oak Ridge† ⁹	NA	NA	NA	NA	6,000	NA	NA	3,000	6,000
Subtotal	NA	4,000	6,000	17,000	17,000	9,000	17,000	9,000	17,000
FINAL CAP CONSTRUCTION/SITE CLOSURE:									
NFSS	NA	9,000	10,000	NA	NA	9,000	NA	9,000	NA
Hanford† ¹⁰	NA	NA	NA	45,000	NA	12,000	45,000	NA	NA
Oak Ridge† ¹⁰	NA	NA	NA	NA	45,000	NA	NA	10,000	45,000
Subtotal	NA	9,000	10,000	45,000	45,000	21,000	45,000	19,000	45,000

Table 4.62. Continued

Activity/Site	Work Force Requirement (worker-days) for Each Alternative								
	1	2a	2b	3a	3b	4a	4b	4c	4d
SITE RESTORATION:									
NFSS	NA	1,000	1,000	3,000	3,000	1,000	3,000	1,000	3,000
Hanford† ²	NA	NA	NA	3,000	NA	1,000	3,000	NA	NA
Oak Ridge† ²	NA	NA	NA	NA	3,000	NA	NA	1,000	3,000
Subtotal	NA	1,000	1,000	6,000	6,000	2,000	6,000	2,000	6,000
OCEAN DISPOSAL OF WASTES:									
Harbor									
Waste unloading/loading† ¹¹	NA	NA	NA	NA	NA	NA	6,800	NA	6,800
Supervisory & monitoring† ¹²	NA	NA	NA	NA	NA	NA	1,400	NA	1,400
Ocean									
Tug & barge† ¹³	NA	NA	NA	NA	NA	NA	2,900	NA	2,900
Supervisory & monitoring	NA	NA	NA	NA	NA	NA	0	NA	0
Subtotal	NA	NA	NA	NA	NA	NA	11,100	NA	11,100
TOTAL AT SITES	8,000	33,000	55,000	194,000	194,000	87,000	170,000	95,000	180,000

†¹ Work force estimates for activities at the various sites are based on estimated work force requirements at NFSS as given by Bechtel National (1984a) and adjusted, as noted, for activities at other sites. Transportation work force not included. Totals given to nearest thousand worker-days. NA = not applicable.

†² Assumed to be same as at NFSS.

†³ Includes, as appropriate to each alternative, removal of all or part of the interim cap, relocation of the central ditch, construction of processing facilities, and other site preparation work.

†⁴ Assumes twice the effort as at NFSS for wastes plus residues and same effort as at NFSS for residues only.

†⁵ Assumes three times the effort as at NFSS for wastes plus residues and twice the effort as at NFSS for residues only.

†⁶ Assumes that the effort required to unload and place the packaged residues into the new trenches at Hanford or the containment area at Oak Ridge is approximately one-third the effort required to retrieve/package/load the residues at NFSS.

†⁷ Assumes slightly more effort to excavate and load the wastes for removal to Hanford than to Oak Ridge or the ocean because of the longer duration of this activity for the Hanford alternative due to transportation limitations (see Appendix D).

†⁸ Assumes that the effort to unload and dispose of the wastes, not including construction of caps and site restoration, is approximately one-half the effort needed to excavate and load the wastes at NFSS.

†⁹ Assumes that the radiological support for reinternment at Hanford or Oak Ridge is approximately one-half of that needed to disinter at NFSS.

†¹⁰ Effort to construct final caps and close sites at Hanford and Oak Ridge are proportioned to the effort at NFSS by the amount of backfill requirements.

†¹¹ Assumes 14 worker-days/shift × 2 shifts/day × 20 days/month × 6 months/year × 2 years.

†¹² Assumes 3 worker-days/shift × 2 shifts/day × 20 days/month × 6 months/year × 2 years.

†¹³ Assumes 11 workers × 4 trips/month × 44 hours/trip × 6 months/year × 2 years × 8 worker-days/8 hours.

Table 4.63. Estimated Injuries and Deaths
(Nontransportation)^{†1}

Alternative	Total Injuries	Total Fatalities
1	0.13	0.0015
2a	12	0.0064
2b	24	0.012
3a	100	0.044
3b	100	0.042
4a	36	0.018
4b	85	0.038
4c	42	0.018
4d	91	0.040

Activity	Injury Rate (no./worker-hour)	
	Nonfatal	Fatal
Construction ^{†2}	7.9×10^{-5}	1.5×10^{-8}
Material handling and processing ^{†3}	8.3×10^{-5}	3.3×10^{-8}
Maintenance, security, and monitoring ^{†4}	2.1×10^{-6}	2.3×10^{-8}

^{†1} Based on estimated total worker-days as given in Table 4.62, 8-hour days, and the injury rates as given in this table. All numbers rounded to two significant figures.

^{†2} Average incidence rates for the construction industry as a whole (U.S. Dep. Labor 1977, 1978, 1979; Argonne Natl. Lab. 1982). Applicable NFSS activities include: site preparation and demolition of building foundations.

^{†3} From U.S. Department of Labor (1978, 1979). Applicable NFSS activities include: residue retrieval/packaging/loading, waste retrieval/loading, construction of final cap, site restoration, and ocean disposal.

^{†4} From U.S. Atomic Energy Commission (1972). Applicable NFSS activities include: field supervision/environmental monitoring and radiological support.

manufacturing, services, etc.). Currently, there is no documentation that the existence of the NFSS wastes and residues in Niagara County has independently (independent of other industries in the area, e.g., SCA) had a negative influence on economic variables such as the distribution of industry, propensity of industry to move in and out of the area, or comparative measures of economic climate such as average household income or property value. The Niagara Falls area is much more dependent upon the volatile tourist industry, which is heavily influenced by negative publicity, than either the Hanford or Oak Ridge sites. This could theoretically lead to a differential influence on local economies. However, the potential for future impacts at NFSS is moderate to low for all alternatives except Alternative 1 (no action) in which the potential need for future remedial actions, with attendant negative publicity, is higher. Even in this case, however, the effect of negative NFSS publicity relative to negative publicity about other hazardous waste facilities in the area may be negligible. Furthermore, if there is an adverse impact, it will likely decrease as negative publicity decreases.

The Oak Ridge and Hanford sites are even less likely than NFSS to experience negative economic impacts associated with the NFSS wastes and residues. These communities are heavily dependent on federal dollars and may be less likely to be adversely affected by negative publicity about the NFSS wastes and residues than the tourist industry at NFSS.

The various alternatives may differentially influence the tax base of the three communities. Under Alternatives 3a, 3b, 4b, and 4d, all of the waste and residues will be removed from the NFSS

site, thus leaving the land available for other use. If the land is sold to private landowners, then the NFSS property will no longer be subject to exemption from property taxes and the county and local school district will benefit from the tax assessments of the land and whatever buildings are built on it. Under Alternatives 1, 2a, 2b, 4a, and 4c, all or some of the contaminated materials will remain at NFSS and the land would continue to be exempt from taxes.

4.6.5.3 Public Facilities and Public Services

At all sites, most local public facilities and services (such as police and fire protection, schools, and hospitals) are not expected to be adversely impacted under any of the alternatives because there will be no significant increase in the populations at any of the sites. Demands on state and local government services (such as public health and safety monitoring, legal, and oversight) will continue at NFSS. If the contaminated materials are taken to Oak Ridge or Hanford, there will be an incremental demand on such services at those sites. (See Section 4.6.3.4 for discussion of demands placed on emergency preparedness services for transportation of radioactive materials.)

4.6.6 Historic and Cultural Resources

At NFSS and Oak Ridge, no impacts on historic and cultural resources are expected (see Sections 3.1.6 and 3.3.6). At Hanford--before Alternatives 3b, 4a or 4b can be implemented--a survey will have to be conducted to determine if any archaeological resources are present at the 218W5 Area where the NFSS wastes and residues will be buried. If any valuable resources are discovered, appropriate measures will have to be taken to document and preserve such resources before construction activities take place. Such measures are readily undertaken and the presence of any archaeological resources will not likely lead to adverse impacts on historic and cultural resources.

4.6.7 Mitigation of Adverse Impacts

Following are some suggested measures to mitigate adverse socioeconomic impacts. The mitigative measures that will actually be implemented, after consideration by DOE, will be included in the Record of Decision.

Because many of the socioeconomic impacts previously discussed are a function of public perceptions, reducing public sensitivity and negative publicity will simultaneously reduce the potential for those socioeconomic impacts. Negative publicity and public sensitivity can be minimized by developing and maintaining formal and informal communication with state and local governments, interested environmental and citizens groups, private citizens and nearby landowners, and the local news media. This communication is especially important during the decision-making process and during the action period but should also continue into the maintenance and monitoring period as well. The affected public at all sites, as well as along transportation routes, should be included. Communication should be timely, voluntary, accurate, and responsive to public concerns.

Formal communication may be developed by providing scheduled periodic updates about ongoing and projected activities to key individuals from the above-mentioned groups. Informal communication may include information briefings and tours, mailings, and media updates.

Land-use and property-value impacts can be reduced by minimizing dust, noise, air pollutants, traffic congestion, and negative publicity. After engineering actions are complete, continued interaction with local planning agencies could reduce the potential for incompatible land uses to develop adjacent to the waste-management site. Land-use controls (e.g., restrictive covenants, zoning, etc.) could be exercised over both the surface and subsurface of the waste-management site as well as on adjacent lands. For example, at NFSS, restrictions on nearby well drilling and controls on drainage ditch development and maintenance could be implemented (Section 4.2). The level of government at which primary responsibility for these controls should lie has yet to be determined, although the trend had been for federal and/or state governments to maintain controls over the actual disposal sites.

Transportation impacts can be minimized by voluntary cooperation with local and state authorities along transportation routes to determine the most appropriate haul routes and trip times to reduce traffic congestion, accident potential, and road deterioration. At Oak Ridge, accelerated deterioration of Rt. 95 (White Wing Road) could possibly be mitigated by coordination with the state of Tennessee regarding the state plan for rebuilding that road. Contribution of federal funds to allow an earlier upgrading to offset the added deterioration caused by NFSS trucks could be considered. Scheduling of vehicle movements during off-peak traffic hours and provision of turning lanes and other safety measures could reduce transportation impacts. Proper maintenance of vehicles can reduce air pollution impacts.

At present, there are no provisions available for DOE to negotiate in-lieu-of tax payments to the town of Lewiston, the town of Porter, Niagara County, or the Lewiston-Porter School District. At the Oak Ridge and Hanford sites, DOE has Congressional authorization to make in-lieu-of tax payments to local governments.

DOE might also set aside a specified amount of money to be used for maintaining and monitoring the NFSS wastes and residues (see Appendix F for estimated maintenance and monitoring costs). However, there is currently no precedent for a federal agency to set up such a fund and special enabling legislation may be required.

4.7 INSTITUTIONAL ISSUES

Several major institutional issues have been identified as having potential bearing on the DOE decision regarding selection of the alternative for long-term management of the NFSS wastes and residues and procedures for implementation of the chosen alternative: (1) environmental regulations, (2) ocean-disposal regulations, (3) transportation regulations, and (4) funding.

4.7.1 Environmental Regulation

DOE has primary responsibility for managing health, safety, and environmental protection programs at DOE-owned, contractor-operated facilities. With respect to most radiological matters, DOE has issued several operating "Orders," pursuant to the Atomic Energy Act, that contain environmental guidelines for its various operations. The major orders that apply to the NFSS alternatives are listed in Section 1.6. However, with respect to nonradiological matters, DOE is generally subject to both the substantive and procedural requirements of most of the major federal environmental statutes.

4.7.1.1 DOE Orders and Internal Guidelines

Order 5480.1A (Environmental Protection, Safety and Health Protection Program for DOE Operations). DOE is in the process of revising its radiation standards for protection of the public in the vicinity of DOE facilities. Interim standards--effective July 1, 1985--limit the continuous dose to any member of the public to 100 mrem/yr for all routine DOE operations. The limit for the whole-body dose from the air pathway alone is 25 mrem/yr (in accordance with 40 CFR 61, Subpart H). Pending development of a revised Order, concentration guides presented in the current Order 5480.1A (Chapter XI--"Requirements for Radiation Protection") will continue to be used. These radiation protection standards are summarized in Table 4.64. Allowable concentrations of various radionuclides in air and water, both onsite and offsite, are also specified in Order 5480.1A. Limits for three radionuclides of particular interest to the NFSS wastes and residues are given in Table 4.65.

Order 5484.1 (Environmental Protection, Safety and Health Protection Information Reporting Requirements). For all of the alternatives, an environmental monitoring program will be implemented in accordance with Chapter III of DOE Order 5484.1. The program will be designed to determine:

- Whether containment and control measures to limit releases of radioactivity from the site are functioning as planned.
- Whether, and to what extent, environmental levels of radioactivity and other pollutants released from the site comply with applicable DOE guidelines.
- What is the overall impact of the site operation on the environment.

The environmental and effluent monitoring programs will be designed to:

- Demonstrate compliance with the requirements of DOE Order 5480.1, Chapters I, XI, and XIII, and with the appropriate criteria specified in DOE's proposed residual-contamination and waste-control criteria for formerly utilized sites and remote surplus facilities sites (Appendix H).
- Determine background levels and contribution from DOE activities of radioactivity and other pollutants in the site environs.
- Determine compliance with applicable environmental quality and public exposure limits and other environmental commitments (e.g., those published in environmental impact statements, Records of Decision, or other official documents).

An environmental monitoring report is currently prepared annually to summarize and interpret the levels of radioactivity and nonradioactive pollutants in the environs at each of the proposed land-management sites. Levels of pollutants are compared to applicable DOE guidelines and other standards and relevant parameters, such as background radioactivity. The environmental monitoring reports also summarize the results of monitoring to determine compliance with applicable nonradiological effluent standards and permit conditions. The results of any pertinent environmental surveys conducted by other federal, state, or local environmental protection agencies (as available) are also summarized and referenced in the reports. Effluent monitoring data for pollutants may be included in the report (a) if needed to demonstrate whether or not such effluents are in compliance with applicable effluent, emission, or environmental standards; or (b) if used to calculate offsite impacts. With regard to effluent monitoring data for radioactivity, the total number of curies in airborne and liquid effluents released to the offsite environment, and the nuclides of particular local interest, are included in the portions of the report dealing with air and water monitoring, respectively. In instances where liquid effluents released to different receiving streams may result in separate routes of potential environmental exposure, the radioactivity discharged to each receiving stream is identified.

Table 4.64. DOE Radiation Protection Guidelines
in Order 5480.1A

Type of Exposure	Exposure Period	Dose (rem)† ¹
<u>Individuals in Controlled Areas</u>		
Whole body, head and trunk, gonads, lens of the eye† ² , red bone marrow, active blood-forming organs	Year	5† ³
	Calendar quarter	3
Unlimited areas of the skin (except hands and forearms); other organs, tissues, and organ systems (except bone)	Year	15
	Calendar quarter	5
Bone	Year	30
	Calendar quarter	10
Forearm† ⁴	Year	30
	Calendar quarter	10
Hand† ⁴ and feet	Year	75
	Calendar quarter	25

	Annual Dose (rem)† ⁵	
Type of Exposure	Dose to Individuals at Points of Maximum Probable Exposure	Average Dose to a Suitable Sample of the Exposed Population
<u>Individuals and Population Groups in Uncontrolled Areas</u>		
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

†¹ To meet the standards, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ--by inhalation, ingestion, or absorption--a quantity of a radionuclide(s) that would commit the individual to an organ dose that exceeds the limits specified in this table.

†² A beta exposure below a maximum energy of 700 keV will not penetrate the lens of the eye; therefore, the applicable limit for these energies would be that for the skin (15 rem/yr).

†³ In special cases and with the appropriate approvals, a worker may exceed 5 rem/yr provided his/her average exposure per year since age 18 will not exceed 5 rem/yr. This does not apply to emergency situations.

†⁴ All reasonable effort shall be made to keep exposures of forearms and hands to the general limit for the skin.

†⁵ In keeping with DOE policy, exposures to the public shall be limited to as small a fraction of the respective annual dose limits as is reasonably achievable.

During 1979-1980, DOE requested that National Lead of Ohio (NLO), the NFSS operating contractor at the time, prepare an environmental monitoring report for that period. Subsequently, the NFSS operating contract was transferred to Bechtel National, Inc. (BNI). BNI continued the environmental monitoring program initiated by NLO and prepared environmental monitoring reports for 1981 and 1982. Any monitoring program modifications that may be necessary as a result of a decision to implement one of the NFSS long-term management alternatives will be summarized in the DOE Record of Decision.

Order 1540.1 (Materials Transportation and Traffic Management). The provisions of Order 1540.1, including the referenced rules and regulations, will control the transportation of the NFSS wastes and residues for any of the offsite alternatives (see Appendix D).

Order 5480.2 (Hazardous and Radioactive Mixed Waste Management). The provisions of Order 5480.2 apply to all DOE operations conducted under the authority of the Atomic Energy Act of 1954 (including any of the alternatives considered in this EIS) that result in the generation, transportation, treatment, storage and/or disposal of hazardous waste. DOE is analyzing the NFSS residues and wastes to determine if they might be classified as hazardous radioactive mixed wastes. (See Sections 3.7 and 3.8 for discussions of the radiological and chemical properties of the residues and wastes.)

Table 4.65. DOE Limits for Concentration of Radionuclides in Effluents Released to Uncontrolled Areas^{†1}

Radionuclide	Onsite Limit (pCi/L)		Offsite Limit (pCi/L)	
	Air	Water	Air	Water
Uranium-natural ^{†2}				
Soluble	0.07	20,000	0.003	600
Insoluble	0.06	500,000	0.003	2,000
Radium-226				
Soluble	0.03	400	0.003	30
Insoluble	0.05	900,000	0.002	30,000
Radon-222				
Soluble	100	NA	3	NA

^{†1} Allowable concentrations are based on DOE Order 5480.1A. NA = not applicable.

^{†2} A curie of natural uranium means the sum of 3.7×10^{10} disintegrations per second (dis/s) from U-238 plus 3.7×10^{10} dis/s from U-234 plus 1.7×10^9 dis/s from U-235. One curie of natural uranium is equivalent to 3000 kg (6600 lb) of natural uranium.

Order 5481.1 (Safety Analysis Review System). The provisions of Order 5481.1 will apply only to the Oak Ridge and Hanford long-term management alternatives.

Order 5482.1A (Environmental, Safety, and Health Appraisal Program--ES&H). Order 4382.1A applies to all contractors performing work for DOE where DOE has established environmental, safety, and health control under the contractual arrangements for the work to be performed. The ES&H appraisal requirement will apply only to the Oak Ridge and Hanford long-term management alternatives.

Order 5820.2 (Radioactive Waste Management). Order 5820 was issued recently on February 6, 1984. It assigns responsibilities and mandates the procedures for various DOE radioactive waste-management activities. Under this Order, the NFSS wastes and residues will be classified as "wastes contaminated with naturally occurring radionuclides." These wastes may be disposed at existing DOE low-level waste-disposal sites, at new facilities developed according to the same criteria specified for low-level waste, or at a disposal site established under the Uranium Mill Tailings Radiation Control Act of 1978 (Pub. L. 95-604). Order 5820 establishes broad guidelines for all DOE radioactive waste-management activities and facilities. The individual DOE field offices are assigned responsibility for developing project-specific or site-specific management criteria.

FUSRAP/SFMP Guidelines. Concurrent with the recent development of Order 5820, DOE Oak Ridge Operations has developed residual contamination guidelines for specific application to DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP) and for certain Surplus Facilities Management Program (SFMP) sites, such as NFSS, that are remote from other DOE production or research facilities. These guidelines are given in Appendix H. Contingent on approval and acceptance of these guidelines by the appropriate DOE authorities, the following additional guidelines may be applied to management of the wastes and/or residues at NFSS (Alternatives 1, 2a, 2b, 4a, and 4c):

1. Continued Interim Storage at NFSS (Alternative 1)
 - a. Control and stabilization features will be designed to ensure, to the extent reasonably achievable, an effective life of at least 25 years.
 - b. Radon concentration in the atmosphere above facility surfaces or openings shall not (1) exceed 100 pCi/L (above background) at any given point, or an average concentration of 30 pCi/L (above background) for the facility site, or (2) exceed an average radon concentration of 3.0 pCi/L (above background) at or above any location outside the facility site.
2. Long-Term Management at NFSS (Alternatives 2a, 2b, 4a, and 4c).
 - a. Control and stabilization features will be designed to ensure, to the extent reasonably achievable, an effective life of 1000 years and, in any case, at least 200 years.

- b. Radon emanation to the atmosphere from facility surfaces or openings shall not (1) exceed an average release rate of 20 pCi/m²/s, or (2) increase the annual average radon concentration at or above any location outside the facility site by more than 0.5 pCi/L (above background).

4.7.1.2 Environmental Laws

DOE facilities are also subject to both the substantive and procedural requirements of several federal environmental statutes. Executive Order 12088 requires federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the following federal laws:

- Toxic Substances Control Act
- Federal Water Pollution Control Act
- Public Health Service Act, as amended by the Safe Drinking Water Act
- Clean Air Act
- Noise Control Act
- Solid Waste Disposal Act, also referred to as the Resource Conservation and Recovery Act

Where a state has been delegated administrative authority by the federal government, state requirements are also applicable.

The regulatory programs and enforcement authorities for environmental statutes are generally shared by the states, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Commission (under the Department of the Interior), the U.S. Army Corps of Engineers, and other agencies. The major environmental laws that may impact a DOE decision regarding the NFSS wastes and residues are discussed below.

National Environmental Policy Act of 1969, as amended (NEPA). NEPA requires that, for major federal actions that may significantly affect the quality of the human environment, responsible officials shall prepare a detailed statement on the following:

- (i) the environmental impact of the proposed action,
- (ii) any adverse environmental effects that cannot be avoided if the proposal is implemented,
- (iii) alternatives to the proposed action,
- (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- (v) any irreversible and irretrievable commitments of resources that would be involved in the proposed action if it were implemented.

DOE has determined that the provisions of NEPA can be satisfied by following the procedures outlined by the Council on Environmental Quality for the preparation of this Environmental Impact Statement.

Clean Air Act. The Clean Air Act imposes certain restrictions and permit requirements on activities that result in the emission of pollutants to the air. Some activities associated with several of the alternatives will result in nominal releases of radon to the atmosphere and, during project action periods, particulate releases of radionuclides. For all of the alternatives except ocean dispersal, it is possible that air emission permits issued by the EPA under Section 112 of the Clean Air Act could be required. On April 6, 1983, EPA proposed control standards for radionuclides under 40 CFR 61, National Emission Standards for Hazardous Air Pollutants (NESHAP), that--when promulgated--will apply to DOE operating facilities. It is not yet clear whether these regulations will apply to any of the alternatives for long-term management of the NFSS wastes and residues. These proposed regulations would limit radionuclide emission to the amount that would not allow a dose equivalent of more than 10 mrem/yr to any organ of an individual living nearby.

Clean Water Act. Under Section 404 of the Clean Water Act, and 40 CFR 122, a discharge permit is usually required for waste water releases to public waters of the United States. Except for the no-action alternative (Alternative 1) and activities at Hanford (Alternatives 3a, 4a, and 4c), waste water containing both radioactive and nonradioactive constituents will be discharged to the environment. The nonradioactive parameters will be subject to concentration and/or quantity restrictions imposed by permits issued under the National Pollutant Discharge Elimination System (NPDES). In New York, the State Department of Environmental Conservation (DEC) is fully authorized to administer the NPDES program and, therefore, issues a State Pollutant Discharge Elimination System (SPDES) permit. DOE applied for and was issued a permit for the ongoing interim activities at NFSS (DEC Permit #NY0110469). If one of the long-term management alternatives is selected for implementation, the terms of the existing permit will have to be modified and extended, as necessary, to cover the new project. If the alternative for long-term management at Oak Ridge is implemented, an NPDES permit

will have to be obtained from the EPA, Region IV, in consultation with the Tennessee Department of Public Health and Environment. For the Hanford long-term management alternatives, decontamination waste water will be handled by natural evaporation. If some discharge to the Columbia River is necessary, an NPDES permit will have to be coordinated through EPA, Region X. For the vehicle and equipment decontamination facilities needed to implement the ocean-disposal alternative, an NPDES permit will have to be obtained from EPA, Region II, in consultation with the state of New Jersey.

Marine Protection Research and Sanctuaries Act. The ocean-disposal alternative will require the issuance of a permit by the EPA pursuant to regulations under 40 CFR 220-229 (see Section 4.7.2 for further discussion).

Resource Conservation and Recovery Act (RCRA) of 1976. DOE's long-term management of the wastes and residues currently at the Niagara Falls storage site will not require a permit under RCRA.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). DOE is conducting this action under the authority of the Atomic Energy Act, and it is not inconsistent with the applicable requirements of the National Contingency Plan. Superfund monies are not available for remedial actions at federal facilities.

Endangered Species Act. Section 7 of the Endangered Species Act requires federal agencies to consult with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in order to ensure that actions carried out by that agency do not jeopardize the continued existence of an endangered or threatened species or result in the adverse modification or destruction of critical habitat. Pursuant to this requirement, inquiries have been sent to the field offices of the Fish and Wildlife Service and to interested state agencies relative to the long-term management alternatives at Niagara Falls, Hanford, and Oak Ridge. The field office in Asheville, North Carolina, has advised that one endangered species, the gray bat, may be present at the Oak Ridge site, as well two plant species currently under status review. They have determined that, prior to implementation of any of the Oak Ridge alternatives, a biological assessment of the proposed Oak Ridge site alternative will be required to verify if these species are present on the Pine Ridge Knolls site.

National Historic Preservation Act. Section 106b of the National Historic Preservation Act requires careful consideration of potential impacts to cultural resources for actions undertaken by or on behalf of any federal agency. For each of the long-term management alternatives, inquiries were sent to the respective State Historic Preservation Officers (SHPOs). The SHPOs in New York and Tennessee have advised that little potential exists for cultural resource impacts at the Niagara Falls and Oak Ridge sites. The State of Washington Office of Archaeology and Historic Preservation recommended that a professional cultural resources survey of the Hanford site be conducted prior to the commencement of any project action at that location.

4.7.2 Ocean Disposal Regulation

Ocean disposal of the NFSS wastes will be subject to U.S. Environmental Protection Agency (EPA) ocean dumping regulations (40 CFR 227), and DOE will have to obtain a dumping permit from EPA. The EPA has been revising regulations to incorporate the London Dumping Convention rules (including the International Atomic Energy Agency [IAEA] waste classification criteria) into U.S. law. It is not yet clear how the NFSS wastes will be classified for purposes of ocean disposal. Based on the analysis presented in Section 4.1, an individual human being is expected to receive a dose of much less than 1 mrem/yr as a result of disposal of the NFSS wastes at Site 106 in the Atlantic Ocean. Therefore, the NFSS wastes may fall into a "de minimis" category. Although there is no official EPA definition, EPA has issued a Notice of Proposed Rulemaking as part of the environmental considerations for shallow-land burial regulations. Although EPA did not necessarily intend that the "de minimis" level for shallow-land burial regulations apply to ocean disposal, the general concept of a "de minimis" level can be applied. It is anticipated that, within the next year, the International Atomic Energy Agency will propose a definition that may be submitted to the London Dumping Convention.

If the IAEA finalizes its definition of what constitutes "de minimis" wastes and if the EPA adopts the IAEA definition, it is expected that the NFSS wastes will be able to be disposed by bulk dispersal under a General Permit according to Annex III of the London Dumping Convention. However, if it is determined that Annex II (governing dumping of radioactive wastes other than high-level wastes) applies, the NFSS wastes would have to be disposed in containers (such disposal is not considered in this EIS). If one of the ocean-disposal alternatives is selected, the EPA will determine the disposal requirements for the NFSS wastes when DOE applies for an ocean-disposal permit. In addition to specifications regarding how the NFSS wastes could be disposed, the EPA will need to designate a particular part of an existing ocean-disposal site or a new site for disposal of the NFSS wastes. Both the permitting and site-designation processes will entail extensive environmental review and public participation. Following are further details on the history of the ocean-disposal issue.

Between 1946 and 1962, the United States disposed of more than 100,000 containers of radioactive materials at about 30 locations off the East and West Coasts. Between 1960 and 1962, the U.S. Atomic Energy Commission (AEC) began to phase out ocean disposal; and, in 1970, the AEC stopped issuing ocean disposal licenses based upon Council on Environmental Quality (CEQ) recommendation that the dumping of

high-level radioactive wastes in the ocean be prohibited (Roberts 1982). This CEQ recommendation was subsequently incorporated into the Marine Protection, Research, and Sanctuaries Act of 1972 which allows dumping permits to be issued only when no alternative means of disposal exists, and even then only if special requirements are met (Norman 1982). This requirement has effectively prohibited ocean disposal of U.S. wastes. The act also requires the EPA to evaluate permit applications for ocean disposal of materials not prohibited by the Act, including low-level radioactive waste.

In order to develop criteria and issue permit requests for the ocean disposal of radioactive waste not covered under the 1972 ban, the EPA conducted a survey to evaluate the consequences of past U.S. ocean dumping. In concurrence with a General Accounting Office report on the same topic (U.S. Gen. Account. Off. 1981), the EPA concluded that past ocean dumping by the United States poses neither an environmental or public health hazard.

In 1973, the United States became a contracting party to the London Dumping Convention. Annex I of the convention prohibits ocean dumping of high-level radioactive wastes, and Annex II states that the contracting parties should take full account of the IAEA recommendations when issuing permits for dumping of other radioactive wastes (Hurd 1982). The EPA is currently considering the incorporation of the LDC rules and the IAEA definitions and recommendations for ocean dumping into the U.S. ocean dumping regulations. The London Dumping Convention rules also permit waste containing trace amounts to naturally occurring radionuclides (such as the NFSS wastes) to be dumped without being packaged. Members of the London Dumping Convention are complying with a voluntary ban on at-sea dumping of low-level radioactive wastes (packaged wastes) until October, 1985, when a report on the safety of at-sea disposal is expected to be completed.

The U.S. Senate and House of Representatives have subsequently amended Section 104 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1431(b)) to read "... during the two-year period beginning on the date of enactment of this subsection [January 6, 1983] no permit may be issued under Title I that authorizes the dumping of any low-level radioactive waste ..." except under special circumstances (Surface Transportation Assistance Act of 1982, Pub. L. 97-424, January 6, 1983)). This moratorium was based upon the concern that radioactive waste disposal might occur before completion of additional research into the possible impacts associated with such disposal (Ocean Dumping Amendments Act of 1982; 97th Congress, Rep. 97-562, Part 1, p. 9).

4.7.3 Transportation Regulation

Transport of the NFSS residues and wastes will be subject to federal regulations. Under federal law, the residues will be classified as radioactive, but the wastes will be classified as nonradioactive (see Appendix D for details). Shipment of the NFSS wastes and residues will be accomplished by commercial carriers contracted either directly to DOE or to a DOE prime contractor acting on behalf of DOE. Although regulations of the NRC do not legally apply to DOE shipments, DOE's own internal directives (DOE Order 1540.1) impose NRC's additional safety standards. (The NRC administrative requirements, however, do not apply.) The regulations of the Department of Transportation (DOT) and Interstate Commerce Commission (ICC) will also apply to shipments of the NFSS wastes and residues. (Details of transportation regulations, especially as they pertain to residue and waste classification, packaging, and routing are given in Appendix D.) Shipments of radioactive materials are generally preempted from state and local regulations (Hazardous Materials Transportation Act, Pub. L. 93-633).

However, a state or local municipality has the option of filing with DOT for a nonpreemption determination (i.e., a waiver of preemption--49 CFR 107.202-107.225). A state or local requirement influencing the transport of radioactive materials will cease to be preempted by federal law if the Secretary of the Department of Transportation finds that the state or local ruling (1) provides an equal or greater level of public safety than the Hazardous Materials Transportation Act or regulations issued thereunder, and (2) does not burden commerce. Preemption determination, therefore, does offer the state or local area with a recourse in the case of disputes over federal preemption. It cannot be determined at this time whether or not certain states might file for waiver of preemption. However, this will not be an issue under Alternatives 1, 2a, and 2b because the wastes and residues will remain at NFSS.

4.7.4 Funding

One of the issues raised during scoping is the question of funding for long-term management of the NFSS wastes and residues. Funds for DOE operations are allocated by Congress on a year-to-year basis. Some of the funds are tied to specific programs and some are not. Currently, funding for the ongoing interim activities at NFSS comes from two DOE programs: the Surplus Facilities Management Program (SFMP) and the Formerly Utilized Sites Management Program (FUSRAP). Both of these programs are under DOE's Nuclear Energy Program. DOE allocates funding to specific sites, including NFSS, within the SFMP and FUSRAP programs.

Funding for NFSS is also provided by payments that Afrimet-Indussa, Inc., is making to DOE as agreed to in the settlement signed by DOE and Afrimet on August 26, 1983 (see Section 1). Accordingly, Afrimet will pay DOE a total of \$8 million, in several installments, by October 14, 1984.

Funding to implement any of the various alternatives discussed in this EIS, regardless of the location of the waste-management facility, will probably be obtained through the Department's annual budget allocation to the Surplus Facilities Management Program. This includes funding for maintenance and monitoring activities. If, at some time in the future, environmental monitoring were to show noncompliance with then-existing criteria or standards, additional funding for corrective actions will have to be requested.

Although there is no precedent for a federal agency to set up a long-term maintenance and monitoring fund, this idea is being investigated as a possible measure to mitigate against potential lack of maintenance and monitoring due to cutbacks in yearly congressional allocations. (See Appendix F for estimated maintenance and monitoring costs.)

REFERENCES (Chapter 4)

- Acres American Incorporated. 1981. Hydrologic and Geologic Characterization of the DOE-Niagara Falls Storage Site. Prepared for NLO, Incorporated, Fernald, OH, by Acres American Incorporated, Buffalo, NY. September 30, 1981.
- Alexander, J.K. 1983. Status of NFSS SPDES Permit (Memorandum to Files dated April 12, 1983).
- American Cancer Society. 1978. 1979 Cancer Facts and Figures.
- Anderson, T.L., J.F. Dettorre, D.R. Jackson, and B.S. Asmus. 1981. A Comprehensive Characterization and Hazard Assessment of the DOE-Niagara Falls Storage Site. BMI-2074 (Revised). Prepared by Battelle Columbus Laboratories for the U.S. Department of Energy, Remedial Action Program.
- Argonne National Laboratory. 1982. Methods of Assessing Environmental Impacts of a FUSRAP Property-Cleanup/Interim-Storage Remedial Action. ANL/EIS-16. Prepared for U.S. Department of Energy Formerly Utilized Sites Remedial Action Program, by Argonne National Laboratory, Division of Environmental Impact Studies.
- Baes, C.F., III, and R.D. Sharp. 1983. A Proposal for Estimation of Soil Leaching and Leaching Constants for Use In Assessment Models. J. Environ. Qual. 12:17-28.
- Baldwin, S.A. 1983. Letter (Kivi Realty, Inc., Lewiston, NY) dated August 11, 1983, to J. Olshansky (Argonne National Laboratory, Argonne, IL).
- Bear, J. 1972. Dynamics of Fluids in Porous Media. American Elsevier Publishing Co., Inc., New York.
- Bechtel Civil and Minerals, Inc. 1982. FUSRAP: Niagara Falls Storage Site. Analysis of Contaminant Migration, Phase I Report. Job No. 14501. June 1982.
- Bechtel National, Inc. 1984a. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. DOE/OR/20722-1. Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. January 1984.
- Bechtel National, Inc. 1984b. Geologic Report, Niagara Falls Storage Site, Lewiston, New York. DOE/OR/20722-8. Prepared for U.S. Department of Energy. June 1984.
- Bechtel National, Inc. 1985. Building 411 Top. Estimates prepared for the U.S. Department of Energy, Oak Ridge Operations. June 1985. Attachment to letter from J. Nemec (Bechtel) to L. Keller (DOE), June 10, 1985.
- Brady, N.C. 1974. The Nature and Properties of Soils. 8th ed. Macmillan Publishing Co., New York, NY. 639 pp.
- Breedlow, P.A., M.C. McShane, and L.L. Caldwell. 1982. Revegetation/Rock Cover for Stabilization of Inactive Uranium Mill Tailings Disposal Sites - A Status Report. PNL 4328. Pacific Northwest Laboratory. 71 pp.
- Brown, D.J., and R.E. Isaacson. 1977. The Hanford Environment as Related to Radioactive Waste Burial Grounds and Transuranium Waste Storage Facilities. Prepared by Atlantic Richfield Hanford Company for the U.S. Energy Research and Development Administration. ARH-ST-155.
- Caldwell, M.M., and O.A. Fernandez. 1975. Dynamics of Great Basin shrub root systems, pp. 36-51. In N.F. Hadley (ed.), Environmental Physiology of Desert Organisms. Dowden, Hutchinson and Ross.
- Chen, S.Y., Y.C. Yuan, and J.M. Peterson. 1981. Estimation of radiological impact from transportation of uranium mill tailings, pp. 209-228. In Uranium Mill Tailings Management - 1981. Proceedings of the Fourth Symposium, October 26-27, 1981, Colorado State University, Fort Collins, CO.

- Chow, V.T. 1968. Handbook of Applied Hydrology. McGraw-Hill Book Company. New York.
- Cline, J.F., and D.W. Uresk. 1979. Revegetation of disturbed grounds in the semi-arid climate of southcentral Washington. Health Phys. 36:289-294.
- Cline, J.F., F.G. Burton, D.A. Cataldo, W.E. Skiens, and K.A. Gano. 1982. Long-Term Biobarriers to Plant and Animal Intrusions of Uranium Tailings. PNL-4340. Pacific Northwest Laboratory. 72 pp.
- Collins, J.F. 1983. Letter (John F. Collins Realty) to S.J. Olshansky (Argonne National Laboratory, Argonne, IL), dated March 30, 1983.
- Daubenmire, R. 1968. Plant Communities: A Textbook of Synecology. Harper and Row Publishers, Inc., New York. 300 pp.
- Dvorak, A.J., et al. 1978. Impacts of Coal-Fired Power Plants on Fish, Wildlife, and Their Habitats. FWS/OBS-78/29. Prepared for U.S. Fish and Wildlife Service, Office of Biological Services, by Argonne National Laboratory, Division of Environmental Impact Studies. 260 pp.
- EAL Corporation. 1984. Analysis Report to Eberline Instrument Corporation. November 19, 1984.
- Eisman P. 1983a. Letter (New York Department of Environmental Conservation), plus attachments, dated February 11, 1983, to E. Keller (Oak Ridge Operations, Oak Ridge, TN).
- Eisman, P. 1983b. Letter (New York Department of Environmental Conservation), plus attachments, dated October 19, 1983, to E. Keller (Oak Ridge Operations, Oak Ridge, TN).
- Exxon Nuclear Company, Inc. 1977. Nuclear Fuel Recovery and Recycling Center. XN-FR-33. Environmental Report, Docket No. 50-564. Vols. 1 and 3.
- Fitzner, R.E., K.A. Gano, W.H. Rickard, and L.E. Rogers. 1979. Characterization of the Hanford 300 Area Burial Grounds. Task IV. Biological Transport. PNL 2774. Pacific Northwest Laboratory. 86 pp.
- Foster, G.R. 1979. Sediment yield from farm fields: the Universal Soil Loss Equation and onfarm 208 plan implementation, pp. 17-24. In Universal Soil Loss Equation: Past, Present, and Future. Soil Sci. Soc. Am. Spec. Publ. No. 8.
- Gamble, H.B., and R.H. Downing. 1981. Effects of the Accident at Three Mile Island on Residential Property Values and Sales. Prepared for Division of Safeguards, Fuel Cycle and Environmental Research, U.S. Nuclear Regulatory Commission. NRC FIN B7078. April 1981.
- Gay, W.F. 1979. National Transportation Statistics. DOT-TSC-RSPA-79-19. U.S. Department of Transportation. August 1979. [As cited by Rao et al. (1982).]
- George, A.C., and A.J. Breslin. 1980. The distribution of ambient radon and radon daughters in residential buildings in the New Jersey-New York area, p. 1272. In T.F. Gesell and W.M. Lowder (eds.), Natural Radiation Environment III. CONF-780422 (Vol. 2). Proceedings of a symposium held at Houston, Texas, April 23-28, 1978.
- Geraghty, J.J., D.W. Miller, F. Van Der Leeden, and F.L. Troise. 1973. Water Atlas of the United States. Water Information Center, Port Washington, NY.
- Gilbert, T.L., P.C. Chee, M.J. Knight, J.M. Peterson, C.J. Roberts, J.E. Robinson, S.Y.H. Tsai, and Y.C. Yuan. 1983. Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites. ORO-832. Prepared for U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN, by Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, IL.
- Greig, R., and D. Wenzloff. 1977. Final report on heavy metals in small pelagic finfish, euphasid crustaceans and apex predators, including sharks, as well as on heavy metals and hydrocarbons (C_{15+}) in sediments collected at stations in and near Deepwater Dumpsite 106, pp. 547-564. In Baseline Report of Environmental Conditions in Deepwater Dumpsite 106, Volume III: Contaminant Inputs and Chemical Characteristics - Appendix. NOAA Dumpsite Eval. Rep. 77-1; PB-272 580. National Oceanic and Atmospheric Administration, Rockville, MD. June 1977.
- Hakonson, T.E. 1983. Personal communication (Environmental Science Group, Los Alamos National Laboratory, Los Alamos, NM) to R. Hinchman (Environmental Research Division, Argonne National Laboratory, Argonne, IL).

- Hakonson, T.E., J.F. Cline, and W.H. Rickard. 1983. Biological intrusion barriers for large volume waste disposal sites, pp. 289-308. In *Proceedings of Symposium on Low-Level Waste Disposal*. NUREG/CP-0028;CONF/820911, Vol. 3. U.S. Nuclear Regulatory Commission, Office of Nuclear Materials, Safety and Safeguards.
- Harris, V.A., J.Y. Yang, M.C. Bynoe, J.S. Warkentien. 1982. *Accident Mitigation: Slurry Wall Barriers*. Argonne National Laboratory.
- Healy, J.W., and J.C. Rodgers. 1978. *A Preliminary Study of Radium Contaminated Soils*. LA-7391-MS. Los Alamos Scientific Laboratory, Los Alamos, NM.
- Higgins, B.A., P.S. Puglia, R.P. Leonard, T.D. Yoakum, and W.A. Wirtz. 1972. *Soil Survey of Niagara County, New York*. U.S. Soil Conservation Service.
- Hinds, W.T., and J.M. Thorp. 1970. Estimates of wind erosion over newly burned sand surfaces, pp. 1.4-1.5. In *Pacific Northwest Laboratory Annual Report for 1970*. BNWL-1550, Vol. 1, Part 2.
- Hurd, M. 1982. Statement (Associate Assistant Administrator for Wastes, U.S. Environmental Protection Agency) before the Subcommittee on Oceanography, Subcommittee on Fisheries and Wildlife Conservation, and the Environment Committee on Merchant Marine and Fisheries, U.S. House of Representatives, March 18, 1982.
- International Commission on Radiological Protection. 1966. *Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract*. Prepared by ICRP Task Group on Lung Dynamics. Health Phys. 12:173-207.
- International Commission on Radiological Protection. 1977. *Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977)*. ICRP Publ. 26. Pergamon Press, Elmsford, NY.
- Joseph, A.B., P.F. Gustafson, I.R. Russell, E.A. Schuert, H.L. Volchok, and A. Tamplin. 1971. Sources of radioactivity and their characteristics, pp. 6-41. In *Radioactivity in the Marine Environment*. National Academy of Sciences, Washington, DC.
- Kelmers, A.D., and F.G. Seeley. 1983. *Geotechnical Studies for the Formerly Utilized Sites Remedial Action Program (FUSRAP) Site Management: Chemical Support*. Progress Reports for the Period February 16 - March 15, 1983 and March 16 - April 15, 1983. Oak Ridge National Laboratory, Chemical Technology Division, Oak Ridge, TN.
- Knight, M.J. 1983a. *The Effect of Soil Erosion on the Long-Term Stability of FUSRAP Near-Surface Waste-Burial Sites*. ANL/ES-18. Prepared by Argonne National Laboratory for the U.S. Department of Energy Formerly Utilized Sites Remedial Action Program.
- Knight, M.J. 1983b. *Uptake by Plants of Radionuclides from FUSRAP Waste Materials*. ANL/EIS-18. Prepared by Argonne National Laboratory, Argonne, IL, for the U.S. Department of Energy Formerly Utilized Sites Remedial Action Program. 22 pp.
- Lindsey, C.G., L.W. Long, and C.W. Begej. 1982. *Long-Term Survivability of Riprap for Armouring Uranium Mill Tailings and Covers: A Literature Review*. NUREG/CR-2642; PNL-4225. Prepared for U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, by Battelle Pacific Northwest Laboratory, Richland, WA.
- Luxmoore, R.J., T. Grizzard, and M.R. Patterson. 1981. *Hydraulic Properties of Fullerton Cherty Silt Loam*. Soil Sci. Soc. Am. J. 45:692-698.
- Martin, F.D., and G.E. Drewry. 1978. *Development of Fishes of the Mid-Atlantic Bight. Volume VI: Stromateidae through Ogcocephalidae*. FWS/OBS-78/12. U.S. Fish and Wildlife Service. January 1978.
- Mitchell, R.L. 1975. *Crop Growth and Culture*. Iowa State University Press, Ames. pp. 188-191.
- Momeni, M.H., Y. Yuan, and A.J. Zielen. 1979. *The Uranium Dispersion and Dosimetry (UDAD) Code. Version IX, A Comprehensive Computer Program to Provide Estimates of Potential Radiation Exposure to Individuals and to the General Population in the Vicinity of a Uranium Processing Facility*. NUREG/CR-0553; ANL/ES-72. Prepared for Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, DC, by Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, IL.
- Moses, H., H.F. Lucas, Jr., and G.A. Zerbe. 1963. The effect of meteorological variables upon radon concentrations three feet above the ground. *J. Air Pollut. Control Assoc.* 13:12-19.

- Musick, J.A., C.A. Wenner, and G.R. Sedberry. 1975. Archibenthic and abyssobenthic fishes of Deepwater Dumpsite 106 and adjacent area, pp. 229-269. In *Baseline Investigation of Deepwater Dumpsite 106* (May 1974). NOAA Dumpsite Eval. Rep. 75-1. National Oceanic and Atmospheric Administration. December 1975.
- National Academy of Sciences. 1960. The Effects of Atomic Radiation. Summary Reports. BEAR Report. Advisory Committee on the Biological Effects of Atomic Radiation, National Research Council, Washington, DC.
- National Academy of Sciences. 1972. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation. BEIR I Report. Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Research Council, Washington, DC.
- National Academy of Sciences. 1980. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation. BEIR III Report. Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Research Council, Washington, DC.
- National Council on Radiation Protection and Measurements. 1975. Natural Background Radiation in the United States. NCRP Report No. 45. Washington, DC.
- Nigg, J.M. 1982. The Media and Environmental Hazards: The Problem of Formulating Social Definitions of Risk. Paper presented at the annual meeting of the Society for the Study of Social Problems, San Francisco, CA, September 3-6, 1982.
- Norman, C. 1982. U.S. considers ocean dumping of radwastes. *Science* 215:1217-1219.
- Nuclear Safety Associates Inc. 1980. Comparison of Alternatives for Long-Term Management of High-Level Radioactive Waste at the Western New York Nuclear Service Center. Prepared by Nuclear Safety Associates Inc., Bethesda, MD, for Argonne National Laboratory, Argonne, IL. Appendix IIIC. September.
- Paul, J.F., V.J. Bierman, Jr., H.A. Walker, and J.H. Gentile. 1983. Application of a Hazard Assessment Research Strategy for Waste Disposal at Deepwater Dumpsite 106. Draft submitted for publication (March 1983).
- Payne, B.A. 1983. Public response as an element of a social environment: direct, feedback, and interaction effects. Submitted to Environmental Impact Assessment Review, April 13, 1983.
- Roberts, L. 1982. Ocean dumping of radioactive waste. *BioScience* 32(10):773-776.
- Skidmore, E.L. 1983. Wind erosion calculator: revision of residue table. *J. Soil Water Conserv.* 38:110-112.
- Skidmore, E.L., and N.P. Woodruff. 1968. Wind Erosion Forces in the United States and Their Use in Predicting Soil Loss. U.S. Dep. Agric. Agric. Handb. No. 436. 42 pp.
- Spurr, S.H., and B.V. Barnes. 1973. *Forest Ecology*. 2nd. ed. Ronald Press, New York. pp. 266-271.
- Streng, D.L., and T.J. Bander. 1981. MILDOS - A Computer Program for Calculating Environmental Radiation Doses from Uranium Recovery Operations. NUREG/CR-2011; PNL-3767. Prepared for the U.S. Nuclear Regulatory Commission, Washington, DC, by Pacific Northwest Laboratory, Richland, WA.
- Swann, M.E., W. Roberts, E.H. Hubbard, and H.C. Porter. 1942. Soil Survey of Roane County, Tennessee. U.S. Department of Agriculture, Bureau of Plant Industry.
- Szabo, M.F. 1978. Environmental Assessment of Coal Transportation. EPA-600/7-78-081. Prepared for the U.S. Environmental Protection Agency by PEDCo Environmental, Inc., Cincinnati, OH. May 1978.
- Templeton, W.L. 1979. Radiological Aspects of Seabed Dumping in the Deep Oceans. Proceedings of the Third NEA Seminar on Marine Radioecology. Nuclear Energy Agency.
- United Nations Scientific Committee on the Effects of Atomic Radiation. 1977. Sources and Effects of Ionizing Radiation. UN Publ. No. E.77.IX.I. Report to the General Assembly, United Nations, New York.
- Uresk, D.W., R.E. Fitzner, L.E. Rogus, and W.H. Rickard. 1977. Biotic Components. In: L.E. Rogers and W.H. Rickard (eds.). *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report* prepared by Battelle Pacific Northwest Laboratories for the U.S. Department of Energy.
- U.S. Atomic Energy Commission. 1972. Operational Accidents and Radiation Exposures Experienced Within the USAEC, 1943-1970. WASH-1192.

- U.S. Department of Agriculture. 1981. Soil Survey of Anderson County, Tennessee. Soil Conservation Service with the Tennessee Agricultural Experiment Station.
- U.S. Department of Energy. 1983a. Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites. ORO-832. March 1983.
- U.S. Department of Energy. 1983b. Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program. ORO-831. March 1983.
- U.S. Department of Energy. 1983c. Action Description Memorandum. Proposed Interim Remedial Actions for FY 1983. February 14, 1983.
- U.S. Department of Energy. 1983d. Action Description Memorandum. Proposed Interim Remedial Actions for FY 1983-85 Accelerated Program.
- U.S. Department of Energy. 1983e. Notice of Intent (Central Waste Disposal Facility at Oak Ridge). November 15, 1982.
- U.S. Department of Labor. 1977. Chartbook on Occupational Injuries and Illnesses in 1975. Report 501. Washington, DC.
- U.S. Department of Labor. 1978. Chartbook on Occupational Injuries and Illnesses. Report 535. Washington, DC.
- U.S. Department of Labor. 1979. Occupational Injuries and Illnesses in 1977: A Summary. Report 561. Washington, DC.
- U.S. Environmental Protection Agency. 1972. Water Quality Criteria.
- U.S. Environmental Protection Agency. 1977a. Compilation of Air Pollution Emission Factors. AP-42. Research Triangle Park, NC.
- U.S. Environmental Protection Agency. 1977b. Multimedia Environmental Goals for Environmental Assessment. Volume II. MEG Charts and Background Information. EPA-600/7-77-136b. November 1977.
- U.S. Environmental Protection Agency. 1980a. Final Environmental Impact Statement (EIS) for 106-Mile Ocean Waste Disposal Site Designation. February 1980.
- U.S. Environmental Protection Agency. 1980b. Water quality criteria documents; availability. Fed. Regist. 45(231):79318-79379 (November 28, 1980).
- U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR 192. Fed. Regist. 48(3):590-609 (January 5, 1983).
- U.S. General Accounting Office. 1981. Hazards of Past Low-Level Radioactive Waste Dumping Have Been Overemphasized. EMD-82-9. October 21, 1981.
- U.S. Nuclear Regulatory Commission. 1977a. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I. Regulatory Guide 1.109 Office of Standards Development.
- U.S. Nuclear Regulatory Commission. 1977b. Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes. Docket No. DR-71, 73 (40 FR 23768). NUREG-0170, Vol. 1. Office of Standards Development. December 1977.
- U.S. Nuclear Regulatory Commission. 1980a. Final Generic Environmental Impact Statement on Uranium Milling. Vol. 1. Summary and Text; Vol. 2, Appendices A-F; Vol. 3, Appendices G-V. NUREG-0706. Office of Nuclear Material Safety and Safeguards. U.S. Nuclear Regulatory Commission, Washington, DC.
- U.S. Nuclear Regulatory Commission. 1980b. Technology, Safety and Costs of Decommissioning a Reference Low-Level Waste Burial Ground. NUREG/CR-0570.
- U.S. Nuclear Regulatory Commission. 1981. Draft Environmental Statement Related to the Operation of WPPSS Nuclear Project No. 2. NUREG-0812. July.
- U.S. Nuclear Regulatory Commission. 1983a. Final Environmental Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois. Docket No. 40-2061. NUREG-09. Office of Nuclear Material Safety and Safeguards. May 1983.
- U.S. Nuclear Regulatory Commission. 1983b. Information Report on State Legislation. NUREG/BR-0025. Office of State Programs. December 15, 1983.

- VanKat, J.L. 1979. The Natural Vegetation of North America: An Introduction. John Wiley and Sons, Inc., New York. 261 pp.
- Whittaker, R.H. 1975. Communities and Ecosystems. 2nd ed. Macmillan Publishing Co., Inc., New York. 385 pp.
- Wischmeier, W.H., and D.O. Smith. 1978. Predicting Rainfall Erosion Losses - A Guide to Conservation Planning. Agricultural Handbook No. 537. Prepared for the U.S. Department of Agriculture by Science and Education Administration, Washington, DC. 58 pp.
- Woodruff, N.P., and F.H. Siddoway. 1965. A Wind Erosion Equation. Soil Sci. Soc. Am. Pro. 29(5):602-608.
- Yamamoto, T. 1982. A Review of Uranium Spoil and Mill Tailings Revegetation in the Western United States. U.S. For. Serv. Gen. Tech. Rep. RM-92. 20 pp.
- Yeh, G.T. 1981. AT123D: Analytical Transient One-, Two-, and Three-Dimensional Simulation of Waste Transport in an Aquifer System. ORNL-5602. Oak Ridge National Laboratory, Oak Ridge, TN. 88 pp.
- Yuan, Y.C., and P.C. Chee. 1982. Estimation of radiological impact from transportation of uranium mill tailings. Part II: dispersion and dosimetry, pp. 165-174. In Uranium Mill Tailings Management - 1982. Proceedings of the Fifth Symposium, December 9-10, 1982, Colorado State University, Fort Collins, CO.

5. LIST OF CONTRIBUTORS

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Paul A. Benioff	Ph.D. Chemistry 8 yr experience in environmental impact assessment, 18 yr experience in chemistry	Chemical description of NFSS wastes/residues, chemical impacts, engineering of modified form, cost analyses
Jean E. Bogner	M.S. Geology 15 yr experience in engineering geology, hydrogeology, and environmental geology	Containment options
Ping C. Chee	Ph.D. Health Physics 8 yr experience in radiological health physics assessment	Radiological impact analyses
Sue Ann Curtis	Ph.D. Anthropology 11 yr experience in socioeconomic and cultural resources assessment; 17 yr experience in archaeology	Discussion of archaeological and cultural resources at Hanford
Ray R. Hinchman	Ph.D. Botany 12 yr experience in environmental impact assessment, including 9 yr experience in reclamation/rehabilitation research	Ecology impacts
Mark J. Knight	M.En. Applied Ecology 8 yr experience in environmental assessment of energy-related projects	Erosion impacts, ecology of affected environments
Pamela Merry-Libby	B.S. Biology 14 yr experience in environmental assessment of energy-related projects	Project Leader
S.J. Olshansky	Ph.D. Sociology 5 yr experience in sociological assessment	Population and socioeconomic description of existing environments; socioeconomic impacts
John M. Peterson	M.S., P.E. Nuclear Engineering 11 yr experience in nuclear programs, including 7 yr in environmental assessment	Engineering, transportation, and radiological analysis

Name and Affiliation	Education/Expertise	EIS Contribution
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Elizabeth A. Stull	Ph.D. Zoology 12 yr experience in environ- mental impact assessment	Ocean disposal site description and marine impacts
Ronald C. Sundell	M. Urban Planning 9 yr experience in environ- mental and land use assess- ment	Description of existing land use and impacts to land use
Roger L. Tobin	Ph.D. Industrial Engineering 12 yr experience in trans- portation modeling and analysis	Rail transportation options
Steven Y.H. Tsai	Ph.D. Civil Engineering 9 yr experience in hydrologic analysis and environmental assessment	Description of existing hydro- logy and hydrologic impact analyses
William S. Vinikour	M.S. Biology (environmental emphasis) 12 yr experience in environ- mental impact assessment and aquatic research	Discussion of endangered species at Oak Ridge
Seymour Vogler	B.S. Chemistry 39 yr experience in nuclear fuel reprocessing, waste management, and assessment of environmental impacts of coal utilization	Engineering options
W. Sedgfield White	Ph.D. Limnology 12 yr experience in environ- mental assessment and aquatic ecology	Description of existing ecology at Oak Ridge
Margery C.B. Winters	M.S. Physical Geography 6 yr experience in geologic analysis and environmental assessment	Assistant Project Leader, description of existing geology, geological impacts, site integrity analyses
Dimis J. Wyman	M.S. Botany, M.A. Library Science 11 yr experience in technical editing	Overall editorial responsibility for preparation of EIS
Yu-Chien Yuan	Ph.D. Nuclear Engineering 10 yr experience in radiological impact assessment of nuclear facilities	Radiological impacts
<u>TECHNICAL STAFF, DOE</u>		
James K. Alexander	M.S. Civil Engineering, M.S. Public Administration 12 yr experience in government environmental programs	Discussion of institutional issues

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APPENDIX B. GLOSSARY

- ABSORBED DOSE**--The amount of energy absorbed in any material from incident radiation. Measured in rads, where 1 rad equals 100 ergs of energy absorbed in 1 gram of matter.
- ACTION PERIOD**--For this EIS, the action period includes the 10-year period during which physical actions such as transportation, stabilization, ocean dispersal, etc., will take place.
- ACTIVITY**--A measure of the rate at which radioactive material is undergoing radioactive decay; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The special unit of activity is the curie (Ci).
- ALLUVIUM**--All material deposited permanently or in transit by streams.
- ALPHA PARTICLE**--A particle emitted from the nucleus during the radioactive decay of certain nuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.
- AQUIFER**--A water-bearing layer of permeable rock or soil that will yield water in usable quantities to wells. Confined aquifers are bounded on top and bottom by less-permeable materials. Unconfined aquifers are bounded on top by a water table.
- ARTESIAN AQUIFER**--An aquifer that is confined so that its hydraulic head rises above the top of the aquifer unit; thus, an artesian water body is one that is confined under hydraulic pressure.
- BACKGROUND RADIATION**--In this EIS, background radiation includes both the natural and man-made (e.g., fallout) radiation in the human environment. It includes cosmic rays and radiation from the naturally radioactive elements that occur both outside and inside the bodies of humans and animals. For persons living in the United States, the individual dose from background radiation ranges from about 80 to 200 millirems per year.
- BASIN**--See SEDIMENTARY BASIN.
- BEDROCK**--A solid rock formation usually underlying one or more other loose formations.
- BENTHIC**--Refers to the bottom of a body of water.
- BETA PARTICLE**--A particle emitted from the nucleus during radioactive decay. Beta particles are easily stopped by a thin sheet of metal or plastic. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body.
- CONTAINMENT**--Confining the radioactive wastes within prescribed boundaries, e.g., within a waste package.
- CUMULATIVE RADIATION DOSE**--The total dose resulting from repeated radiation exposures of the same organ or the whole body over a period of time.
- CURIE**--A measure of the rate of radioactive decay. One curie is equal to 37 billion disintegrations per second (3.7×10^{10} dis/s), which is approximately equal to the decay of one gram of radium.
- CUTOFF WALL**--A low-permeability, engineered subsurface structure designed to minimize groundwater flow in direction perpendicular to the wall.
- DECAY CHAIN (DECAY SERIES)**--The nuclides in the sequence of radioactive decay from one nuclide to another until a stable (nonradioactive) nuclide is reached. The uranium-238 decay chain starts with naturally radioactive uranium-238 and ends with stable lead-206. The term "decay" is also referred to as "disintegration" or "transformation."
- DECOMMISSIONING**--To remove a facility from service and reduce or stabilize radioactive contamination.
- DECONTAMINATION**--The selective removal of radioactive material from a surface or from within another material.
- DEMOGRAPHY**--Study of human population--size, density, distribution, and vital statistics (e.g., age, sex, and ethnicity).

DISCHARGE--In groundwater hydrology, water that issues naturally or is withdrawn from an aquifer.

DISPERSAL--Act or result of scattering a material in the environment.

DISPERSION--The continuous variation in the concentration of a pollutant or tracer as it moves through a porous medium. Refers to the rate of mixing and transport of the pollutant in the medium (e.g., atmosphere, groundwater, etc.).

DISPOSAL, RADIOACTIVE WASTE--Emplacement of radioactive waste in a manner considered permanent and for which further management is not provided.

DISTRIBUTION COEFFICIENT (K_d)--Ratio of the concentration of a constituent absorbed on soil particles to the concentration of the dissolved constituent in water.

DOSE--Total radiation delivered to a specific part of the body, or to the body as a whole.

DOSE COMMITMENT--The dose that an organ or tissue would receive during a specified period of time (e.g., 50 or 100 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from one-year's release.

DOSE EQUIVALENT--A term used to express the amount of effective radiation when modifying factors have been considered. It is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rems (roentgen equivalent man).

DOSE RATE--Radiation per unit time (i.e., rem per minute, rem per hour) as it is being delivered to the body.

EFFLUENT--Liquid, gaseous, or solid discharges into the environment generated by a process or procedure.

EPICENTER--The point on the surface of the earth above the focus of an earthquake.

EXPOSURE, RADIATION--The amount of ionization produced in air by X-rays or gamma rays, measured in roentgens (R). A person standing for one hour in a one-roentgen-per-hour (1 R/h) radiation field of X-rays or gamma rays will incur a dose equivalent of about 1 rem.

FAULT--A fracture or fracture zone along which there has been displacement of the sides relative to one another, parallel to the fracture.

FLOODPLAIN--The portion of a river or stream valley that periodically is inundated. The 100-year floodplain is the area that is likely to be inundated once in 100 years.

FRACTURE--Breaks in rock formations due to structural stresses. Fractures may occur as faults, shears, joints, or planes of fracture cleavage.

GAMMA RADIATION--Penetrating high-energy, short-wavelength, electromagnetic radiation (similar to X-rays) emitted during radioactive decay. Gamma rays are very penetrating and require dense materials (such as lead or uranium) for shielding or to be stopped.

GEOHYDROLOGY--The study of the character, source, and mode of occurrence of underground water.

GENETIC EFFECTS OF RADIATION--Effects of radiation on subsequent generations as a result of damage to the genetic structure of the exposed individual.

GROUNDWATER--Usually considered to be the water within the zone of saturation below the soil surface.

GROUT--A mortar fluid combined with liquid to provide a matrix for sealing an area.

HALF-LIFE--The time it takes for half the atoms of a quantity of a particular radioactive element to decay into another form. Half-lives of different isotopes vary from millionths of a second to billions of years.

HORIZONTAL ACCELERATION--A measure of earthquake severity, expressed as surface movement in terms of acceleration due to gravity (g).

HYDRAULIC CONDUCTIVITY--The quantity of water that will flow through a unit cross-sectional area of porous material per unit of time under a hydraulic gradient of 100 at a specific temperature.

HYDRAULIC GRADIENT--The change in static head per unit of lateral distance in a given direction.

HYDROLOGIC--Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

IMMOBILIZATION--Treatment and/or emplacement of the wastes so as to impede their movement.

IMPERMEABLE LINER--Material placed on the bottom and sides of a waste impoundment to contain the waste material. No liner is completely impermeable, but many synthetic materials are relatively impermeable compared to natural earth liners.

INDIVIDUAL DOSE--The radiation dose received by an individual in the vicinity of an activity involving the handling of radioactive material.

INFILTRATION RATE, SOIL--The rate at which water enters the surface layer of soil.

INSTITUTIONAL CONTROL--Management by any governmental or other organized body. Institutional controls may include: record keeping, limitations on land ownership and use, maintenance and security activities, monitoring, or other enforced restrictions.

INTERIM REMEDIAL ACTION--Operations for which (a) monitoring and human control are provided and (b) subsequent action involving treatment, transportation, or final disposition is expected.

INTRUSION--Any action by a person that brings that person in contact with all or part of radioactive wastes so as to produce a radiation dose to that person or to others.

ION EXCHANGE--Replacement of ions adsorbed on a solid, such as a clay particle, or exposed at the surface of a solid by ions from solution, usually in natural water. The phenomenon is known to occur when natural water moves through clays, zeolitic rocks, and other materials of the earth's crust.

ISOTOPE--Nuclides having the same atomic number but different mass numbers.

LEACH--To remove or separate soluble components from a solid by contact with water or other liquids.

LITTORAL--Belonging to, inhabiting, or taking place on or near the shore of a body of water.

LONG-TERM PERIOD--For this EIS, the period between the completion of the maintenance/monitoring period (200 years) and 1000 years. Loss of various site controls are assumed during this period.

MAINTENANCE/MONITORING PERIOD--For this EIS, the period during which the wastes and residues will continue to be managed and containment structures will be maintained.

MANAGEMENT, RADIOACTIVE WASTE--The act of managing or controlling radioactive waste. In this EIS, the term "long-term management" is used instead of the term "disposal" for those alternatives wherein the NFSS wastes and residues will remain on land. Because the radionuclides in the NFSS wastes and residues have long half-lives and the potential hazard will not diminish appreciably for thousands of years, there will be a continuing need for management of these materials.

MODIFIED MERCALLI (MM) INTENSITIES--Descriptions of ground effects of an earthquake in the absence of instruments. The MM scale describes a range of observations and bodily sensations characterizing 12 different levels of ground shaking. The MM scale is nonlinear.

OLD-FIELD SUCCESSION--The progressive changes in vegetation and animal species structure and community processes that follow the abandonment of cropland or pasture.

OVERBURDEN--All material (loose soil, sand, gravel, etc.) that lies above bedrock.

ORGANIC CHEMICAL--Carbon compounds, especially those in which hydrogen is attached to carbon, whether derived from living organisms or not.

ORGAN DOSE--The radiation dose to a specific organ.

PERMEABILITY--The relative ease with which a porous medium can transmit a liquid under a hydraulic gradient. In hydrology, the capacity of rock, soil, or sediment for allowing the passage of water.

PERSON-REM--The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem (1/1000 rem) would have a collective dose of 1 person-rem.

PIEZOMETRIC SURFACE--The surface defined by the levels to which groundwater will rise in tightly cased wells that tap an artesian aquifer.

PLANT COMMUNITY--Any assemblage of plant populations living in a prescribed area or physical habitat. An organized unit having characteristics additional to its individual and population components.

POPULATION DOSE--Summation of the doses received by all individuals in a specified population in the vicinity of an activity involving the handling of radioactive material.

POROSITY--That property of a rock or soil that enables the rock or soil to contain water in voids or interstices, usually expressed in percentage or as a decimal fraction of void volume as compared to total volume.

RADIONUCLIDE--An unstable nuclide that undergoes radioactive decay.

RAD--Unit of absorbed dose; acronym for radiation absorbed dose (see ABSORBED DOSE).

RADIATION--A very general term that covers many forms of particles and energy, from sunlight and radio waves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, X-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIOISOTOPE--An unstable isotope of an element that spontaneously loses particles and energy through radioactive decay.

RADIOLOGICAL CONVERSION FACTORS--

	<u>SI Units</u>	<u>Conventional Units</u>
Dose	Gray (1 Gy = 1 J/kg = 100 rad)	rad
Dose equivalent	Sievert (1 Sv = 100 rem)	rem
Activity	Becquerel (1 Bq = 1 t/s = 2.703×10^{-11} Ci)	Ci (Curie)

RADIUM-226--A radioactive solid produced by the decay of thorium-230. It is an alpha emitter and is hazardous when it gets into the body. Radium-226 has a half-life of 1600 years and can accumulate in certain parts of the body such as bone.

RADON-222--A radioactive gas produced by the decay of radium-226. It is hazardous mainly because its solid decay products can be deposited in the lungs where they decay in a matter of minutes, emitting alpha radiation that irradiates nearby tissue. Radon-222 has a half-life of 3.8 days.

RECHARGE--In hydrology, a source or means for replenishment of water withdrawn or discharged from an aquifer.

REGULATION--A law promulgated by an administrative agency or regulatory commission. Federal agencies and commissions obtain their power to promulgate laws from the U.S. Congress; state agencies and commissions obtain such power from their respective state legislatures.

REM (ROENTGEN EQUIVALENT MAN)--A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. It is the product of the adsorbed dose in rads and factors related to relative biological effectiveness.

RESIDUES--For this EIS, the K-65, L-30/F-32, and L-50 residues that resulted from the processing of uranium ores.

RETRIEVABLE--Radioactive material in a safe storage mode, packaged and secured in such a way that subsequent removal can be done easily, with minimum environmental impact and personnel exposure.

RISK--Assuming the factors can be quantified, risk equals the consequences per event multiplied by the probability of the event's occurrence.

ROENTGEN (R)--Unit of exposure. One roentgen is the amount of gamma rays or X-rays required to produce one electrostatic unit (esu) of charge of one sign (either positive or negative) in one cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, a German scientist, who discovered X-rays in 1895.

RUNOFF--All rainfall and snowmelt that does not soak into the ground, does not evaporate immediately, or is not used by vegetation, and hence flows over the land surface.

SCOPING--The process of determining the range of actions, alternatives, and impacts to be considered in an EIS.

SECULAR EQUILIBRIUM--In a radioactive decay series, the state that prevails when the ratios between the amounts of successive members of the series remain constant over time.

SEDIMENTARY BASIN--A geologically depressed area that has thick sediments in the interior and thinner sediments at the edges.

SEEPAGE--Any water or liquid effluent that flows through a porous medium (e.g., water lost through the bottom of a containment area).

SEISMIC--Having to do with the geology of earthquakes and extending to prediction of earthquake frequency and severity.

SHIELDING--A material interposed between a source of radiation and people for protection against the danger of radiation. Commonly used shielding materials are concrete, water, and lead.

SOLIDIFICATION--For this EIS, conversion of the radioactive residues to a stable solid.

SOLUTION CAVITIES/CHANNELS--Cavities or channels formed in carbonate rocks--such as limestone, dolomite, and marble--caused by the chemical solutioning of the rock along fractures, joints, etc.

SOMATIC EFFECTS OF RADIATION--Effects of radiation that are limited to the exposed individual, as distinguished from genetic effects that may also affect subsequent unexposed generations.

SOURCE TERMS--The quantity of radioactive material (or other pollutant) released to the environment at its point of release (source).

SPECIFIC ACTIVITY--The activity per unit volume of a pure substance (see ACTIVITY).

STORAGE--For this EIS, retention of waste in some type of man-made device in a manner permitting retrieval.

STORAGE COEFFICIENT--The amount of water in storage released from a column of aquifer with a unit cross section under a unit decline of head.

STRATUM--Sedimentary bed or layer, regardless of thickness, of homogeneous or gradational rock material.

TECTONIC--Of, pertaining to, or designating the process causing, and the rock structures resulting from, deformation of the earth's crust.

THORIUM-230--A radioactive solid produced by the decay of uranium-238. It has a half-life of 77,000 years.

TILL--Unstratified glacial deposits consisting of clay, sand, gravel, and boulders intermingled.

TRACE ELEMENTS--Chemical elements that normally are present in minute (trace) quantities. Includes metals such as chromium, zinc, cadmium, and copper, and nonmetals such as selenium, boron, and arsenic.

TRANSMISSIVITY--Volume of water flowing through a unit width of aquifer of given thickness under a unit gradient (1 m vertically for each 1 m laterally) and at the viscosity prevailing in the field. Mathematically, it is the product of permeability and aquifer thickness.

TRENCH, SHALLOW-LAND BURIAL--A long, narrow excavation with unsupported walls, into which solid radioactive wastes are emplaced and covered with excavated earth.

URANIUM--A naturally occurring radioactive element that consists of 99.2830% by weight uranium-238, 0.7110% uranium-235, and 0.0054% uranium-234.

WASTES--For this EIS, all contaminated materials (primarily soils) not defined as residues.

WASTE IMMOBILIZATION--Process of converting waste to a stable solid form that is relatively insoluble.

WATERSHED--An area of land that drains into a water body. Watersheds are separated by divides.

WATER TABLE--The upper surface of the zone of water saturation in the subsurface at which the pressure is equal to atmospheric pressure--the upper surface of an unconfined aquifer.

WELL YIELD--The rate at which a well yields water.

WHOLE-BODY DOSE--The radiation dose to the entire body.

WORKING LEVEL (WL)--Any combination of radon-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of radon-222 in 1 liter of air, where the decay products are in radiological equilibrium with the parent.

APPENDIX C. ENGINEERING OPTIONS

The alternatives analyzed in this EIS are based on several conceptual designs that span the range of alternatives available to the DOE decision-maker. Within each alternative are several steps towards the ultimate long-term management of the NFSS wastes and residues. At each of these steps, there are several options available, only a few of which are included in the definition of those alternatives in this EIS. Following are discussions of engineering options for: (1) retrieval, packaging, and loading of the contaminated materials (Section C.1), (2) modification of the form of the residues, including possible recovery of valuable resources (Section C.2), and (3) containment of the wastes and residues (Section C.3). Transportation options are discussed in Appendix D.

In developing engineering options, the two types of radioactive materials at NFSS must be considered:

- (1) Wastes--180,000 m³ of contaminated soils (including the R-10 residues, see Section 3.1.7), having an estimated average radium-226 concentration of 36 pCi/g and a total of 7.8 Ci of radium-226
- (2) Residues--11,000 m³ of residues from the processing of uranium ores, having an average radium-226 concentration of 67,000 pCi/g and a total of 870 Ci of radium-226

Upon completion of interim remedial actions in 1985 or 1986, the assumed baseline for analysis in this EIS, all the radioactive materials will be in a diked containment area at NFSS. The residues will be buried from 7.7- to 10.7-m deep in concrete building foundations and covered over with wastes. The wastes and residues will be covered by an interim cap of clay, sand, and soil. Detailed descriptions of the radiological, physical, and chemical nature of the NFSS wastes and residues are given in Sections 3.1.7 and 3.1.8. Description of the NFSS site upon completion of interim remedial actions is given in Sections 1 and 2.1.

C.1 RETRIEVAL, PACKAGING, AND LOADING OF CONTAMINATED MATERIALS

Before the wastes can be moved (as proposed for Alternatives 3 and 4), portions of the interim cap must be removed and set aside as uncontaminated fill material. The lower portion of the clay in the cap is assumed to be contaminated because of its proximity to the wastes and will be treated as being part of the wastes (see Section 3.1.7). Before the residues can be retrieved (Alternatives 2b, 3a, 3b, 4a, 4b, 4c, and 4d), the portion of the interim cap over that part of the diked area containing the residues must first be removed and set aside as fill material. Then the wastes overlying the residues (see Figure 2.1) must be removed (and either stored for later replacement in the diked area or transported to an alternative site, depending on the alternative selected).

C.1.1 Movement of the Wastes

The NFSS wastes are only slightly contaminated, and they can be excavated and loaded directly onto transport vehicles. No packaging is required. Standard earth-moving equipment such as bulldozers and front-end loaders can be used for excavating and loading.

C.1.2 Movement of the Residues

The residues might be retrieved for one of two reasons: (1) to remove them to an alternative site for disposal, or (2) to treat them for recovering valuable resources and/or changing their physical form. There are two basic options for removing the residues from their location in the old foundations of Buildings 413, 414, and 411 (see Figure 1.2): (1) mechanical movement using conventional earth-moving equipment, and (2) removal as a slurry. These options are discussed in the following subsections; changing the physical form of the residues is discussed in Section C.2.

C.1.2.1 Conventional Mechanical Movement of the Residues

The residues could be moved by mechanical means similar to those used for moving the wastes, i.e., uranium mining techniques. Special operating techniques would be used to minimize exposure of workers to radiation (Nuexco 1982). Operator cabs on equipment would be environmentally controlled by utilizing special air filtration, regulating temperature, and maintaining air pressure in the cab at 50% above outside air. All equipment would have built-in radiation shielding. In order to allow movement of such machinery, parts of the building foundations would have to be demolished. Only the portion of the residues actually being excavated would be uncovered at any point in time.

If the residues were to be removed to an alternative site, they could be loaded directly into large containers such as the bins described in Appendix D. If the residues were to be processed, a conveyor might be suitable for moving the residues to a nearby processing facility.

C.1.2.2 Removal of Residues as a Slurry

Removal of the residues as a slurry could be accomplished by hydraulic mining techniques such as those described by Bechtel National (1984). High-pressure water jets would be used to force the residues into a slurry (approximately 30% residue by weight). At NFSS, the slurry would be pumped to a process building where it would be discharged into a thickener for settling of the suspended residue particles and then to a dryer where more water would be removed by evaporation. The material from the dryer could be placed in containers, such as 55-gal drums, for shipment offsite or transferred to a residue-processing facility. The supernatant liquid from the thickener could be re-used for further hydraulic mining. The entire slurry-mining, drying, and packaging process would be remote-controlled to minimize radiation exposure of workers. Also, because of the much higher activity levels in the K-65 residues (average of 220,000 pCi/g radium-226), a water layer would be placed over the residues and slurrying would take place under water.

C.1.2.3 Evaluation of Options for Residue Movement

The advantages and disadvantages associated with the two options for retrieval, packaging, and loading of the residues are summarized in Table C.1. Movement of the residues by conventional mechanical methods is the option selected for analysis of environmental impacts for alternatives involving removal of the residues to alternative sites. This option has the advantage of being less complex than the slurry-mining/drying process and requires less initial preparation (e.g., no construction of special drying/packaging facilities). Loading into large containers is required because the bulk, damp soil material cannot be readily loaded into small packages, such as 55-gallon drums, by the large earth-moving equipment. Also, by using large containers with easily removable lids, void spaces above the residues can be readily filled with other earthen material (or wastes) at the alternative sites so as to minimize long-term subsidence in the burial caps. The conventional mechanical method also has the advantage of not requiring watering and resultant dewatering of the slurried residues, which is energy-consuming and would require control and treatment of large volumes (millions of gallons) of water before eventual discharge to the central ditch would be allowed.

Table C.1. Comparison of Options for the Retrieval and Packaging of NFSS Residues

Parameter	Comparison per Method of Retrieval and Packaging	
	Conventional	Slurrying
Complexity	Less	More
Initial preparation	Less	More
Overall radon-222 release	About the same	About the same
Equipment needs	Modified earth-moving equipment	Slurry equipment, remotely controlled drying and packaging equipment
Work force requirements	More	Less
Occupational doses	About the same	About the same
Packaging ease	About the same (large bins, damper material)	About the same (55-gal drums, drier material)
Transportation requirements	May be slightly greater (30% moisture in residues)	May be less (15% moisture in residues)
Disposal requirements	Fewer containers, easier to handle, easier to fill void spaces	More containers, more handling, more difficult to fill void spaces
Cleanup requirements	Minimal (decontamination of equipment and disposal of small volumes of decontamination water)	More required (disassembly and decontamination of equipment and building, cleanup and disposal of large volumes of slurry water)

Some disadvantages of the conventional mechanical option are as follows. This option might require that modifications be made to standard earth-moving equipment to reduce exposure of equipment operators to direct radiation and to radon-222 gas and particulates. Also, even though large containers would be used, there might be some difficulty in loading the damp (30% moisture) clayey materials into the containers. Furthermore, the total weight of residues to be transported would be greater than in the slurry option because the residues would be essentially saturated with water (at 30% moisture) rather than dried to approximately 15% moisture. Because of vehicle weight limitations, this could result in additional trips to remove packaged residues to alternative sites. Finally, more workers would be in close proximity to the residues and more dust-control measures would be required than for the slurry option.

Retrieval of the residues by the slurry method is assumed for analysis of Alternative 2b, which involves processing of the residues for resource recovery followed by reburial of the radioactive waste slag. Because the residues must be slurried at some point in the wet chemical extraction process (see Section C.2.1), it is assumed that the residues would be retrieved using the slurry method. This is the method that was selected for transferring the F-32 and L-30 residues to the east bay of Building 411 and the K-65 residues from the tower (Building 434) to the west bay of Building 411 during the interim remedial actions (Bechtel Natl. 1982).

It is likely that overall radon-222 emissions using the slurry method would be about the same as for the conventional mechanical method. Although water is generally a good radon-222 barrier, agitation of the slurry might result in radon-222 releases that were higher than during mechanical excavation of the damp residues (which have a relatively low radon-222 diffusion coefficient). Also, the slurried residues would be dried to a greater extent prior to shipment (15% moisture) than for excavation by mechanical means (30% moisture), and the release of radon-222 from these drier residues would be greater.

If the residues were to be removed to an alternative site, the slurry method has the advantage of less total weight to ship because the residues would be drier (15% instead of 30% moisture). However, the drier residues would have a much higher radon-222 diffusion coefficient (Section 4.1.2) and, although the containers would have tight lids in both options, some radon-222 gas would still escape and total releases during transport might be similar. Also, although remote loading of drier residues into smaller containers might be easier at NFSS, the unloading and placement into a disposal area at an alternative site might require more effort because more containers would be involved. Also, if the lids of each drum were not removed to allow filling of void spaces created in the containers as the residues settled during transport, potential long-term containment problems due to cap subsidence could be exacerbated. Finally, the facilities used to dry and package the residues would have to be decontaminated and demolished, and portions might have to be disposed as contaminated rubble.

C.2 MODIFICATION OF RESIDUE FORM

The NFSS residues amount to 6% of the volume of contaminated materials at NFSS but account for 99% of the radionuclide inventory. One alternative for the long-term management of the residues is to modify their form so that they or their constituent radionuclides may not be as easily dispersed into the environment. Modification of the large volume of very slightly contaminated wastes is not considered because the reduction of potential long-term dispersal would be negligible.

There are several options for achieving a modified form, one of which is recovery of some of the metals in the residues. Other options are direct vitrification of the residues, in-situ vitrification, and solidification in bitumen, resins (e.g., urea-formaldehyde), or concrete. The slag from the metal recovery process and the products of these other solidification techniques could be returned to the containment area at NFSS. The several advantages and disadvantages for each option are discussed below.

C.2.1 Resource Recovery Leading to Modified Form

Based on current analyses of the NFSS residues, the residues contain a wide assortment of metals (Section 3.1.8)--some of which may be present in commercially significant amounts. Recent commercial values for metals (per unit weight) suggest that recovery of uranium, cobalt, nickel, molybdenum, and lead might be advantageous (See Table F.4). The ranges of resource values represent the ranges in metal contents found by different analyses. It is not known at present whether these variations represent statistical errors in carrying out the analyses or real inhomogeneities in the residue piles. The total average value of metals in significant concentrations may be about \$5.5 million; of this total, uranium represents 40%, cobalt 22%, nickel 17%, and molybdenum 12%. The R-10 residues, which are included in the NFSS wastes, have little resource value (Section 3.1.8).

C.2.1.1 Description

One process for recovering metals from the residues, consisting of three basic stages, has been described by Bechtel National (1984). In stage 1, the residues would be leached with a carbonate-bicarbonate solution to solubilize the uranium and separate it from the bulk material; molybdenum

would also be leached out of the residues and carried along with the uranium as impurities. In stage 2, the carbonate solution would be treated with sodium hydroxide to precipitate sodium diuranate ($\text{Na}_2\text{U}_2\text{O}_7$). After separation of the precipitate and supernatant, the precipitate would be dissolved in sulfuric acid. This solution would then be treated with ammonia to yield a precipitate of ammonium diuranate (yellowcake). After filtration, washing, and drying, the yellowcake would be suitable for further processing in the fuel cycle. In stage 3, the leached and dried residue from the carbonate leach would be fed to an electric furnace. Sufficient activated carbon would be added to reduce lead oxides, carbonates, and sulfates to metals at a temperature of 1300-1500°C. Molten lead would form at the bottom of the furnace crucible and would contain the noble metals silver, palladium, platinum, and gold. About one hour after reduction was complete, the slag containing the remaining materials would be poured into a second furnace. More activated charcoal would be added to reduce, at 1500°C, the remaining metal compounds containing nickel, iron, cobalt, and copper. Iron sulfide would be added to yield a metal sulfide matte. Lime or soda ash could be added to reduce the viscosity of the slag. The remaining slag, predicted to contain most of the radium and comprising about 50% of the original waste volume, would be transferred to a ladle and then poured into a mold for subsequent disposal. Bechtel National (1984) estimates a 90% extraction efficiency for this recovery process.

C.2.1.2 Evaluation of Resource Recovery Option

The advantages and disadvantages of the resource recovery option are summarized in Table C.2. One advantage of this option is that sale of the recovered metals could yield sufficient revenue to partially or perhaps completely offset the cost of the recovery operation. The amount of cost offset would depend on the concentrations of metals in the residues, the actual efficiency of the recovery process, and the unit value of these metals. All of these factors are quite uncertain. Another advantage of such a recovery scheme is that the economic value of the residue slag remaining after the valuable metals have been removed is negligible, thus markedly reducing any potential for future human intrusion to remove the residues for attempted recovery of the contained metals (with resultant potential for release of radioactive contaminants).

In the above-mentioned process, the vitreous slag is presumed to contain most of the radioactivity. Such a slag would be expected to have very low leach rates and radon-222 emanation rates when compared to other modified forms. Without further testing of the process and the slag, these rates are very uncertain (see further discussions in Section C.2.3).

The above-mentioned resource recovery process would have to be demonstrated on a laboratory scale, and such research and development activities could turn out to be quite expensive. Several aspects of the residue processing would have to be examined, especially the efficiency of the extraction process, the purity of the products, and the physical and chemical characteristics of the various waste products.

It must first be shown that the recovery efficiency will be high. Otherwise, the monetary advantages of such a process are reduced or lost. The process as currently outlined only separates the metals into two major groups: the noble metals (gold, silver, platinum, and palladium) and the transition metals (iron, cobalt, nickel, and copper). After the major separations were demonstrated, some developmental work would be necessary to provide for separations within each group. Work would also be necessary to verify the separation into the two groups because some copper or other transition metal might be reduced along with the lead in the first reduction step.

Second, it must be shown that the radioactivity of the recovered metals will be sufficiently low that the metals can be used in ordinary commerce.* Inadequate decontamination of the recovered metals would make it difficult, if not impossible, to sell them in normal commerce. If the radioactivity of the recovered metals cannot be reduced to acceptable levels by further treatment, the recovery process could result in two types of hazardous waste materials--contaminated valuable metals and the vitrified slag.

Third, the characteristics of all waste products from the process must be determined, especially with regard to their radioactive content. This includes gases vented to the atmosphere from drying and smelting operations, waste water, and solid wastes (including the slag). Of particular note is a waste lime precipitate generated in the uranium purification phase of the recovery scheme (Bechtel Natl. 1984). If this precipitate--which would be discarded along with the slag into the waste-containment area at NFSS--contains an appreciable amount of radioactivity as radium-226, then the advantages of the vitrified slag in reducing radioactive emissions are much reduced. Such a precipitate would not be effective in reducing leaching or radon-222 emanations. Experiments would be necessary to determine the probable radioactive content of this precipitate. Also, the vitreous slag produced would have to be tested to determine if both the leach rate and radon-222 emanation rate are

*Although there are criteria for release to the general public of equipment and materials having radioactively contaminated surfaces (e.g., U.S. Nuclear Regulatory Commission Guide 1.86 and proposed ANSI standard N13.12), there are no generally accepted criteria for unrestricted use of materials containing low levels of radioactivity distributed throughout their volume.

Table C.2. Comparison of Options for Preparing a Modified Form for the NFSS Residues

Parameter	Vitrification			
	With Prior Resource Recovery	Furnace Heating	Cement Kiln	In-Situ
Resource recovery	Yes	No	No	No
Residue handling required	Yes	Yes	Yes	No
Leach rate† ¹	Much less	Much less	Much less	Much less
Radon-222 emanation† ²	Much less	Much less	Much less	Much less
Radiation resistance of material† ³	Excellent	Excellent	Excellent	Excellent
Simplicity	Complex (total process needs demonstration)	Simple	Simple	Simple (but difficult to verify complete vitrification)
Effluent treatment	Offgases, water	Offgases	Offgases	Offgases

Parameter	Matrix Isolation			
	Asphalt/Bitumen	Cement	Urea-Formaldehyde	
Resource recovery	No	No	No	
Residue handling required	Yes	Yes	Yes	
Leach rate† ¹	Less	About the same	Less	
Radon-222 emanation† ²	Much less	Same	Questionable	
Radiation resistance of material† ³	Good	Good	Questionable	
Simplicity	Some processes complex	Very simple	Simple	
Effluent treatment	Water	Negligible water	Water† ⁴	

†¹ Compared to unmodified residues. Depending on site characteristics, reduction in groundwater contamination may be minimal.

†² Compared to unmodified residues. Depending on containment system characteristics, reduction in radon-222 releases at the surface of the waste-management area may be negligible.

†³ Resistance of the modified material to radiation-induced breakdown, especially in the product that incorporates the K-65 residues.

†⁴ For NFSS residues, neutralization of Na_2CO_3 is required, yielding salts and waste water. The presence of salt could compromise stability and leach resistance.

indeed low and characteristic of other vitrified materials. There are studies that show that direct vitrification of uranium mill tailings (which are similar to the NFSS residues) at 1200°C yields a reduction in radon-222 emanation by a factor of from 100 to 1000 (Dreesen et al. 1981). The long-term (thousands of years) physical and chemical stability of the slag relative to water leaching would also have to be determined.

Results from leaching experiments (Bechtel Natl. 1984) indicates that molybdenum (~33%) will leach along with uranium in carbonate-bicarbonate solutions whereas vanadium will not. A procedure for separating uranium from molybdenum thus becomes necessary. This separation has been considered for the case of high molybdenum ores (Costa et al. 1971). Separation of the molybdenum is desirable because this element accounts for 12% of the potential market value of the resources in the residues.

Other processes have been proposed for recovery of some of the metal values of uranium mill tailings (Litz 1974). One process is aimed at isolating the radium, thus reducing the amount of waste yielding high levels of radon-222. This is accomplished by having an initial acid leach step (Williams et al. 1981). These tests show that barium and radium may be solubilized and then precipitated from the tailings with concentrated sulfuric acid. Sulfuric acid leaching is also capable of removing uranium-238 and thorium-230, which are radium-226 precursors, from the tailings. Such an approach offers the advantage of concentrating the radium-226 and its precursors into a small package for waste management.

C.2.2 Vitrification

Another option for treatment of the NFSS residues is vitrification. This is a process whereby the residues would be partially or completely melted to obtain a vitreous (glass) slag-like material. Vitrification methods require high temperatures and large amounts of energy to melt the contaminated residues. The residues could be removed and vitrified or left in place and vitrified (in-situ vitrification). (The option of recovering valuable resources before vitrification has been discussed previously in Section C.2.1.)

C.2.2.1 Electric Furnace Fusion

The residues could be fused using an electric-resistance-furnace fusion technique. The molten material would be poured into containers or molds. The cooled product, which is a composite of a glass phase and crystallites, could then be buried (Bechtel Natl. 1984--Appendix B). The electric energy and power requirements for such a process are considerable. Vitrification of the 11,000 m³ of residues would require about 26,000 MWh of electric energy, assuming a requirement of 275 kWh/metric ton of residues (Bechtel Natl. 1984).

C.2.2.2 Rotary Kiln

An alternative method of vitrification involves use of a coal-fired rotary cement kiln to sinter the contaminated materials. An analysis of the use of this method at a site in Cannonsburg, Pennsylvania, yielded a net cost of \$43.25/ton sintered. This included purchase of a used kiln (no salvage value because of contamination), labor, the cost of delivered coal, flue-gas desulfurization, and contingencies (Thode and Dreesen 1981). Application of this cost to the NFSS residues (assuming that the residues have a total weight of 13,000 MT) yields a total cost of \$620,000 to sinter the residues in a cement kiln.

C.2.2.3 In-Situ Vitrification

In-situ vitrification would be the conversion of the residues into a durable glass waste form through melting by joule heating, i.e., passing of an electric current through the molten residues. Development and testing of this technique has proceeded from an engineering scale with a 50-kg block product to a pilot scale yielding a 10-ton block mass (Oma et al. 1983). Currently, effort is focused on the conceptual design of a large-scale unit that will yield a solidified block of 175 tons.

Engineering- and pilot-scale tests have been carried out in which up to 25,000 kg have been solidified to a depth of 1.5 m. To carry out the vitrification, a set of graphite electrodes is placed in holes in the ground with a predetermined spacing between the electrodes. Graphite is placed on the ground between the electrodes to form a conductive path. An electric current is passed between the electrodes, yielding temperatures high enough to melt the contaminated material. Deeper molten masses are achievable at the expense of longer operating times. To accommodate gaseous effluents, a large hood is placed over the melting zone, maintaining a vacuum seal to collect the off-gases and direct them to the offgas treatment system.

Cost estimates for in-situ vitrification range from \$116 to \$179 per m³. Thus, for the 11,000 m³ of NFSS residues, vitrification is estimated to cost approximately \$2 million. For the bulk of the residues in Building 411, with a total area of 3200 m², in-situ vitrification might be accomplished in 280 days with an energy requirement of 20 million kWh.

C.2.2.4. Evaluation of Vitrification Options

The advantages and disadvantages of vitrification options are summarized in Table C.2. The main advantage of vitrification is that the vitreous product is more stable relative to leaching, structural change, and radon-222 emissions. Leach tests using a Soxhlet extractor with samples of vitrified soil gave leach rates that were about the same as those for Pyrex glass (1×10^{-5} g/cm²·d) and were less than one-fifth the values obtained for bottle glass (Oma et al. 1983). Burial (17 years) of glass containing radioactive strontium, cesium, ruthenium, and cerium below the water table resulted in leach rates of about 7×10^{-10} g/cm²·d (Walton and Merritt 1980).

Other experiments have shown a large decrease in leach rate as the leach time increased (Dukes et al. 1980). Glass, ceramic, and concrete waste forms can sustain damage produced by amounts of radiation greatly in excess of that which even the most radioactive (K-65) residues will give, even for periods of many thousands of years (Permer and McDonnell 1980). Tests on 100- to 200-g samples of uranium mine tailings vitrified at 1200°C showed good radon-222 retention, with radon-222 reduction factors ranging from 22 to 1400. Reduction factors were much higher for fines than for sands (Dreesen et al. 1981). It is expected that the above experimental data would be applicable to either the vitrified residues or to the vitreous slag produced in the resource recovery scheme. Also, complete melting to produce a slag or glass would be expected to be more effective than heating just enough to bind the residue particles together.

A particular advantage of the in-situ vitrification technique is the avoidance of handling the residues. Most of the current cap and overlying wastes would have to be removed (leaving about a 0.5-m cover of wastes) and then in-situ vitrification could be carried out. At the conclusion of vitrification, the removed cover materials could be returned. Two drawbacks of vitrification by electric resistance heating are the production of offgases that must be treated to remove radioactive and nonradioactive pollutants and the large electric energy and power requirements. An additional disadvantage is the difficulty of verifying that all of residues have in fact been vitrified.

Vitrification of the residues by use of a coal-fired cement kiln could be done for about one-quarter the cost and in one-quarter the time compared to vitrification by electric resistance heating (assuming the cost/ton figures given in the literature [Thode and Dreesen 1981] are realistic). However, carrying out such a process at NFSS would require extensive auxiliary activity. Large amounts of coal would have to be brought in and stockpiled and appreciable amounts of fly ash and scrubber sludges would require disposal.

Finally, vitrification without prior resource recovery has the disadvantage that the potential valuable resources in the residues would be more difficult to extract at some future date from the vitrified residues than from the untreated residues. Also, all vitrification methods involving removal of the residues require eventual decontamination and demolition of the vitrification facilities.

C.2.3 Matrix Isolation Methods

Matrix isolation methods consist of mixing the radioactive material with some other material that hardens into a solid. This solid material can then be buried. The solid matrix reduces the mobility and leachability of the radioactive materials. Matrix-binding materials that have been used include: asphalt or bitumen, cements (with or without additives such as vermiculite or sodium silicate), and polymers (such as urea-formaldehyde) (Holcomb 1978). Such methods have been used routinely for shorter-lived low-level radioactive wastes.

C.2.3.1 Bitumen or Asphalt

In the processes that use bitumen or asphalt, the radioactive material is mixed with commercial emulsified asphalt or molten base asphalt, and the temperature is raised to evaporate the water. The resulting molten material flows into containers (or pits) where it solidifies. Various methods of mixing the bitumen with the radioactive materials and evaporating the liquid are used: the stirred evaporator batch process (in which mixing and evaporation are done batchwise in a heated tank with stirring), the emulsified bitumen process (in which the waste is mixed with bitumen and surface active agents, heated, and then dried), the film evaporator process (in which water evaporation from the bitumen waste mixture takes place as the mixture flows as a film down the walls of a heated tube), and the screw extrusion process (in which the waste and preheated bitumen are mixed and transported to waste containers by screw extruder-driers) (Holcomb 1978). A cold-mix process using a cationic asphalt emulsion and a flocculant, which requires no heat to expel the water, has also been considered by Bechtel National (1982). This process is especially suited for small-sized particles because a chemical bond is formed between the residues and asphalt whereas a physical bond is formed in the "hot-mix" methods. Bechtel National (1982) has estimated that the cost of applying a cold-mix asphalt process to the NFSS residues, including hydraulic slurry mining, would be approximately \$6.2 million.

C.2.3.2 Cement

Portland cement, with or without additives, can be mixed with radioactive waste. Typical processes use 1-2 kg of cement for every liter of waste. Vermiculite and sodium silicate are often

used as additives to improve the properties of the final product. Sodium silicate also greatly reduces the setting time (to as low as 10 seconds), and the volume of the final product is less than that obtained without use of the additive. Other additives include clays and polymers (Holcomb 1978; Arora et al. 1980; Bechtel Natl. 1982--Appendix D). Bechtel National (1982) has estimated that the cost of the cement process for the NFSS residues would be about \$3.7 million.

C.2.3.3 Resins

Another process consists of mixing the waste with a urea-formaldehyde resin and a polymerizing catalyst in either a mixer or in the final receptacle. The solidification process can take place either at ambient temperatures or at elevated temperatures (60°C). The resultant product, although solid, does not really solidify the waste; rather the long-chain molecules of the polymer form a matrix with voids that trap the waste (Holcomb 1978; Bechtel Natl. 1982).

C.2.3.4 Evaluation of Matrix Isolation Options

Each of the matrix isolation methods has advantages and disadvantages for use at NFSS (Table C.2). First, waste water produced in the various processes would have to be treated before discharge. Waste water would be produced in processes using bitumen or cement, although use of sodium silicate as an additive would greatly reduce the amount of or eliminate the waste water produced (Arora et al. 1980).

Asphalt or bitumen has the advantage of good coating and adhesion characteristics and is essentially insoluble in water. Bitumen is chemically inert, has relatively high resistance to ionizing radiation, and the leach rate of its product can be 100 to 1000 times less than for cement-stabilized materials (Holcomb 1978; Bechtel Natl. 1982). One disadvantage is that some of the processes for mixing are complex and require strict temperature control. Also, accidental fires can occur when heating bitumen (except in the cold-mix process), and waste water is produced that must be treated.

There are several advantages in using cement as a stabilizer. The cement process is cheap, mixing is simple, equipment costs are low, and no heating is required. Also, the chemical and physical properties of cement are well known. Cement has good radiation shielding properties and is more radiation resistant than bitumen. The disadvantages in using cement involve the final product. It is relatively bulky and heavy, does not greatly reduce radon-222 emanation, and is quite leachable by groundwater or percolating rainwater (Holcomb 1978; Bechtel Natl. 1982).

Processes using urea-formaldehyde polymer are simple and the technology is well developed; also the process reduces leachability. However, polymerization requires an acid environment, the solidified product has questionable long-term stability properties, and the radon-222 emanation reduction is questionable. Also, use of this process at NFSS would require neutralization of all the sodium carbonate in the residues by addition of large amounts of acid. As a result, the stabilized product and waste water would contain large amounts of salts. This could cause problems regarding the long-term leachability and stability of the product.

C.3 CONTAINMENT OPTIONS

C.3.1 Introduction

There are several options for the design of engineered containment systems for long-term management of the NFSS residues and wastes. Three basic conceptual containment designs at three different sites are analyzed in this EIS:

1. Burial at NFSS in the diked containment area (Alternatives 1, 2a, 2b, 4a, and 4c).
2. Trench burial at the 218W5 Area on the Hanford Reservation (Alternatives 3a, 4a, and 4b).
3. Mounded burial at the Pine Ridge Knolls site on the Oak Ridge Reservation (Alternatives 3b, 4c, and 4d).

Figures illustrating these conceptual designs are given in Section 2.

There are several engineering options that might be substituted for the above-mentioned conceptual designs. These options can be divided into two groups: (1) modification to the basic conceptual designs, and (2) optional design concepts. Because of the long half-lives of the radionuclides in the NFSS wastes and residues (Section 4), these materials will remain radioactive for thousands of years (see Section 4). Therefore, the following discussion focuses on comparison of various containment designs with respect to long-term impacts, particularly the impacts that are important through geologic time. These impacts include: radon-222 emissions, leaching of radionuclides (especially radium-226) to groundwater, erosion (including potential downslope mass movement), and potential detrimental effects on a resident-intruder (see Section 4.1.2). Consideration of short-term impacts, costs, and institutional issues are beyond the scope of this analysis of design options. Such factors are considered for the basic conceptual designs analyzed in the main body of this EIS.

The design options discussed in this appendix all focus on increasing the effectiveness and duration of containment systems. Other options that are beyond the scope of this analysis are designs that focus on "planned dispersion" to the environment (Cartwright et al. 1981; Gilbert et al. 1983). Because of the extremely long duration of the radiological hazard associated with wastes containing naturally occurring radionuclides, it has been suggested that containment systems might be designed that take into account the dispersion of the contaminated materials through geologic time. Systems could conceivably be designed so that the rates of eventual dispersion and release to the environment would be slow, probable flow paths would be well defined, and dilution of radionuclides would be maximal--resulting in potentially lower long-term radiological impacts to humans.

C.3.2 Modifications to the Basic Conceptual Designs

Modifications to the basic conceptual designs include changes in dimensions, changes in materials, or additional features to retard radon emissions, leaching of radionuclides to groundwater, erosion, or impacts to a potential resident-intruder (Table C.3). For the long term, it is assumed that the near-surface materials at Hanford are unsaturated whereas the near-surface materials at NFSS and Oak Ridge, both located in areas of humid climate, are saturated. The subsurface clay cutoff wall at NFSS and the lower capillary barrier at Oak Ridge are assumed to have negligible effects through geologic time. Breaching of the cover materials is assumed for the resident-intruder scenario.

There are often trade-offs between potential long-term impacts (see Table C.3). For example, when sites are located in areas of humid climate, some modifications such as thicker, higher caps to retard radon emissions may cause increased hydraulic gradients--resulting in increased surface runoff, increased erosion rates, and possible leachate springs at the containment area perimeter (Hughes et al. 1971; Johnson and Cartwright 1980).

A major concern by commenters on the Draft EIS was the potential impacts to a resident intruder. The NFSS wastes and residues are both in the same category of "wastes contaminated with naturally occurring radionuclides" under Section IV of DOE Order 5820.2. For management of these materials, DOE is using the EPA uranium mill tailings regulations (40 CFR 192) as guidance (see introduction to Section 4). It is explicitly stated in the preamble to these regulations that "institutional oversight is an essential backup to passive controls," that "it would not be safe to build habitable structures on the disposal sites," and that "Federal ownership of the site is assumed to preclude such inappropriate uses" (U.S. Environ. Prot. Agency 1983). DOE has explicitly stated in the introduction to Section 2 (p. 2-1) that it intends to take perpetual care of whatever site is used for long-term management of the NFSS wastes and residues. If controls are effective, the resident-intruder scenario will not occur. Even if controls cease, the intrusion barrier (riprap layer) incorporated into the long-term cap of preferred Alternative 2 will deter the intruder and make the resident-intruder scenario unlikely to occur.

As a result of further discussions with EPA and New York officials, DOE has given consideration to an additional intruder barrier over the residues in Building 411 (in addition to the riprap layer in the cap). The engineering aspects and costs of several options have been investigated (Bechtel Natl. 1985). It is assumed that such a barrier would be constructed at the time of installation of the final cap. This would allow time for further consolidation of the residues that were transferred to Building 411 during 1984-1985 and are currently being dewatered. The interim placement of about 10 m (30 ft) of slightly contaminated wastes plus the interim cap over the residues will provide surcharge that will cause some settling of the residues. Prior to such settling, major extra costs would be required to construct an additional intruder barrier over Building 411 that could carry the unsupported weight of the overlying wastes and cap.

In order to install the additional barrier, the cap and wastes overlying Building 411 would have to be excavated and stored. A barrier could be constructed of reinforced concrete, asphalt, cement-stabilized sand, cement-stabilized fly ash, or stone. Reinforced concrete would provide the only practical means to tie the barrier into the building walls and would provide the most positive means of deterring an inadvertent intruder. Construction of such a barrier is estimated to cost an additional \$1.3 million (Bechtel Natl. 1985).

C.3.3 Optional Design Concepts

The advantages and disadvantages of some optional design concepts for containment of the NFSS wastes and residues are presented in Table C.4. In general, above-ground, near-surface, or intermediate-depth containment designs could be developed (Gilbert et al. 1983). It should be noted that these optional designs could be implemented at other sites in the general area near NFSS, the 218W5 Area at Hanford, and the Pine Ridge Knolls Site at Oak Ridge.

C.3.3.1 Options at NFSS

At NFSS, trench disposal would result in the residues and wastes being placed completely in the zone of saturation (they are currently only partially within the zone of saturation). Radon emissions might be slightly reduced due to an increased saturation of the wastes and residues and the clay cover. Leaching rates of radionuclides to groundwater might be increased slightly because all of the

Table C.3. Advantages and Disadvantages of Modifications to the Basic Conceptual Designs for Long-Term Management of NFSS Wastes and Residues

Site/ Alternative	Design Type	Modification	Radon-222 Emissions† ¹ / Unit Area/Time	Rate of Leaching of Radionuclides to Groundwater† ²	Erosion Rates/ Potential for Downslope Mass Movement† ²	Detrimental Effects† ³ on Resident-Intruder
<u>NFSS</u>						
1, 2a, 2b, 4a, 4c	Diked disposal	Less steep side slopes	NC/MC† ⁴	Increased	Decreased	NC/MC
		Steeper side slopes (increased cap thickness)	NC/MC	Decreased	Increased	NC/MC
		Increased area of residue/waste fill	NC/MC† ⁵	Increased	Decreased	Decreased† ⁶
		Improved subsurface permeability barrier	NC/MC	Decreased	NC/MC	Decreased† ⁷
		Improved intruder barrier	NC/MC	Decreased	Decreased	NC/MC† ⁸
		Additional intruder barrier on top of Building 411	NC/MC	NC/MC	NC/MC	NC/MC† ⁸
<u>HANFORD</u>						
3a, 4a, 4b	Trench burial	Diversion ditches intersecting riprap	NC/MC	NC/MC† ⁹	NC/MC† ¹⁰	NC/MC
		Deeper trenches (thicker fill, fewer trenches)	Decreased	NC/MC† ⁹	NC/MC† ¹⁰	Increased
		Increased barrier between trenches or increased area of residue/waste fill	NC/MC† ¹¹	NC/MC† ⁹	NC/MC† ¹⁰	Decreased† ⁶
		Addition of subsurface permeability barrier	NC/MC† ¹¹	NC/MC† ⁹	NC/MC† ¹⁰	NC/MC
		More impermeable cover	Decreased	NC/MC† ⁹	NC/MC† ¹⁰	NC/MC
		More permeable cover	Increased	NC/MC† ⁹	NC/MC† ¹⁰	NC/MC
		Improved intruder barrier	Decreased	NC/MC† ⁹	NC/MC† ¹⁰	NC/MC† ⁸

Table C.3. Continued

Site/ Alternative	Design Type	Modification	Radon-222 Emissions† ¹ / Unit Area/Time	Rate of Leaching of Radionuclides to Groundwater† ²	Erosion Rates/ Potential for Downslope Mass Movement† ²	Detrimental Effects† ³ on Resident-Intruder
<u>OAK RIDGE</u>						
3b, 4c, 4d	Mounded disposal	Steeper slopes (increased cap thickness)	NC/MC† ¹¹	Decreased	Increased	NC/MC
		Increased area of residue/waste fill	NC/MC† ¹¹	NC/MC	Decreased	Decreased† ⁶
		More permeable cover	Increased	Increased	Increased	NC/MC
		More impermeable cover	Decreased	Decreased	Decreased	NC/MC
		Improved intruder barrier	NC/MC	Decreased	Decreased	NC/MC† ⁸

†¹ Change in rate from base case assuming all other factors constant--especially, assumes no exhumation of buried residues or wastes.

†² Change in potential rate from base case, assuming all other factors constant. Only the rate of leaching from the wastes and residues is considered here. This should not be interpreted as being synonymous with increased or decreased impact. Impacts to humans will also depend on peak concentrations in groundwater, the time interval over which concentrations in groundwater are elevated, and the number of people (if any) using the contaminated water.

†³ Assumes intrusion into residues/wastes (see Section 4.1).

†⁴ NC/MC = No Change/Minimal Change.

†⁵ Assumes that the residues would still be buried deeply enough so that radon-222 gas from the residues would decay before it reached the surface of the containment system (Section 4.1).

†⁶ Although impacts to a resident-intruder would decrease because the wastes/residues would cover a larger area, thus lowering the average radionuclide concentrations in the containment area, the larger area might lead to a higher potential for such intrusion to occur.

†⁷ Due to decreased peak concentrations of radionuclides in water obtained from a well drilled next to the containment area.

†⁸ Although impacts to the intruder would remain the same, the potential for intrusion would be lowered until the improved barrier were broken down by natural forces.

†⁹ Assumes the semiarid climate at Hanford remains for long geologic time spans. The rate of leaching is extremely low in the base case (Section 4.2).

†¹⁰ Due to the generally low relief of trench covers at Hanford site.

†¹¹ Assumes that the depth of the cover material is the same.

Table C.4. Advantages and Disadvantages of Optional Design Concepts for Long-Term Management of the NFSS Wastes and Residues

Location	Optional Design Concept	Radon-222 Emissions† ¹ / Unit Area/Time	Rate of Leaching of Radionuclides to Groundwater† ²	Erosion Rates/ Potential for Downslope Mass Movement† ²	Detrimental Effects† ³ on Resident-Intruder
NFSS	Trench disposal	NC/MC† ⁴ ,† ⁵	NC/MC	Decreased	Decreased† ⁶
	Disposal in excavated bedrock caverns	Decreased	Decreased	Decreased	Decreased† ⁷
	Hydrofracture/grout injection	Decreased	Decreased or NC/MC	Decreased	Decreased† ⁷
	Concrete bunkers or vaults	NC/MC or increased	NC/MC	NC/MC or increased	NC/MC
	"French system"	NC/MC	NC/MC	NC/MC	NC/MC

HANFORD	Diked disposal area	Increased	NC/MC† ⁸	Increased	Increased
	Disposal in excavated bedrock caverns	Decreased	NC/MC	Decreased	Decreased† ⁷

OAK RIDGE	Disposal in excavated bedrock caverns	Decreased	NC/MC	Decreased	Decreased† ⁷
	Disposal in natural bedrock caverns	Decreased	Increased (due to solution channels)	Decreased	Decreased† ⁷
	Hydrofracture/grout injection	Decreased	Decreased	Decreased	Decreased† ⁷
	Disposal in surface pits, quarries (assume unlined)	NC/MC	Increased	Decreased	NC/MC
	Disposal in engineered valley fill	Decreased	Increased	Increased	NC/MC
	Trench disposal	NC/MC	Increased	Decreased	Decreased† ⁶

†¹ Change in rate from base case assuming all other factors constant--especially, assumes no exhumation of buried residues or wastes.

†² Change in potential rate from base case, assuming all other factors constant. Only the rate of leaching from the wastes and residues is considered here. This should not be interpreted as being synonymous with increased or decreased impact. Impacts to humans will also depend on peak concentrations in groundwater, the time interval over which concentrations in groundwater are elevated, and the number of people (if any) using the contaminated water.

†³ Assumes intrusion into wastes and residues (see Section 4.1).

†⁴ NC/MC = No Change/Minimal Change.

†⁵ Assumes that the residues would still be buried deeply enough so that radon-222 gas from the residues would decay before it reached the surface of the containment system (see Section 4.1).

†⁶ Although impacts to a resident-intruder would decrease because average radionuclide concentrations in the containment area would be lower, the larger area might lead to a higher potential for such intrusion to occur.

†⁷ Potential for intrusion is less. Also, although intrusion might occur, residence in the wastes/residues would not be likely.

†⁸ Assumes that the semiarid climate at Hanford remains for long geologic time spans. The rate of leaching is extremely low in the base case.

contaminated materials would be within the zone of saturation. However, the long-term impact would be minimal because hydraulic gradients are very low. The potential for erosion would be reduced because of reduced slope angles and slope lengths. Voorhees et al. (1983) have suggested that eventual erosion of the cover material must be assumed in cases of slopes greater than 3-5°. In the trench disposal option, the cover could still be breached by a resident-intruder. Disposal in excavated bedrock caverns would remove the residues and wastes from the near-surface environment. At NFSS, such disposal would probably be below the Queenston Formation in deeper, more impermeable Paleozoic or older rocks. However, the definition of local and regional flow systems in such environments is difficult, exploration and development costs escalate rapidly, and construction of the excavated disposal system would have to be carefully controlled to avoid creating hydraulic pathways from upper water-bearing zones down into the disposal cavern.

As a result of comments on the Draft EIS, other optional design concepts for NFSS were considered, including: (1) deep well injection or hydrofracture/grout injection, (2) storage in concrete bunkers or vaults, and (3) the "French system".

Deep Well Injection or Hydrofracture/Grout Injection. The U.S. Environmental Protection Agency suggested that DOE consider deep-well injection. However, deep-well injection is not technically feasible for the solid NFSS residues. Furthermore, no new permits for deep well injection of any hazardous materials are being granted by the state of New York.

A method called hydrofracture/grout injection has been suggested by the New York Department of Health. This option would entail drilling holes and forcing water under high pressure down into a shale rock or other low-permeability formation to create fractures. The residues would be mixed with cement and other additives to form a grout and then injected under pressure down the drill holes and into the fractures that have been created in the shale. The grout would then solidify in the rock formation.

This option was identified for the DOE Oak Ridge Reservation in the Draft EIS (Table C.4) because there has been such a disposal operation for intermediate-level radioactive wastes at the Reservation (Nat'l. Res. Council. 1985). The hydrofracture/grout injection operations at Oak Ridge ceased after the state of Tennessee promulgated its new underground injection control regulations that require DOE to obtain a permit for DOE operations. DOE has evaluated whether or not its operations can meet the new regulations and has decided not to apply for a permit to resume operations. A National Research Council (1985) report concluded that disposal of certain types of radioactive wastes via the hydrofracture/grout injection method can be acceptable. However, the report also notes that an extensive research program would be necessary to support any future hydrofracture operations at Oak Ridge or other sites.

Hydrofracture/grout injection is not considered to be a viable option for the Niagara Falls area. This alternative was rejected for disposal of high-level wastes at the West Valley site, located south of Buffalo, New York, because it has several serious shortcomings: "there are prospects for future drilling in the West Valley area for natural gas, and extensive drilling in the area near the shale beds could lead to eventual leakage of radioactivity from the shale beds; some question remains about the type of fractures that would be produced in the shale at West Valley (possibly extending beyond the impermeable shale into other types of water-bearing rocks); and if the disposal technique were judged to be inadequate for West Valley wastes at some future date, the wastes would be in an irretrievable form that would not allow corrective measures to be taken" (U.S. Dep. Energy 1982). An extensive drilling characterization and feasibility study would have to be undertaken to determine if the Niagara Falls area is suitable for hydrofracture/grout injection of the NFSS residues.

In addition, hydrofracture has several major disadvantages at whatever site such operations might take place, including: (1) the residues would be in an irretrievable form, and corrective actions could not reasonably be taken if unacceptable groundwater impacts were detected in the future, (2) there is some question about the type and extent of fractures that would be produced--possibly leading to injection of the residue grout beyond the intended formation or providing pathways for radionuclide migration into water-bearing rocks, and (3) future drilling (for hydrocarbons, water, etc.) could lead to leakage of radioactivity from the shale bed.

Storage in Concrete Bunkers or Vaults. Storage in above-grade concrete bunkers or vaults is not specifically analyzed in this EIS. Such storage would offer the following advantages: (1) the vaults would be more visible in the sense that they would look like buildings rather than mounds of dirt, thus possibly serving as a short-term reminder that the contaminated materials are "stored" or "managed" rather than disposed, and (2) they might afford a better opportunity to collect and monitor any leachate and might be easier to repair, if necessary. However, vaults could offer the following disadvantages: (1) they would not provide "passive" containment and would be more costly to construct and maintain, (2) airborne radioactive gaseous releases (radon) might be higher (unless a thick earthen cover was placed over the vaults or unless they were deeply buried--thus negating the possible advantages of visibility and leachate collection and increasing costs even more), (3) in the long term, greater visibility could be a disadvantage because the likelihood of human intrusion might be increased if the vaults were above-grade and not covered with dirt (if they were below-grade and/or covered with dirt, intrusion might be delayed more), (4) because concrete is not expected to be any

more durable over thousands of years than multilayered engineered earthen covers, the vaults would probably offer no significantly greater long-term containment relative to contamination of ground-water, and (5) if controls were lost and the vaults did not have an earthen cover, loss of containment due to physical forces (such as weathering) or human intrusion might occur sooner.

The preferred Alternative 2 is essentially a variation of a concrete vault/tumulus system. If implemented, the residues (which account for 99% of the radioactivity) would be buried in the basement of a reinforced-concrete building beneath a mound of wastes and a thick earthen cap. DOE is also considering an additional intruder barrier (e.g., a reinforced-concrete slab over the building--see discussion in Section 4.1.2.3).

The "French System". It was suggested by EPA that DOE consider the "French system". For contaminated materials similar to the NFSS wastes and residues (i.e., uranium mill tailings), the French use a management system that is similar to that recommended by the EPA for uranium mill tailings in the United States--specifically, containing the wastes in a large pile at their current locations (Pradel 1982). This is the alternative that DOE prefers for the NFSS wastes and residues (Alternative 2). For low-level wastes, the French use a tumulus system wherein the most hazardous wastes are placed in a solid form at the bottom of the containment system (Van Kote 1982). This is similar to all NFSS alternatives wherein the more hazardous residues are located at the bottom of the mound. In Alternative 2b, the residues would also be solidified and replaced at the bottom of the mound. DOE has not determined whether or not the residues should be solidified. If DOE decides to implement Alternative 2, a later decision will be made at the time of implementation regarding whether or not the residues should be solidified. (See Figure 1.3 for details of the DOE decision-making process.)

C.3.3.2 Options at Hanford

Optional design concepts for the Hanford area include a diked disposal area (such as is currently the case at NFSS) and deeper subsurface burial in excavated caverns. In an area such as Hanford--with a semiarid climate; high rates of evapotranspiration; and erodible, poorly consolidated surficial materials--diked disposal would lead to increased radon emissions, increased erosion, and increased detrimental effects on the resident-intruder (the smaller containment area would lead to higher average radionuclide concentrations in the containment area). Deeper subsurface burial, possibly in excavated caverns in relatively impermeable zones in the Columbia River basalts, would generally lead to decreases in the variables considered in Table C.4. The Columbia basalts have been studied extensively relative to possible location of a deep geologic radioactive waste repository in these rocks. A detailed geologic simulation model has been developed to examine the long-term impacts of such disposal (Foley et al. 1982).

C.3.3.3 Options at Oak Ridge

Optional design concepts for the Oak Ridge site include various types of deeper subsurface burial--including excavated bedrock caverns, natural caverns, surface pits and quarries, and an engineered valley fill. In general, the use of subsurface openings made specifically for the purpose of burial of NFSS residues/ wastes would offer the most long-term advantages. Disadvantages associated with the other options include extensive networks of solution cavities around pre-existing caves, creation of relief fractures and blasting cracking around quarry sites, and a high proportion of permeable materials around gravel pits. The engineered valley fill option consists of lifts of residues/wastes placed in a terraced valley fill with provisions for subsurface and surface drainage. An advantage to this design type is that natural processes of colluviation (deposition in valleys from erosion of highlands) would tend to increase surface cover over the wastes/residues through geologic time. Disadvantages center mainly on the potential for breaching of the cover by periodic flooding and the potential for leaching of radionuclides to surface water.

C.3.4 Discussion

When considering any modifications to the basic conceptual designs or optional design concepts for long-term management of the NFSS residues and wastes, there are three major geologic factors that are frequently interacting and must be evaluated: (1) the hydrogeologic environment surrounding the wastes and residues (including local and regional flow systems and physicochemical properties of earth materials), (2) the placement of the disposal site in a geomorphic setting where fluvial, mass-wasting, and other processes may be active through geologic time (such as on top of a knoll), and (3) the seismotectonic framework of the burial site (which influences the long-term stability and integrity of the site). Four major interacting long-term impacts related primarily to the first two geologic factors are of major importance in evaluating the relative advantages and disadvantages of containment systems through geologic time. These impacts are: radon-222 emissions, leaching rates of radionuclides to groundwater, erosion rates, and impacts to a potential resident-intruder. Often, a design option that offers an advantage with respect to one impact also offers a disadvantage with respect to another impact.

Selection of any design modifications or optional design concepts for further consideration depends on subsequent analysis of factors not considered herein (e.g., near-term impacts and costs). A detailed subsurface investigation, laboratory testing, and engineering analyses would also be necessary.

REFERENCES (Appendix C)

- Arora, H.S., T. Tamura, and W.J. Boegly. 1980. In-Situ Stabilization of Radioactively Contaminated Low-Level Solid Wastes Buried in Shallow Trenches--An Assessment. Oak Ridge National Laboratory Report No. ORNL/TM-7130.
- Bechtel National, Inc. 1982. Niagara Falls Storage Site Long Range Planning Study, Phase II. Report No. 10-05-AB-002. Prepared for U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN, September 1982.
- Bechtel National, Inc. 1984. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. DOE/OR/20722-1. Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. January 1984.
- Bechtel National, Inc. 1985. Building 411 Top. Estimates prepared for the U.S. Department of Energy, Oak Ridge Operations. June 1985. Attachment to letter from J. Nemec (Bechtel) to L. Keller (DOE), June 10, 1985.
- Cartwright, K., R.H. Gilkeson, R.A. Griffin, T.M. Johnson, D.E. Lindorff, and P.B. DuMontelle. 1981. Hydrogeologic considerations in hazardous waste disposal in Illinois. Ill. State Geol. Surv. Environ. Geol. Note 94.
- Costa, E.C., H.F. Batista, L.O. Castro, and A.G. DeOliveira. 1971. Processing of a Molybdenum-Uranium Ore from the Pocos de Celdas Plateau. Proceedings of a Symposium on the Recovery of Uranium, Sao Paulo, Brazil, August 17-21, 1970. International Atomic Energy Agency, Vienna.
- Dreesen, D.R., J.M. Williams, and E.J. Cokal. 1981. Thermal Stabilization of Uranium Mill Tailings. Presented at Symposium on Uranium Mill Tailings Management, Fort Collins, CO, October 26-27, 1981.
- Dukes, M.D., W.C. Moseley, W.M. Rankin, M.H. Tennant, and J.R. Wiley. 1980. Multibarrier storage of Savannah River Plant Waste, pp. 231-238. In C.J.M. Northrup, Jr. (ed.) Scientific Basis for Nuclear Waste Management, Vol. 2. Plenum Press, New York.
- Foley, M.G., G.M. Petrie, A.J. Baldwin, and R.G. Craig. 1982. Geologic simulation model for a hypothetical site in the Columbia Plateau. Volume 2: Results. PNL-3542-2. Battelle Pacific Northwest Laboratory.
- Gilbert, T.L., J.M. Peterson, R.W. Vocke, and J.K. Alexander. 1983. Alternatives for Management of Wastes Generated by the Formerly Utilized Sites Remedial Action Program and Supplement. ANL/EIS-20. Prepared for U.S. Department of Energy, Oak Ridge, TN, by Division of Environmental Impact Studies, Argonne National Laboratory, Argonne, IL.
- Holcomb, W.F. 1978. A Survey of Available Methods of Solidification for Radioactive Wastes. Report No. ORP/TAD-78-2. Prepared for U.S. Environmental Protection Agency, Washington, DC. November 1978.
- Hughes, G.M., R.A. Landon, and R.N. Farvolden. 1971. Hydrogeology of Solid Waste Disposal Sites in Northeastern Illinois. U.S. Environmental Protection Agency SW-12d. Prepared under Demonstration Grant G06-EC-00006.
- Johnson, T.M., and K. Cartwright. 1980. Monitoring of leachate migration in the unsaturated zone in the vicinity of sanitary landfills. Ill. State Geol. Surv. Circ. 514.
- Litz, J.E. 1974. Treatment of Pitchblende Residues for Recovery of Metal Values. HRI Project No. 137. Prepared by Hazen Research, Incorporated, Golden, CO, for Cotter Corporation, Canon City, CO. May 1974.
- National Research Council. 1985. The Management of Radioactive Waste at the Oak Ridge National Laboratory, A Technical Review. National Academy Press.
- Nuexco. 1982. Monthly Report on the Uranium Market. Report No. 165. Menlo Park, CA. May 1982.
- Oma, K.H., et al. 1983. In Situ Vitrification of Transuranic Waste: Systems Evaluation and Applications Assessment. PNL 4800. September 1983.
- Permer, P.H., and W.R. McDonnell. 1980. Significance of Radiation Effects in Solid Radioactive Waste. Paper presented at the 10th Symposium on Effects of Radiation on Materials, EI DuPont de Nemours & Co. Report No. DP-MS-80-27.
- Pradel, J. 1982. La Gestion des Dechets Solides de l'Extraction et du Traitement des Minerals d'Uranium en France. Management of Wastes from Uranium and Milling. Proceedings of a Symposium, International Atomic Energy Agency, Vienna, Austria.

- Thode, E.F., and D.R. Dreesen. 1981. Technico-Economic Analysis of Uranium Mill Tailings Conditioning Alternatives. Symposium on Uranium Mill Tailings Management, Fort Collins, CO, October 26-27, 1981.
- U.S. Department of Energy. 1982. Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley, New York. Final Environmental Impact Statement. DOE/EIS-0081. June 1982.
- U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR 192. Fed. Regist. 48(3):590-609 (January 5, 1983).
- Van Kote, F. 1982. 12 years of experience of shallow land disposal of low and intermediate level radioactive waste in France. In Proceedings of the Symposium on Low-Level Waste Disposal, September 29-30, 1982. NUREG/CP-0028; CONF-820911. U.S. Nuclear Regulatory Commission.
- Voorhees, L.D., M.J. Sale, J.W. Webb, and P.J. Mulholland. 1983. Guidance for Disposal of Uranium Mill Tailings: Long-Term Stabilization of Earthen Cover Materials. ORNL/TM-8685; NUREG/CR-3199. Oak Ridge National Laboratory, Oak Ridge, TN.
- Walton, F.B., and W.F. Merritt. 1980. Long-term extrapolation of laboratory glass leaching data for the prediction of fission product release under actual groundwater conditions, pp. 155-166. In C.J.M. Northrup (ed.), Scientific Basis for Nuclear Waste Management, Vol. 2. Plenum Press, New York.
- Williams, J.M., E.J. Cokal, and D.R. Dreesen. 1981. Removal of Radioactivity and Mineral Values from Uranium Mill Tailings. Paper presented at Symposium on Uranium Mill Tailings Management, Fort Collins, CO, October 26-27, 1981.

APPENDIX D. TRANSPORTATION OF NFSS WASTES AND RESIDUES

D.1 INTRODUCTION

All, or portions of, the NFSS contaminated materials will be shipped to other sites if Alternative 3a, 3b, 4a, 4b, 4c, or 4d is implemented (Table D.1). In Alternative 3, all 190,000 m³ of the residues and wastes will be moved to either Hanford, Washington, (3a) or Oak Ridge, Tennessee (3b). In Alternative 4, the 11,000 m³ of residues will be moved to either Hanford (4a, 4b) or Oak Ridge (4c, 4d), whereas the 180,000 m³ of wastes will either remain at NFSS (4a, 4c) or be transported to the New York/New Jersey harbor area for ocean disposal (4b, 4d).

Detailed descriptions of the NFSS residues and wastes are given in Section 3.1.7 of this report. The residues have a much higher concentration of radium-226 than do the wastes (Table D.1). For transportation purposes, the NFSS residues will be classified as low-specific-activity (LSA) radioactive wastes. The NFSS wastes, on the other hand, are only slightly contaminated and do not need to be classified as radioactive for transportation purposes. (Details on transportation regulations and waste classification are provided in Section D.2.)

Table D.1. Summary of Alternatives Involving Transport of NFSS Residues and Wastes to Other Sites^{†1}

Destination	Distance (km)	Alternative	NFSS Material to be Transported	Volume of Material (m ³)
Hanford	4100	3a, 4a, 4b	Residues	11,000
		3a	Wastes	180,000
Oak Ridge	1300	3b, 4c, 4d	Residues	11,000
		3b	Wastes	180,000
NY/NJ harbor area ^{†2}	770-1000	4b, 4d	Wastes	180,000

Contaminated Material	Volume (m ³)	Average Radium-226 Concentration ^{†3} (pCi/g)	Packaging	Type of Transport Vehicle
K-65 residues	3,000	220,000	Bins	Shielded vans
L-30/F-32 residues	6,500	12,000	Bins	Shielded vans
L-50 residues	<u>1,500</u>	3,300	Bins	Low-boy, semi-trailer, flat-bed trucks
Subtotal	11,000			
Wastes	<u>180,000</u>	36	None	Dump trucks
Total	190,000			

^{†1} All values rounded to two significant figures.

^{†2} From the barge dock in the New York/New Jersey harbor area, the wastes will be transported on barges to the ocean dump site. See Section 2.7 and Appendix E.

^{†3} From Table 3.5.

There are three potential modes of transport for the NFSS residues and wastes: truck, rail, and barge. Barge transport has been shown to be unreasonable (Bechtel Natl. 1984), primarily because of the much greater distances involved and because of the need for truck transport at both ends, thus necessitating two additional transfers. Rail transport may be feasible (see Section D.5), but transport of bulk radioactive materials similar to the NFSS residues and wastes is currently accomplished primarily by truck. There may be some advantages in shipping the large volume of NFSS wastes and residues by rail rather than truck (e.g., fewer number of shipments) but there are also disadvantages (see Section D.5). For purposes of defining the major alternatives in this EIS, truck transport is assumed for all NFSS wastes and residues. If DOE decides to implement one of the transportation alternatives, the relative merits and costs of rail versus truck transport will be given more detailed consideration.

There are several alternative truck routes to the three sites. The preferred routes are described in Section 3.5; the criteria for choosing routes and descriptions of alternative routes are given in Section D.4. To the extent possible, all NFSS residues and wastes will be shipped on interstate highways.

A detailed discussion of truck transportation--including the bases for determining numbers of shipments, duration of shipments, and other parameters needed for the environmental impact analysis in this EIS--is provided in Section D.3. Barge transportation for the ocean disposal alternatives is described in Appendix E.

D.2 TRANSPORTATION REGULATIONS

D.2.1 Federal

The transportation of radioactive materials is subject to the regulations and jurisdiction of many federal, state, and local authorities. Four federal agencies have jurisdiction over shipments of radioactive materials:

- The Department of Transportation (DOT) has primary responsibility for issuing regulations for the safe transportation of all hazardous materials, including radioactive materials. The DOT regulations apply to all shippers and carriers of radioactive materials except for shipments made on federal government vehicles.
- The Nuclear Regulatory Commission (NRC) issues additional regulations for certain highly radioactive materials such as spent nuclear fuel and high-level wastes. Those regulations apply to all NRC licensees.* The NRC regulations also apply in certain cases to commercial carriers.
- The Interstate Commerce Commission (ICC) regulates rates, charges, and conditions of truck and rail services operating in interstate commerce. The role of the ICC in interstate commerce is diminishing as a result of gradual deregulation of the transportation industry.
- The Department of Energy (DOE) exerts operational control of the shipment activities of its "government-owned" contractors. Except for shipments made on government-owned vehicles, all DOE shipments are subject to DOT regulations. By the DOE's own internal directives, the additional safety standards imposed by NRC also apply to DOE shipments, although the administrative requirements of NRC do not apply.

Providing for adequate control of radiation is a requirement that must be met when transporting the NFSS residues. Radiation control limits are met by providing the necessary shielding to reduce external radiation levels to within allowable limits. Because the NFSS residues will probably be shipped in vehicles consigned for exclusive use, the following dose limits specified in 49 CFR Part 173.441 apply**:

- 1000 mrem/h at any point on the accessible external surface of a package (closed transport vehicle).
- 200 mrem/h at any point on the accessible external surface of a package (open transport vehicle).

*The Afrimet residues were formerly owned by Afrimet-Indussa and were under a state of New York license (New York is an NRC agreement state). As a result of recently concluded negotiations with Afrimet-Indussa, DOE assumed ownership of the residues and, thus, they are no longer subject to a New York license.

**These regulations apply only to shipments of residues. The NFSS wastes are not considered to be radioactive for transportation purposes. See later discussion.

- 200 mrem/h at any point on the external surface of the vehicle.
- 10 mrem/h at 2 m (6.6 ft) from the sides of the vehicle.
- 2 mrem/h in any normally occupied position in the vehicle.

Recently revised regulations were issued by the Department of Transportation on March 10, 1983 (U.S. Dep. Transp. 1983a); these regulations went into effect on July 1, 1983. In Section 173.403 (y) of revised 49 CFR Part 173, radioactive material, for transportation purposes, is defined to be any material that has a specific activity greater than 0.002 $\mu\text{Ci/g}$ (2000 pCi/g).

The NFSS residues contain between 3,300 and 220,000 pCi/g of radium-226 (dry weight basis) as well as small amounts of uranium and other radionuclides. Assuming secular equilibrium between the radium-226 and its decay products, and noting that the residues will be shipped damp, the total specific activity of the residues, as transported, will range from 22,000 to 1,500,000 pCi/g.* All the residues will be classified as low-specific-activity (LSA) materials because they are physical and chemical concentrates of uranium ores (49 CFR 173.403 (n)); the residues will therefore be shipped as radioactive materials.

The NFSS wastes have an average radium-226 concentration of about 36 pCi/g and, using the same assumptions as for the residues, the estimated total specific activity of the wastes is about 240 pCi/g. Thus, these wastes could be transported as nonradioactive materials. However, due to heterogeneities in the wastes, some mixing of the wastes may be necessary to ensure that the individual shipments do not exceed a total specific activity of 2000 pCi/g.

Another major federal regulation concerning transport of the NFSS wastes and residues is the gross vehicle weight limit of 36,000 kg (80,000 lb) (Pub. L. 97-424, Highway Improvement Act of 1982), which applies to all states.

D.2.2 State and Local

Several state and local governments have issued regulations and passed statutes that impose restrictions on shipments of radioactive materials. The U.S. Congress has, by statute, given DOT preemptive regulatory authority over state and local jurisdictions in the matter of transportation of radioactive materials. The U.S. Supreme Court has recently upheld this preemptive authority in a case where the city of New York filed suit against DOT, challenging DOT's regulatory authority (U.S. Supreme Court 1984).

Although state or local regulations regarding the transport of radioactive materials are preempted by federal law (Federal Materials Transportation Act, Section 12, Title I, of Public Law 93-633), a state or local municipality has the option of filing with the Department of Transportation for a nonpreemption determination (i.e., a waiver of preemption). A state or local requirement influencing the transport of radioactive materials will cease to be preempted by federal law if, upon application for the nonpreemption determination, the Secretary of the Department of Transportation finds that the state or local ruling (1) provides an equal or greater level of public safety than the Hazardous Materials Transportation Act or regulations issued thereunder, and (2) does not burden commerce. Preemption determination, therefore, does offer the state or local area with a recourse in the case of disputes over federal preemption.

The NFSS residues will be classified as radioactive, but the NFSS wastes will be classified as nonradioactive materials under existing federal regulations. Although DOE shipments of NFSS wastes will also not be legally subject to state and local regulations, as a matter of comity (courtesy), DOE attempts to comply with state and local general transportation regulations.

D.3 PACKAGING AND VEHICULAR REQUIREMENTS FOR NFSS RESIDUES AND WASTES

D.3.1 General

It is assumed that the NFSS residues will be packaged prior to transportation to ensure compliance with regulations for transporting radioactive materials. There are a variety of packages that could be used to transport the NFSS residues, including 55-gallon drums and various-sized boxes. For

*Assuming secular equilibrium between the radium-226 and its decay products, the total specific activity is approximately 10 times the radium-226 activity. Taking into account the increased weight of damp residues, another multiplier of 0.67 is applied (see Table 3.5). Loss of radon-222 gas and contributions from other radioactive elements such as uranium-238, -234, and -235 are not expected to significantly affect the estimated total specific activity.

purposes of analysis in this EIS, it is assumed that large steel boxes will be used, specifically the Mark-III bins that are used for transport and disposal of low-level radioactive wastes at Argonne National Laboratory. These bins are sturdy (made of 12-gauge welded steel), watertight (gasketed), certified for transport of LSA materials (meet DOT requirements of "strong and tight" packaging), of suitable size (1.2 m × 1.5 m × 1.8 m [4 ft × 5 ft × 6 ft]), could be filled with the NFSS residues using conventional construction equipment,* and could be easily loaded and unloaded from transport vehicles using cranes. Use of these containers also offers the advantage of enabling retrieval of the residues within a few (10 to 20) years should this be desired.

Three types of vehicles are assumed to be used to transport the NFSS residues and wastes (Table D.2): shielded vans, flat-bed semitrailer trucks, and dump trucks. The shielded vans (for transport of the K-65 and L-30/F-32 residue packages) are standard vans that can be modified to allow the bins to be easily loaded and unloaded and to allow for varying amounts of shielding to reduce the radiation levels outside of the van. The most stringent radiation limit of 10 mrem/h at 2 m (6.6 ft) from the side of the vehicle can be met by using vans equipped with lead shielding (Bechtel Natl. 1984). These vans will have canvas tops for ease of loading and unloading using cranes. The 200 mrem/h limit for the top of the van will be met by adding an extra 2 cm (0.75 in.) of steel shielding on top of the bins containing the K-65 residues (Table D.2). No special shielding is required for the L-50 residues, so they will be transported in the bins on flat-bed, semitrailer trucks.

Table D.2. Shipping Status of NFSS Wastes†¹

Material Transported	Density (kg/m³)	Average Concentration (dry wt.) of Ra-226 (pCi/g)	Average Ra-226 Inventory per Shipment (Ci)	Shielding		Number of Bins	Number of Truck Trips
				Top	Side		
Residues:							
K-65	1,800	220,000	1.6	Yes	Yes	2,000	500† ²
L-30 and F-32	1,800	12,000	0.10	No	Yes	3,900	960† ²
L-50	1,800	3,300	0.043	No	No	850	140† ³
Subtotal							1,600
Wastes:	1,800	36	0.00052	No	No	NA	15,000† ⁴
TOTAL							16,000

†¹ All values rounded to two significant figures.

†² Assumes use of shielded vans with payload (reduced by shielding) of about 14,000 kg (30,000 lb) (Chem-Nuclear Systems 1983), or 4 bins per van.

†³ Assumes use of low-boy, semitrailer, flat-bed truck weighing 14,500 kg (32,000 lb) when empty and able to carry 6 bins per trip.

†⁴ Assumes use of dump trucks covered with canvas and having a gasketed seal for the rear end. Each vehicle has an empty weight of 15,000 kg (32,000 lb) and can carry a payload of 22,000 kg (48,000 lb) of NFSS wastes.

The NFSS wastes will not be classified as radioactive materials for transportation purposes and therefore will be transported in the most expeditious manner. It is assumed that these wastes will be transported in 15-m³ (20-yd³) dump trucks having gasketed seals on the rear end and canvas covers on top to minimize potential loss of the contaminated soils during transport. Gasketed trucks are assumed in order to avoid having to use and dispose of plastic liners.

It is assumed that all vehicles will be obtained from commercial operators and dedicated to NFSS operations (i.e., exclusive use for transporting these materials, returning empty to NFSS for another load). When necessary, extra shielding will be added to protect the driver. All vehicles will be decontaminated if necessary, according to the limits specified in 49 CFR Part 173.443 (U.S. Dep. Transp. 1983a), primarily by washing with water.

*Shielding on the equipment would be provided, as needed, to protect equipment operators.

D.3.2 Residue Packaging and Transportation

The lead-shielded vans for residue transport are assumed to weigh approximately 23,000 kg (50,000 lb). Because the interstate vehicle weight limit is 36,000 kg (80,000 lb) (Pub. L. 97-424), each van can carry about 14,000 kg (30,000 lb) of NFSS payload per trip. Each Mark-III bin has a volume capacity of 3.4 m³ (4.4 yd³), a container weight of 340 kg (750 lb), and a maximum weight capacity of 3600 kg (8000 lb) (including container weight). Additional steel shielding for the top of a bin containing K-65 wastes weighs 280 kg (630 lb). Assuming a residue density of 1800 kg/m³ (3000 lb/yd³), each bin could therefore carry a maximum of 3000 kg (6000 lb) or 1.7 m³ (2.2 yd³)* of K-65 residues. To meet the payload restrictions for the van (14,000 kg or 30,000 lb), however, each van will carry a maximum of 4 bins loaded with 2800 kg (6100 lb) or 1.5 m³ (2.0 yd³) per bin. Therefore, approximately 500 truck trips will be required to transport the 3000 m³ (4000 yd³) or 2000 bins of K-65 residues from NFSS.

No additional steel shielding on top of the bins will be required for the L-30/F-32 residues, so each van can carry a maximum of 4 bins loaded with 3000 kg (6100 lb) or 1.7 m³ (2.2 yd³) of L-30/F-32 residues and meet payload limitations. Approximately 960 truck trips will be required to remove the 6500 m³ (8500 yd³) or 3900 bins of L-30/F-32 residues.

Because of their lower specific activity, the L-50 residues will not require lead shielding during transport and will be transported on flat-bed, semitrailer trucks. Assuming an empty flat-bed, semitrailer truck weighs 15,000 kg (32,000 lb) and has a payload of 22,000 kg (48,000 lb), 6 Mark-III bins filled to their design weight limit can be loaded on each truck. Thus, each bin will contain 1.8 m³ (2.4 yd³) and each shipment will contain approximately 11 m³. Assuming a total L-50 volume of 1,500 m³ (2,000 yd³), 140 truck trips will therefore be required to remove the 850 bins of L-50 residues from NFSS for a combined total of 1600 truck trips for all residues.

D.3.3 Waste Transportation

The NFSS wastes will be transported in 15-m³ (20-yd³) dump trucks. Assuming the empty weight of the truck is 15,000 kg (32,000 lb) with a payload of 22,000 kg (48,000 lb), and assuming a waste density of 1,800 kg/m³ (3,000 lb/yd³), one truck can carry at maximum weight 12 m³ (16 yd³) of waste per trip (allowing for an average 15% increase in volume with handling). Approximately 15,000 truck trips will therefore be required to remove the wastes from NFSS (Table D.2).

During implementation of any of the action alternatives, an additional small amount of radioactive waste will be produced (e.g., contaminated clothing, filters, gloves). These wastes will be treated to minimize their volume and will be disposed with the NFSS residues. These additional wastes are not covered explicitly in this EIS because their volume will be very small relative to the residues and wastes.

D.3.4 Time and Equipment Needs

About 16,000 truck trips will be required to transport all wastes and residues from NFSS. The equipment and time required to transport the contaminated materials from NFSS to Hanford or Oak Ridge under Alternatives 3a and 3b are listed in Table D.3. Assumptions made in performing the calculations of the values in Table D.3 include: a weather-restricted work period of 6 months each year consisting of 120 working days; a daily transport distance of 730 km (450 mi); and round-trip travel times (including loading/unloading) of 12 days to Hanford, Washington, and 5 days to Oak Ridge, Tennessee. A contingency of enough trucks to cover one additional working day has been included in the totals to serve as replacements for vehicles out-of-service or requiring maintenance. It is assumed that it will take 2 years to ship the residues to either Hanford or Oak Ridge. It is also assumed that it will take 5 years to complete transport of the wastes in Alternative 3a (shipping to Hanford) and 2 years in Alternative 3b (shipping to Oak Ridge), limited primarily because of the number of dedicated trucks required. Thus, implementation of Alternative 3a is limited by the 5 years needed to transport the wastes. The requirements associated with completing this activity in different time periods are also shown in Table D.3.

The vehicle and time requirements to implement Alternatives 4a, 4b, 4c, and 4d are listed in Table D.4. For this analysis, it is assumed that it will take 2 years to implement Alternative 4a, 4b, 4c, or 4d. The requirements associated with completing this activity in different time periods are also shown in Table D.4.

*Volumes quoted represent preexcavation volumes. With excavation and handling of residue materials, volumes may be expected to increase by as much as 30% (Peele and Church 1941).

Table D.3. Truck Requirements for Shipment of NFSS Residues and Wastes in Alternatives 3a and 3b^{†1†3}

	Destination							
	Hanford, WA				Oak Ridge, TN			
	2 yr	3 yr	4 yr	5 yr	2 yr	3 yr	4 yr	5 yr
Round trips	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000
Rate:								
Departing NFSS								
trucks/day	68	45	34	27	68	45	34	27
trucks/hour	8.5	5.7	4.3	3.4	8.5	5.7	4.3	3.4
Departing and arriving at NFSS								
trucks/day	140	90	68	54	140	90	68	54
trucks/hour	17	11	8.6	6.8	17	11	8.6	6.8
Dedicated trucks required ^{†2}	880	580	440	350	370	240	180	150
Material transported:								
m ³ /yr	96,000	64,000	48,000	38,000	96,000	64,000	48,000	38,000
m ³ /mo	16,000	11,000	8,000	6,400	16,000	11,000	8,000	6,400
m ³ /wk	3,700	2,500	1,800	1,500	3,700	2,500	1,800	1,500
Total distance travelled (km)	130,000,000				42,000,000			

^{†1} Assumes (1) 190,000 m³ of total contaminated material transported (see Table D.1); (2) 6-month (120-day) transport season; (3) 8-hour working day; (4) round-trip travel time of 12 days to Hanford, and 5 days Oak Ridge.

^{†2} Includes a 1-day excess contingency of trucks to cover repairs and maintenance.

^{†3} All values rounded to two significant figures.

D.4 ALTERNATIVE TRUCK ROUTES

D.4.1 Route Selection Criteria

Guidelines listed in regulations on the routing of radioactive materials indicate that transportation of the NFSS residues will be restricted to certain routes to minimize the radiation risk to the general public (U.S. Dep. Transp. 1981). The routes selected for the various transportation alternatives in this EIS are based on the more restrictive transportation routing guidelines applicable for "route-controlled quantities" of radioactive materials, even though it may not be necessary to meet these restrictive guidelines (U.S. Dep. Transp. 1983a, 1983b). These more stringent requirements require transporters of radioactive materials to be confined to the interstate highway system, unless otherwise specified by the states. Interstate beltways or state-designated bypass routes are to be used around large metropolitan areas where possible. The restriction to interstate highways results from national average highway accident data being lower for interstates than on any other class of roadway; analyses also indicate that the radiological risk to the public from transporting radioactive materials on interstates is lower than that on other highways (U.S. Dep. Transp. 1981). Vehicles transporting radioactive materials can deviate from the interstate system for emergencies, for obtaining fuel and repairs, and for travel to and from off-interstate pick-up and delivery sites.

Three alternative routes to each destination (Hanford, Oak Ridge, Harbor) are identified. Because only county-level population data are readily available, the average population density for each route is determined by calculating the means of the mean population density for each county through which the route passes. The preferred route is the one that has the fewest people living near it. Preferred routes are described in Section 3.5.

D.4.2 Alternative Routes to Arid Site (Hanford)

Alternative Route 1 to Hanford (Figure D.1) consists of taking I-94 west from Wisconsin rather than I-90. The route then traverses central Minnesota, North Dakota, and Montana and merges with the

Table D.4. Truck Requirements for Shipment of NFSS Residues to Hanford or Oak Ridge and the Wastes to the New York/New Jersey Harbor Area in Alternatives 4a, 4b, 4c, and 4d^{†1††3}

	Destination													
	Hanford, WA					Oak Ridge, TN					New York/New Jersey Harbor Area ^{†3}			
	1 yr	2 yr	3 yr	4 yr	5 yr	1 yr	2 yr	3 yr	4yr	5yr	2 yr	3 yr	4 yr	5 yr
Round trips	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	15,000	15,000	15,000	15,000
Rate:														
Departing NFSS														
trucks/day	13	6.7	4.4	3.3	2.7	1.3	6.7	4.4	3.3	2.7	61	41	31	25
trucks/hour	1.6	0.8	0.6	0.4	0.3	1.7	0.8	0.6	0.4	0.3	7.7	5.1	3.8	3.1
Departing and arriving at NFSS														
trucks/day	26	13	8.8	6.6	5.4	2.6	13	8.8	6.6	5.4	120	82	62	50
trucks/hour	3.2	1.6	1.2	0.8	0.6	3.4	1.6	1.2	0.8	0.6	15	10	7.6	6.2
Dedicated trucks required ^{†2}	180	87	57	43	35	70	36	24	18	15	170	110	84	68
Material transported:														
m ³ /yr	11,000	5,500	3,700	2,800	2,200	11,000	5,500	3,700	2,800	2,200	90,000	60,000	45,000	36,000
m ³ /mo	1,800	920	610	460	370	1,800	920	660	460	370	15,000	10,000	7,500	6,000
m ³ /wk	640	320	210	160	130	640	310	210	160	130	3,500	2,300	1,700	1,400
Total distance travelled (km)	13,000,000					4,200,000					30,000,000			

^{†1} Assumes (1) 11,000 m³ of residues and 180,000 m³ of remaining residues, soils, and rubble transported (see Table D.1); (2) 6-month (120-day) transport season; (3) 8-hour working day; (4) round-trip travel time of 12 days to Hanford; 5 days to Oak Ridge; and 2.5 days to the Harbor.

^{†2} Includes 1-day excess of trucks to cover losses due to repair and maintenance.

^{†3} All values rounded to two significant figures.

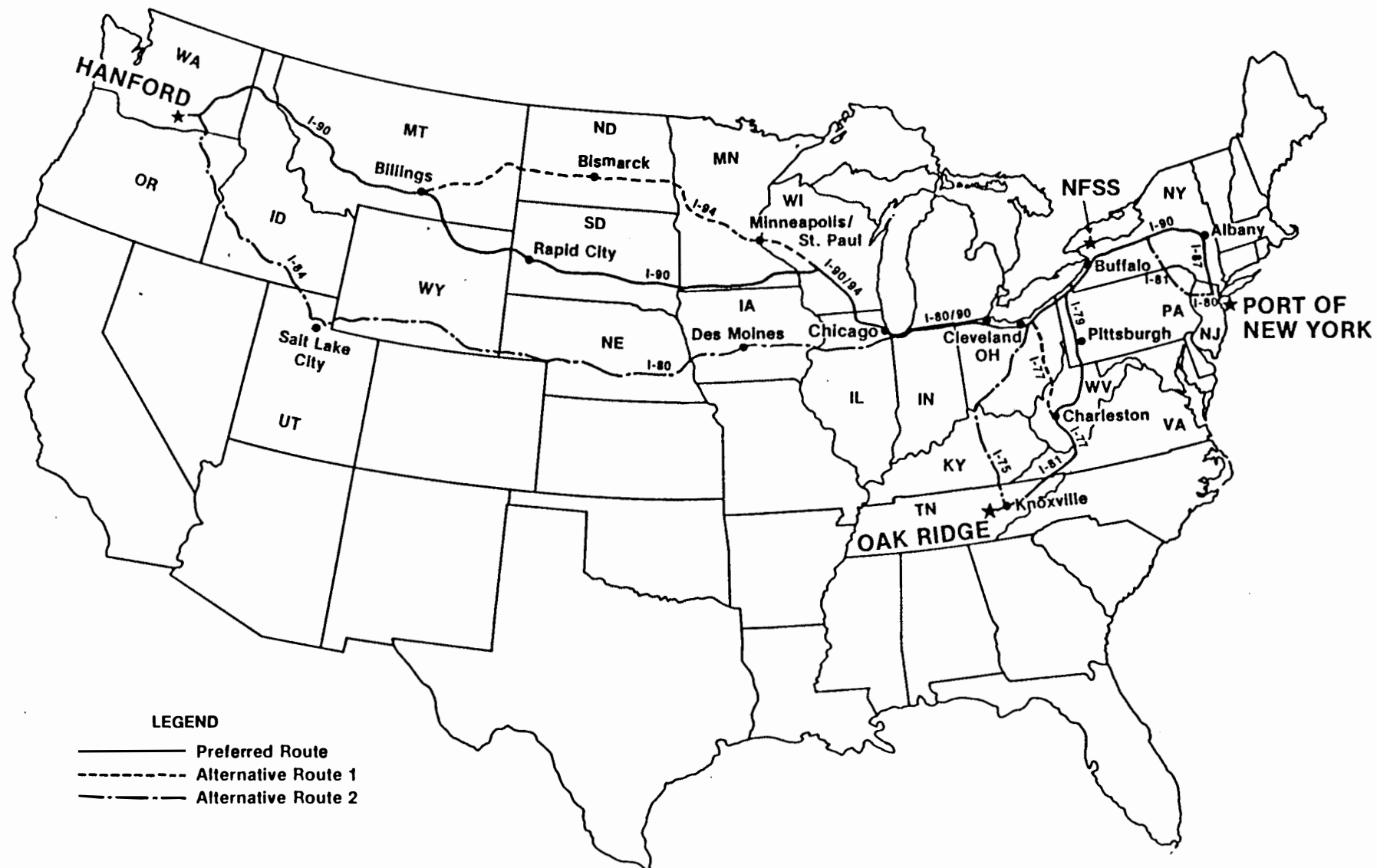


Figure D.1. Preferred and Alternative Truck Routes to Hanford, Oak Ridge, and NY/NJ Harbor (Port of New York).

preferred route again at Billings, MT. Alternative Route 2 (Figure D.1) to Hanford departs from the preferred route south of Chicago, Illinois, and continues on I-80 through Illinois, Iowa, Nebraska, and Wyoming to Salt Lake City, Utah; northwest on I-84 through Idaho to Stanfield, Oregon; north on Route 395 across the Columbia River; north on Route 14 to Kennewick; and west on Route 12 to Richland where it again merges with the preferred route.

D.4.3 Alternative Routes to Humid Site (Oak Ridge)

Alternative Route 1 (Figure D.1) to Oak Ridge consists of taking I-90 along Lake Erie southwest to Cleveland; south on I-271 to Akron; south on I-77 through southern Ohio to Charleston, West Virginia, where it rejoins the preferred route. Alternative Route 2 (Figure D.1) involves taking I-271 south around Cleveland and continuing southwest on I-71 to Cincinnati, Ohio; south on I-75 through central Kentucky to Knoxville, Tennessee, where it rejoins the preferred route.

D.4.4 Alternative Routes to New York/New Jersey Harbor Area

Alternative Route 1 to the Harbor (Port of New York) consists of taking I-90 east of Buffalo, I-81 south from Syracuse, and Route 17 and I-87/287 from Binghamton into the Port of New York. Alternative Route 2 consists of continuing on I-81 through Binghamton to Scranton, Pennsylvania; I-380 southeast to I-80; and I-80 east through northern New Jersey to the Port of New York.

D.5 RAIL TRANSPORTATION

There are several options for transporting the NFSS wastes and residues that could make use of use of rail transportation. Determining which of these rail options is "best" requires analysis of several complex trade-offs and the "best" option is likely to be different for each type of waste and residue and for each offsite disposal alternative. Evaluating the monetary costs of transportation for each option (including construction costs and environmental impact mitigation costs) also requires analysis of several factors. In particular, the rates that a railroad would charge are uncertain because they would be influenced by the special requirements imposed for NFSS wastes and residues (routing, transit time, etc.), by the railroad's perception of potential hazards and by concerns about adverse public reaction. What the actual rates would be can only be determined by negotiation with the railroads. In addition to the monetary costs, the environmental impacts of each of the rail options must be considered. The most economical option may not necessarily be the best with regard to environmental impacts.

D.5.1 Transportation Options Using Rail

There are three basic groups of options for using rail to transport NFSS wastes and residues to disposal sites. These groups, which are defined by the type of equipment used for offsite transport of NFSS wastes and residues, are: (1) site to site on rail, (2) truck to offsite loading to rail, and (3) truck to trailer-on-flatcar (TOFC) to truck.

For site to site transport on rail, a rail spur would have to be constructed into NFSS. In this case, the wastes and residues would be trucked onsite to the onsite rail spur and loaded directly to railcars. The wastes would remain in railcars until they reached the disposal site, where they would again be loaded onto trucks for transport to the burial trenches (Hanford) or mounds (Oak Ridge). The required rail connection to NFSS would be approximately 8 km (5 mi) in length. In the case where no rail spur is constructed to NFSS, the wastes and residues would be trucked to an offsite loading facility in the Niagara/Buffalo area. Rail transport from the offsite loading facility to the disposal site could be accomplished in two ways: (1) the wastes and residues could be transferred to railcars for shipment to the disposal site and final transport on trucks to the disposal trenches or mounds, or (2) the truck trailers could be loaded onto flatcars for a TOFC move and, for final delivery, the trailers would be trucked to the disposal site. This latter option would make use of existing TOFC ramps near the origin and destinations. Upon completion of transport to an alternative site, all loading and transfer facilities would have to be decontaminated.

The NFSS wastes are chosen to illustrate these options because the wastes make up most of the transportation requirements. Figure D.2 shows the operations required to load NFSS wastes to bulk-handling railcars, or gondolas, both with and without a rail spur constructed to NFSS. Figure D.3 shows the operations at the disposal sites if the wastes arrive in gondolas. Figure D.4 shows the operations at NFSS and at the disposal sites if TOFC rail transportation is used.

All options using rail require trucks to some extent, and, except for the TOFC option, they also require transferring the wastes from truck trailer to railcar at or near NFSS. If this transfer occurs offsite, the environmental considerations of constructing, operating, and decontaminating an offsite loading facility must be taken into account. If the transfer occurs onsite at NFSS, the environmental considerations of constructing a rail spur must be considered. Also for these options, transfer back to truck is required at the disposal site to move the wastes and residues from the railcars to the final disposal location (e.g., into the trenches at Hanford or onto the knolls at Oak Ridge), except for the ocean-disposal alternative in which direct loading onto barges could be used. At Oak Ridge, there is a trade-off to be considered between costs and impacts of rail spur

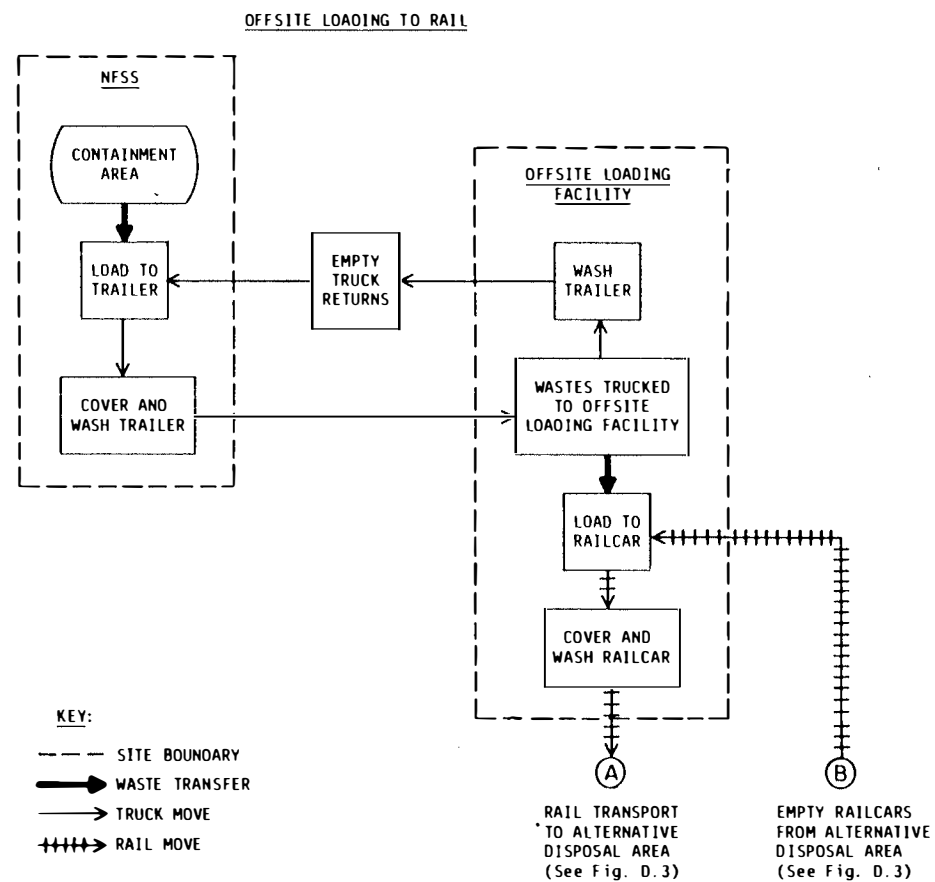
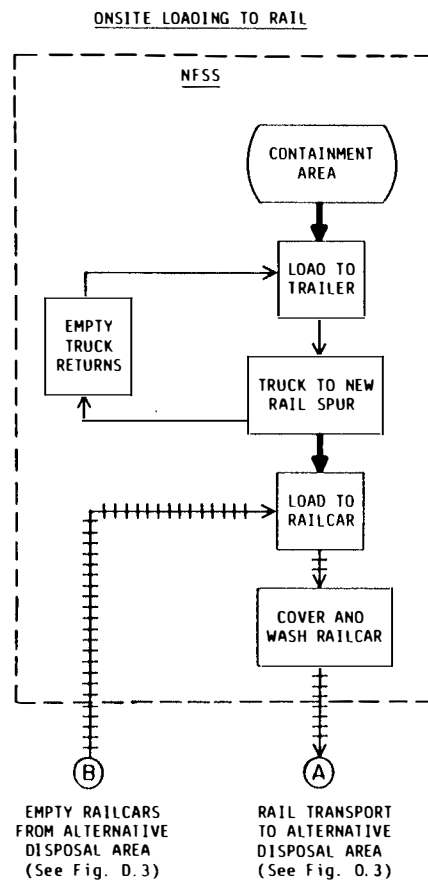


Figure D.2. Transport of Wastes from NFSS Using Bulk Handling Railcars.

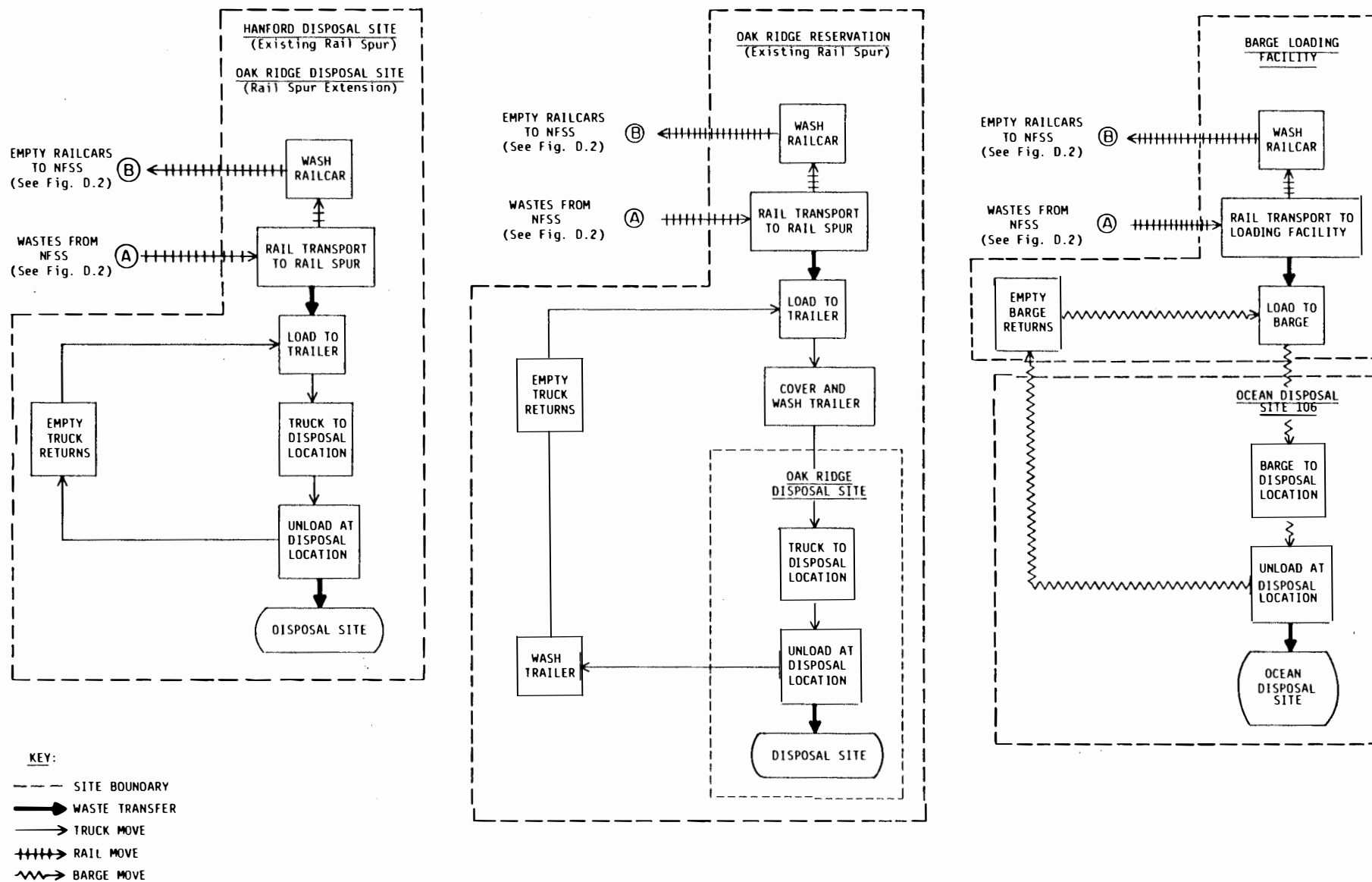


Figure D.3. Waste Transport to Disposal Sites Using Bulk Handling Railcars.

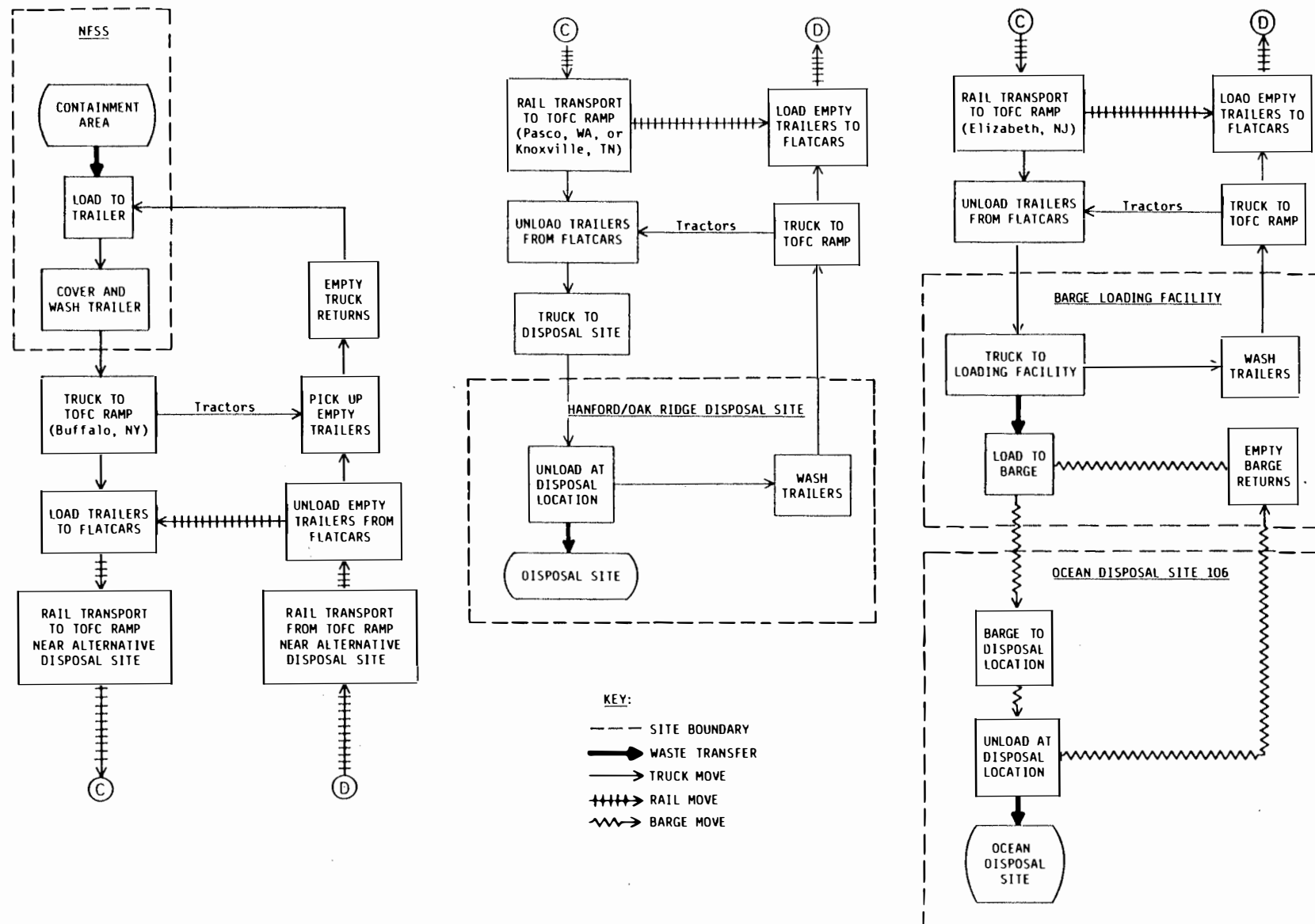


Figure D.4. Transport of Wastes from NFSS to Disposal Sites Using Trailer on Flatcar (TOFC).

construction and costs and impacts of a relatively long truck move to the disposal area. Rail access to the actual disposal site is already available at Hanford.

Within each of the particular options, there are several considerations for the rail portion of the move that will influence the rates and environmental impacts. Among these are whether or not the railcars move in dedicated trains or general-manifest trains and whether or not the railroads own the railcars. Use of dedicated trains will affect turnaround time and routing which, in turn, will affect equipment costs and environmental impacts. Railcar ownership affects rail rates charged and capital investment required (see Section D.5.2).

The purpose of the preceding discussion is to illustrate the interdependency of all decisions and show the effect that the choice of transport mode has on other operational costs and environmental impacts. In the following discussion of rail options and the trade-offs that must be considered, the rail options are categorized into three groups by their offsite transportation requirements. These groups are: (1) from NFSS to the disposal site by rail; (2) from NFSS to offsite transfer by truck, then by rail to the disposal site; and (3) from NFSS to the nearest TOFC ramp by truck, then by rail to a TOFC ramp near the disposal site, and then to the disposal site by truck.

D.5.1.1 Site to Site on Rail

For bulk transport of NFSS wastes, gondolas designed for clamshell loading and unloading will most likely be used. Each gondola has a capacity of 91 MT (100 tons) and will be equipped with removable fiberglass covers. Other possibilities are side-dump or bottom-dump hopper cars. However, because of the moisture content required for dust control, the wastes would probably not be free-flowing enough for bottom-dump cars. In both of these cases, more expensive unloading facilities would be required, but use of such facilities would result in faster unloading rates.

The K-65 and L-30/F-32 residues will be packaged in Mark-III bins (see Section D.3). These bins will need additional shielding during transport and could be palletized or blocked for fork-truck loading to shielded boxcars. An alternative to boxcars would be use of a shielded, covered gondola so that the bins could be loaded with a crane; however, this would require bins less than 1.2-km (4-ft) high. The L-50 residues will also be packaged in Mark-III bins but will not require any additional shielding. These could be loaded onto flatcars using a crane or fork-truck. The cars could move in either manifest or dedicated trains. Dedicated trains would provide much faster turnaround times and therefore would reduce the number of cars required.

Both the Hanford and Oak Ridge Reservations have rail access. Access to the Pine Ridge disposal site on the Oak Ridge Reservation may require construction of a rail spur of approximately 11 km (7 mi) in length in order to move the railcars close to the disposal site and reduce the impacts of onsite trucking. Rail service is available to the Perth Amboy Port area for direct loading to barges for the ocean-disposal alternative.

D.5.1.2 Truck to Offsite Loading to Rail

If a rail spur is not built to NFSS, an offsite loading facility would have to be constructed. The wastes will be transported to the facility using trucks and safeguards as described in Section D.3, and they will be transferred by clamshell or other bulk transfer equipment to gondolas. Containment safeguards will have to be provided at the transfer facility. The K-65 and L-30/F-32 residues will be transported to a transfer point in shielded vans as described in Section D.3. There they will be transferred to shielded boxcars or shielded gondolas using appropriate material-handling equipment (fork-lifts or cranes), with shielding provided on the equipment as needed to protect the equipment operators. The L-50 residues will be transported to a transfer point on flat-bed truck trailers, and they will be transferred to flatcars using a crane. A similar transfer back to truck will be required for the final move to the disposal site.

D.5.1.3 Truck to Trailer-on-Flatcar to Truck

In the truck to TOFC to truck rail option, all wastes and residues will be packaged and loaded on truck trailers as described in Section D.3. The trailers will be moved to a TOFC ramp, loaded onto flatcars, and transported by rail to a TOFC ramp near the disposal site. There they will be off-loaded from the flatcar and trucked to the disposal site. TOFC ramps are located in Buffalo, New York, for loading from NFSS. Near the Oak Ridge site, ramps are located in Knoxville, Tennessee; and near the Hanford site, there is a ramp located in Pasco, Washington. A ramp in Elizabeth, New Jersey, is convenient to the Port of New York area for the ocean disposal alternative.

D.5.2 Comparison of Rail Options

Determining which rail option is best depends on many trade-offs. The transportation costs, equipment requirements, material-handling costs, environmental impacts, and mitigation costs vary among the options. The rates that would be charged by the railroads for NFSS wastes and residues are uncertain and would require negotiation. These rates would also depend on car ownership and whether dedicated trains or general-manifest trains were used. The various factors affecting components of

the total monetary cost of the rail transportation options are summarized in Table D.5. Many of these factors have an effect on more than one of the cost components and on other factors (see Figures D.2 through D.4).

In the following discussion, the major considerations for the basic transportation options for the NFSS wastes and residues are summarized, including comparison of the advantages and disadvantages that must be traded off against the transportation rates negotiated with the carriers. The advantages and disadvantages of options for transporting NFSS wastes are listed in Table D.6. The major trade-off between onsite loading to rail and offsite loading to rail is between the costs and environmental impacts of constructing a rail spur from Niagara Falls to NFSS and the costs and environmental impacts of operating an offsite transfer facility plus the cost of the additional trucking equipment required. The major trade-off between onsite loading to rail and TOFC is between the impacts and costs of rail spur construction to NFSS and the higher equipment requirements and possibly higher rates of TOFC. The major trade-off between offsite loading to rail and TOFC is between the costs and environmental impacts of offsite material handling and the possibly higher transportation rates and equipment requirements of TOFC. The major advantage of TOFC over direct truck is lower labor costs.

The advantages and disadvantages of the rail options for transportation of the K-65 and L-30/F-32 residues are listed in Table D.7. Again, the trade-offs between direct rail and the other options are: (1) in the case of truck/rail, rail spur construction costs, impacts, and handling considerations, and (2) in the case of TOFC, transportation rates and equipment requirements. The environmental problems associated with offsite transfer of packaged residues would be less than those associated with the bulk-handled wastes.

The advantages and disadvantages for the L-50 residues are listed in Table D.8. In this case, handling the packaged wastes offsite presents no problem; thus, either direct rail (if a rail spur were built to handle NFSS bulk wastes) or truck/rail would most likely be preferable to the higher equipment needs and possibly higher rates of TOFC or direct truck.

D.5.3 Transportation Equipment Requirements

In comparing the equipment requirements for the rail options, trucks and trailers required for onsite transfer of materials are not included because these requirements will depend on site-specific decisions. If a rail spur to NFSS is not built, then the tractors and trailers used to move the materials to the offsite loading location would also handle onsite movements. However, even if the rail spur is built, some equipment would be required to move the materials from the containment area to the onsite loading facility. The requirements for onsite movement at Oak Ridge will depend on whether or not the rail spur is extended. In the case of TOFC (and truck), the equipment requirements for offsite transportation are sufficient for any onsite movements because the tractor trailers can move from the containment area at NFSS and to the disposal area at either Hanford or Oak Ridge.

D.5.3.1 Site to Site on Rail

For the direct rail option, only railcars are required for offsite transport. Gondolas would be used for the NFSS wastes, boxcars or covered gondolas for the K-65 and L-30/F-32 residues, and flatcars for the L-50 residues. A 91-MT (100-ton) gondola has a volume carrying capacity of approximately 52 m³ (70 yd³). Transporting all the NFSS wastes would require 3200 car trips. Standard boxcars have a load carrying capacity of 64 MT (70 tons). Carrying 14 bins per car would allow for 16,000 kg (35,000 lb) of shielding per car. Transporting all the K-65 and L-30/F-32 residues would require about 420 car trips. A standard flatcar has a nominal capacity of 70 MT (77 tons) and could carry 18 fully loaded bins. Transporting the L-50 residues would require 47 car trips. The equipment requirements for shipments to Hanford and Oak Ridge for Alternatives 3a and 3b are shown in Table D.9.

D.5.3.2 Truck to Offsite Loading to Rail

In addition to the rail equipment required for direct rail as described above, the truck to offsite loading to rail option also requires tractors and trailers to transport the wastes and residues from NFSS to an offsite loading facility in or near the city of Niagara Falls, New York. This would require, in addition to the 3665 railcar trips, approximately 16,000 truck trips. However, these truck trips are short and, therefore, the equipment requirements are low (see Table D.9).

D.5.3.3 Truck to Trailer-on-Flatcar to Truck

The equipment requirements for TOFC include semitrailers in numbers sufficient to make the number of truck trips required to transport the wastes and residues. However, because the turnaround time for a dedicated train would most likely be shorter than the turnaround time for truck, the number of trailers required would be smaller than required for using trucks only. In addition, one rail flatcar is required for every two semitrailers for the rail portion of the trip. The flatcars have a nominal capacity of 70 MT (77 tons) and are 16 m (52 ft) in length. A standard 15-m³ (20-yd³) dump trailer is 5.5 m (18 ft) in length. Longer vans and flat-bed trailers used for residues could be matched with dump trailers to accommodate their longer lengths, if necessary. Truck tractors would be required at each end to move the trailers between the TOFC ramps and the sites. The equipment requirements for the TOFC option are shown in Table D.9.

Table D.5. Factors Affecting Transportation Costs

Construction Costs	Rolling Stock Requirements	Rates Charged by Carriers	Operating and Handling Costs	Environmental Mitigation
• Rail spurs • Offsite loading facilities • Truck washing facilities • Railcar washing facilities	• Type of shipment • Bulk • Boxcar • Flatcar • TOFC • Truck • Turnaround times • Cleanup schedule	• Type of shipment • Bulk • Boxcar • Flatcar • TOFC • Truck • Classification of material • Distance • Special requirements • Routing • Turnaround times • Dedicated trains • Special handling • Ownership of equipment • Perceptions of potential problems	• Transfer costs • Bulk • TOFC • Crane • Fork-truck • Railcar washing • Truck washing • Truck shielding • Railcar shielding	• Construction • Rail spur • Offsite loading facilities • Routing • Shielding • Truck washing • Railcar washing • Offsite transfer

Table D.6. Summary Comparison of Rail and Truck Transportation Options for NFSS Wastes

Option† ¹	Advantages	Disadvantages
Rail--Onsite loading and unloading	• No offsite material handling	• Requires rail spur construction
Rail--Truck to offsite loading	• No rail spur construction	• Material handling doubled • Offsite material handling • Liners, covers, and gaskets required for both truck trailers and railcars
TOFC--Truck to nearest TOFC ramp	• Material handling minimized • No offsite material handling • No rail spur construction	• Higher equipment requirements
Truck	• Material handling minimized • No offsite material handling • No rail spur construction	• Highest equipment requirements • Highest labor requirements

†¹TOFC = trailer-on-flatcar.

Table D.7. Comparison of Rail and Truck Transportation Options for NFSS K-65 and L-30/F-32 Residues

Option† ¹	Advantages	Disadvantages
Rail--Onsite loading and unloading	• Minimum handling • Minimum shielding (railcar only)	• Requires rail spur construction
Rail--Truck to offsite loading	• No rail spur construction	• Both truck trailers and railcars require shielding • Radiation protection required at offsite transfer facility
TOFC--Truck to nearest TOFC ramp	• Minimum handling • Minimum shielding (trailer only) • No rail spur construction	• Higher equipment requirements
Truck	• Minimum handling • Minimum shielding (trailer only) • No rail spur construction	• Highest equipment requirements • Highest labor requirements

†¹TOFC = trailer-on-flatcar.

Table D.8. Comparison of Rail and Truck Transportation Options for NFSS L-50 Residues

Option† ¹	Advantages	Disadvantages
Rail--Onsite loading and unloading	• Minimal loading onsite	• Requires rail spur construction
Rail--Truck to offsite loading	• No rail spur construction	• Minimal loading offsite
TOFC--Truck to nearest TOFC ramp	• No rail spur construction	• Higher equipment requirements
Truck	• No rail spur construction	• Highest equipment requirements • Highest labor requirements

†¹TOFC = trailer-on-flatcar.

Table D.9. Offsite Transportation Equipment Requirements for Rail Options for Alternatives 3a and 3b

Option	Trips Required per Destination							
	Hanford				Oak Ridge			
	2 yr	3 yr	4 yr	5 yr	2 yr	3 yr	4 yr	5 yr
Direct Rail								
Railcarst ¹	150	100	75	60	105	70	53	42
Semitrailers† ²	-	-	-	-	-	-	-	-
Tractorst ²	-	-	-	-	-	-	-	-
Truck/Rail:								
Railcarst ¹	150	100	75	60	105	70	53	42
Semitrailers† ³	17	11	9	7	17	11	9	7
Tractorst ³	17	11	9	7	17	11	9	7
TOFC:								
Railcarst ⁴	272	180	136	108	170	90	68	54
Semitrailers† ^{4,†5}	601	398	301	239	386	210	160	126
Tractorst ⁵	57	38	29	23	46	30	24	18

†¹ Assumes dedicated unit train travel times with round trip of 10 days for Hanford (6 travel, 4 loading and unloading) and 7 days for Oak Ridge (3 travel, 4 loading and unloading).

†² Onsite equipment to move from containment area to rail spur or from rail spur to disposal location is not included.

†³ Assumes 4 round trips per day between NFSS and loading location. No onsite equipment is included to move from rail spur to disposal locations.

†⁴ Assumes dedicated unit train travel times with round trip of 8 days (6 travel, 2 loading and unloading) to Pasco, Washington, and 5 days (3 travel, 2 loading and unloading) to Knoxville, Tennessee.

†⁵ Assumes 3 round trips per day between NFSS and the Buffalo TOFC ramp, 2 round trips per day between Hanford and the Pasco TOFC ramp and 3 round trips per day between Oak Ridge and the Knoxville TOFC ramp.

D.5.4 Routing for Rail and Trailer-on-Flatcar

D.5.4.1 Direct Rail Routings

Niagara Falls is served by Conrail, and both the Norfolk Southern (NS) and CSX systems have trackage rights between Niagara Falls and Buffalo, New York. All three of these railroads have trackage rights on lines on the north side of Lake Erie through Canada to Detroit, Michigan. In some cases, this route is part of the most direct route, but it was eliminated from consideration because of the sensitive nature of the material being transported.

The Oak Ridge disposal site is served by a rail spur connected to the Louisville and Nashville (L&N) line about 2 km (1.2 mi) south of Dossett, Tennessee. The L&N is part of the CSX system so it is reasonable for shipments from NFSS to Oak Ridge to be made entirely on the CSX system. A likely routing on the CSX system from Niagara Falls to Oak Ridge (1365 km [852 mi]) is shown in Figure D.5.* The Hanford site is served by a Burlington Northern (BN) rail line out of Richland Junction. Because the BN cannot originate shipments out of Niagara Falls, an interline is necessary with another originating carrier. Figure D.6 shows a likely route for shipments originated by Conrail with an interline with the BN at Gary, Indiana (4322 km [2698 mi]); Figure D.7 shows a likely route for shipments originated by the NS system with an interline in Peoria, Illinois (4308 km [2689 mi]); and Figure D.8 shows a route originating on the CSX system with an interline at Chicago (4619 km [2883 mi]). The Port of New York area is served by Conrail; Figure D.9 shows a Conrail route from Niagara Falls to Perth Amboy, New Jersey (658 km [411 mi]).

*The Oak Ridge Reservation is also served by a rail spur connected to the Norfolk Southern Railroad line west of Dossett. Shipments, therefore, could be made from Niagara Falls on the Norfolk Southern.

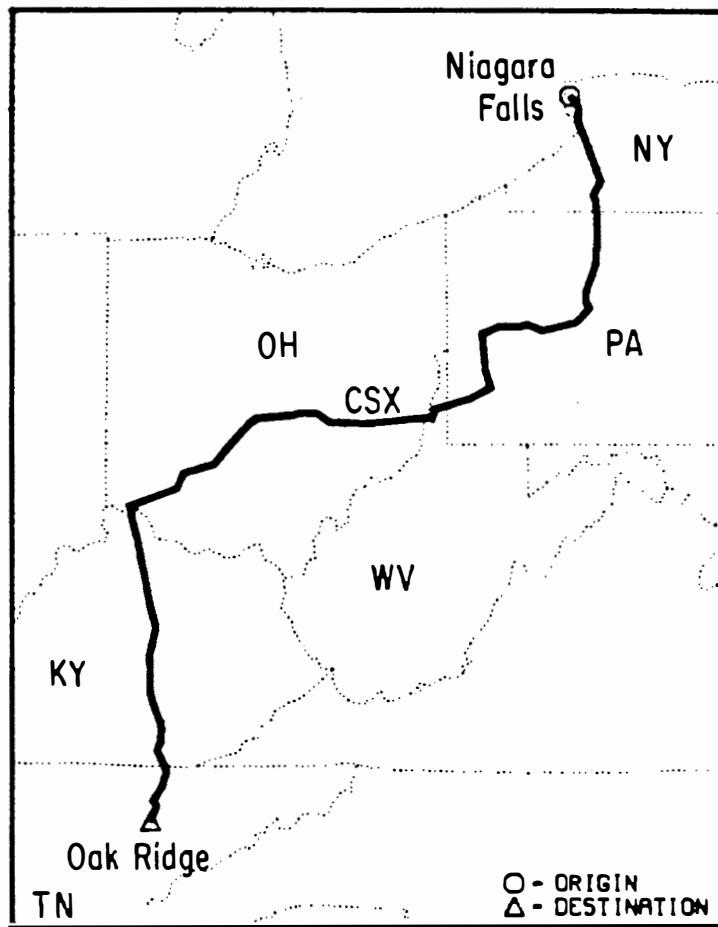


Figure D.5. CSX Route from Niagara Falls to Oak Ridge.

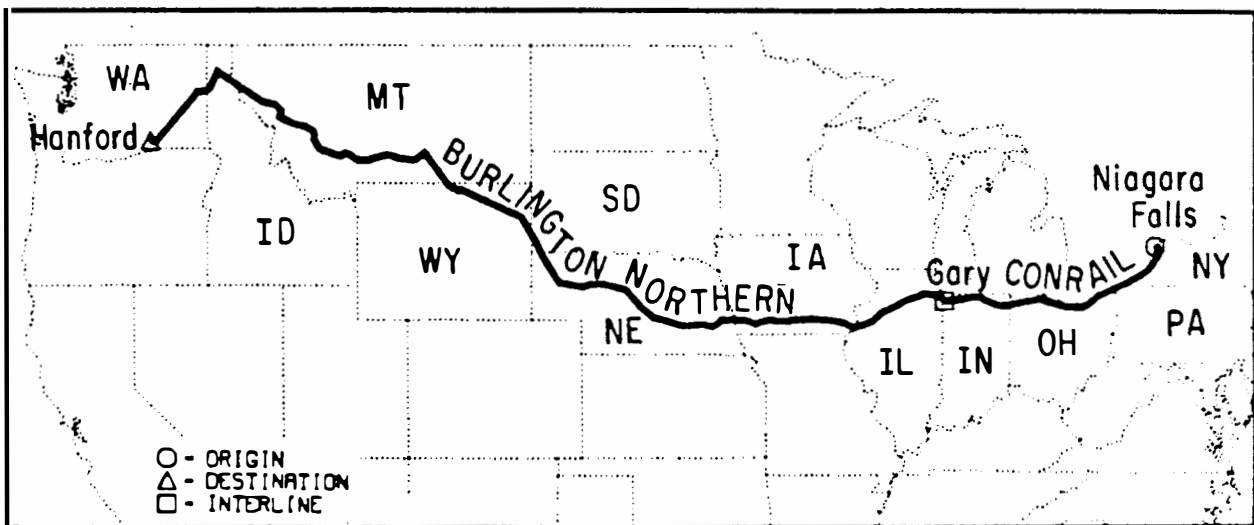


Figure D.6. Conrail/Burlington Northern Route from Niagara Falls to Hanford.

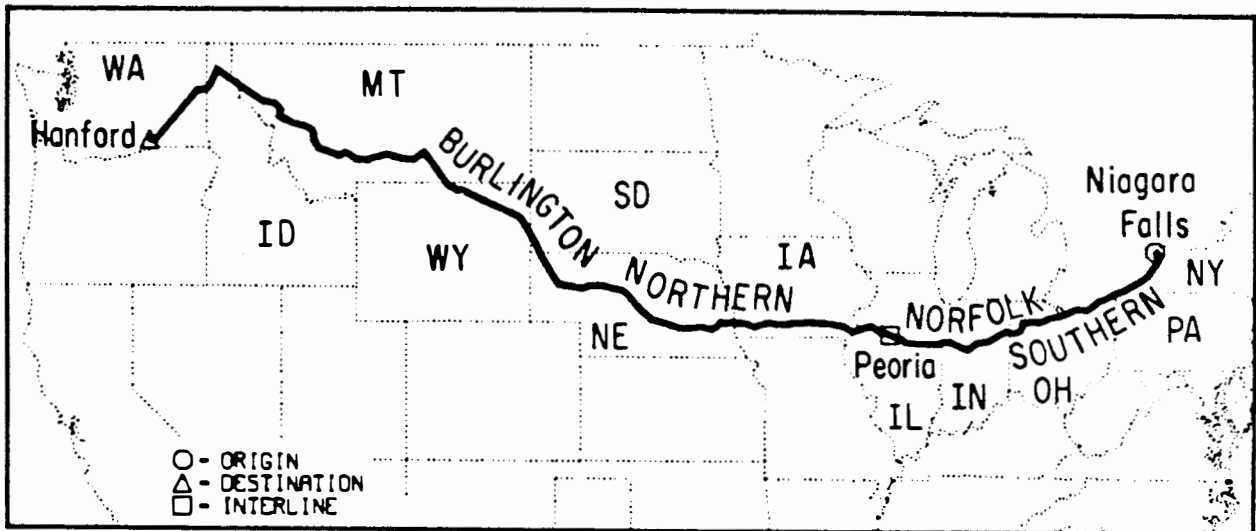


Figure D.7. Norfolk Southern/Burlington Northern Route from Niagara Falls to Hanford.

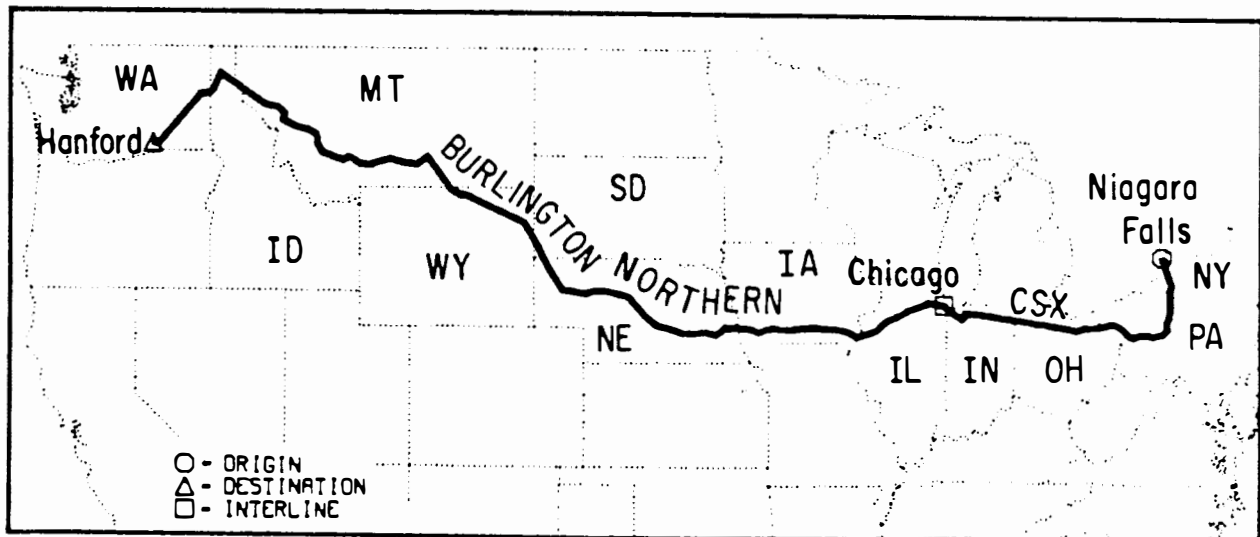


Figure D.8. CSX/Burlington Northern Route from Niagara Falls to Hanford.

D.5.4.2 Trailer-on-Flatcar Routings

The closest TOFC ramps to Niagara Falls are those operated by Conrail, Grand Trunk, and NS in Buffalo, New York. Ramps are operated in Knoxville, Tennessee, by Southern (part of the NS system) and by Seaboard (part of the CSX system). Therefore, for TOFC shipments from Buffalo to Knoxville, the NS system is the logical choice. Figure D.10 shows a likely routing for such a move on the NS system (1344 km [839 mi]). The BN system operates a ramp near the Hanford site at Pasco, Washington. Figure D.11 shows a routing from Buffalo to Pasco for TOFC shipments originating at the Conrail ramp in Buffalo, with an interline in Gary, Indiana (4276 km [2669 mi]). Figure D.12 shows a routing from Buffalo to Pasco for TOFC shipments originating at the NS ramp in Buffalo, with an interline in Peoria, Illinois (4263 km [2661 mi]). Conrail operates a ramp in Elizabeth, New Jersey, which would be convenient for shipments to the Port of New York area. Figure D.13 shows a routing on the Conrail system from Buffalo to Elizabeth, New Jersey (623 km [389 mi]).

D.5.5 Regulations

The effect of carrier tariffs and operating restrictions on shipments of NFSS wastes and residues is uncertain. The nation's railroads have been engaged in litigation with industrial and governmental shippers of radioactive materials for over 10 years. The Interstate Commerce Commission has ruled against the carriers in each case, and the federal courts have upheld the shippers. However, the rail carriers are still persistent in their demands for special trains and higher freight rates for transport of radioactive materials. Further litigation is likely, although the railroads have apparently given up their alleged right of refusal to carry shipments of radioactive materials.

Although the NFSS wastes are not classified as radioactive for transportation purposes, the published rates for transport of bulk materials--such as sand and gravel--probably will not apply. The NFSS wastes will require special handling and also may be perceived by the railroads as presenting potential hazards or problems to the general public. Therefore, special constraints and tariffs on shipments of NFSS wastes are likely to be imposed. The residues are defined as radioactive and, therefore, the special tariffs for these materials will apply.

D.6 TRUCK REQUIREMENTS FOR FILL MATERIALS

It is assumed that all fill material will be transported to the sites by 15-m³ (20-yd³) dump trucks. Assuming the empty weight of the truck to be 15,000 kg (32,000 lb), a payload of 22,000 kg (48,000 lb), and a density of 1,800 kg/m³ (3,000 lb/yd³) for all fill materials, one truck can carry a maximum weight of 12 m³ (16 yd³) of fill per trip. The fill requirements for Alternatives 2a, 2b, 3a, 3b, 4a, 4b, 4c, and 4d and the number of truck trips required to transport this fill are presented in Table D.10. The fill requirements are greatest for Alternative 3b (long-term management of both residues and wastes at Oak Ridge). The vehicle requirements to implement all alternatives are presented in Table D.11.

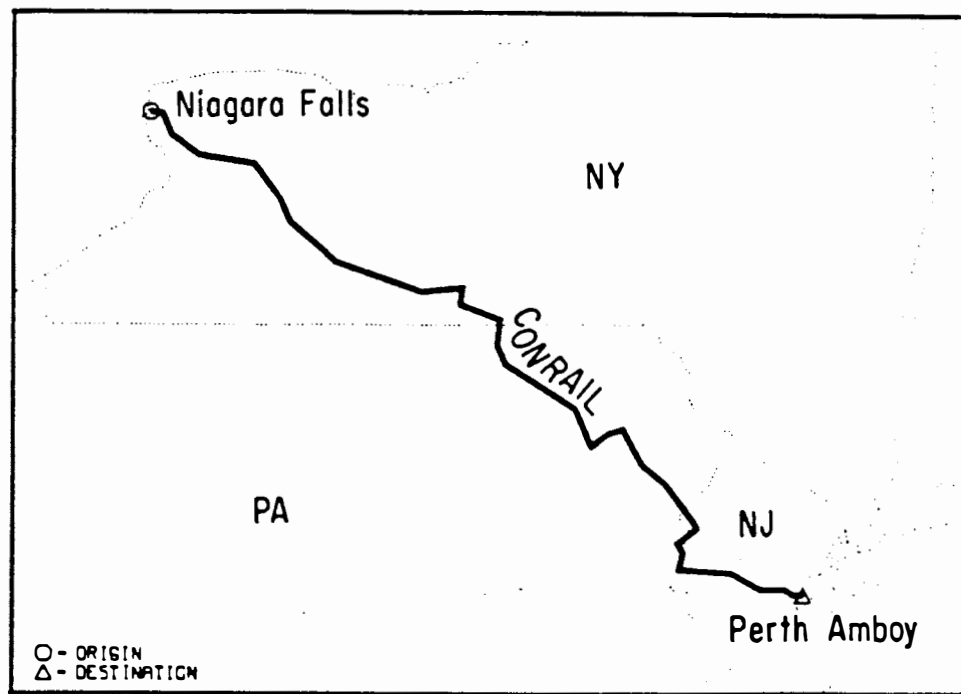


Figure D.9. Conrail Route from Niagara Falls to Perth Amboy, New Jersey.

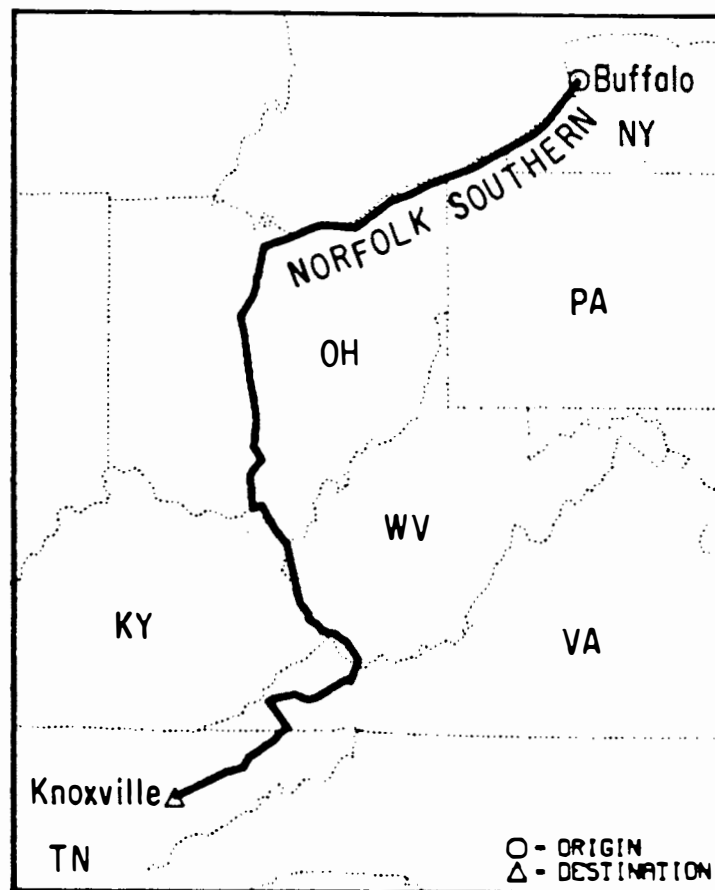


Figure D.10. Norfolk Southern Route from Buffalo, New York, to Knoxville, Tennessee.

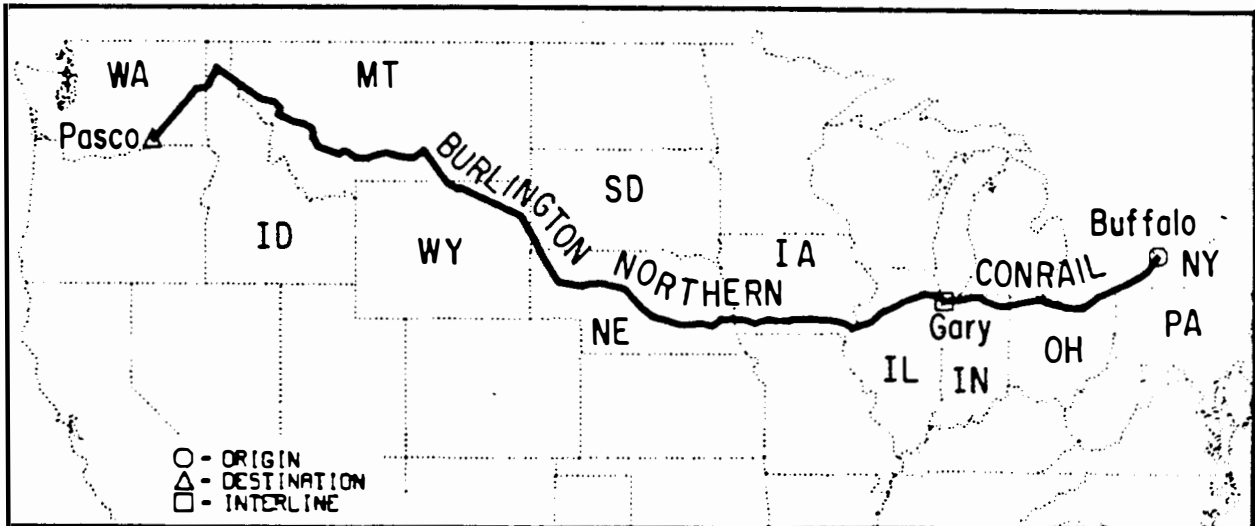


Figure D.11. Conrail/Burlington Northern Route from Buffalo, New York, to Pasco, Washington.

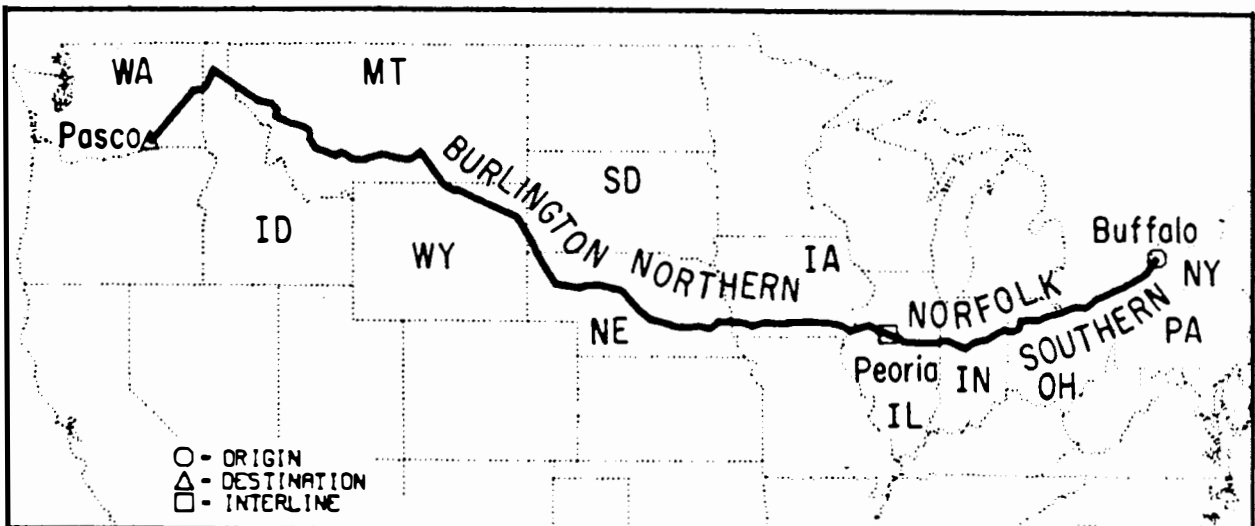


Figure D.12. Norfolk Southern/Burlington Northern Route from Buffalo, New York, to Pasco, Washington.

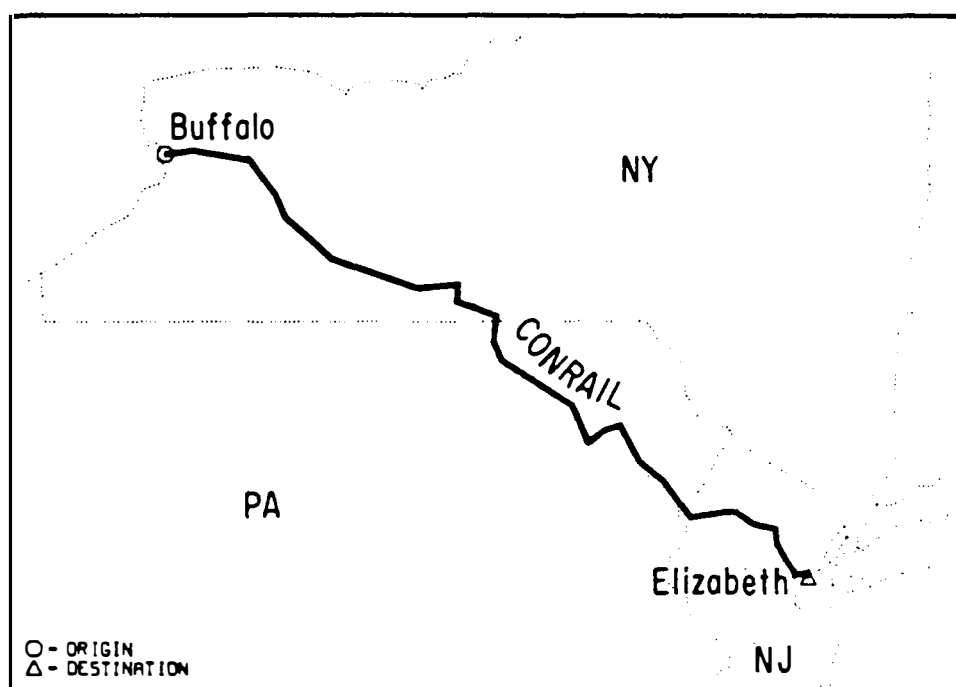


Figure D.13. Conrail Route from Buffalo, New York, to Elizabeth, New Jersey.

Table D.10. Fill Requirements and Transportation Requirements†¹

Site/Alternative	Fill Requirements (m³)†²					Number of One-Way Truck Trips†³
	Clay	Sand/Gravel	Soil	Riprap	Total	
<u>NFSS</u>						
2a, 2b†⁴	47,000	14,000	5,900	41,000	110,000	9,200
3a, 3b, 4b, 4d†⁵	-	-	20,000	-	20,000	1,700
4a, 4c†⁶	57,000	14,000	5,900	41,000	120,000	10,600
<u>Hanford</u>						
3a†⁶	-	-	-	150,000	150,000	13,000
4a, 4b†⁷	-	-	-	37,000	37,000	3,100
<u>Oak Ridge</u>						
3b	290,000	72,000	54,000	110,000	530,000	44,000
4c, 4d	65,000	16,000	12,000	24,000	120,000	9,800

†¹ All values rounded to two significant figures.

†² Assuming containment designs and waste-containment areas as described in Sections 2 and 4.6.

†³ Assuming average truck capacity of 12 m³ (16 yd³).

†⁴ Additional materials needed to construct the long-term cap, assuming that the clay and soil in the interim cap can be used in the long-term cap.

†⁵ Fill materials needed to restore grade in containment area.

†⁶ Additional materials needed to construct the long-term cap, plus 11,000 m³ of clay needed to fill void left by removed residues.

†⁷ Only riprap is needed at Hanford because the native soils excavated from the trenches will be used as backfill.

Table D.11. Truck Requirements for Hauling Fill Material†¹

	NFSS† ²			Hanford† ²		Oak Ridge† ²	
	2a, 2b	3a, 3b 4b, 4d	4a, 4c	3a	4a, 4b	3b	4c, 4d
Round trips	9,200	1,700	10,000	13,000	3,100	44,000	9,800
Rate of trucks arriving and departing:							
trucks/day	150	28	170	44	10	360	82
trucks/hour	19	3.5	21	6	1.3	45	10
Dedicated trucks required† ⁴	52	10	57	17	4	120	28
Material transported:							
m ³ /yr	110,000	20,000	120,000	31,000	7,400	260,000	59,000
m ³ /mo	18,000	3,400	20,000	5,200	1,200	44,000	9,800
m ³ /wk	4,500	800	5,000	1,200	290	10,000	2,300
Total distance travelled (m)	370,000	68,000	400,000	520,000	120,000	1,700,000	390,000

†¹ Assumes that fill materials will be obtained within a 32-km (20-mi) radius of the site. All values rounded to two significant figures.

†² Assumes that it will take 1 year to complete fill operations for Alternatives 2a, 2b, 3a, 3b, 4a, and 4c at NFSS; 2 years for Alternatives 3b, 4c, and 4d at Oak Ridge; and 5 years for Alternatives 3a, 4a, and 4b at Hanford.

†³ Assumes a 6-month (120-day) construction season, 8-hour working day, and 2.5-hour round-trip loading/travel time for all sites.

†⁴ Includes 10% excess contingency of trucks to cover repairs and maintenance.

REFERENCES (Appendix D)

- Bechtel National, Inc. 1984. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. DOE/OR/20722-1. Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. January 1984.
- Chem-Nuclear Systems Incorporated. 1983. CNSI Cask Specifications. Channahon, Illinois 60410.
- Peele, R., and J.A. Church. 1941. Mining Engineers' Handbook. 3rd ed. John Wiley & Sons, Inc., New York.
- U.S. Department of Transportation. 1981. Radioactive Materials; Routing and Driver Training Requirements (49 CFR Parts 171, 172, 173, 177); Final Rule. Materials Transportation Bureau, Research and Special Programs Administration. Fed. Regist. 46(12):5298-5318 (January 19, 1981).
- U.S. Department of Transportation. 1983a. Requirements for Transportation of Radioactive Materials (49 CFR Parts 171, 172, 173, 174, 175, 176, 177, and 178); Final Rule. Materials Transportation Bureau, Research and Special Programs Administration. Fed. Regist. 48(48):10218-10247 (March 10, 1983).
- U.S. Department of Transportation. 1983b. Requirements for Transportation of Radioactive Materials; Corrections and Clarifications (49 CFR Parts 171, 172, 173, 174, 175, 176, 177, and 178); Final Rule. Materials Transportation Bureau, Research and Special Programs Administration. Fed. Regist. 48(131):31214-31220 (July 7, 1983).
- U.S. Supreme Court. 1984. City of New York vs. U.S. Department of Transportation. 715 Sec. F2d 732 (2d Circ., 1983) Sert denied 104 S. Ct 1403 (1984).

APPENDIX E. OCEAN DISPOSAL

E.1 INTRODUCTION

This appendix presents technical analyses and data used to assess the impacts of Alternatives 4b and 4d, which propose onland storage of NFSS residues and dispersal of the remaining wastes in the ocean. The residues represent only 6% of the NFSS contaminated materials but contain 99% of the radium-226 inventory (872 of 879 Ci). The remaining wastes--i.e., excavated materials and residues from the R-10 area and excavated contaminated soils and containment systems--represent 94% of the volume (179,000 m³) of contaminated materials at NFSS but only 1% (7 pCi) of the radium-226 inventory. The average activity of radionuclides in these wastes is 36 pCi/g, which is 20-40 times the radium-226 content of uncontaminated soils. Further details on waste composition are presented in Sections 3.1.7 and 3.1.8.

The analyses used in this appendix are based on existing techniques for evaluating the fate of both radioactive and nonradioactive wastes in the sea. Both the data and methods are available in published reports, journal articles, and books. The purpose of this study is to provide scenarios of waste fate that could be used to compare the radiological risk of Alternatives 4b and 4d with the other alternatives for long-term management of NFSS wastes and residues.

E.2 DUMPSITE CHARACTERISTICS

Implementation of Alternatives 4b and 4d will result in onland disposal of the NFSS residues at Hanford or Oak Ridge and permanent disposal of the NFSS wastes in the ocean. In this EIS, the site assumed for ocean disposal is the 106-Mile Ocean Waste Disposal Site (Site 106) managed by the U.S. Environmental Protection Agency (Figure E.1).

E.2.1 Location

Site 106 is a designated waste-disposal site located between 38°40' N to 39°00' N latitude and 72°00' W to 72°30' W longitude, which bounds 1300 km² (430 nmi²) of ocean surface lying over the lower Continental Slope and Upper Continental Rise where water depths range from 1440 to 2750 m (Figure E.1). Site 106 is 110 nmi southeast of the entrance to New York Harbor and 90 nmi east of Cape Henopen, Delaware (U.S. Environ. Prot. Agency 1980).

E.2.2 Disposal Activities

Site 106 has been used for waste disposal since 1961, and in 1973 the site was given interim designation as an industrial waste site by the U.S. Environmental Protection Agency, which prepared an environmental impact statement for final site designation in 1980 (U.S. Environ. Prot. Agency 1980). By 1978, the site had received 5,100,000 MT of chemical waste, 102,000 MT of sewage sludge, 287,000 MT of digester residue, and an unspecified quantity of munitions wastes that was dumped on the northwest corner of the site. Since 1978, waste disposal at Site 106 has decreased to 272,000 MT in 1981 (Paul et al. 1983). Other waste-disposal activities in the vicinity of Site 106 include the dumping of 41,400 Ci of low-level radioactive wastes contained in drums from 1951 to 1956 and from 1959 to 1961 at a location 10 nmi to the south (U.S. Environ. Prot. Agency 1980).

Passage of the Marine Protection, Research and Sanctuaries Act of 1972 required that permits for ocean disposal of wastes be issued only if no other alternative disposal method were available. Thus, the number of parties disposing of wastes declined from 150 to 13 in 1978. During this period, average annual dump rates were 163,000 MT/yr, with peak dumping activity of 779,100 MT in 1978. These wastes included elevated concentrations of the trace metals cadmium, chromium, copper, lead, mercury, nickel, and zinc. The concentrations of metals in wastes dumped at Site 106 are presented in Table E.1. The quantity of trace metals dumped varied greatly from year to year, with maximum mass loading rates of: cadmium, 19,503 kg/yr; chromium, 99,960 kg/yr; copper, 3,695 kg/yr; lead, 15,336 kg/yr; mercury, 1,626 kg/yr; nickel, 11,579 kg/yr; and zinc, 52,540 kg/yr (Table E.2). Further discussion of disposal at Site 106 is found in the site designation EIS (U.S. Environ. Prot. Agency 1980) and Anderson and Dewling (1981). The institutional issues associated with ocean disposal at the NFSS wastes are discussed in Section 4.7.2.

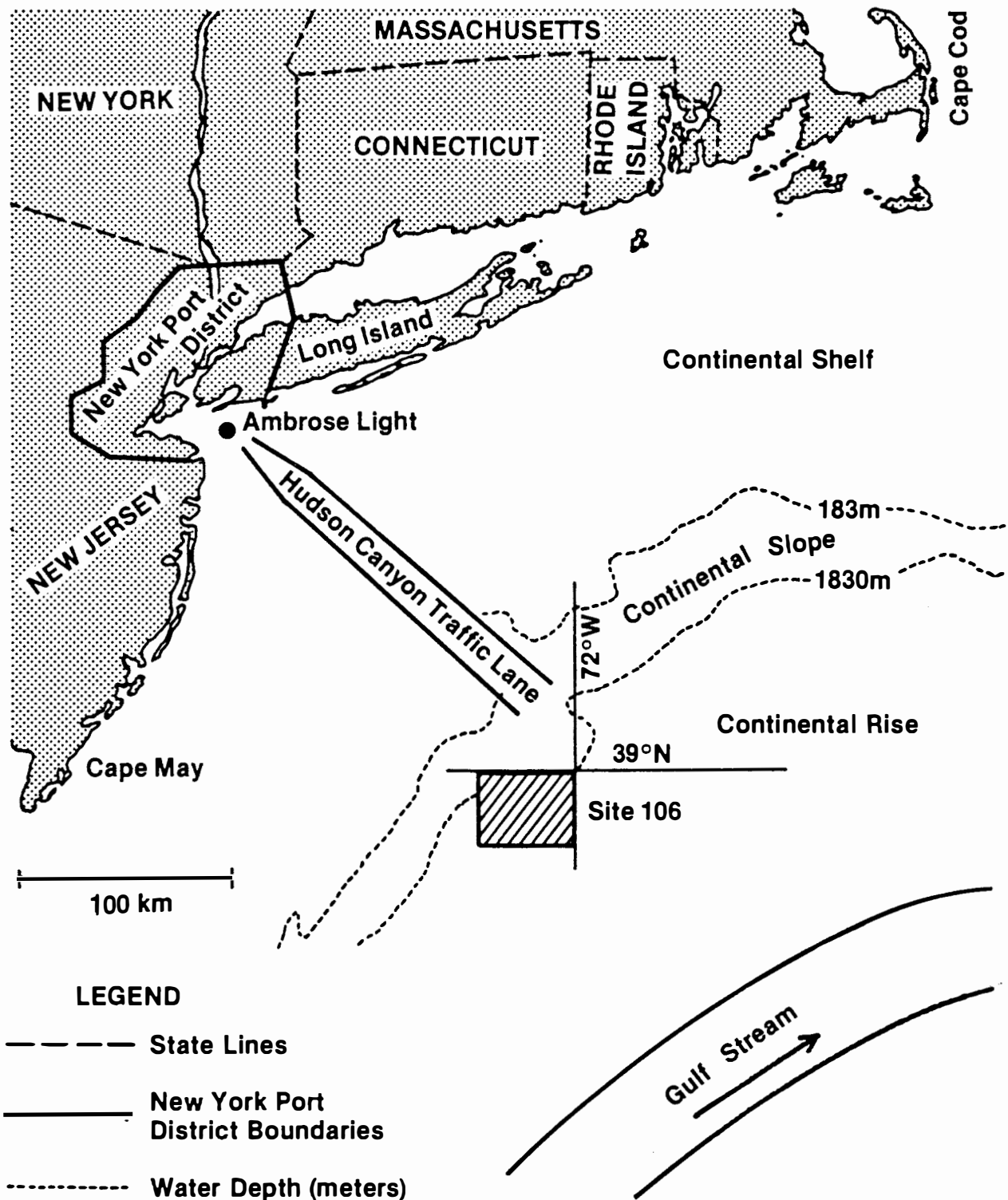


Figure E.1. Location of Site 106.

Table E.1. Average Metal Concentrations in Wastes at the 106-Mile Site

Metal	Natural Seawater Concentration ($\mu\text{g/L}$)	Concentration in Wastes ($\mu\text{g/L}$)			
		American Cyanamid		DuPont-Edge Moor	
		Mean	Range	Mean	Range
Arsenic	2-3	620	20-2,600	140	5-525
Cadmium	0.15	4	1-150	320	20-900
Chromium	1	550	45-4,900	270,200	52,600-900,000
Copper	3.0	350	1-4,100	3,250	4-7,400
Lead	0.03	120	1-1,000	40,540	2,700-76,000
Mercury	0.05-0.19	30	1-200	30	<1-500
Nickel	5-7	1,100	145-6,400	29,060	200-65,000
Zinc	10	560	7-5,150	100,960	110-530,000

Metal	Natural Seawater Concentration ($\mu\text{g/L}$)	Concentration in Wastes ($\mu\text{g/L}$)			
		DuPont-Grasselli		Mixed Industries	
		Mean	Range	Mean	Range
Arsenic	2-3	7	1-30	30	1-130
Cadmium	0.15	170	3-700	3,200	20-15,600
Chromium	1	330	10-3,500	21,170	4-170,000
Copper	3.0	3,150	25-154,700	10,900	1-115,000
Lead	0.03	900	10-4,900	8,840	8-62,000
Mercury	0.05-0.19	7	<1-20	300	21-3,830
Nickel	5-7	730	30-2,000	4,900	20-31,500
Zinc	10	540	30-2,700	163,800	15-1,400,000

Source: U.S. Environmental Protection Agency (1980).

Table E.2. Total Annual Mass Loading of Trace Metals from Waste Disposal

Trace Metal	Mass Loading (kg/yr)					
	1973	1974	1975	1976	1977	1978
Cadmium	211	5,516	19,503	213	812	168
Chromium	677	696	705	215	73,845	99,960
Copper	1,011	603	826	535	3,695	1,863
Lead	251	933	1,086	928	15,336	13,010
Mercury	45	14	1,626	964	10	11
Nickel	420	355	785	571	8,009	11,579
Zinc	12,125	15,803	7,279	3,231	23,382	52,540

Data from U.S. Environmental Protection Agency (1980).

E.2.3 Hydrodynamic Characteristics

E.2.3.1 Major Oceanographic Features

Site 106 is located in an area of considerable hydrodynamic complexity, due to movement of major regional oceanographic features. The site lies between shelf waters overlying the Continental Shelf to the west and the Gulf Stream to the south and east (Figure E.2). The characteristic water of the site, slope water, is a mixture of waters from the Continental Shelf and Gulf Stream and is separated from them by sharp gradients in temperature and salinity. The sharp transitions between water masses, called fronts, inhibit mixing between adjacent water masses; however, at the same time, fronts are energetic areas of convergence and turbulence. Both shelf/slope and slope/Gulf Stream fronts are highly mobile and undulating, and may move out over the Continental Slope beyond the vicinity of Site 106 (Figure E.3). The shelf/slope front may also pinch off tongues of water that form isolated lenses in the slope waters. The average shelf/slope front is located at the edge of the Continental Shelf (200 m isobath), varying about 50 km on either side of that position. In general, the front tends to move offshore during winter and onshore during summer.

The boundary between slope water and the Gulf Stream is also highly mobile because the Gulf Stream meanders with increasing amplitude from Cape Hatteras to an area southwest of Georges Bank where the looping meanders may pinch off and form large-scale (100-km) anticyclonic eddies. Because these features are composed of interleaved layers of colder shelf and slope waters around a central core of water derived from the Sargasso Sea, they are called warm-core rings. The rings are very energetic, with high water velocities (30-140 cm/s). Warm-core rings move slowly to the southeast (3-15 km/d) until they dissipate or merge with the Gulf Stream in the vicinity of Cape Hatteras. Site 106 is in the path of warm-core ring movement along the Continental Slope (Figure E.4). It is estimated that rings occupy Site 106 approximately 20% of the time (70 days per year) (Bisagni 1976; Bisagni and Kester 1981).

E.2.3.2 Water Masses

From water temperature and salinity data, Goulet and Hausknecht (1977) distinguish nine water types in the area of Site 106 (Figure E.5). Four of the water types have narrow and distinctive ranges of temperature and salinity representing major regional water masses. These four--the North Atlantic deep water, western North Atlantic water, North Atlantic central water, and deep slope water--are subsurface waters found below the permanent pycnocline* separating surface waters from deeper waters. Five of the water types are varieties of surface waters, called water categories. Three of the categories are related to place of origin: shelf water, slope water, and Gulf Stream water; the fourth category is related to mixing in warm-core rings: eddy water; and the fifth category is related to place of origin and seasonal weather: summer shelf water. Figure E.6 is a schematic diagram showing the relative position of water types during passage of a warm-core ring.

E.2.3.3 Water Stratification

Water stratification is the result of regions of sharp changes in water density with depth (pycnoclines). Two such features are characteristic of the dumpsite region: a seasonal thermocline that develops during summer heating of the surface waters, and a permanent pycnocline that separates surface waters from deeper waters. The seasonal thermocline is a relatively shallow feature that develops in slope and shelf waters during the spring and summer. Selected depth profiles of temperature and salinity are presented in Figures E.7 and E.8. The seasonal thermocline is evident from sharp decreases in temperature in a depth range of near-surface to 50 m (June) or 30 to 50 m (October). During winter months (November to April), the temperature profiles of the upper 100 m do not show such temperature declines. The permanent pycnocline is evident in both the temperature and salinity diagrams as an area of sharp temperature decrease and slight salinity increases beginning at 100 m.

E.2.3.4 Currents

Analyses of currents in the region of Site 106 come from two sources. Woods Hole Oceanographic Institution has operated current meters at Site D (Figure E.9), 198 km northeast of Site 106, in an area of the upper Continental Rise similar to the lower portions of Site 106. Ingham et al. (1977) have analyzed these data, calculating average current speed and direction (Table E.3). Average currents are greatest in the upper waters and decline with depth. Current direction was generally to the west, which is parallel to the bottom contours at Site D. Extrapolating these data to Site 106 results in the assumption that average currents of similar magnitude flow to the southwest in the vicinity of Site 106. This assumption is supported in a summary by Warsh (1975) of these and other current measurements in the vicinity of Site 106.

*A pycnocline is an area of sharp changes in water density due to changes in salinity (halocline) and/or temperature (thermocline).

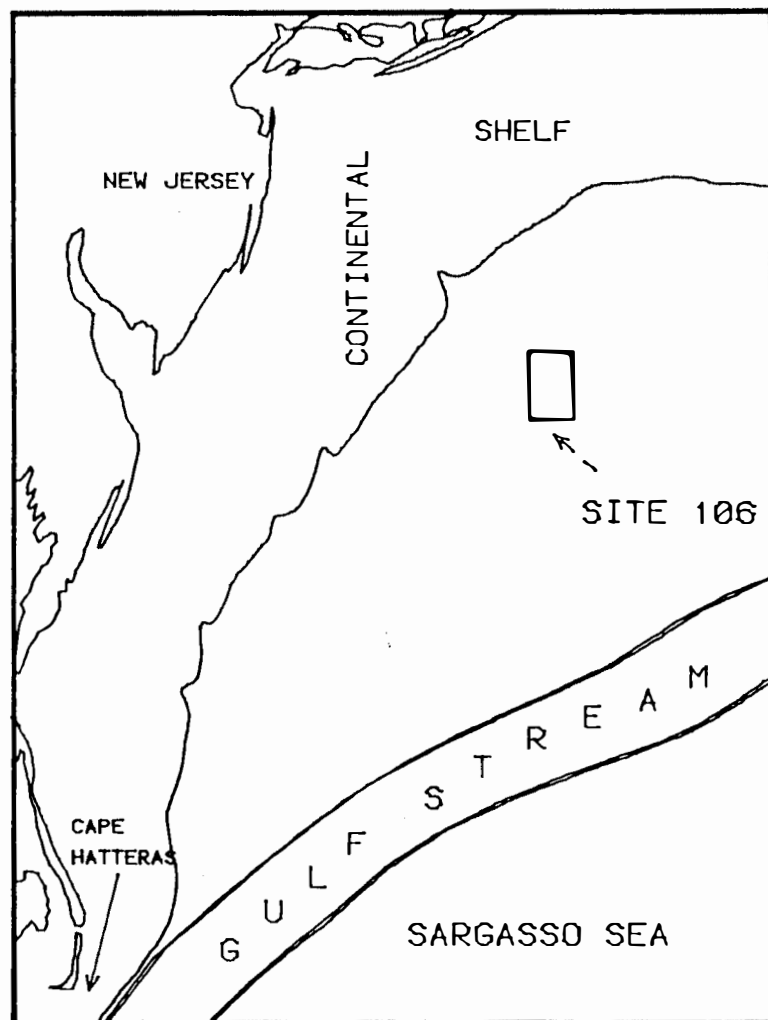


Figure E.2. Generalized Diagram of Surface Water Masses in the Vicinity of Site 106. Adapted from: Warsh (1975).

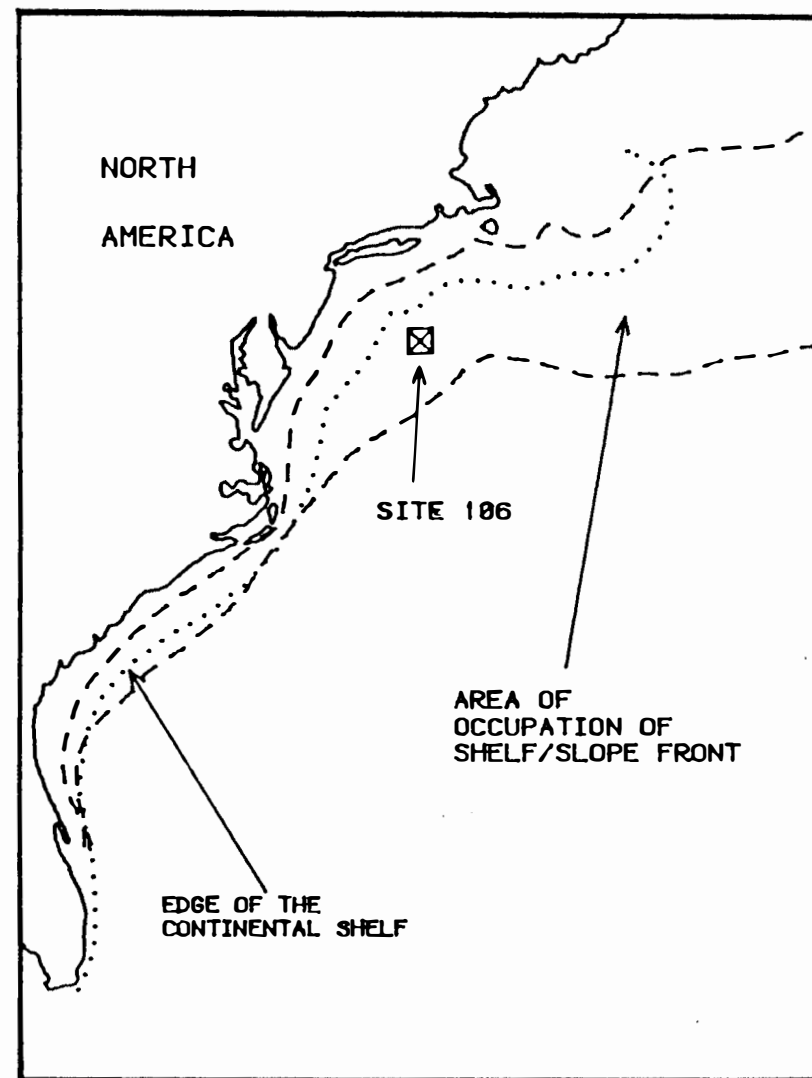


Figure E.3. Domain of Occupation of the Shelf-Slope Front During June 1973-December 1974. Adapted from: National Oceanic and Atmospheric Administration (1982).

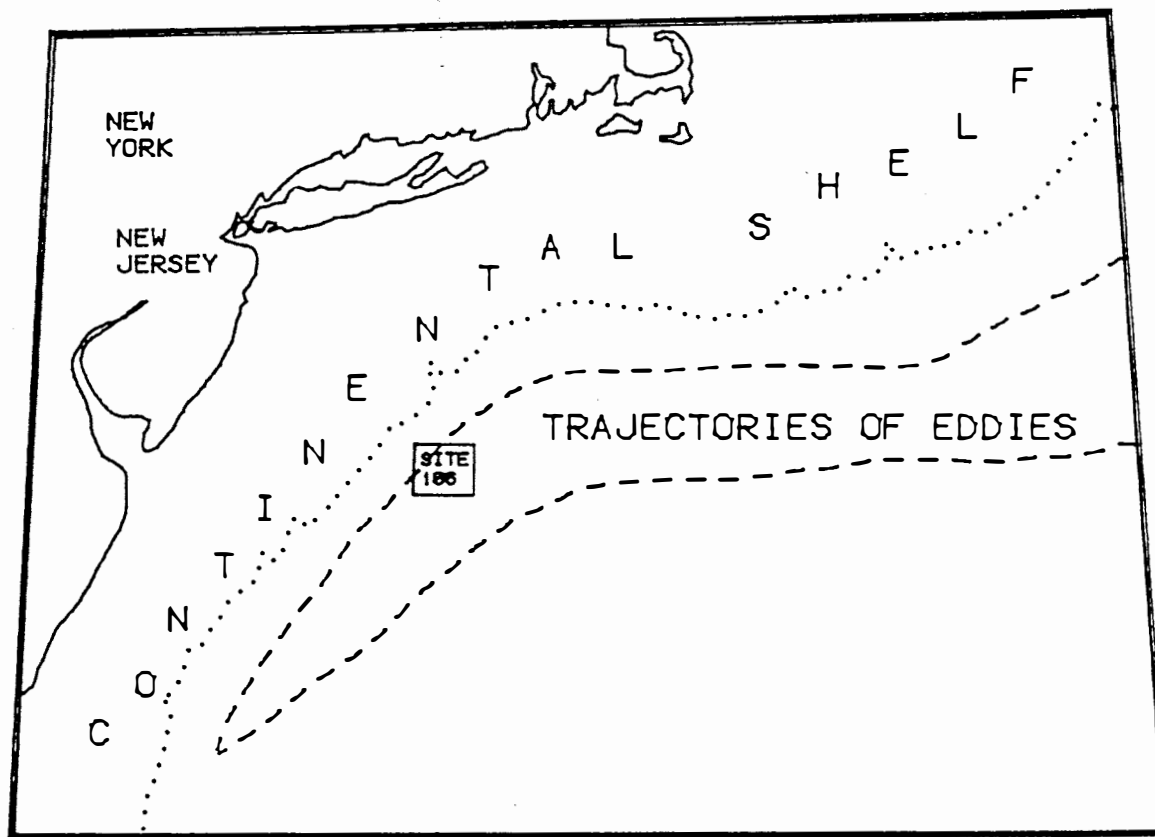


Figure E.4. Envelope for Anticyclonic Eddy Trajectories. Adapted from: Ingham et al. (1977) and Bisagni (1976).

The U.S. Environmental Protection Agency has operated current meters at a site used for low-level radioactive waste disposal known as the Atlantic 2800 m Site. This site occupies an area of 350 km² that is centered at 38°30'N and 72°06'W--coordinates near the southern boundary of Site 106. Current meters deployed at 5.1 m and 96 m off the bottom measured average currents at the bottom that were southwesterly at 3-4 cm/s. Variability in currents results from low-frequency variability attributed to trapped topographic Rossby waves, internal oscillations due to hurricanes, and tides. Maximum motions were on the order of 20 cm/s, great enough to suspend fine-grained sediments. However, speeds above 18 cm/s occurred less than 1% of the time (Hamilton 1982).

E.2.3.5 Sediments

The bottom topography of Site 106 is illustrated in Figure E.10. The shallower northeastern corner of the site contains the lower portion of Mey, Hendrickson, Tom's, and Tom's Middle canyons--which transect the Continental Slope. The average slope in this area is 4% compared to the relatively flatter southeastern portion of the site where the average slope is 1%. Sediments are silts and sands, with silts predominating (U.S. Environ. Prot. Agency 1980). The boundary between the lower Continental Slope and upper Continental Rise shows some evidence of past erosion, but erosion was not evident in observations made with submersibles. The upper Continental Rise appears to have been an area of tranquil deposition for at least 1000 years (Heezen 1975). Biscaye and Olsen (1976) reported that the percent of fine sediment on the bottom surface of the lower slope and upper rise was greater than 80%, with several patches of sediments containing 40-80% fines within Site 106. Suspended sediments at 10 m above the bottom were less than 100 µg/L.

E.3 DESCRIPTION AND TECHNICAL ASPECTS

The various facilities and actions involved in the ocean disposal operation are summarized in Table E.4. DOE will seek a permit from the EPA to dispose of the NFSS wastes at Site 106. The dock will be located in the Port of New York, which encompasses an area from Sandy Hook and Raritan Bay on the south to the New York/New Jersey and New York/Connecticut state lines on the north (Figure E.1). Dock facilities for loading NFSS wastes for marine transport will be secured by contract with the owner/operator of the facility.

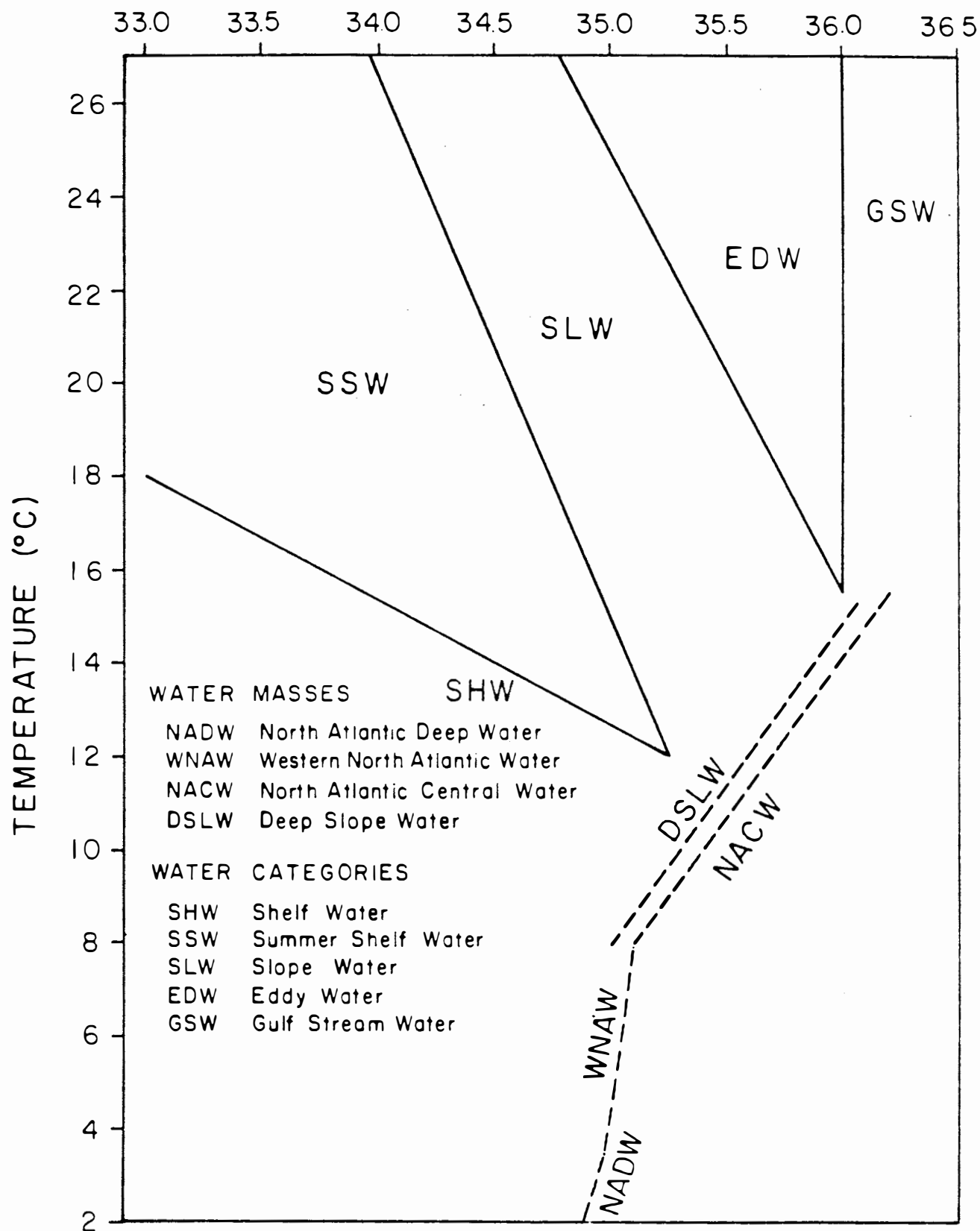


Figure E.5. Temperature-Salinity Lines of Water Masses (Dashed Lines) and Boundaries (Solid Lines) Between Surface Water Categories in the Area of DWD 106. Source: Goulet and Hausknecht (1977).

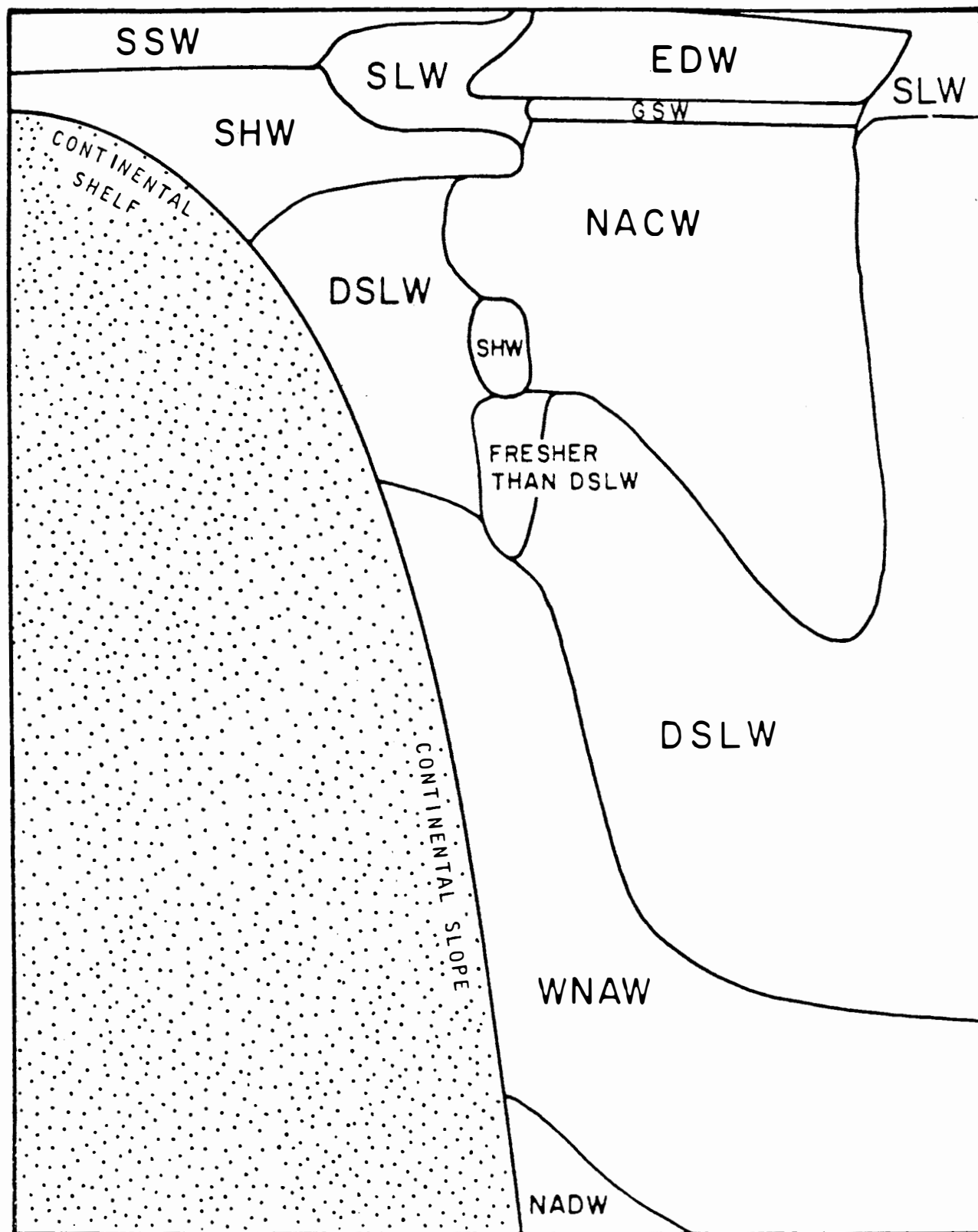


Figure E.6. Schematic Diagram of Water Types from the Continental Shelf Through a Warm-Core Ring in the Vicinity of Site 106. Source: Adapted from Goulet and Hausknecht (1977).

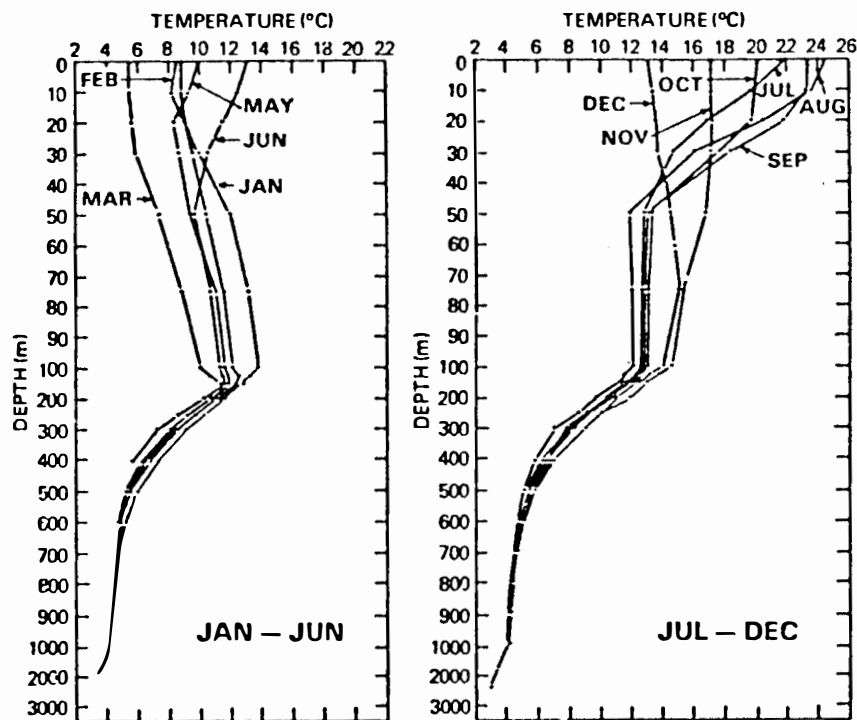


Figure E.7. Temperature Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 91. Source: Warsh (1975).

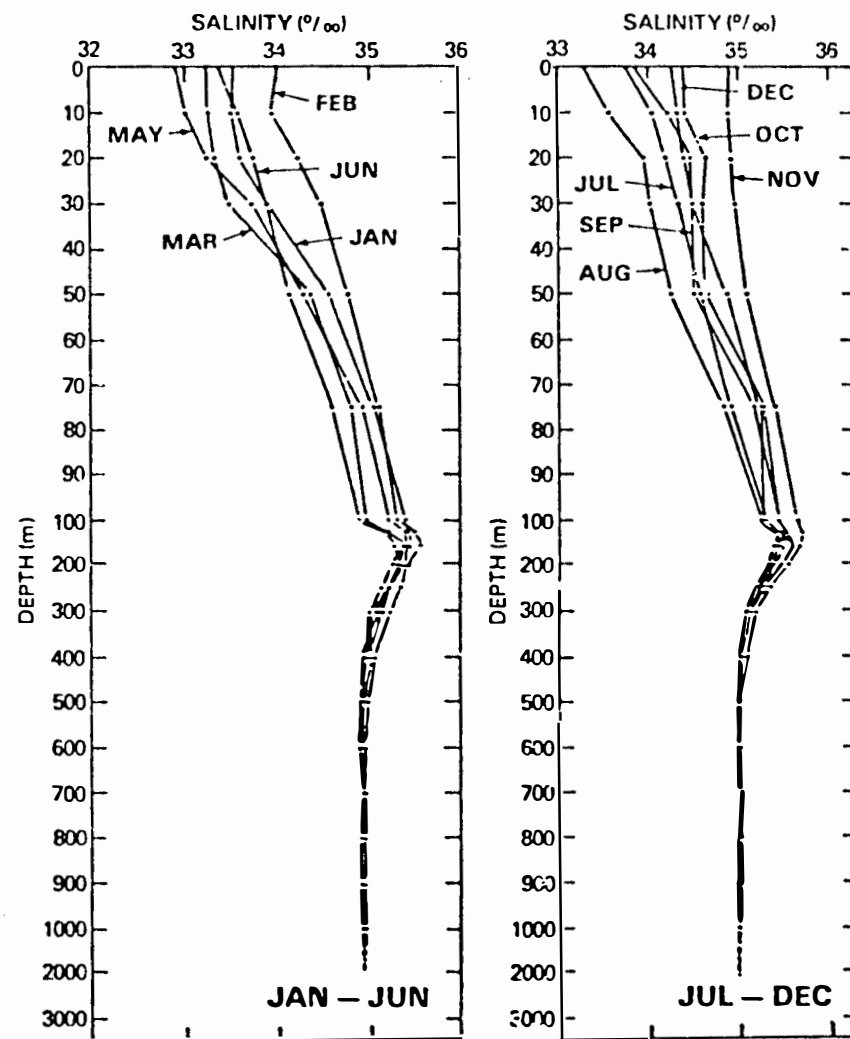


Figure E.8. Salinity Versus Depth, Monthly Averages for Marsden Square 116, Subsquare 91. Source: Warsh (1975).

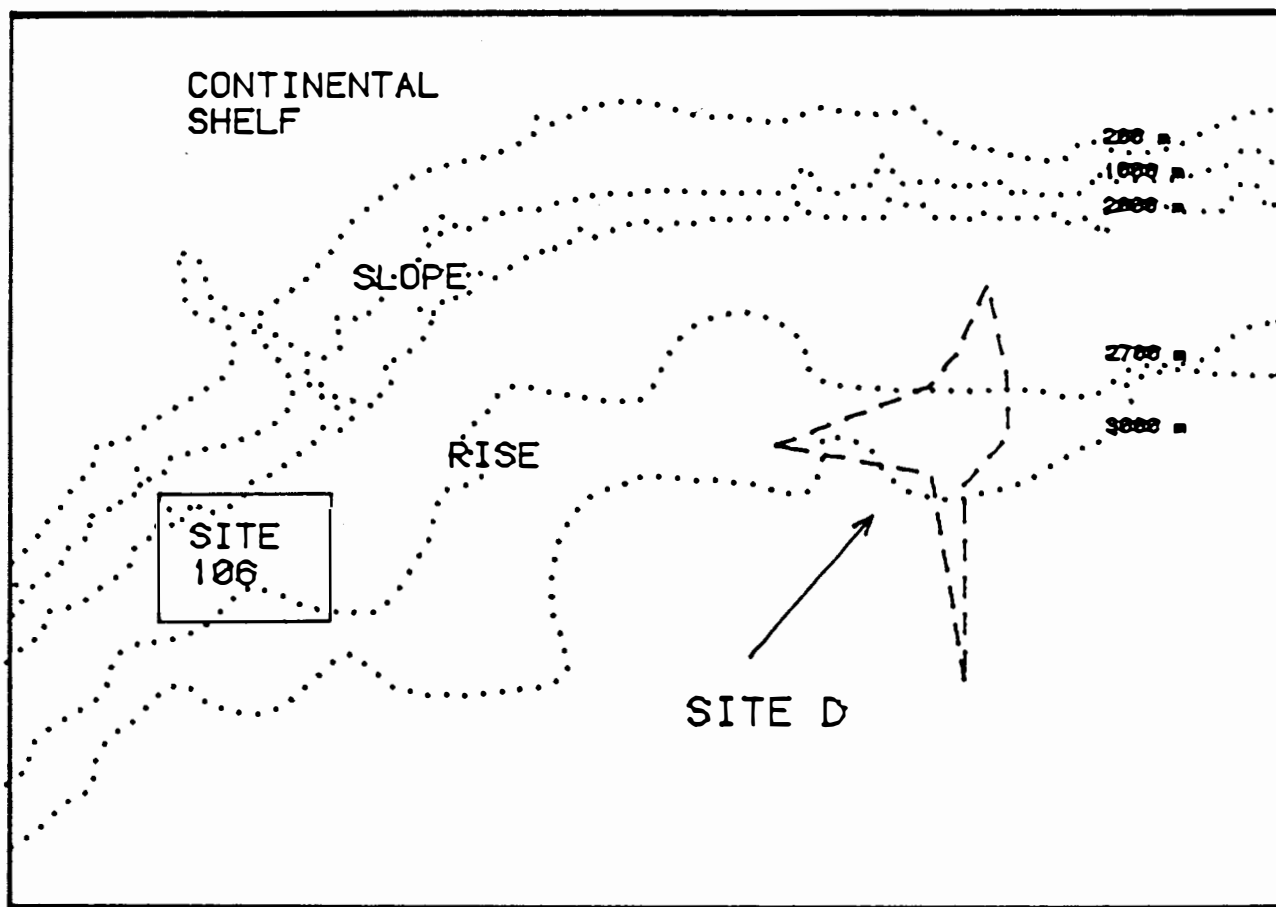


Figure E.9. Current Meter Moorings Around Site D.
Adapted from: Ingham et al. (1977).

Table E.3. Vector Average Currents from Meters Deployed
by Woods Hole Oceanographic Institution Near Site D

Meter Depths (m)	Cumulative Record Length (days)	Vector Average Currents
0-20	261	11 cm/s at 298°
20-60	205	6 cm/s at 304°
60-150	385	8 cm/s at 271°
150-600	326	2 cm/s at 298°
900-1100	249	3 cm/s at 284°
1900-50 above bottom	574	2 cm/s at 278°

Source: Ingham et al. (1977).

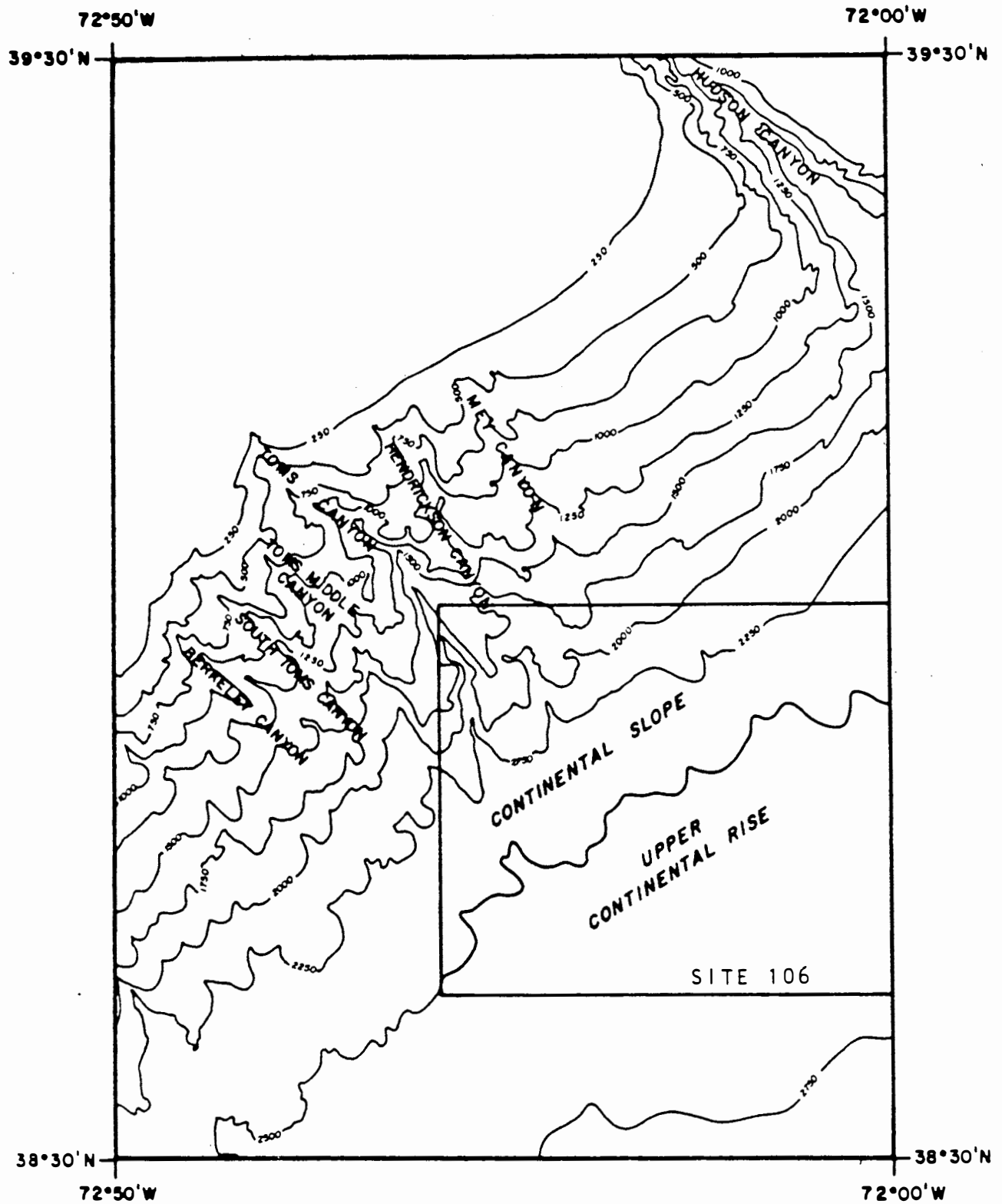


Figure E.10. Bathymetry in the Vicinity of Deepwater Dumpsite 106. Source: Bisagni (1977).

Table E.4. Summary of a Conceptual Design for Ocean Disposal of the NFSS Wastes

<u>FACILITIES</u>	<u>DESCRIPTION</u>
Disposal site	Site 106, 196 km (106 mi) SE of New York Harbor
Berthing	Dock in Port of New York, constructed of bulkhead with earth fill
Barges	Three, bottom-dump type, each with a capacity of 2600 m ³ (3400 yd ³)
Tug	Ocean-going for barge tow
Waste handling	2 crawler cranes with 1.5-m ³ (2-yd ³) clamshell buckets
Waste receiving	Waste bin, 350-m ³ (450-yd ³) capacity
Truck cleanup	Decontamination pad, water-treatment facility
Utilities services	Water, electricity
<u>ACTIONS</u>	<u>DESCRIPTIONS</u>
Waste delivery	61 trucks delivering 690 m ³ (920 yd ³) per day
Barge loading	120 m ³ (150 yd ³) per hour by clamshell bucket
Barge trips	3-5 per month (1-2 barges per tow)
Duration between barge trips	2.5 to 6 days
Round trip time to site	44 hours at 9 km/h (5 knots)
Dumping action time	Less than 30 minutes

NFSS wastes will be delivered to the dock in 15-m³ (20-yd³) capacity trucks, each truck containing about 12 m³ (16 yd³) of wastes due to weight limitations (see Appendix D). Ocean-disposal activities will last for 2 years, with a 6-month season (May-October) in which 61 truckloads of waste (approximately 690 m³) are shipped each working day. Dock operations will continue for 2 shifts, from 7 a.m. to 10 p.m., in order to allow flexibility in scheduling arrivals and departures. On arriving at the dock, the trucks will dump their load into a large bin that will be lined with EPDM so that any runoff or other accumulated water can be collected for disposal. After dumping their load into the bin, the trucks will be decontaminated. Activities at the dock will be confined to an area within about 100 m (330 ft) of the waste bin.

All runoff and other water will be collected, settled to remove particulates, treated to remove dissolved contaminants, and then discharged into the waters near the dock. Fugitive dust emissions from the bin and barges will be controlled by keeping the surface of the wastes moist. Upon termination of the contract for the dock facility, when all the NFSS wastes have been disposed at Site 106, the dock area and equipment will be surveyed and decontaminated.

Three bottom-dump barges will be dedicated to this action to allow continuous waste loading at the dock and to provide contingency waste-storage capacity at the dock. The barges will have a capacity of 4100 MT (4500 tons), which is equivalent to 2600 m³ (3400 yd³) of wastes. Wastes will be loaded on the barge from the bin with clamshell buckets operated by two crawler cranes.

The barges will be towed to sea by an ocean-going tug secured on contract. The barge route to the dumpsite will be through the channels of the Port of New York to Ambrose Light and along the Ambrose-Hudson Canyon traffic lane to the vicinity of the dumpsite (Figure E.1). Dumping will occur at a sector of the dumpsite determined by the EPA. The barge bottom will open up while the barge is under tow, and the NFSS wastes will be released into the water. After the wastes are dumped, the barges will be decontaminated by washing down with hoses at the ocean dumpsite.

A round-trip time of 44 hours is expected for the disposal action. The frequency of trips to Site 106 will be determined by the rate of waste delivery to the dock. At a delivery rate of 690 m³ (900 yd³) per day, disposal trips are expected every 4 days on the average, ranging from 2.5 to 6 days. Use of three barges will provide waste-storage space to allow 5- to 6-day delays in barge operations without impeding waste-removal activities at NFSS. The three barges can hold about 11 days of waste delivery. Barge operations will be suspended from November through April when the probability of extreme weather is high (Section 3.4).

A total of 26 to 28 people will be involved in the disposal action--including dock, tug, and barge workers, and supervisory and monitoring personnel. In addition, regulatory agency personnel may occasionally be aboard the tugs as observers.

E.4 WASTE-FATE SCENARIOS

E.4.1 Physical Processes Related to Waste Fate

The NFSS wastes will be carried to the dumpsite in a barge with a split-type hull. Wastes will be dumped by opening the hull while the barge is being towed, and it is assumed that the wastes will leave the barge quickly, perhaps in a single mass. The fate of the wastes after the dump will depend on their mechanical properties as well as ocean mixing processes.

NFSS wastes will be composed primarily of soils that have been excavated and recompact several times during the site cleanup period. These soils are a heterogeneous mixture of topsoils and subsoils with variable contents of clays, silts, and sands (Anderson et al. 1981). Some portions of the wastes may be very sandy, whereas other portions may be very clayey. In addition, organic matter in surface soils may contribute to a very different soil texture than inorganic subsoils. NFSS soils on the average contain 37% clays, 26% silts, and 37% sands. Clays make soils sticky (wet) or cloddy (dry) and decrease the rate of water movement. Clayey clumps or clods will be resistant to mixing with water because water will be slow to penetrate them, and they will sink because their density (1.8 g/cm^3) is greater than that of seawater (1.024 g/cm^3).

Sands and humus make soils friable, more easily broken into small soil aggregates. The sodium content of seawater should tend to destabilize aggregates by disrupting the bonds between soil particles and organic matter. Very small soil particles, plucked by turbulence from the soil clumps and aggregates, could become well mixed with seawater and sink slowly due to their small particle size (see Section E.4.2). The forces that will tend to mix the wastes with water are turbulence due to the wake of the barge and tug, oceanic turbulence at the sea surface, and water turbulence at the surface of waste clumps that are sinking through the water. No method is available to directly calculate the breakup of soil aggregates or clumps into individual soil particles, even if the texture and aggregation of NFSS soils were known and the effect of seawater on the soils was described.

Even if all the soil particles mix thoroughly with seawater at the instant they enter the water, it is not clear whether they would remain in the surface waters or sink to deep depths. Concentrations of particles in water raise the density of the water so that it tends to sink, a process called convective descent. Baumgartner (1970) has presented a simplified calculation for estimating convective descent of a waste cloud of solids dumped from a barge. The method assumes that the barge load is dumped instantaneously, forming a slurry with seawater. The initial size of the waste mass is assumed to be small in comparison to the depth of the water, but as the mass sinks, its volume grows as it entrains (captures) seawater at a rate proportional to its mean velocity. Currents are ignored in this model; they are expected to increase the dilution and decrease the descent rate of the cloud. The formulation of this analysis is:

$$Z_{\max} = \frac{3.8 R^{3/4} \Delta \rho_i^{1/4}}{\left(\frac{\Delta \rho}{\Delta z}\right)^{1/4}}$$

where:

$Z_{\max}$ = the depth of cloud descent,

R = initial radius of the waste mass,

$\Delta \rho_i$ = initial difference in density between the surrounding water and the waste mass, and

$\frac{\Delta \rho}{\Delta z}$ = vertical density gradient.

Applying this model to NFSS waste disposal achieves the following results. The radius of the waste mass is not known because a barge is long (150 m) and narrow (16 m). Therefore, a calculation is made for each dimension, and the predicted depth of cloud descent is assumed to be somewhere between these two values. The wet wastes in the barges have a density of 1600 kg/m^3 (1.6 g/mL) whereas the density of seawater at the surface of the site is 1024 kg/m^3 (1.024 g/mL) (Table E.5). Thus, $\Delta \rho$ is equal to 576 kg/m^3 . Because the density of water at 100 m is 1028 kg/m^3 and the density of water at the surface is 1024 kg/m^3 (Table E.5), the density gradient is 0.04 kg/m^4 . For a waste cloud with a radius of 8 m, $Z_{\max}$ is:

$$Z_{\max} = \frac{3.8 (8 \text{ m})^{3/4} (576 \text{ kg/m}^3)^{1/4}}{(0.04 \text{ kg/m}^4)^{1/4}} = 150 \text{ m}$$

For a waste cloud with a radius of 80 m, $Z_{\max}$ is:

$$Z_{\max} = \frac{3.8 (80 \text{ m})^{3/4} (576 \text{ kg/m}^3)^{1/4}}{(0.04 \text{ kg/m}^4)^{1/4}} = 1,100 \text{ m}$$

Even if the wastes were diluted 10-fold during the dump to a density of 0.090 kg/m^3 before they began their descent, $Z_{\max}$ would be:

$$Z_{\max} = \frac{3.8 (6 \text{ m})^{3/4} (66 \text{ kg/m}^3)^{1/4}}{(0.04 \text{ kg/m}^4)^{1/4}} = 88 \text{ m}$$

where: $\Delta\rho = 66 \text{ kg/m}^3$ and $R = 6 \text{ m}$;

or,

$$Z_{\max} = \frac{3.8 (80 \text{ m})^{3/4} (66 \text{ kg/m}^3)^{1/4}}{(0.04 \text{ kg/m}^4)^{1/4}} = 647 \text{ m}$$

where: $\Delta\rho = 66 \text{ kg/m}^3$ and $R = 80 \text{ m}$.

This analysis illustrates that, if wastes are completely mixed with water during dumping operations, small portions of the waste mass that are well mixed with water will lose their momentum due to convective descent while still in the surface waters above the permanent pycnocline. Even if a small initial waste mass is of high density, convective descent would barely carry the wastes through the permanent pycnocline. However, if the waste mass left the barge as a single large mass, as described in this action, convective descent should carry the mass to the intermediate or lower waters of the dumpsite, even if the wastes are initially diluted by additional seawater.

The assessment used in this analysis is based on two waste-fate scenarios, as defined in Section 4.5.2. The first scenario assumes that all the wastes sink directly to the bottom of the dumpsite without mixing. This scenario is used to assess impacts from disposal of wastes to the sea floor. The second scenario assumes that all wastes are immediately mixed in the surface waters (from the surface to the upper boundary of the pycnocline). This scenario is used to assess impacts from dispersion of wastes in the upper layers of the dumpsite.

Table E.5. Estimated Seawater Viscosity and Density Used for Stokes' Equation Calculation of Settling Rates of NFSS Waste Particles at Site 106†¹

Depth Interval (m)	Temperature (°C)	Salinity (%)	Viscosity (poise)† ²	Density (g/mL)† ³
0-10	22	35.00	0.0105	1.024
10-20	18	35.20	0.0115	1.025
20-30	14.5	35.33	0.0122	1.026
30-40	14	35.40	0.0126	1.026
40-50	13.5	35.53	0.0126	1.027
50-60	13	35.00	0.0129	1.027
60-70	12.5	35.73	0.0133	1.028
70-100	12	35.73	0.0133	1.028
100-200	9	35.4	0.0140	1.028
200-300	8	35.13	0.0142	1.028
300-400	5.5	35.0	0.0144	1.028
400-500	4.5	35.0	0.0144	1.028
500-600	4.5	35.0	0.0144	1.028
600-700	4.3	35.0	0.0144	1.028
700-900	4.0	34.9	0.0180	1.028
900-1000	4.0	34.9	0.0180	1.028
1000-2000	3.75	34.9	0.0180	1.028
2000-2500	3.00	34.9	0.0171	1.028

†¹ Derived from tables of Walton Smith (1974) using data for temperature and salinity in July from Figure E.8.

†² 1 poise = 1 g/cm·s.

†³ 1 g/mL = 1000 kg/m³.

E.4.2 Scenario I. Waste Deposition to the Sediments

Scenario I analyzes a case in which it is assumed that all the wastes sink directly to the bottom of the dumpsite without mixing. The waters of Site 106 are 1750- to 2750-m deep, with average current speeds of 2-11 cm/s (11 cm/s at the surface and 2 cm/s in deeper water). It is unlikely that sinking of NFSS soils will fall to the sediments directly under the location of the dump due to the effects of currents on particle movement. The sinking rate of the soil will be determined by soil density, water density, size and geometry of soil clumps, and turbulence due to passage of the soil particles.

Sinking of particles that are small, such as soil particles, has been approximated by several formulae, one of which is the Stokes' equation. This equation assumes that particles are spheres and small enough (<0.2 cm) so that drag due to friction and turbulence is negligible. Other equations used to predict particle settling rates for shapes other than spheres result in smaller settling velocities than predicted by Stokes' equation for particles larger than 0.01 cm (Graf 1971), and the differences increase with particle size.

Although NFSS soil particles are not perfect spheres or smooth-surfaced, the application of Stokes' equation to calculate theoretical settling rates of NFSS wastes is still valid because the soil fractionation method used to determine the size range of soil particles is based on measurements of their settling rates (Day 1965). Thus, the data on the percent of soils in each size class are actually the proportion of soils that act as though they are perfect spheres of uniform density ($\rho = 2.65$) in that size class. The particle-size composition of NFSS soils, which indicates a clay-loam soil type, are listed in Anderson et al. (1981). On the average, clays represent 37% by weight of the soils, silts represent 26%, and sands represent 37%.

Stokes' equation defines the settling velocity as the result of a downward force due to the negative buoyancy of the particles that is resisted by the viscosity of the medium. Stokes' equation is:

$$v = \frac{2}{9} g \frac{(\rho_p - \rho_m)}{\mu} r^2$$

where: v = settling velocity,

g = acceleration due to gravity,

ρ_p = density of the particles,

ρ_m = density of the medium,

r = radius of the particle, and

μ = viscosity of the medium.

Settling rates for NFSS waste particles through the water column at Site 106 are calculated based on a representative physical description of Site 106 oceanography (Table E.5) obtained from a profile of average temperature and salinity for July for an area adjacent to Site 106 (Marsden Square 116, Subsquare 91, in Warsh [1975]). These data are representative of conditions that will be found during the NFSS dumping action. From these data, seawater density and viscosity are determined from standard tables of relative density and viscosity (Walton Smith 1974).

Settling rates for NFSS wastes at sea surface density and viscosity are a function of soil particle size. Settling rates are: ≤ 0.003 cm/s for clay particles (<0.002 mm); from 0.003 to 0.17 cm/s for silt particles (0.002-0.02 mm); from 0.17 to 13 cm/s for fine-grained sand particles (0.02-0.2 mm); and from 13 to 3600 cm/s for coarse-grained sand particles (>0.2 mm).

Settling rates at different depths are presented in Table E.6 for clay particles (0.002 mm), silt particles (0.02 mm), and fine sand particles (0.2 mm). These estimates indicate that settling rates are higher in the surface waters and decrease with depth. This effect is due to increasing density and viscosity of seawater at greater depths. Total descent times for particles are calculated by dividing settling rates into depth intervals and then summing over the entire water column (Table E.7). These results show that fine sand could sink to the bottom in 38 hours, due only to the density of the particles.

It is not possible to directly calculate the sinking of soil clumps and aggregates because there is no information on their size, shape, or roughness. These characteristics will cause their sinking rates to be less than predicted by Stokes' equation for particles larger than 0.2 mm. However sinking of large clumps and clods of NFSS wastes should be no less rapid than the largest particle for which the Stoke's equation can reasonably be used, and particles of this size (0.2 mm) would sink to the sediments of the dumpsite in 38 hours.

Table E.6. Settling Rates of Waste Particles at Site 106

Depth (m)	Settling Rates (cm/s) per Size of Particles		
	0.002 mm	0.02 mm	0.2 mm
0	0.00034	0.034	3.4
10	0.00034	0.034	3.4
20	0.00031	0.031	3.1
30	0.00029	0.029	2.9
40	0.00028	0.028	2.8
50	0.00028	0.028	2.8
60	0.00027	0.027	2.7
70	0.00027	0.026	2.6
100	0.00027	0.026	2.6
200	0.00025	0.025	2.5
300	0.00025	0.025	2.5
400	0.00025	0.025	2.5
500	0.00025	0.024	2.4
600	0.00025	0.024	2.4
700	0.00025	0.024	2.4
900	0.00020	0.020	2.0
1000	0.00020	0.020	2.0
2000	0.00020	0.020	2.0
2500	0.00020	0.020	2.0

Table E.7. Descent Time to Depth for
Waste Particles at Site 106

Depth (m)	Descent Times (h) per Size of Particles		
	0.002 mm	0.02 mm	0.2 mm
10	820	8	0.08
20	1,700	17	0.17
30	2,700	27	0.27
40	3,700	37	0.37
50	4,600	46	0.46
60	5,700	57	0.57
70	6,700	67	0.67
100	9,800	98	0.98
200	21,800	210	2.1
300	32,000	320	3.2
400	43,000	430	4.3
500	54,000	540	5.4
600	66,000	660	6.6
700	77,000	770	7.7
900	105,000	1000	10
1000	120,000	1200	12
2000	260,000	2600	26
2500	330,000	3800	38

Graf (1971) has presented curves of settling velocity versus particle diameter for different equations and particle shapes. At particle sizes larger than 0.2 mm, settling velocities depart from the predictions of Stokes' equation. Settling rates for nonspherical particles 10 mm in diameter, such as small clumps of soil, are on the order of 40 to 100 cm/s. At this velocity, particles would reach the bottom of the dumpsite in 0.8 to 2 hours. During their descent to the bottom of the dumpsite, the clumps or clods will be translocated by currents. During a 0.8- to 38-hour descent time, clumps and clods would be deposited from within 0.3 to 1.6 km of the dump location under average currents such as given in Table E.3.

Radionuclide concentrations in wastes deposited on the ocean floor would be essentially undiluted as long as waste deposits were thick enough to prevent mixing with uncontaminated sediments by the stirring action of burrowing animals, a process called bioturbation. Based on radionuclide distributions in sediment cores, Cochran (1982) estimates that sediment mixing depths are 7 to 15 cm and mixing rates range from 1×10^{-9} to 15×10^{-9} cm²/s in the deep sea (1600-5040 m). Waste deposits greater than 7 to 15 cm thick would, therefore, not be appreciably diluted by bioturbation and the radium-226 concentration would therefore remain close to the original 36 pCi/g. Waste deposits less than this thickness would be diluted with underlying sediments by bioturbation activities.

It is unlikely that wastes from repeated dumps will land at the same spot on the bottom of Site 106 because barge location and current strength and direction will be somewhat variable. Maximum areal coverage of the dumpsite sediments would occur if each waste dump were deposited in a different area and if the sediments spread laterally as they descended through the water. If wastes were deposited an average of 7 cm (the minimal depth of bioturbation) over an area of 2.6 km², less than 0.2% of the area of Site 106 would be covered with wastes.

Trace elements, including radium-226, in the wastes will enter the water filling the pores of the waste deposit and move into the water above the waste. In order to directly calculate the quantity of trace elements entering the bottom waters of the dumpsite, it is necessary to know the flux of each element from the sediment, the rate of water movement over the surface of the waste pile, and the distance the water moves over the waste pile. The amount of an element such as radium-226 entering a given volume of water moving over the waste pile is then equal to the flux from the sediments multiplied by the length of the waste pile and divided by the rate of water movement over the waste pile.

The fluxes of trace metals from soils such as NFSS wastes in seawater are not known. However, an approximation can be obtained from the work of Cochran (1979) who developed a model based on the radionuclide disequilibria sediment cores from various deep-sea ocean environments. From this model, Cochran calculated the radium-226 fluxes (release of radium-226 through the sediment surface) from sediments to water as 0.04 to 0.1 pCi/cm²-yr. The largest flux was from a core in the Pacific Ocean where the sediment radium-226 concentration was in excess of 25 pCi/g (solids). At this location, sedimentation rates were very low (< 0.5 cm/1000 yr). In the Mid-Atlantic, flux rates were low and higher sedimentation rates were higher (> 1.0 cm/1000 yr). Although sedimentation rates at Site 106 are probably high due to the site's proximity to the Continental Shelf and Slope, the wastes will not be covered by new sediments for some time after waste deposition. Therefore, the largest flux reported by Cochran (1979) is the most appropriate value for estimating movement of radium-226 from the sediments to the overlying waters.

Fluxes of radium-226 similar to the largest calculated by Cochran (1979) would be required to raise the concentration of radium-226 in the bottom waters of the dumpsite a measurable amount above background, even if radium-226 mixed only in a layer of water 1-m deep. Actually, the depth of the near-bottom water is probably 20-50 m. The contamination of bottom water moving over the waste piles from radium-226 flux from the wastes is calculated based on the assumption that a front of water 1 meter in depth moves over a waste pile that has been deposited 0.3-1.6 km from the dump location. The length of the waste pile is therefore 1.3 km. (The other dimensions of the waste pile are irrelevant to the calculation--see previous discussions). Data from current moorings at the 2800 m radioactive waste-disposal site just south of Site 106 indicate that average current speed within 5 m of the bottom are 3-4 cm/s (Hamilton 1982). At a rate of travel of 3 cm/s, the front of bottom water would take 12 h to pass over the wastes. The greatest radium-226 flux measured by Cochran was 0.1 pCi/cm²-yr, which is equal to 0.1 pCi/m²-h. As a cubic meter of water (1 m² by 1 m high) traveled over the deposited wastes for 12 hours, it would receive less than 2 pCi/m³ (0.002 pCi/L) of radium-226. The average natural radium-226 content of sea water is 0.1 pCi/L (Joseph et al. 1971); therefore, the predicted radium-226 content of bottom water flowing over the waste would be raised only 2% above natural concentrations.

E.4.3 Scenario II: Waste Dispersion in Surface Waters

Because it cannot be determined what portion of the NFSS wastes will be well mixed with seawater and whether well-mixed wastes will be carried to deeper waters below the pycnocline by convective cloud descent, Scenario II analyzes a case in which it is assumed that all the wastes remain in the surface waters. It is also assumed that the wastes are well mixed with seawater from the surface to the upper edge of the pycnocline (100 m) by convective cloud descent shortly after being dumped. The wastes will form a patch that will move with the currents and be dispersed by the mixing processes of the sea.

Many physical oceanographic features contain energy in turbulent motions that mix water. Some of these features occurring at Site 106 are currents, waves, small-scale eddy diffusivity, fronts, and warm-core rings (Section E.2).

Pritchard et al. (1971) have reviewed theoretical formulations for two-dimensional horizontal dispersion in the sea. The solutions to the formulations propose that the variance, σ^2 (mean square distance of particles from the center of the waste mass), should be proportional to time to the second (t^2) or third (t^3) power. Such solutions indicate that the strength of the diffusive processes increase with the size of the diffusing patch. Pritchard et al. (1971) report an analysis by Okubo (1962) where regression of the variance (σ^2) versus time (t) for experimental data of dispersion in the ocean gives the relationship between variance and time to be:

$$\sigma^2 = 0.006 \times t^{2.5}$$

This relationship suggests that waste-patch spreading in the ocean would be somewhat less than that predicted by the "4/3rds law of diffusion" (diffusion coefficient is a function of width of the patch to the 4/3 power), which is equivalent to $\sigma^2 = f(t^3)$.

The variance (σ^2) of the waste-patch distribution is related to the distribution of wastes in a cross section of a waste-patch center. Solutions to diffusion equations result in a normal or Gaussian distribution of wastes across a waste patch; therefore, the Gaussian parameter σ^2 (variance) is used to indicate the distribution of waste concentrations across the width of a waste patch.

The Gaussian distribution (Figure E.11) is described by two parameters: the mean ($\bar{x}$), which identifies the center of the distribution; and the standard deviation ($\sigma = \text{sigma}$), which defines the spread of the curve away from the center of the distribution. The standard deviation (σ) is the square root of the variance (σ^2). The equation for any point (x, y) on the Gaussian distribution is:

$$y_x = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\bar{x})^2/2\sigma^2}$$

where: y_x = height of the curve at any point along the abscissa,

x = position of the point on the abscissa relative to the mean ($\bar{x}$),

σ = standard deviation, and

$\bar{x}$ = mean or center of the distribution, located somewhere on the abscissa.

The Gaussian distribution represents the concentration of wastes in a cross section through an area containing wastes. Concentrations (y_x) are plotted against distance (x) across the waste-filled area. The center of the wastes is designated $x = 0$, and distance is measured to either side of that point. Waste concentrations are highest at the center of the wastes (x) and decrease with distance away from that point. The decrease in waste concentration with distance is defined by σ . When σ is small, the curve is narrow and high; when σ is large, the curve is wide and low. The location of σ on the x axis is the point where 34.13% of the area under the bell-shaped curve is enclosed between $x = 0$ and $x = \sigma$ (or $-\sigma$ as in Figure E.11).

With a Gaussian waste distribution, the waste concentrations within a waste cloud are at a maximum in the center and decline toward the edge. The observed boundaries of waste-filled areas are 4 to 4.3 times σ . With time, dispersion processes cause the wastes to spread (σ increases), reducing the concentration of the wastes throughout the cloud. If the wastes spread in only one direction, the proportion of wastes (y) at the cloud center ($x = x$) will be:

$$y = \frac{1}{\sigma\sqrt{2\pi}}$$

because $e^{-(x-x)^2/2\sigma^2}$ becomes 1.

$$y_{w,l} = \frac{1}{\sigma_w \sigma_l \sqrt{2\pi}}$$

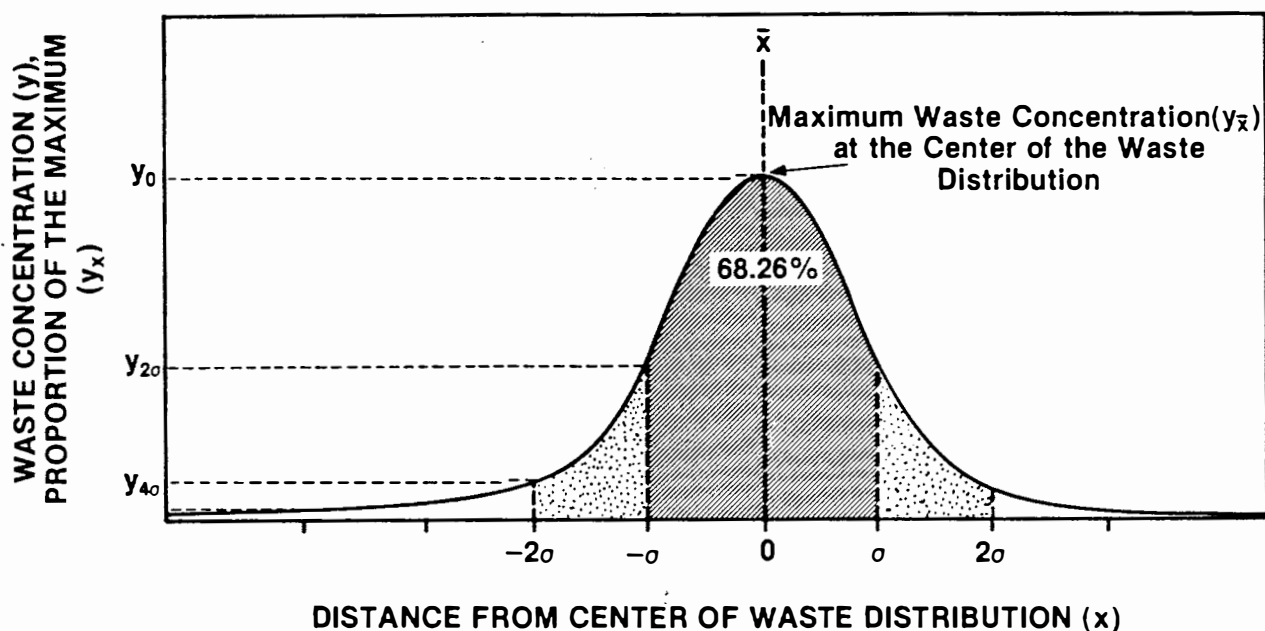


Figure E.11. The Gaussian, or Normal, Distribution as Applied to Waste Dispersion.

For wastes of total weight of Q dispersed in a water volume with a depth of h , waste concentration per unit volume at the waste cloud center (V_t) at time (t) is:

$$C_t = \frac{Q}{\sigma\sqrt{2\pi}}$$

Csanady (1978) has used a one-dimensional Gaussian relationship to estimate the standard deviation (σ) across a waste plume using experimental observations of the decreases in maximum waste concentration in the wake with time. Two sets of data were analyzed: one in which the standard deviation (σ) of the wake was 42 m at 480 min, the other in which the standard deviation was 24 m at 180 min. Kohn and Rowe (1981) present data from two other experimental barge dumps where wastes were discharged into long plumes. Maximum concentrations within the plumes decreased 4.3 times in 17 hours in one plume and 2.4 times in 17 hours in the other plume. Using Csanady's (1978) method, the standard deviations (Q) of the plumes would be 51.5 m and 28.7 m, respectively. From these calculations, various dispersion constants can be calculated for different forms of the dispersion relationships presented by Pritchard et al. (1971) (Table E.8), and upper and lower bounds can be placed on waste-patch dispersion (Table E.9).

Using these data on dispersion of waste plumes, dispersion constants are derived for the different forms of dispersion equations presented by Pritchard et al. (1971). These constants describe the growth of a waste cloud or plume through time and are used to estimate waste dilution due to dispersion for NFSS wastes. Because Site 106 is a dedicated industrial and municipal waste-disposal site, impacts to biota within the site are compatible with the designated use of the site and these impacts are controlled by stipulations in the disposal permit. Therefore, only impacts to areas outside the dumpsite are evaluated here. Immediately after disposal, the wastes will be moved by the currents toward the site boundary. Wastes dumped at the center of the site would have to travel 37 km to reach the nearest (southern) boundary of the site. Because average current speeds in the surface are 11 cm/s (Table E.3), the wastes could reach the edge of the dumpsite in 93 hours or about 4 days. The standard deviations of wastes across waste clouds are presented in Table E.9; after 4 days, the expected limits of the width of waste clouds are 0.6 to 1.6 km under low mixing conditions and 2 to 68 km under high mixing conditions (Table E.10).

The limits of the range of dilutions under these conditions depend on both the width of the waste cloud and the depth to which mixing occurs. For wastes mixed to the pycnocline (100 m), the range of dilutions and waste concentrations expected are presented in Table E.10.

Table E.8. Dispersion Constants for Experimental Waste Dumps

		Csanady (1978)		Kohn and Rowe (1981)	
	Constant	Plume 1 $\sigma = 42$ m $t = 480$ min	Plume 2 $\sigma = 24$ m $t = 180$ min	Plume 1 $\sigma = 51.5$ m $t = 1020$ min	Plume 2 $\sigma = 28.7$ m $t = 1020$ min
Case I:					
$\sigma^2 = K_1(t^2)$	$K_1 =$	0.02	0.04	0.007	0.002
$K_e \propto (L^1)$					
Case II: Okubo's Regression:					
$\sigma^2 = K_2(t^{2.5})$	$K_2 =$	0.001	0.004	0.00003	0.00001
$K_e \propto (L^{1.2})$					
Case III: 4/3rds law"					
$\sigma^2 = K_3(t^3)$	$K_3 =$	0.00007	0.000005	0.0000001	0.00000004
$K_e \propto (L^{1.3})$					

Table E.9. Standard Deviation of σ in the Waste Patch^{†1}

t (days)	Highest Mixing ^{†2}			Lowest Mixing ^{†2}		
	Case I $K_1 =$ 0.02	Case II $K_2 =$ 0.0001	Case III $K_3 =$ 0.00007	Case I $K_1 =$ 0.002	Case II $K_2 =$ 0.00001	Case III $K_3 =$ 0.00000004
1 (86,400 s)	0.12	0.18	2.1	0.039	0.047	0.051
2	0.24	0.35	6.0	0.077	0.11	0.14
4	0.49	0.84	17	0.16	0.27	0.41
8	0.98	2.0	48	0.31	0.63	1.2
16	2.0	4.7	140	0.62	1.5	3.3
32	3.9	11	390	1.2	3.6	9.2
64	7.8	27	1100	2.5	8.5	26
128	16	64	3100	5.0	20	74

^{†1} Patch width = 4σ .^{†2} From the plume experiments described in Table E.8.

Table E.10. Waste Patch Width and Waste Dilution
Four Days After Waste Disposal

Conditions	Patch Width, 4xσ (km)	Waste Dilution† ¹	Average Concentration† ² (mg/L)
I. High Mixing			
A. Case I	2.0	120,000	10
B. Case II	3.4	350,000	4
C. Case III	17	8,900,000	0.1
II. Low Mixing			
A. Case I	0.64	12,300	100
B. Case II	1.1	36,500	40
C. Case III	1.6	77,300	20

†¹ Mixing depth = 100 m.†² Initial waste concentration = 1.3 g dry solids/cm³.

These estimates of waste dilution appear to be very conservative, based on the work of Paul et al. (1983) who have performed a risk assessment related to disposal of municipal or industrial wastes at Site 106. Primary emphasis of the study was the interaction of dispersing contaminants (copper and PCBs) with biological resources. Statistical analysis of long-term current data from Site D was used to develop spatial probability distributions that describe contamination fields, areas in which the wastes could be found. Two cases were postulated: a high-mixing case developed from winter data for Site D and a low-mixing case where the coefficient of variation in current velocity was one-tenth the high-mixing case. Assumed oceanographic conditions were a uniformly mixed surface layer (no seasonal thermocline) above a permanent pycnocline at 100 m through which there was no vertical flux of materials, either by settling of waste particles or other oceanographic processes. Concentrations were calculated for total contaminants and the separation into dissolved and particulate forms was ignored.

In cases of both high and low mixing, the rate of movement of the center of the waste mass was the same because average current speed was the same from between 38°40'N to 39°00'N; after 30 days, the center of mass had progressed southwestward to approximately 36°00'N latitude. Under high-mixing conditions, the waste distribution spread rapidly, expanding to include parts of the Continental Shelf after 10 days. Under low-mixing conditions, the waste distribution after 30 days was still limited to the Continental Slope and Rise (Paul et al. 1983--Figures 9 and 10).

Waste distributions for high and low mixing conditions were also calculated for continuous daily waste disposal at Site 106, equivalent to 100 dumps of sewage sludge per day. Dilutions of 6,000,000-fold were reached in the immediate vicinity of the dumsite under high mixing conditions, whereas a narrow tongue of wastes extending southwest of the site underwent 2,000,000-fold dilution. These estimates of waste dilution are within the range of estimates derived from analysis of experimental waste dumps presented in Tables E.8 and E.9.

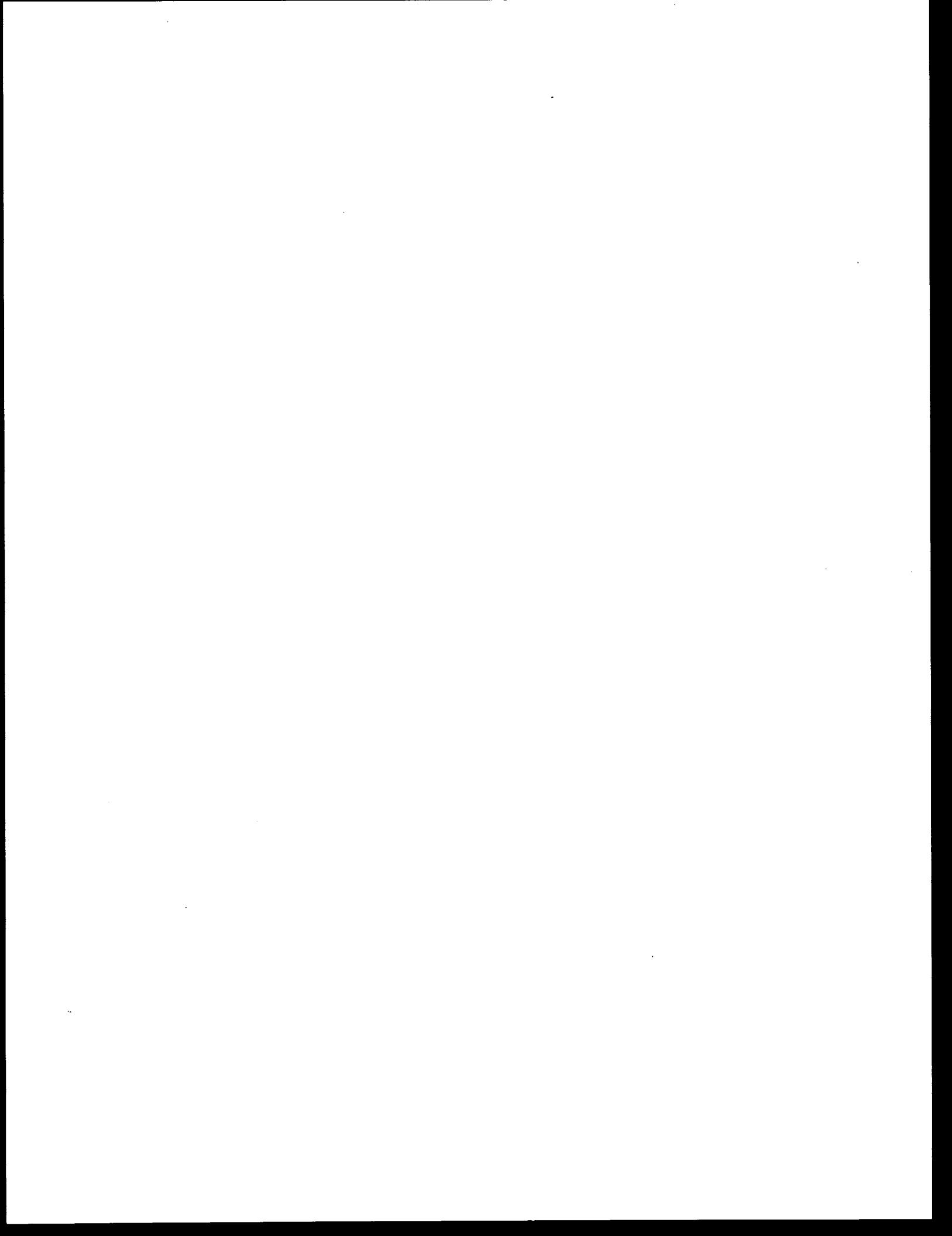
REFERENCES (Appendix E)

- Anderson, T.L., J.F. Dettorre, D.R. Jackson, and B.S. Ausmus. 1981. A Comprehensive Characterization and Hazard Assessment of the DOE Niagara Falls Storage Site, Final Report. Prepared by Battelle Columbus Laboratory for the U.S. Department of Energy, June 1981, Report No. BMI-2074 (revised).
- Anderson, P.W., and R.T. Dewling. 1981. Industrial ocean dumping in EPA Region II - regulatory aspects, pp. 25-39. In B.H. Ketchum, D.R. Kester, and P.K. Parks (eds.), Ocean Dumping of Industrial Wastes. Plenum Press, New York.
- Baumgartner, D.J. 1970. Disposal of liquid and particulate wastes to the ocean. Chem. Eng. Symp. Prog. Ser. (Water - 1970) 67(107):46-53.
- Bisagni, J.J. 1976. Passage of Anticyclonic Gulf Stream Eddies Through Deepwater Dumpsite 106 During 1974 and 1975. NOAA Dumpsite Eval. Rep. 76-1. National Oceanic and Atmospheric Administration.
- Bisagni, J.J. 1977. Deepwater Dumpsite 106 bathymetry and bottom morphology, pp. 1-8. In Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Volume I, Physical Characteristics. NOAA Dumpsite Eval. Rep. 77-1. National Oceanic and Atmospheric Administration. June 1977.

- Bisagni, J.J., and D.R. Kester. 1981. Physical variability in an East Coast United States offshore dumpsite, pp. 89-107. In B.H. Ketchum, D.R. Kester, and P.K. Park (eds.), *Ocean Dumping of Industrial Wastes*. Plenum Press, New York.
- Biscaye, P., and C.R. Olsen. 1976. Suspended particulate concentrations and compositions in the New York Bight, pp. 124-137. In *Middle Atlantic Continental Shelf and the New York Bight. Special Symposia, Volume 2*. The American Society of Limnology and Oceanography, Inc.
- Cochran, K.J. 1979. The Geochemistry of ^{226}Ra and ^{228}Ra in Marine Deposits. Ph.D. Dissertation, Yale University. May 1979.
- Cochran, K.J. 1982. The use of naturally occurring radionuclides as tracers for biologically related processes in deep-sea sediments, pp. 55-72. In W.G. Ernst and J.G. Marin (eds.), *The Environment of the Deep Sea. Rubey Volume II*. Prentice Hall, Inc., Englewood Cliffs, NJ.
- Csanady, G.T. 1978. An analysis of dumpsite diffusion experiments, pp. 109-129. In B.H. Ketchum, D.R. Kester, and P.K. Park (eds.), *Ocean Dumping of Industrial Wastes. Marine Science, Volume 12*. Plenum Press.
- Day, P.R. 1965. Particle fractionation and particle size analysis, pp. 545-567. In C.A. Black (ed.), *Methods of Soil Analysis, Part 1*. American Society of Agronomy. Chapter 43.
- Goulet, J.R., and K.A. Hausknecht. 1977. Physical oceanography of Deepwater Dumpsite 106, Update: July 1975. In *Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Volume I, Physical Characteristics*. NOAA Dumpsite Eval. Rep. 77-1. June 1977.
- Graf, W.H. 1971. Settling velocity of particles, pp. 35-63. In *Hydraulics of Sediment Transport*. McGraw-Hill Book Company. 513 pp.
- Hamilton, P. 1982. Analysis of Current Meter Records at the Northwest Atlantic 2800 Metre Radioactive Waste Dumpsite. EPA 520/1-82-002. U.S. Environmental Protection Agency. June 1982.
- Heezen, B.C. 1975. Photographic reconnaissance of Continental Slope and Upper Continental Rise, pp. 27-104. In *Baseline Investigation of Deepwater Dumpsite 106 (May 1974)*. NOAA Dumpsite Eval. Rep. 75-1. National Oceanic and Atmospheric Administration. December 1975.
- Ingham, M.C.; J.J. Bisagni, and D. Mizenko. 1977. The general physical oceanography of Deepwater Dumpsite 106, pp. 29-54. In *Baseline Report of Environmental Conditions in Deepwater Dumpsite 106. Volume 1, Physical Characteristics*. NOAA Dumpsite Eval. Rep. 77-1. National Oceanic and Atmospheric Administration. June 1977.
- Joseph, A.B., P.F. Gustafson, I.R. Russell, E.A. Schuert, H.L. Volchok, and A. Tamplin. 1971. Sources of radioactivity and their characteristics, pp. 6-41. In *Radioactivity in the Marine Environment*. Prepared by the Panel on Radioactivity in the Marine Environment of the Committee on Oceanography, National Research Council. National Academy of Sciences, Washington, DC.
- Kohn, B., and G.T. Rowe. 1981. Dispersion of two liquid industrial wastes at 106-Mile Site. In *Assessment Report on the Effects of Waste Dumping in 106-Mile Ocean Waste Disposal Site*. NOAA Dumpsite Eval. Rep. 81-1. National Oceanic and Atmospheric Administration. May 1981.
- National Oceanic and Atmospheric Administration. 1982. Summary of the Physical Oceanographic Processes and Features Pertinent to Pollution Distribution in the Coastal and Offshore Waters of the Northeastern United States, Virginia to Maine. NOAA Tech. Memo. NMFS-F/NEC-17. December 1982.
- Okubu, A. 1962. Horizontal Diffusion from an Instantaneous Point-Source Due to Oceanic Turbulence. Tech. Rep. No. 32. Chesapeake Bay Institute, Johns Hopkins University, Baltimore, MD. [As cited by Pritchard et al. (1971).]
- Paul, J.F., V.J. Bierman, Jr., H.A. Walker, and J.H. Gentile. 1983. Application of a Hazard Assessment Research Strategy for Waste Disposal at Deepwater Dumpsite 106. Draft submitted for publication (March 1983).
- Pritchard, D.W., R.O. Reid, A. Okubo, and H.H. Carter. 1971. Physical processes of water movement and mixing, pp. 90-136. In *Radioactivity in the Marine Environment*. National Academy of Sciences, Washington, DC.
- U.S. Environmental Protection Agency. 1980. Final Environmental Impact Statement (EIS) for 106-Mile Ocean Waste Disposal Site Designation. February 1980.

Walton Smith, F.G. 1974. Handbook of Marine Science. Vol. I. CRC Press.

Warsh, C.E. 1975. Physical oceanography historical data for Deepwater Dumpsite 106, pp. 105-140. In Baseline Investigation of Deepwater Dumpsite 106 (May 1974). NOAA Dumpsite Eval. Rep. 75-1. National Oceanic and Atmospheric Administration, Washington, DC. December 1975.



APPENDIX F. COST ESTIMATES

F.1 INTRODUCTION

Estimates of the costs of carrying out each of the alternatives for the wastes and residues at NFSS are given in this Appendix. The costs are given in 1981-1982 dollars, and, therefore, no inflation cost escalation is included even for actions that last for several years. Because of the large uncertainties involved, the total costs for the action period for each alternative are given to two significant figures only. More significant figures are kept for intermediate costs to avoid cumulation of roundoff errors.

Many of the costs for activities are figured using unit costs. These include subcontractors' overhead and profit. Because unit costs obtained from the literature are given in English units, amounts of materials presented in all tables except F.1 and F.4 are also given in these units. Both metric and English units are used in the text. The general contractor's markup (which includes management support) is included as part of overhead and is taken as 22% of the total cost of the action period (exclusive of land disposal costs) (Means Co. 1982). The other component of overhead cost is that associated with maintenance, monitoring, surveillance, and engineering during the action period. To estimate this component, the number of person-years assigned by Bechtel National (1984) to maintenance, monitoring, surveillance, and engineering is multiplied by \$61,000/person-year. This cost per person-year is obtained by dividing Bechtel's estimate of the cost for surveillance, construction, and management by the estimated number of person-years required for these activities in Alternative 2 (Bechtel Natl. 1984).

Maintenance, monitoring, and surveillance costs for the 200-year period following site closure are very uncertain because of the lack of experience for such long periods of time for containment systems having the types of design considered for the NFSS alternatives. For Alternatives 2a, 2b, 3a, and 3b, the maintenance and monitoring costs are assumed to be \$85,000/year. This figure is higher than Bechtel's estimate of \$20,000/year for the 195-year period beginning 5 years after site closure (Bechtel Natl. 1984). A range of \$59,000/year to \$99,000/year is obtained by appropriately scaling EG&G Idaho (1983) cost estimates of extended care following closure of commercial low-level radio-active waste sites to the amount of wastes and residues stored at NFSS. This range results from the fact that the NFSS waste volume is intermediate between the sizes of the two sites considered by EG&G Idaho. Scaling up from the smaller site (85,000 m³) gives the high figure of \$99,000/year and scaling down from the larger site (424,000 m³) gives the low figure of \$59,000/year. The \$85,000/year estimate assumed herein is closer to the high value because the amount of NFSS wastes is closer to the size of the small site.

For Alternatives 4a and 4c, there are two sites to maintain and monitor: NFSS containing the wastes and Hanford or Oak Ridge containing the residues. Maintenance and monitoring costs at NFSS are expected to be the same as for Alternatives 2a and 2b. However, at Hanford and Oak Ridge, the maintenance costs are expected to be lower because of the reduced area needed to store the residues, whereas the monitoring costs should remain the same. Because of these factors, maintenance and monitoring costs will be set at \$85,000/yr at NFSS and \$43,000/yr at Hanford or Oak Ridge. This gives a total of \$128,000/yr maintenance and monitoring costs for Alternatives 4a and 4c.

For Alternatives 4b and 4d, with residues only stored at Hanford or Oak Ridge, the maintenance and monitoring costs are set at \$43,000/yr.

Cost estimates for a 200-year extended care period can be presented as a cost per year, as a total amount needed over the 200-year period, or as a sinking fund that vanishes at 200 years. A cost of \$85,000/year amounts to a payout of \$17,000,000 over 200 years. It can be provided by a sinking fund of about \$2,820,000--assuming a real interest rate of 3% (Bechtel Natl. 1984). For costs of \$128,000/yr and \$43,000/yr, the corresponding payouts are \$25,600,000 and \$8,600,000 and sinking funds are \$4,226,000 and \$1,420,000. The cost of a perpetual care fund is approximately equal to the cost of a 200-year sinking fund.

The unit disposal costs at Hanford should be less than at Oak Ridge because Hanford has a large waste-disposal facility that will not require much expansion to accommodate the NFSS wastes and/or residues. Also, wastes are disposed in trenches and covered with excavated materials, and riprap is the only imported material. At Oak Ridge, a new waste-disposal site must be opened with the resultant expenses. Also, the wastes would be covered with a relatively expensive engineered cap built from imported materials.

These factors will be accounted for herein by assuming the following unit disposal costs: for Hanford, the cost is assumed to be that for a large facility, \$3.40/ft³ (in 1981 dollars), that disposes of 1×10^6 m³ (3.6×10^7 ft³) of wastes over 30 years. For Oak Ridge, the cost is assumed to be that for a medium-sized facility, \$5.50/ft³ (in 1981 dollars), that disposes of 4.2×10^5 m³ (1.5×10^7 ft³) of wastes in 30 years (for a small facility that disposes of 8.5×10^4 m³ [3×10^6 ft³] of wastes over 30 years, the unit cost is given as \$16.90/ft³) (EG&G Idaho 1983).

There are many cost uncertainties, some of which are common to all alternatives whereas others apply to only a few of the alternatives. Cost uncertainties common to all alternatives include such factors as (a) frequency of cap repair, (b) lack of exact knowledge of basic unit costs of various activities and needed materials, (c) hauling distances, (d) work force requirements for support activities such as engineering and maintenance, monitoring, and surveillance activities during the action period, and (e) other costs associated with overhead, and (f) delays due to problems of coordination with radiological surveys, decontamination, and other health-physics procedures. Also, unexpected problems may arise or some phase of the activity may be completed sooner than expected.

These uncertainties are sufficiently large that many small factors affecting the costs were not included, e.g., the dependency of unit cost on where in the United States the activity is carried out. Geographic cost multiplying factors were ignored because their variation is small compared to the uncertainties in the estimated costs.

Cost uncertainties are accounted for herein by estimating an action period cost and then using the estimate to determine a range in which the true cost should lie (in 1981-1982 dollars). For most alternatives, the lower and upper points of the range are taken to be 75 and 150%, respectively, of the estimate. For some alternatives with more uncertainties--such as Alternative 2b, the range is larger.

F.2. SUMMARY

A summary of the estimated costs for various activities carried out in the action period for the different alternatives is presented in Table F.1. The most costly activity is transportation, especially where the wastes are involved. Disposal on land is also expensive and appears to be more expensive than ocean disposal (compare Alternatives 4b and 4d with either 3a or 3b). Overhead costs vary a lot between the alternatives because they depend on the cost of and time spent on other activities in the action period. Figure F.1 illustrates the ranges of costs during the action period and the total payout costs for the 200-year maintenance and monitoring (extended-care) period.

F.3 ALTERNATIVE 1

In Alternative 1, no action will be taken other than long-term (200-year) maintenance, monitoring, and surveillance of the interim cap. The annual cost is assumed herein to be \$85,000 (see Section F.1) plus the additional amount needed to maintain the interim cap. The annual cost for interim cap maintenance is given by Bechtel National (1984) as \$35,000 for Alternative 1. The total annual cost of extended care is therefore assumed to be \$120,000/year. This amounts to a total payout of \$24,000,000 over 200 years and can be provided by a sinking fund (at 3% real interest) of \$4,000,000.

F.4 ALTERNATIVE 2a

The main activities during the action period will consist of relocating the central ditch and Lutts Road, removing and storing the interim cap, and constructing the long-term cap. It is assumed that about 350 m (1150 ft) of the ditch and Lutts Road will have to be moved. Using an average cross-sectional area of 35 m² (41.7 yd²) for the ditch (Bechtel Natl. 1984), a volume of about 12,200 m³ (16,000 yd³) must be excavated and backfilled. The rate for excavating the new ditch and backfilling and air tamping for compaction of the old ditch are taken as \$1.88/yd³ and \$4.92/yd³, respectively (Means Co. 1982). For Lutts Road, it is assumed that about 3,100 m³ (3,700 yd³) of new road will be paved at a cost of \$5.30/yd² (Means Co. 1982).

All 16,400 m³ (21,500 yd³) of topsoil and 5,500 m³ (7,200 yd³) of sand will be removed from the interim cap and stored for later use in constructing the long-term cap. The cost of removal by bulldozer is taken as \$2.34/yd³ (Means Co. 1982).

For materials needed to construct the long-term cap, the costs of buying, hauling 8 km (5 mi) to the site, spreading by bulldozer, and compacting are as follows: clay, \$9.80/yd³; sand, \$9.80/yd³; soil, \$11.85/yd³; and riprap, \$19.45/yd³ (Means Co. 1982). Volumes of the needed materials are given in Table D.10. The cost of replacing the interim cap materials was taken to be that of removing the cap plus an additional \$2.13/yd³ for compaction (Means Co. 1982).

Overhead is calculated as described in Section F.1. Maintenance, monitoring, and surveillance costs are computed using a work force requirement of 32 person-years. This includes engineers but not

Table F.1. Summary of Costs for the Alternatives

	Costs (in thousands of dollars)				
Activity	Alternative 1	Alternative 2a	Alternative 2b	Alternative 3a	Alternative 3b
Central ditch relocation	-	128	128	-	-
Interim cap removal† ¹	-	67	156	168	168
NFSS site restoration	-	-	-	550	550
Residue excavation	-	-	700	3,360	3,360
Residue processing	-	-	4,720	-	-
Residue storage (Bldg. 411)	-	-	700	-	-
Transportation	-	-	-	114,000† ³	34,800† ³
Long-term cap construction	-	1,670	1,860	-	-
Land disposal	-	-	-	22,800	37,000
Ocean disposal	-	-	-	-	-
Overhead	-	2,360	6,100	31,200	13,200
Credit for metal recovery	-	-	-5,540	-	-
Cost for action period† ²	-	4,200	8,800† ⁴	170,000	89,000
Cost range	-	3,200-6,300	4,400-18,000	130,000-260,000	67,000-130,000
<u>Extended care:</u>					
Annual costs	120	85	85	85	85
Total payout (200 years)	24,000	17,000	17,000	17,000	17,000
Sinking fund† ⁵	4,000	2,800	2,800	2,800	2,800

	Costs (in thousands of dollars)				
Activity	Alternative 4a	Alternative 4b	Alternative 4c	Alternative 4d	
Central ditch relocation	128	-	128	-	
Interim cap removal† ¹	153	231	153	231	
NFSS site restoration	-	550	-	550	
Residue excavation	3,360	3,360	3,360	3,360	
Residue processing	-	-	-	-	
Residue storage (Bldg. 411)	-	-	-	-	
Transportation	11,100	37,700	3,440	30,100	
Long-term cap construction	1,980	-	1,980	-	
Land disposal	1,320	1,320	2,140	2,140	
Ocean disposal	-	6,750	-	6,750	
Overhead	8,620	15,600	5,570	12,800	
Credit for metal recovery	-	-	-	-	
Cost for action period† ²	27,000	66,000	17,000	56,000	
Cost range	20,000-40,000	50,000-99,000	13,000-26,000	42,000-84,000	
<u>Extended care:</u>					
Annual costs	128	43	130	43	
Total payout (200 years)	26,000	8,600	26,000	8,600	
Sinking fund† ⁵	4,200	1,400	4,200	1,400	

†¹ Includes removal of residue overburden where applicable.†² Rounded to two significant figures.†³ Includes excavation of wastes.†⁴ Includes credit for metal recovery.†⁵ The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

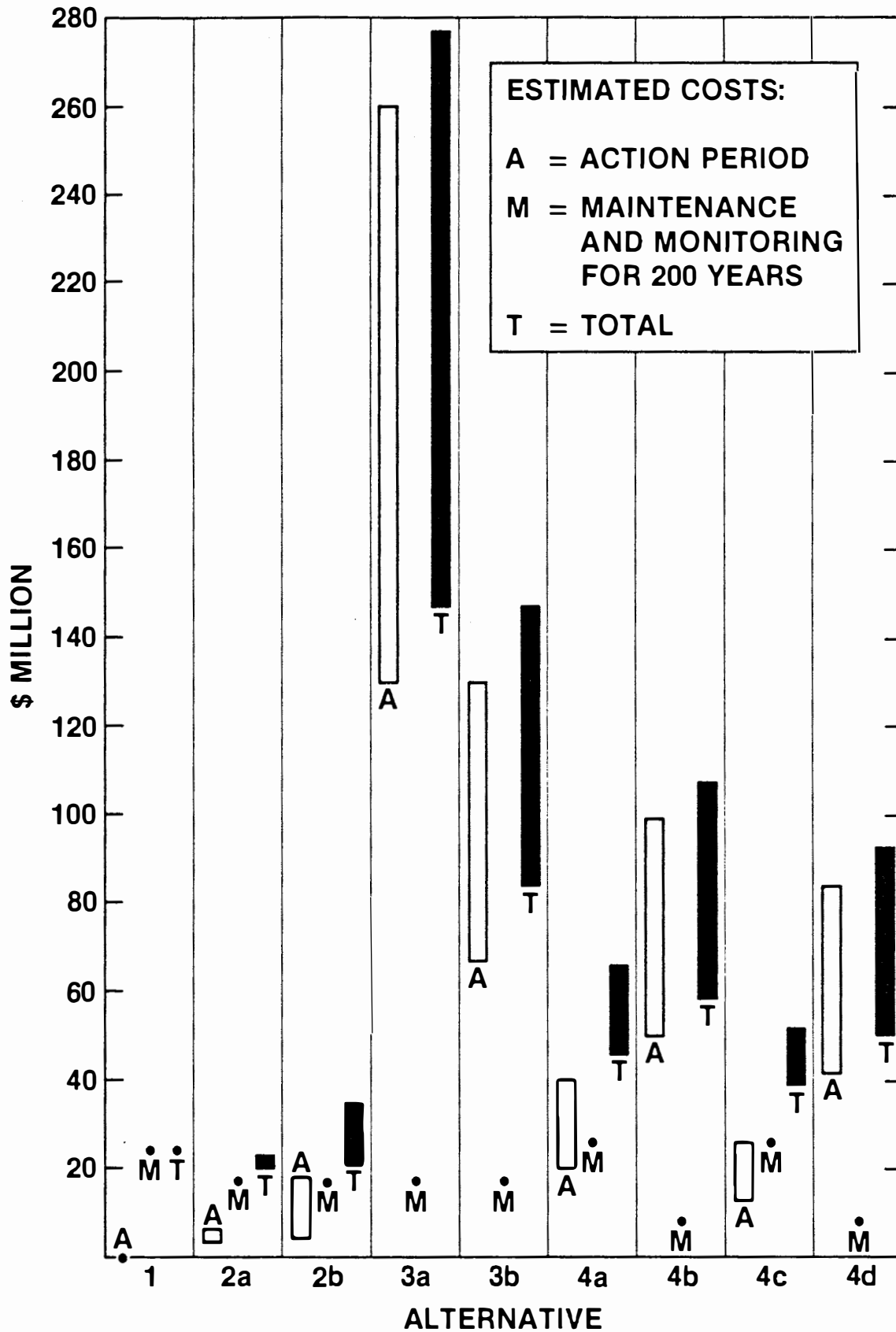


Figure F.1. Summary of Estimated Costs for the Alternatives for Long-Term Management of the NFSS Wastes and Residues.

management as given by Bechtel National (1984) for Alternative 2. The unit cost used is \$61,000/person-year.

The costs for Alternative 2a are summarized in Table F.2. The total cost estimate for the action period is \$4,200,000. The cost estimates summarized in Table F.2 are subject to many uncertainties, including the unit costs for the various activities--which depend on the methods used to carry out the activities and on hauling distances. Also, there are uncertainties in the volumes of materials to be excavated, moved, and compacted as well as contingencies that might arise, etc. It is expected that the action period cost in 1982 dollars will range from 75 to 150% of the estimate, or \$3,200,000 to \$6,300,000.

Table F.2. Summary of Costs for Alternative 2a

Relocation:	
Central Ditch	
Excavating, 16,000 yd ³ @ \$1.88/yd ³	\$30,000
Backfilling, compacting, 16,000 yd ³ @ \$4.92/yd ³	\$78,000
Lutts Road new paving, 3,700 yd ² @ \$5.30/yd ²	\$20,000
Subtotal (Relocation)	\$128,000
Interim Cap Removal, 28,700 yd ³ @ \$2.34/yd ³	\$67,000
Long-Term Cap Construction:	
Clay, 61,500 yd ³ @ \$9.80/yd ³	\$603,000
Sand, 18,300 yd ³ @ \$9.80/yd ³	\$180,000
Soil, 6,500 yd ³ @ \$11.85/yd ³	\$78,000
Riprap, 35,000 yd ³ @ \$19.45/yd ³	\$681,000
Interim cap materials:	
Replace	\$67,000
Compaction, 28,700 yd ³ @ \$2.10/yd ³	\$60,000
Subtotal (Long-Term Cap Construction)	\$1,669,000
<u>Subtotal</u>	\$1,864,000
Overhead:	
General contractor (22% of subtotal)	\$410,000
Maintenance, monitoring, and surveillance, 32 person-years @ \$61,000/person-year	\$1,952,000
Subtotal (Overhead)	\$2,362,000
TOTAL FOR ACTION PERIOD† ¹	\$4,200,000
Extended Care:	
Annual cost	\$85,000
Total payout (200 years)	\$17,000,000
Sinking fund (3% real interest rate)† ²	\$2,800,000

†¹ Rounded to two significant figures.

†² The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

F.5 ALTERNATIVE 2b

For Alternative 2b, the same activities will be carried out in the action period as for Alternative 2a. In addition, the wastes and clay overlying Buildings 411, 413, and 414 will be removed; the residues will be moved to an onsite processing plant where commercially valuable metals will be extracted; and the remaining residues will be converted to slag. The slag will be stored in Building 411, the wastes replaced, and the long-term cap constructed.

About one-quarter of the clay in the interim cap, or 8,400 m³ (11,000 yd³) (Bechtel Natl. 1984), will be removed to expose the wastes over the buildings. Removal costs are taken to be \$2.34/yd³ (Means Co. 1982). All the wastes, clay, and contaminated soils over and in Buildings 411, 413, and 414 must be removed. The removal cost for this 20,600 m³ (27,000 yd³) of materials is taken to be \$2.34/yd³ (Means Co. 1982). Using the estimate of Bechtel National (1984), it is assumed that 14 person-years are needed to remove the residues by hydraulic mining. The unit cost is taken to be \$50,000/person-year. This is an average for skilled workers over 35 trades and includes the sub-contractors' overhead and profit (Means Co. 1982). For processing the residues, the total setup cost

of the equipment is taken to be \$2,000,000 (Bechtel National 1982--Table G-1). This includes the cost of the equipment as well as labor, rent, electricity, piping, instrumentation, and miscellaneous costs. The setup cost for hydraulic mining (\$190,000) is also included in this figure.

The main operating costs are considered herein to be labor and electricity costs for smelting. Electricity costs can be crudely estimated from an energy requirement of 250 kWh/ton of residues (Bechtel Natl. 1984), a residue weight (including 15% water) of 15,000 MT (16,500 tons), and an electricity cost of \$0.06-0.07/kWh (Skarim 1983--personal communication). Labor costs are calculated assuming that 49 person-years (Bechtel Natl. 1984) at \$50,000/person-year (Means Co. 1982) are needed to process and immobilize the residues. The cost of moving and storing the residues as pieces of slag is assumed to be the same as the cost of hydraulic mining of the residues.

Construction of the long-term cap for Alternative 2b will involve the same activities as for Alternative 2a as well as replacement of the removed wastes and clay over the residues and in the interim cap. Replacement costs are assumed to be the same as removal costs plus an extra \$2.10/yd³ (Means Co. 1982) for compaction. To compensate for the volume loss resulting from vitrification of the residues, 5,500 m³ (7,200 yd³) of new clay will be needed at \$9.80/yd³ (Means Co. 1982).

Overhead is calculated as described in Section F.1. Maintenance, monitoring, and surveillance costs are calculated assuming a work force requirement of 70 person-years (Bechtel Natl. 1984--Alternative 4) at \$61,000/person-year. Long-term maintenance, monitoring, and surveillance costs following completion of the proposed action should be the same as for Alternative 2a.

A summary of the costs for Alternative 2b is presented in Table F.3. The credit for metal recovery is calculated from the component credits outlined in Table F.4. The total net cost estimate for the action period is \$8,800,000 (Table F.3).

The cost estimates for Alternative 2b (Table F.3) are more uncertain than those for Alternative 2a. Most of the increased uncertainty originates in the cost estimate for the recovery process. For example, the process as proposed by Bechtel has not been tried on a pilot scale and does not include steps for removal of molybdenum. Also, the estimate of credit for metal recovery (Table F.4) is quite uncertain. The commercial value of metals varies widely from year to year and the assumption of a 90% recovery for the metals may be quite optimistic. In addition, the recovered purified lead will be quite radioactive (due to the presence of lead-210 with a half-life of 22 years) and may have to be stored for hundreds of years before it can be sold. As a crude guess, it is estimated that the value of \$8,800,000 given in Table F.3 could be high or low by a factor of 2. This gives a range of \$4,400,000 to \$18,000,000.

F.6 ALTERNATIVE 3a

The actions in Alternative 3a will consist of complete removal of the interim cap, excavating and packaging the residues, and transporting the residues and wastes (without packaging) to Hanford for disposal. The Niagara Falls site will be reclaimed and released for public use. Interim cap removal will involve removal of 55,000 m³ (72,000 yd³) of material (Bechtel Natl. 1984) at a unit cost of \$2.34/yd³ (Means Co. 1982). The residues will be excavated and packaged in Mark-3 bins. For packaging, 6,750 bins (Table D.3) will be required at a cost of \$384/bin (Ditch 1983--personal communication). Recent information (Cheever 1984--personal communication) on costs for a few bins used to transport wastes to New Brunswick Labs give a cost of \$416/bin. However, because a large number of bins are needed for the NFSS residues, it is expected that the cost/bin could be reduced for large quantities. Also, costs are given here in 1981-1982 dollars. Excavation and packaging costs for the residues are assumed to be the same as Bechtel's cost estimate for hydraulically mining the residues, or \$770,000 (Bechtel Natl. 1984). The cost of simple excavation and packaging of 11,000 m³ of material is much less than \$770,000 (Means Co. 1982). However, the fact that the material is radioactive would be expected to increase the cost substantially. The 180,000 m³ (236,000 yd³) of wastes will be loaded directly onto dump trucks at a cost of \$2.34/yd³ (Means Co. 1982).

For the 8,000 km (5000-mi) round-trip distance to Hanford, the residues will be transported in shielded vans or flatbed trucks and the wastes will be transported in unshielded dump trucks. Both types of vehicles are assumed to return empty (Appendix D). The cost of transport is assumed to be \$1.37/mile (EG&G Idaho 1983), which gives a round-trip cost of \$6850 per shipment.* The number of

*Even if it is possible to arrange a lower price for transport of the residues based on the one-way trip distance, the transportation costs will not be lowered much. The reason is that the dump trucks used to transport the wastes will be slightly contaminated and will probably have to return empty. Because of the large number of truck trips and the locations of the alternative sites, carriers may not be amenable to negotiating one-way prices. Even if the cost of transportation could be lowered by negotiating lower prices (or by using other transport modes--Appendix D), the overall cost of the offsite alternatives would not be reduced by more than a few percent. This is well within the error of these cost estimates.

Table F.3. Summary of Costs for Alternative 2b

Relocation (Alternative 2a)	\$128,000
Interim Cap Removal:	
Clay, 11,000 yd ³ @ \$2.34/yd ³	\$26,000
Alternative 2a	<u>\$67,000</u>
Subtotal (Interim Cap Removal)	\$93,000
Removal of Residue Overburden:	
Wastes, clay, and soil, 27,000 yd ³ @ \$2.34/yd ³	\$63,000
Residue Removal:	
Hydraulic mining, 14 person-years @ \$50,000/person-year	\$700,000
Residue Processing:	
Equipment setup	\$2,000,000
Operating costs:	
Electricity, 4100 Mwh @ \$65/Mwh	\$267,000
Labor, 49 person-years @ \$50,000/person-year	<u>\$2,450,000</u>
Subtotal (Residue Processing)	\$4,717,000
Slag Moving, Storing	\$700,000
Long-Term Cap Construction:	
New clay, 7,200 yd ³ @ \$9.80/yd ³	\$70,000
Residue overburden:	
Backfill	\$63,000
Compaction, 27,000 yd ³ @ \$2.10/yd ³	<u>\$57,000</u>
Subtotal (residue overburden)	\$120,000
Alternative 2a	<u>\$1,634,000</u>
Subtotal (Long-Term Cap Construction)	\$1,864,000
<u>Subtotal</u>	\$8,265,000
Overhead:	
General contractor (22% of subtotal)	\$1,817,000
Maintenance, monitoring, and surveillance, 70 person-years @ \$61,000/person-year	<u>\$4,270,000</u>
	\$6,087,000
TOTAL FOR ACTION PERIOD	\$14,352,000
Credit for Metal Recovery	<u>\$5,575,000</u>
NET COST FOR ACTION PERIOD† ¹	\$8,800,000
Extended Care (Alternative 2a):	
Annual cost	\$85,000
Total payout (200 years)	\$17,000,000
Sinking fund (3% real interest)† ²	<u>\$2,800,000</u>

†¹ Rounded to two significant figures.

†² The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

Table F.4. Components of Credit for Metal Recovery

Metal	\$/kg† ¹	K-65			L-30/F-32			L-50		
		Avg. ppm† ²	kg† ³	10 ³ \$	Avg. ppm	kg† ³	10 ³ \$	Avg. ppm	kg† ³	10 ³ \$
Uranium	45	3,800	11,800	531	5,000	36,000	1,620	790	1,100	50
Lead	0.50	56,000	14,000	57	13,000	94,000	47	4,900	6,600	3.3
Gold	13,300	0.2	0.62	8	0.37	2.7	36	<0.2	0.27	3.6
Platinum	12,500	<0.5	1.5	6	0.32	2.3	29	0.5	0.68	8.5
Palladium	3,400	20	62	211	3.5	25	85	2.4	3.2	10.9
Copper	1.74	500	1,550	3	2,300	16,500	29	2,400	3,200	5.6
Cobalt	22.9	2,000	6,200	142	5,100	36,700	840	7,700	10,400	238
Nickel	5.8	3,000	9,300	54	17,000	122,400	710	24,000	32,400	188
Molybdenum	17	10,000	31,000	527	860	6,200	105	300	400	6.8
Subtotals				1,539			3,501			515
Total Credit: \$5,545,000										

†¹ From Bechtel National (1984). Molybdenum value is from U.S. Bureau of Mines (1980).

†² From Table 3.7 of this report.

†³ Average dry weights of the K-65, L-30/F-32, and L-50 residues were obtained from Table 3.5 of this report as 3450 MT, 8,000 MT, and 1,500 MT, respectively. A 90% recovery factor (Bechtel Natl. 1984) is also included.

trips needed to transport the residues and wastes is given in Table D.3. Disposal costs are assumed to be \$3.40/ft³ (see Section F.1).

Although state fees for transport of the NFSS residues are not applicable to DOE shipments, such fees are often used to fund state emergency preparedness efforts (Section 4.6.3.4). For these cost analyses, the state of New York fees of \$1,000 for the transport permit plus \$100 per truckload are included as an example. Actual costs may be higher or lower, depending on whether or not DOE negotiates payments to offset the costs of state emergency preparedness efforts.

The cost of reclaiming and releasing NFSS is assumed to be \$550,000 (Bechtel Natl. 1984). Overhead is calculated as described in Section F.1. Maintenance, monitoring, and surveillance activities are taken to require 84 person-years (Bechtel Natl. 1984--Alternative 8) at \$61,000/person-year. Long-term maintenance, monitoring, and surveillance costs that apply to the Hanford site only are assumed to be the same as those for NFSS under Alternative 2a.

The costs for Alternative 3a are summarized in Table F.5. The main contribution to the \$170,000,000 for the cost for the action period is the direct cost of truck transport, \$114,000,000. Consequently, most of the uncertainties in the total cost estimate arise from uncertainties in the cost of this activity. Because transport by truck of all sorts of loads under different conditions is very common, the cost estimates should not be too uncertain. However, the disposal and overhead costs are more uncertain. Thus, the range in which the true total cost should lie can probably be set at 75% to 150% of \$170,000,000, or \$130,000,000 to \$260,000,000.

F.7 ALTERNATIVE 3b

Alternative 3b differs from Alternative 3a in that the residues and wastes will be disposed at Oak Ridge rather than at Hanford and will be disposed in piles covered with caps rather than in trenches. The costs for all activities are the same for Alternative 3b as for Alternative 3a, except transportation and disposal costs. Transportation costs are less because of the shorter round-trip distance, 2,400 km (1500 mi). The cost of \$1.37/mile (EG&G Idaho 1983) is the same as for Alternative 3a. The unit disposal cost is taken to be \$5.50/ft³ at Oak Ridge (see Section F.1).

Overhead costs are calculated in the same manner as for Alternative 3a. Maintenance, monitoring, and surveillance activities will require 76 person-years (Bechtel Natl. 1984--Alternative 5) at \$61,000/person-year. Extended care costs are assumed to be the same as for Alternative 3a.

The costs for Alternative 3b are summarized in Table F.6. As for Alternative 3a, the main contributions to the action period cost estimate of \$89,000,000 are transportation (\$34,260,000) and disposal (\$36,960,000). Uncertainties in the cost estimates should be about the same as those for Alternative 3a. Thus, the range will be from 75% to 150% of the estimate, or \$67,000,000 to \$130,000,000.

Table F.5. Summary of Costs for Alternative 3a

Interim Cap Removal, 72,000 yd ³ @ \$2.34/yd ³	\$168,000
Excavation, Packaging:	
Residues:	
Bins, 6750 @ \$384/bin	\$2,592,000
Excavate, fill bins	<u>\$770,000</u>
Subtotal (residues)	\$3,362,000
Wastes, 236,000 yd ³ @ \$2.34/yd ³	<u>\$552,000</u>
Subtotal (Excavation, Packaging)	\$3,914,000
Transportation:† ¹	
Residues:	
K-65, 500 trips @ \$6,850/trip	\$3,425,000
L-30/F-32, 960 trips @ \$6,850/trip	\$6,576,000
L-50, 140 trips @ \$6,850/trip	\$959,000
License fees:	
K-65 + L-30/F32, 1,460 trips @ \$100/trip + \$1,000	<u>\$147,000</u>
Subtotal (Residues, incl. license fees)	\$11,107,000
Wastes, 15,000 trips @ \$6,850/trip	<u>\$102,750,000</u>
Subtotal (Transportation)	\$113,857,000
NFSS Site Restoration	\$550,000
<u>Subtotal</u>	\$118,489,000
Overhead:	
General contractor (22% of subtotal)	\$26,067,000
Maintenance, monitoring, and surveillance, 84 person-years @ \$62,000/person-year	<u>\$5,124,000</u>
Subtotal (Overhead)	\$31,191,000
Disposal at Hanford, 6.72 × 10 ⁶ ft ³ @ \$3.40/ft ³	\$22,848,000
TOTAL FOR ACTION PERIOD† ²	\$170,000,000
Extended Care (Alternative 2a):	
Annual cost	\$85,000
Total payout (200 years)	\$17,000,000
Sinking fund (3% real interest)† ³	\$2,800,000

†¹ Costs are calculated assuming that the trucks return empty.

†² Rounded to two significant figures.

†³ The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

F.8 ALTERNATIVE 4a

Many of the activities during the action period for Alternative 4a will be the same as those for Alternative 2b or 3a. Costs for relocation of the central ditch and Lutts Road and for removal of the interim cap and wastes over the residues are assumed to be the same as for Alternative 2b. Costs for excavation, packaging, and transportation of the residues are assumed to be the same as for Alternative 3a. Construction of the long-term cap at NFSS is the same as for Alternative 2b except that 5,500 m³ (7,200 yd³) of new clay at \$9.80/yd³ is needed to fill the space left by removal of the residues (the other 5,500 m³ is already accounted for in Alternative 2b). The unit disposal cost is assumed to be the same as for Alternative 3a.

Overhead costs are calculated in the same manner as for Alternative 3a. Maintenance, monitoring, and surveillance activities are assumed to require 81 person-years (Bechtel Natl. 1984--Alternative 12) at \$61,000/person-year. Costs for extended care for the 200-year period following the action period are taken to be \$128,000/yr (see Section F.1).

Table F.6. Summary of Costs for Alternative 3b

Interim Cap Removal (Alternative 3a)	\$168,000
Excavation, Packaging (Alternative 3a)	\$3,914,000
Transportation:† ¹	
Residues, 1,600 trips at \$2,055/trip	\$3,288,000
License fees (Alternative 3a)	\$147,000
Wastes, 15,000 trips @ \$2,055/trip	<u>\$30,825,000</u>
Subtotal (Transportation)	\$34,260,000
NFSS Site Restoration (Alternative 3a)	<u>\$550,000</u>
<u>Subtotal</u>	\$38,892,000
Overhead:	
General contractor (22% of subtotal)	\$8,556,000
Maintenance, monitoring, and surveillance, 76 person-years @ \$61,000/person-year	<u>\$4,636,000</u>
Subtotal (Overhead)	\$13,182,000
Disposal at Oak Ridge, $6.72 \times 10^6 \text{ ft}^3$ @ \$5.50/ft ³	\$36,960,000
TOTAL FOR ACTION PERIOD† ²	\$89,000,000
Extended Care (Alternative 2a):	
Annual cost	\$85,000
Total payout (200 years)	\$17,000,000
Sinking fund (3% real interest)† ³	<u>\$2,800,000</u>

†¹ Costs are calculated assuming that the trucks return empty.

†² Rounded to two significant figures.

†³ The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

Table F.7. Summary of Costs for Alternative 4a

Relocate Ditch, Lutts Road (Alternative 2b)	\$128,000
Remove Interim Cap, Wastes over Residues (Alternative 2b)	\$153,000
Excavate, Package Residues (Alternative 3a)	\$3,362,000
Transport, License Residues (Alternative 3a)† ¹	\$11,107,000
Construct Long-Term Cap (NFSS)	
Clay, 7,200 yd ³ @ \$9.80/yd ³	\$71,000
Alternative 2b	<u>\$1,904,000</u>
Subtotal (Construct Long-Term Cap)	\$1,975,000
<u>Subtotal</u>	\$16,725,000
Overhead:	
General contractor (22% of overhead)	\$3,680,000
Maintenance, monitoring, and surveillance, 81 person-years @ \$61,000/person-year	<u>\$4,941,000</u>
Subtotal (Overhead)	\$8,621,000
Disposal at Hanford, 389,000 ft ³ @ \$3.40/ft ³	\$1,323,000
TOTAL FOR ACTION PERIOD† ²	\$27,000,000
Extended Care (Alternative 2a):	
Annual cost	\$130,000
Total payout (200 years)	\$26,000,000
Sinking fund (3% real interest)† ³	<u>\$4,200,000</u>

†¹ Costs are calculated assuming the trucks return empty.

†² Rounded to two significant figures.

†³ The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

The costs for Alternative 4a are summarized in Table F.7. The main contributions to the action period cost of \$27,000,000 are transportation of the residues (\$11,107,000) and overhead \$8,892,000. The uncertainties in the cost estimate for Alternative 4a should be roughly similar to those for Alternatives 3a and 2a. Consequently, the range for the true cost can probably be set at from 75% to 150% of the estimate, or \$20,000,000 to \$40,000,000.

F.9 ALTERNATIVE 4b

In Alternative 4b, the residues will be shipped to Hanford as in Alternative 4a. However, the wastes will be disposed in the ocean, and the NFSS site will be restored and released. Interim cap removal costs and NFSS restoration costs are the same as for Alternative 3a. The cost of removing the wastes from over the residues is the same as for Alternative 2b. The costs of excavation, packaging, transportation, and disposal of the residues at Hanford are the same as for Alternative 4a.

For ocean disposal, the wastes will be transported 1,000 km (625 mi) to a dock in the Port of New York, unloaded into a bin at dockside, and loaded by clamshell bucket cranes into barges at 120 m³ (150 yd³) per hour (Appendix E). The same type of trucks will be used for transporting the wastes in Alternative 4b as in the other alternatives. An estimated 15,000 trips are required at a cost of \$1.42/mile for a round-trip distance of 2,000 km (1,250 mi). The 180,000 m³ (236,000 yd³) of wastes are loaded onto the barge at a cost of \$4.34/yd³ (Means Co. 1982).

The cost of ocean disposal 160 km (100 mi) offshore by barge and tug was given as about \$10/dry ton in a 1977 report (Little 1977). Use of the annual percent increases in consumer price index (U.S. Bur. Census 1983) to convert to 1982 dollars gives a value of about \$16/dry ton or \$17.60/dry MT. The total weight of wastes can be determined from the data in Table 3.5. It is also assumed that four monitoring trips at a cost of \$480,000 per trip (Little 1977) (corrected to 1982 dollars) occur during the disposal.

The general contractor component of the overhead costs is determined as 22% of all costs, except residue disposal at Hanford. Maintenance, monitoring, and surveillance costs are calculated assuming that the number of person-years required is the same as for Alternative 4a. Extended care costs are set at \$43,000/year (Section F.1). The costs for Alternative 4b are summarized in Table F.8. Uncertainties in the total action period cost estimate of \$65,000,000 are assumed to be the same as those given for Alternative 4a, namely 25% lower to 50% higher. This gives a cost range of \$49,000,000 to \$98,000,000. (The fact that the cost estimates for ocean disposal of wastes are more uncertain than those for retaining the wastes at NFSS does not have much effect because the cost of this activity is only 10% of the total.)

F.10 ALTERNATIVE 4c

Alternative 4c is the same as Alternative 4a except that the residues will be shipped to Oak Ridge for disposal. The costs or unit costs are the same as those for Alternative 4a or 3b. Maintenance, monitoring, and surveillance activities are assumed to require 62 person-years (Bechtel Natl. 1984--Alternative 11) at \$61,000/person-year. Extended care costs are assumed to be the same as for Alternative 4a.

The costs for Alternative 4c are summarized in Table F.9. The total cost for the action period is estimated to be \$17,000,000. The uncertainty ranges are assumed to be the same as for Alternative 4a--i.e., from 75 to 150% of the estimate, or \$13,000,000 to \$26,000,000.

F.11 ALTERNATIVE 4d

The activities for Alternative 4d during the action period are a composite of the activities for Alternatives 4b and 4c. In particular, the residues will be treated as in Alternative 4c and the wastes will be treated as in Alternative 4b. Maintenance, monitoring, and surveillance activities are assumed to cost the same as for Alternative 4c, and extended care is assumed to cost the same as for Alternative 4b.

The costs for Alternative 4d are summarized in Table F.10. The total cost during the action period is \$56,000,000. The uncertainty factors should be the same as for Alternative 4b, resulting in a cost range of \$42,000,000 to \$84,000,000.

Table F.8. Summary of Costs for Alternative 4b

Remove:	
Interim cap (Alternative 3a)	\$168,000
Wastes over residues (Alternative 2b)	<u>\$63,000</u>
Subtotal (Remove)	\$231,000
Excavate, Package Residues (Alternative 4a)	\$3,362,000
Transportation: ^{†1}	
Residues (incl. license fees) (Alternative 4a)	\$11,107,000
Wastes, 15,000 trips @ \$1,775/trip	<u>\$26,625,000</u>
Subtotal (Transportation)	\$37,732,000
Ocean Disposal of Wastes:	
Barge loading, 240,000 yd ³ @ \$4.34/yd ³	\$1,042,000
Barge towing, dumping, 215,000 MT @ \$17.60/MT	\$3,784,000
Monitoring trips, 4 @ \$480,000/trip	<u>\$1,920,000</u>
Subtotal (Ocean Disposal of Wastes)	\$6,745,000
NFSS Site Restoration (Alternative 3a)	\$550,000
<u>Subtotal</u>	\$48,620,000
Overhead:	
General contractor (22% of subtotal)	\$10,696,000
Maintenance, monitoring, and surveillance (Alternative 4a)	<u>\$4,941,000</u>
Subtotal (Overhead)	\$15,637,000
Residue Disposal at Hanford (Alternative 4a)	\$1,323,000
TOTAL FOR ACTION PERIOD ^{†2}	\$66,000,000
Extended Care (Alternative 2a):	
Annual cost	\$43,000
Total payout (200 years)	\$8,600,000
Sinking fund (3% real interest) ^{†3}	<u>\$1,400,000</u>

^{†1} Costs are calculated assuming that the trucks return empty.

^{†2} Rounded to two significant figures.

^{†3} The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

Table F.9. Summary of Costs for Alternative 4c

Relocate Ditch, Lutts Road (Alternative 4a)	\$128,000
Remove Interim Cap, Wastes over Residues (Alternative 4a)	\$153,000
Excavate, Package Residues (Alternative 4a)	\$3,362,000
Transport, License Residues (Alternative 3b)† ¹	\$3,435,000
Construct Long-Term Cap (Alternative 4a)	\$1,975,000
<u>Subtotal</u>	\$9,053,000
Overhead:	
General contractor (22% of subtotal)	\$1,992,000
Maintenance monitoring, and surveillance, 62 person-years @ \$61,000/person-year	<u>\$3,782,000</u>
Subtotal (Overhead)	\$5,774,000
Disposal of Residues, 389,000 ft ³ @ \$5.50/ft ³	\$2,139,000
TOTAL FOR ACTION PERIOD† ²	\$17,000,000
Extended Care (Alternative 2a):	
Annual cost	\$130,000
Total payout (200 years)	\$26,000,000
Sinking fund (3% real interest)† ³	\$4,200,000

†¹ Costs are calculated assuming that the trucks return empty.

†² Rounded to two significant figures.

†³ The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

Table F.10. Summary of Costs for Alternative 4d

Remove Interim Cap, Residue Overburden (Alternative 4b)	\$231,000
Excavate, Package Residues (Alternative 4c)	\$3,362,000
Transport, License Residues (Alternative 4c)† ¹	\$3,435,000
Transport Wastes (Alternative 4b)† ¹	\$26,625,000
Ocean Disposal of Wastes (Alternative 4b)	\$6,745,000
NFSS Site Restoration (Alternative 4b)	\$550,000
<u>Subtotal</u>	\$40,948,000
Overhead:	
General contractor (22% of subtotal)	\$9,008,000
Maintenance, monitoring, and surveillance (Alternative 4c)	<u>\$3,782,000</u>
Subtotal (Overhead)	\$12,791,000
Disposal of Residues (Alternative 4c)	\$2,139,000
TOTAL FOR ACTION PERIOD† ²	\$56,000,000
Extended Care (Alternative 4b):	
Annual cost	\$43,000
Total payout (200 years)	\$8,600,000
Sinking fund (3% real interest)† ³	\$1,400,000

†¹ Costs are calculated assuming that the trucks return empty.

†² Rounded to two significant figures.

†³ The cost of a perpetual care fund is equal to the cost of a 200-year sinking fund (within the two significant figures reported here).

REFERENCES (Appendix F)

- Bechtel National, Inc. 1982. Niagara Falls Storage Site Long-Range Planning Study, Phase II. Appendix G. Prepared for the U.S. Department of Energy. September 1982.
- Bechtel National, Inc. 1984. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. Prepared for the U.S. Department of Energy. January 1984.
- Cheever, L. 1984. Personal Communication (Argonne National Laboratory) to P. Benioff (Argonne National Laboratory).
- Ditch, R. 1983. Personal communication (Argonne National Laboratory) to P. Benioff (Argonne National Laboratory).
- EG&G Idaho, Inc. 1983. Directions in Low-Level Radioactive Waste Management: An Analysis of Low Level Waste Disposal Facility and Transportation Costs. Report No. DOE/LLW-6Td. Prepared for the U.S. Department of Energy. April 1983.
- Little (Arthur D.), Inc. 1977. An Evaluation of the Disposal of Flue Gas Desulfurization Wastes in Mines and the Ocean: Initial Assessment. EPA-600/7-77-05. Prepared for the U.S. Environmental Protection Agency. pp. 300-307.
- Means (Robert Snow) Company, Inc. 1982. Building Construction Cost Data. Kingston, MA.
- Skarim, R. 1983. Personal communication (Manager, Consumer Services, Niagara Mohawk Power Co.).
- U.S. Bureau of the Census. 1983. Statistical Abstract of the United States 1982/1983.
- U.S. Bureau of Mines. 1980. U.S. Minerals Yearbook, 1978-1979. Vol. I, Metals and Minerals. U.S. Department of the Interior, Washington, DC.

APPENDIX G. SCOPING

G.1 SCOPING PROCESS

As part of its Surplus Facilities Management Program (SFMP) and Formerly Utilized Sites Remedial Action Program (FUSRAP), the Department of Energy (DOE) issued a Notice of Intent (NOI) on February 1, 1983, in the Federal Register (U.S. Dep. Energy 1983a) that an environmental impact statement will be prepared to assess the environmental impacts of several alternatives for the long-term management of existing radioactive wastes and residues stored at DOE's Niagara Falls Storage Site (NFSS) as of completion of interim remedial actions in 1985.* The NOI was mailed directly to federal, state (New York, Tennessee, and Washington), and local governments and agencies; to Representative LaFalce's NFSS Oversight Committee; and to the general public.

In accordance with regulations of the Council on Environmental Quality (CEQ) and DOE guidelines for implementing NEPA, the Department conducted a scoping process to determine the alternatives to be analyzed in this EIS, the significant issues to be analyzed in depth, and the issues to be eliminated from further detailed study. The results of the scoping process are given in the DOE Implementation Plan for this EIS (U.S. Dep. Energy 1984). Following is a brief summary.

Public input to the scoping process included:

- Presentations made at two public meetings held at Lewiston-Porter High School, Lewiston, New York, on February 17 and 19, 1983
- Presentations made at a public meeting held at the Museum of Science and Energy, Oak Ridge, Tennessee, on October 19, 1983
- Letters received by DOE regarding the scope of the EIS

A list of the persons and organizations who commented during the public scoping process is given in Table G.1. About half the public comments were from government organizations and half were from organized public-interest or environmental groups. Very few private citizens offered comments.

Technical input to the scoping process included:

- Preliminary engineering evaluation of several alternatives for the disposition of NFSS residues and wastes by Bechtel National, Inc. (BNI)
- Meetings, correspondence, and telephone communications between Argonne National Laboratory (ANL) and BNI regarding estimates of volumes and levels of contamination of the various wastes and residues at NFSS
- Meetings and correspondence between ANL and the DOE operations offices at Oak Ridge, Tennessee (DOE-OR), and Richland, Washington (DOE-RL), regarding locations and conceptual designs for long-term management of the NFSS wastes and residues at the DOE Oak Ridge and Hanford Reservations
- Meetings, correspondence, and review of alternatives and issues by FUSRAP and SFMP program managers at DOE-OR, DOE-RL, and DOE Headquarters (DOE-HQ)
- Preliminary evaluation by ANL of technical options and conceptual designs for barge transportation and ocean dispersal of the NFSS wastes based on previous studies by ANL, Sandia National Laboratories (SNL), and BNI
- Preliminary evaluation by ANL of technical options and development of conceptual designs for an additional fourth alternative of offsite storage of the residues (see discussion below)
- Meetings with New York State agencies (Departments of Environmental Conservation, Labor, and Health)

*The impacts associated with the interim activities will not be covered in the EIS on long-term management. The interim actions are addressed in separate documents (U.S. Dep. Energy 1982a, 1982b, 1983b, 1983c). There is a possibility that some of the interim actions may not be completed until 1986.

Table G.1. Public Scoping Input

PRESENTATIONS AT SCOPING MEETINGS

- February 17: (Lewiston)
1. Richard T. Lee, Representative for Congressman John LaFalce
 2. Robert Naum, Citizen's Oversight Committee
 3. Robert E. Lee, Town of Lewiston
 4. James McElfish, Attorney for Town of Lewiston
 5. Danielle DeGolier, Citizens Against Pollution
 6. Terry Kuehn, Representative for Assemblyman Murphy
 7. Richard Rooker, Niagara County Board of Health
 8. Raymond Vaughn
 9. Walter Klabunde
 10. Steven R. Nathanson, No LOOW Committee
 11. Steven Doleski, New York Department of Environmental Conservation
 12. Terry Mudd, Representative for Assemblyman Pillittere
 13. Calvin C. Schultz, Town of Lewiston Supt. of Highways
- February 19: (Lewiston)
1. Al MacBain, Member of Parliament, Canada
 2. Kathleen Lima, Greenpeace
 3. Calvin C. Schultz, Lewiston Supt. of Highways
 4. C.W. Shonnard
 5. John Daly, New York State Senator
 6. Diane D'Arrigo, Sierra Club
 7. Alfred Guillette, Sierra Club Radioactive Waste Campaign
 8. Margherita Howe, Operation Clean, Ontario, Canada
 9. Robert Franki
 10. Darwin Langlois
- October 19: (Oak Ridge)
1. Frances Pleasonton
 2. Charles Coutant, City of Oak Ridge Environmental Quality Advisory Board
 3. Gary Davis, American Environmental Association
 4. John Williams
 5. Barry McConnell
 6. John Dabbs
 7. John Peele, Member of the Roane County Legislature
 8. Susan Williams
 9. Jim Young
 10. Harold Jernigan, Member of the Oak Ridge City Council
 11. Russ Driver

CORRESPONDENCEDuring Scoping at NFSS

1. Irwin D.J. Bross, Director of Biostatistics, Roswell Park Memorial Institute
2. Joseph F. Drayton, Director, New York Department of Labor, Division of Safety and Health
3. Glen H. Spain, General Counsel, Farallon Foundation
4. Carol Mongerson, Coalition on West Valley Nuclear Wastes
5. D. Pascoe, Manager, Environmental Contaminants Division, Environment Canada
6. Shirley J. Quarantillo, School District Clerk, Lewiston-Porter Central School
7. Gerald F. Schuur, Niagara Falls Area Chamber of Commerce
8. Paul P. Hamilton, Field Supervisor, U.S. Department of Interior, Fish and Wildlife Service
9. Diana D'Arrigo and Lisa Finaldi, Sierra Club
10. Richard E. Cunningham, Director, Division of Fuel Cycle and Material Safety, U.S. Nuclear Regulatory Commission
11. Anne Norton Miller, Chief, Environmental Impacts Branch, U.S. Environmental Protection Agency
12. Christopher Roosevelt, President, The Oceanic Society
13. James M. McElfish, Attorney, Town of Lewiston, NY
14. Donald H. Henry, Karen Graf; et al., Operation Clean, Inc.
15. Karen Graf
16. Louis M. Condra, Director, Division of Regulatory Affairs, New York Department of Environmental Conservation
17. Clifton E. Curtis, Center for Law and Social Policy
18. Glyn G. Caldwell, Center for Environmental Health, Department of Health and Human Services

During Scoping at Oak Ridge and Hanford

1. John W. Peele, Member of the Roane County Legislature
 2. Kenneth E. Yager, Roane County Executive
 3. Donald W. Moos, State of Washington Department of Ecology
 4. Allen W. Neel, East Tennessee Development District
 5. M.T. Bruner, Tennessee Department of Health and Environment
 6. C.H. Dean, Chairman, TVA
 7. Sheppard N. Moore, USEPA Region IV
 8. M. Lyle Lacy III, City Manager, Oak Ridge, TN
 9. Herbert L. Harper, Tennessee Historical Commission
 10. Dan Sherry, Tennessee Wildlife Resources Agency
 11. V. Gary Henry, U.S. Fish and Wildlife Service, Asheville, NC
 12. Robert G. Whitlam, State of Washington Office of Archaeology and Historic Preservation
 13. P.T. Perdue
 14. Irwin D. Bross, Biomedical Technology, Inc.
 15. Kenneth S. Warren
 16. Harry C. Francke
 17. R.F. Perkins
 18. James M. McElfish, Attorney for Town of Lewiston, NY
 19. Susan Williams
 20. Renee P. Bender
-

G.2 ALTERNATIVES

In addition to the alternatives given in the NOI, a fourth alternative involving offsite storage of only the NFSS residues was suggested during the scoping process. Further technical input has confirmed the reasonableness of evaluating such an alternative. These residues account for almost 99% of the total radium-226 inventory at NFSS but less than 6% of the total volume of contaminated materials. Removal of the relatively small volume of residues from NFSS would eliminate most of the potential long-term radiological hazard from NFSS. This fourth alternative was therefore added for analysis in this EIS.

Within each of the four basic alternatives, numerous subalternatives could have been constructed out of the various options for long-term management sites and designs, transportation modes, etc. . Permutations of all options would have created an unwieldy set of alternatives for analysis and comparison. Therefore, combinations of options covering the range of alternatives to be considered by the DOE decision-maker were selected for analysis. Discussions of options that were dismissed from detailed study are summarized in Appendices C and D of this EIS.

G.3 ISSUES

Based on the scoping input, several issues were determined to be beyond the scope of this EIS:

1. Use of NFSS for management of other wastes--This is no longer being considered by DOE.
2. NEPA compliance for Afrimet lease settlement--DOE has determined that settlement of the Afrimet leases (U.S. Dep. Energy 1983d) was an action which, in and of itself, will have a clearly insignificant impact on the quality of the human environment. No further NEPA compliance is necessary (U.S. Dep. Energy 1983e).
3. Comparison of various regulations--As provided under the Atomic Energy Act (as amended), DOE is exempt from regulation by states and other federal agencies with respect to radiological aspects of DOE operations. DOE develops its own regulations ("Orders") for general application to DOE operations. Development of such Orders is not part of the currently proposed action and is therefore beyond the scope of this EIS. A summary of applicable orders is given in this EIS.
4. Psychological impacts--In a case involving the proposed restart of one of the Three Mile Island reactors, the U.S. Supreme Court held that analysis of psychological impacts is beyond the intent of NEPA (Supreme Court of the United States 1983).
5. Impacts of past operations at NFSS and Oak Ridge--The impacts of the various alternatives on the existing environment are assessed in this EIS. However, in the above-mentioned Supreme Court decision, it was stated that "NEPA is not directed at the effects of past accidents and does not create a remedial scheme for past federal actions." Therefore, a detailed analysis of past operations is considered to be beyond the scope of this EIS.
6. Cumulative effects of all past, present, and future operations at the DOE Oak Ridge Reservation--DOE has determined that this issue is beyond the scope of this EIS. Cumulative effects are addressed only insofar as there are projected interactions with other existing DOE activities on the Reservation.
7. Global impacts of ocean disposal--DOE has determined that the global impacts of any of the alternatives, including ocean disposal, are clearly beyond the scope of the current decision and the current EIS. The spatial impacts of ocean disposal are considered to the point that impacts become insignificant.
8. Other disposal sites--Two specific and reasonably available sites on DOE Reservations are included in the alternatives to be analyzed in this EIS. Only DOE-owned sites are currently available for disposal of wastes from DOE operations. Long-term management of the NFSS wastes and residues on non-DOE sites is not an alternative reasonably available to DOE. Other DOE Reservations are not considered because the Hanford Reservation is representative of an arid site and the Oak Ridge Reservation is representative of a humid site--thus allowing comparison of two sites spanning the range of sites available to the DOE decision-maker.
9. Processing residues at a uranium mill to recover valuable elements--Uranium mills are designed to recover uranium. Extra equipment is needed to recover the other valuable elements in the NFSS residues. Thus, it is more reasonable to consider an alternative wherein such equipment is installed at NFSS rather than shipping residues to another unequipped site.
10. Lack of public participation in the DOE decision-making process and distrust of federal officials--This is a very broad social issue that is beyond the scope of this EIS. DOE has received both oral and written comments from the public during the scoping process for this EIS and intends to hold a public meeting after the Draft EIS has been issued.

11. Inequitable distribution of risks; potential precedent for allowing disposal of other Manhattan Project wastes, and concern that the site chosen for management of the NFSS wastes and residues may develop a bad image as a dumping ground for the nation's nuclear wastes--These are also broad social issues that are addressed via other political and legal institutions and are beyond the scope of this EIS.

Analysis of both the oral and written public scoping comments indicated that concerns about potential radiological health effects, especially those associated with various pathways through the environment, were the issues of greatest concern. Although not raised as a primary issue by the public, impacts associated with potential human intrusion into the contaminated materials was retained as a primary issue because of past experience at uranium mill tailings sites (where people have intruded into the contaminated residues).

Based on public scoping input, radiological contamination of the oceanic environment was added as a primary issue. This issue was one of the major concerns of the organized public-interest and environmental groups. Although these groups basically recommended that ocean disposal be eliminated as an alternative, technical input indicated that such an alternative is technically feasible and may be available to the DOE decision-maker in the near future. A two-year moratorium on disposal of radioactive wastes in the ocean is scheduled to expire before the NFSS alternatives can be implemented, and EPA is considering revising its ocean dumping regulations. Ocean dispersal of high-volume bulk wastes--such as dirt, sludges, and industrial effluents--is common practice in the northeastern United States. The 106-Mile Site, located over the continental slope southeast of New York harbor, is an EPA-approved dumpsite for high-volume bulk wastes similar in composition to the trace-contaminated NFSS wastes. The radioisotopes of concern in the NFSS wastes occur naturally in the ocean and are the same as those carried to the sea by erosion of the land masses. Thus, ocean disposal was retained as a reasonable alternative to the long-term maintenance and monitoring that will be required if the NFSS wastes are managed by near-surface containment on land.

A few public commentators desired analysis of synergistic effects associated with radiological pollutants from the NFSS wastes and residues and chemical pollutants from other hazardous waste facilities (e.g., the SCA facility north of NFSS or other DOE facilities on the Oak Ridge Reservation). There is essentially no scientific evidence for synergistic effects between radionuclides and the many potential chemicals, and there is no projected interaction with existing facilities. In addition, DOE considers assessment of synergistic effects with chemical releases from future facilities near each alternative site to be beyond the scope of this EIS.

REFERENCES (Appendix G)

- Supreme Court of the United States. 1983. Metropolitan Edison Co. et al. v. People Against Nuclear Energy et al. (103S.C.T.1556). Argued March 1, 1983--Decided April 19, 1983.
- U.S. Department of Energy. 1982a. Action Description Memorandum, Niagara Falls Storage Site, Proposed 1982 Interim Remedial Action (R-10 Pile Stabilization). Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. April 1982.
- U.S. Department of Energy. 1982b. Action Description Memorandum, Niagara Falls Storage Site, Proposed Interim Remedial Action for Buildings 413 and 414. Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. April 1982.
- U.S. Department of Energy. 1983a. Long-Term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site: Notice of Intent to Prepare an Environmental Impact Statement and Conduct a Public Scoping Meeting. Fed. Regist. 48(22):4522 (February 1, 1983).
- U.S. Department of Energy. 1983b. Action Description Memorandum, Niagara Falls Storage Site. Proposed Interim Remedial Actions for FY 1983. Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. February 1983.
- U.S. Department of Energy. 1983c. Action Description Memorandum, Niagara Falls Storage Site, Proposed Interim Remedial Actions for FY 1983-85 Accelerated Program. Oak Ridge Operations, Technical Services Division, Oak Ridge, TN. May 5, 1983.
- U.S. Department of Energy. 1983d. Contract of Agreement and Settlement; Lease Agreements AT(40-1)-2427 and AT(40-1)-2429. Effective 1 July 1983. Signed 26 August 1983 by J. LaGrone (Contracting Officer), Department of Energy, and V. Shick (President and Chief Executive Officer), Afrimet-Indussa Inc.
- U.S. Department of Energy. 1983e. NEPA Compliance for Settlement of DOE Leases AT(40-1)-2427 and -2429 with Afrimet-Indussa, Inc. Memorandum from Frank Coffman, Office of Terminal Waste Disposal and Remedial Action, to Joseph LaGrone, Manager, Oak Ridge Operations Office. June 7, 1983.
- U.S. Department of Energy. 1984. Implementation Plan for the Environmental Impact Statement, Long-Term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site. January 1984.

APPENDIX H.

U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVITY AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Rev. 1, July 1985)

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).^{*} The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactivity, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Dept. Energy 1984). More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactivity from basic dose limits, is contained in a supplementary document--referred to herein as the "supplement" (U.S. Dept. Energy 1985).

"Residual radioactivity" includes: (1) residual concentrations of radionuclides in soil material,** (2) concentrations of airborne radon decay products, (3) external gamma radiation level, and (4) surface contamination. A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). Basic dose limits are used explicitly for deriving guidelines for residual concentrations of radionuclides in soil material, except for thorium and radium. Guidelines for residual concentrations of thorium and radium and for the other three quantities (airborne radon decay products, external gamma radiation level, and surface contamination) are based on existing radiological protection standards (U.S. Environ. Prot. Agency 1983; U.S. Nucl. Reg. Comm. 1982). These standards are assumed to be consistent with basic dose limits within the uncertainty of derivations of levels of residual radioactivity from basic limits.

A "guideline" for residual radioactivity is a level of residual radioactivity that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactivity presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement.

An "authorized limit" is a level of residual radioactivity that must not be exceeded if the remedial action is to be considered completed. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the residual radioactivity does not exceed guideline values at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the residual radioactivity exceeds guideline values. The applicable controls and restrictions are specified in Section E.

^{*}A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

^{**}The term "soil material" refers to all material below grade level after remedial action is completed.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). Implementation of ALARA policy is specified as procedures to be applied after authorized limits have been set. For sites to be released for unrestricted use, the intent is to reduce residual radioactivity to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual radioactivity is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as is reasonably achievable. Procedures for implementing ALARA policy are described in the supplement. ALARA policies, procedures, and actions must be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime. The committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), shall be used for determining the dose.

C. GUIDELINES FOR RESIDUAL RADIOACTIVITY

C.1 Residual Radionuclides in Soil Material

Residual concentrations of radionuclides in soil material shall be specified as above-background concentrations averaged over an area of 100 m². If the concentration in any area is found to exceed the average by a factor greater than 3, guidelines for local concentrations shall also be applicable. These "hot spot" guidelines depend on the extent of the elevated local concentrations and are given in the supplement.

The generic guidelines for residual concentrations of Th-232, Th-230, Ra-228, and Ra-226 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit. Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

The guidelines for residual concentrations in soil material of all other radionuclides shall be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. Procedures for deriving these guidelines are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μ R/h.

*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.4 Surface Contamination

The following generic guidelines, adapted from standards of the U.S. Nuclear Regulatory Commission (1982), are applicable only to existing structures and equipment that will not be demolished and buried. They apply to both interior and exterior surfaces. If a building is demolished and buried, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

Radionuclides† ²	Allowable Total Residual Surface Contamination (dpm/100 cm ²)† ¹		
	Average† ³ ,† ⁴	Maximum† ⁴ ,† ⁵	Removable† ⁴ ,† ⁶
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β - γ	15,000 β - γ	1,000 β - γ

†¹ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

†² Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

†³ Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

†⁴ The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

†⁵ The maximum contamination level applies to an area of not more than 100 cm².

†⁶ The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVITY

The remedial action shall not be considered complete unless the residual radioactivity is below authorized limits. Authorized limits shall be set equal to guidelines for residual radioactivity unless: (1) exceptions specified in Section F of this document are applicable, in which case an authorized limit may be set above the guideline value for the specific location or condition to which the exception is applicable; or (2) on the basis of site-specific data not used in establishing the guidelines, it can be clearly established that limits below the guidelines are reasonable and can be achieved without appreciable increase in cost of the remedial action. Authorized limits that differ from guidelines must be justified and established on a site-specific basis, with documentation that must be filed as a permanent record upon completion of remedial action at a site. Authorized limits differing from the guidelines must be approved by the Director, Oak Ridge Technical Services Division, for FUSRAP and by the Director, Richland Surplus Facilities Management Program Office, for remote SFMP--with concurrence by the Director of Remedial Action Projects for both programs.

E. CONTROL OF RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES

Residual radioactivity above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A requires compliance with applicable federal, state, and local environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

- a. 5440.1B, Implementation of the National Environmental Policy Act
- b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations
- c. 5480.2, Hazardous and Radioactive Mixed Waste Management
- d. 5480.4, Environmental Protection, Safety, and Health Protection Standards
- e. 5482.1A, Environmental, Safety, and Health Appraisal Program
- f. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities
- g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements
- h. 5484.2, Unusual Occurrence Reporting System
- i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

- a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.
- b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).
- c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing federal, state, or local standards.
- d. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactivity shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The federal government shall have title to the property.

E.2 Interim Management

- a. A site may be released under interim management when the residual radioactivity exceeds guideline values if the residual radioactivity is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.
- b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.
- c. The owner of the site or appropriate federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

- a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.
- b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 pCi/m²/s, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.
- c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the

generation and escape of biogenic gases will not cause the requirement in paragraph b of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a of this section (E.3).

- d. Groundwater shall be protected in accordance with 40 CFR 192.20(a)(2) and 192.20(a)(3), as applicable to FUSRAP and remote SFMP sites.
- e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The federal government shall have title to the property.

Other Radionuclides

- f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. EXCEPTIONS

Exceptions to the requirement that authorized limits be set equal to the guidelines may be made on the basis of an analysis of site-specific aspects of a designated site that were not taken into account in deriving the guidelines. Exceptions require approvals as stated in Section D. Specific situations that warrant exceptions are:

- a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.
- b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.
- c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. In order to invoke this exception, a site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactivity must be included in the appropriate state and local records.
- d. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be effected by remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of remedial actions that would be less costly than removal of the residual radioactive materials. A statement specifying the residual radioactivity must be included in the appropriate state and local records.
- e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
<u>Basic Dose Limits</u>	
Dosimetry Model and Dose Limits	International Commission on Radiological Protection (1977, 1978)
<u>Generic Guidelines for Residual Radioactivity</u>	
Residual Concentrations of Radium and Thorium in Soil Material	40 CFR 192
Airborne Radon Decay Products	40 CFR 192
External Gamma Radiation	40 CFR 192
Surface Contamination	Adapted from U.S. Nuclear Regulatory Commission (1982)
<u>Control of Radioactive Wastes and Residues</u>	
Interim Storage	DOE Order 5480.1A
Long-Term Management	DOE Order 5480.1A; 40 CFR 192

H. REFERENCES

- International Commission on Radiological Protection. 1977. Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977). ICRP Publication 26. Pergamon Press, Oxford. [As modified by "Statement from the 1978 Stockholm Meeting of the ICRP." Annals of the ICRP, Vol. 2, No. 1, 1978.]
- International Commission on Radiological Protection. 1978. Limits for Intakes of Radionuclides by Workers. A Report of Committee 2 of the International Commission on Radiological Protection. Adopted by the Commission in July 1978. ICRP Publication 30. Part 1 (and Supplement), Part 2 (and Supplement), Part 3 (and Supplements A and B), and Index. Pergamon Press, Oxford.
- U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule (40 CFR Part 192). Fed. Regist. 48(3):590-604 (January 5, 1983).
- U.S. Department of Energy. 1984. Formerly Utilized Sites Remedial Action Program. Summary Protocol: Identification - Characterization - Designation - Remedial Action - Certification. Office of Nuclear Energy, Office of Terminal Waste Disposal and Remedial Action, Division of Remedial Action Projects. April 1984.
- U.S. Department of Energy. 1985. Supplement to U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites. A Manual for Implementing Residual Radioactivity Guidelines. Prepared by Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest Laboratory for the U.S. Department of Energy. (In preparation.)
- U.S. Nuclear Regulatory Commission. 1982. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, DC. July 1982.

APPENDIX I. ENGLISH/METRIC EQUIVALENTS

Multiply	By	To obtain
Acres	0.4047	Hectares (ha)
Cubic feet (ft ³)	0.0283	Cubic meters (m ³)
Cubic yards (yd ³)	0.76455	Cubic meters (m ³)
Degrees Fahrenheit (°F) - 32	5/9	Degrees Celsius (°C)
Feet (ft)	0.3048	Meters (m)
Gallons (gal)	3.7854	Liters (L)
Gallons (gal)	0.0038	Cubic meters (m ³)
Inches (in.)	2.540	Centimeters (cm)
Miles (mi)	1.6093	Kilometers (km)
Nautical miles (nmi)	1.8520	Kilometers (km)
Pounds (lb)	0.4536	Kilograms (kg)
Square feet (ft ²)	0.0929	Square meters (m ²)
Square yards (mi ²)	0.03613	Square meters (m ²)
Square miles (mi ²)	2.590	Square kilometers (km ²)
Tons, short (t)	9.0718 × 10 ²	Kilograms (kg)
Tons, short (t)	0.9072	Tons, metric (MT)

APPENDIX J. CORRESPONDENCE REGARDING ENDANGERED SPECIES
AND HISTORIC PRESERVATION



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
100 Grange Place
Room 202
Cortland, New York 13245

February 22, 1983

Mr. L.F. Campbell, Deputy Director
Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy
P.O. Box E
Oak Ridge, Tennessee 37830

Dear Mr. Campbell:

We have reviewed the notice of intent to prepare an EIS for long-term management of existing radioactive wastes and residues at the Niagara Falls storage site, Niagara County, New York.

We have no comments or suggestions to offer at this time and due to manpower and funding constraints we are not able to participate in follow-up scoping activities. However, we would like to receive a copy of the draft EIS for review and comment on the pertinent fish and wildlife resources.

Sincerely yours,

Paul P. Hamilton
Paul P. Hamilton
Field Supervisor



New York State Office of Parks, Recreation and Historic Preservation
The Governor, Nelson A. Rockefeller Empire State Plaza
Agency Building 1 Albany, New York 12236

April 26, 1983

Mr. Lowell F. Campbell
Deputy Director
Technical Services Division
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37830

Dear Mr. Campbell:

Niagara Falls Storage Site(NFSS)
Lewiston, Niagara County(DOE)

Thank you for submitting the above referenced project to the State Historic Preservation Officer(SHPO). The SHPO has provided comments on this project in a March 10, 1983 letter to Bechtel National, Inc. (copy attached).

If you have any questions, please contact the project review staff at 518 474-3176.

Sincerely,

Stephen J. Raiche
Stephen J. Raiche
Director
Historic Preservation Field
Services

CAF:mr
Enc.

cc: Raymond Berube
Robert L. Rudolph

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New York State Office of Parks, Recreation and Historic Preservation
The Governor Nelson A. Rockefeller Empire State Plaza
Agency Building Albany New York 12236

518-474-0456

March 10, 1983

JOHN SPILMAN
Governor



JACOB THOMAS
Director

STATE OF WASHINGTON

OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION

111 West Twentyfirst Avenue, AL-11 • Olympia Washington 98504 • (206) 753-4011

September 29, 1983

Mr. Robert L. Rudolph
Project Manager - FUSRAP
Bechtel National, Inc.
P.O. Box 350
Oak Ridge, Tenn. 37830

Dear Mr. Rudolph:

Niagara Falls Storage (DOE)
Lewiston, Niagara County

The State Historic Preservation Officer (SHPO) has reviewed the above project in accordance with the Advisory Council on Historic Preservation's regulations, "Protection of Historic and Cultural Properties," 36 CFR 600.

Based upon this review, it is the opinion of the SHPO that this project will have no effect upon cultural resources included in or eligible for inclusion in the National Register of Historic Places.

Should you have any questions, please contact the project review staff at 518-474-3176.

Sincerely,

Ann Webster Smith
Deputy Commissioner for
Historic Preservation

BJ:MAR

cc: Raymond Berube

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37831

Log Reference: 450-F-DOE-02

Re: DOE'S NIAGARA FALLS STORAGE
SITE RADIOACTIVE WASTE
MANAGEMENT PROJECT

Dear Mr. Campbell:

We have reviewed the materials forwarded to us for the above referenced project. A search of our records, including the National and State Registers of Historic Places and the Washington State Archaeological and Historic Sites Inventories, indicates the project area has not been surveyed for the presence of cultural resources. We recommend professional cultural resource surveys of the project area be conducted.

Please feel free to contact us if we can be of any further assistance.

Sincerely,

Robert G. Whitlam
Robert G. Whitlam, Ph.D.
Archaeologist

dj

213



United States Department of the Interior

FISH AND WILDLIFE SERVICE
ENDANGERED SPECIES FIELD OFFICE
PLANTAL BUILDING, ROOM A-5
50 SOUTH FRENCH BROAD AVENUE
ASHEVILLE, NORTH CAROLINA 28801

September 28, 1983

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
Department of Energy
Oak Ridge Operations
P. O. Box 1
Oak Ridge, Tennessee 37831

Re: 4-2-83-941

Dear Mr. Campbell:

We have reviewed the proposed alternative to relocate some or all of the radioactive wastes and residues currently stored at the Niagara Falls Storage Site near Lewiston, New York at a new facility built on the Department of Energy's Oak Ridge Operations Reservation in Anderson County, Tennessee, as requested by letter of September 13, 1983, received September 14, 1983.

Federally listed Endangered (E) and/or Threatened (T) and/or species proposed for listing as Endangered (PE) or Threatened (PT) may occur in the area of influence of this action.

To facilitate compliance with Section 7(c) of the Endangered Species Act of 1973, as amended, (Act) Federal agencies or designated non-Federal representatives are required to obtain from the Fish and Wildlife Service information concerning the possible presence of any species, listed or proposed to be listed, which may be present in the impact area of a proposed major Federal action significantly affecting the quality of the human environment. Therefore, we are furnishing you the following list of species which may be present in the concerned area:

MAMMALS

Gray bat - Myotis grisescens (E)

In addition to listed and proposed Endangered and Threatened species, there are species which, although not now listed or officially proposed for listing as Endangered or Threatened, are under status review (SR) by the Service and may be listed at some time in the future. Status review species are not legally protected under the Endangered Species Act and the biological assessment requirements do not apply to them. However, we would appreciate any efforts you might make to avoid adversely impacting them. The following species under status review may occur within the project area:

PLANTS

Appalachian bluebelle - Cimicifuga rubrifolia
Carey's saxifrage - Saxifraga careyana

Section 7(c) and regulations being prepared to implement Section 7(c) also require the Federal agency or the designated non-Federal representative proposing a major Federal action to conduct and submit to the Service a biological assessment to determine the effects of the proposal on listed and proposed Endangered and Threatened species. The biological assessment shall be completed within 180 days after the date on which initiated or within a time frame mutually agreed upon between the agency and the Service and before initiating the proposed action. If the biological assessment is not begun within 90 days, this list must be verified informally (via phone) with us prior to initiation of your assessment. We do not feel that we can adequately assess the effects of the proposed action on listed and proposed Endangered and Threatened species or Critical Habitat without a complete assessment. When conducting a biological assessment, the Federal agency or the designated non-Federal representative must, at a minimum:

1. Conduct a scientifically sound on-site inspection of the area affected by the action, which must, unless otherwise directed by the Service, include a detailed survey of the area to determine if listed or proposed species are present or occur seasonally and whether suitable habitat exists within the area for either expanding the existing population or potential reintroduction of populations;
2. Interview recognized experts on the species at issue, including those within the Fish and Wildlife Service, the National Marine Fisheries Service, state conservation agencies, universities, and others who may have data not yet found in scientific literature;
3. Review literature and other scientific data to determine the species' distribution, habitat needs, and other biological requirements;
4. Review and analyze the effects of the action on the species, in terms of individuals and populations, including consideration of the cumulative effects of the action on the species and habitat;
5. Analyze alternative actions that may provide conservation measures;
6. Conduct any studies necessary to fulfill the requirements of (1) through (5) above;
7. Review any other relevant information.

Should you require additional information on this subject, please contact Mr. Gary Henry, Mr. Robert Currie, or Ms. Nora Murdock in the Asheville Endangered Species Field Office, FTS 672-0321, commercial 704/258-2850, ext. 321.

After the assessment has been completed and reviewed, it is the responsibility of the Federal agency to determine if the proposed action "may affect" any of the listed species or Critical Habitats or if it is

likely to jeopardize the continued existence of proposed species or result in the destruction or adverse modification of any Critical Habitat proposed for such species. If the determination is "may affect" for listed species the Federal agency must request in writing formal consultation from this office. Requests for formal consultation must include: (1) a description of the action to be considered; (2) a description of the specific area that may be affected by the action; (3) a description of any listed species or Critical Habitat that may be affected by the action; (4) a description of the manner in which the action may affect any listed species or Critical Habitat and an assessment of any cumulative effects; (5) reports including any environmental impact statement, environmental assessment, or biological assessments prepared; and (6) any other relevant available information on the action, the affected listed species, or Critical Habitat.

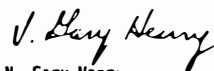
In addition, if the proposed action is likely to jeopardize the continued existence of proposed Endangered or Threatened species or result in the destruction or adverse modification of proposed Critical Habitat, the Federal agency must confer with this office for assistance in identifying and resolving potential conflicts at an early stage in the planning process.

If this proposed action is not a major Federal action significantly affecting the quality of the human environment, the requirements of Section 7(c), i.e., species list, biological assessment, do not apply. However, the requirements to (1) determine if the proposed action "may affect" listed species or Critical Habitats, (2) determine if the proposed action is likely to jeopardize the continued existence of proposed species or result in destruction or adverse modification of proposed Critical Habitat, (3) request formal consultation for "may affect" actions, and (4) confer with this office if the proposed action is likely to jeopardize the continued existence of proposed Endangered or Threatened species or result in the destruction or adverse modification of proposed Critical Habitat are still applicable.

Attention is also directed to Section 7(d) of the Act, which underscores the requirement that the Federal agency and/or the permit or license applicant shall not make any irreversible or irretrievable commitment of resources during the consultation period which, in effect, would deny the formulation or implementation of reasonable and prudent alternatives regarding their actions on any listed Endangered or Threatened species.

If we can be of further assistance, please advise.

Sincerely yours,



V. Gary Henry
Acting Field Supervisor
Endangered Species Field Office

cc:

Mr. Bob Hatcher, Wildlife Res. Agency, Nashville, TN
Program Administrator, TN Heritage Program, Nashville, TN
Director, FWS, Washington, DC (AFA/OES)
Regional Director, FWS, Atlanta, GA (ARD-FA/SE)
Field Supervisor, ES, FWS, Cookeville, TN



TENNESSEE WILDLIFE RESOURCES AGENCY

ELLINGTON AGRICULTURAL CENTER
P. O. BOX 40747
NASHVILLE, TENNESSEE 37204

September 26, 1983

Mr. L. F. Campbell, Deputy Director
Technical Services Division
Oak Ridge Operations Office
U. S. Department of Energy
P. O. Box E
Oak Ridge, Tennessee 37830

RE: Scoping Comments for the DEIS for Niagara Falls Storage Site

Dear Mr. Campbell:

The Tennessee Wildlife Resources Agency has received and reviewed the materials sent to us regarding the upcoming Niagara Falls Storage Site EIS. In the short term, at least, we would expect minimal wildlife impacts if the disposal site were located at the Oak Ridge site. However, there are very serious potential human health problems that, if by remote chance they were incurred, would also affect wildlife populations.

You will probably find from your endangered species contacts that the endangered Bald Eagle is found in the project area. Since the question of compatibility of this project with the human environment is paramount here, the immediate disturbance of wildlife habitat would be minimal, and any immediate impacts could be mitigated without great problems, we do not feel that it is appropriate for us to comment further at this time. We will monitor the comments that come from the Department of Health and Environment. Should the need arise for this Agency to comment in connection with those human health matters, we will do so. When the DEIS is distributed, we may have comments regarding the habitat disturbance associated with proposed waste burial.

Thank you for offering us this opportunity to comment.

Sincerely,

TENNESSEE WILDLIFE RESOURCES AGENCY

Dan Sherry

Dan Sherry
Wildlife & Fish Environmentalist

DS:jef

cc: Mike Webb
Bob Ripley
Bill Yambert

The State of Tennessee

AN EQUAL OPPORTUNITY EMPLOYER



TENNESSEE HISTORICAL COMMISSION
701 BROADWAY, NASHVILLE 37203
615/742 6716

September 23, 1983

Lowell Campbell
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37831

Re: DOE's Niagra Falls Storage Site
Radioactive Waste Management Project

Dear Mr. Campbell:

The above referenced project has been reviewed by our office with regard to Section 106 of the National Historic Preservation Act and related historic preservation regulations.

Historic and archaeological resources in the project area have been previously identified under a Cultural Resource Survey of the Exxon Nuclear Facility in 1975.

Enclosed is a copy of the State Historic Preservation Officer's opinion on the significance of those resources when we reviewed the proposed Nuclear Fuels Recovery and Recycling Center.

No further compliance action is needed at this time unless the project area is enlarged or project plans are changed.

Thank you for your cooperation in this matter.

Sincerely,

Herbert L. Harper

Herbert L. Harper,
Executive Director and
Deputy State Historic
Preservation Officer

HLH:jed



TENNESSEE HISTORICAL COMMISSION
701 BROADWAY NASHVILLE 37203
615/742-8718

October 6, 1977

Mr. D. A. Brodnick
Division of Environmental Impact
Studies
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Re: Historic and Archaeological Resources in the Nuclear
Fuels Recovery and Recycling Center, Roane County,
Tennessee, Impact Area

Dear Mr. Brodnick:

In response to your letter of September 13 and in accordance with our responsibilities under the National Historic Preservation Act (PL 89-665) Section 106, and the Advisory Council on Historic Preservation's procedures for the protection of historical and cultural properties (36 CFR Part 800), the State Historic Preservation Officer and his staff have reviewed the proposed project plans and the results of impact area archaeological and historical/architectural research.

Specifically, the review is based on information and opinions contained in the following documents:

Environmental Report, NFR&RC, Docket 50-564, Exxon Nuclear Co.
EN-FR033 Rev. 0

Cultural Resource Survey of the Exxon Nuclear Facility, Oak Ridge,
Tennessee; May 1975, George F. Fielder, Jr.

Project Map supplied by Exxon Nuclear on September 13, 1977

They were reviewed by myself and George Fielder, SEPO staff archaeologist. It should be noted that the original project survey was made by Mr. Fielder when he was employed as a research archaeologist at the University of Tennessee, Knoxville.

It is our opinion that none of the buildings recorded in the area meet the criteria for inclusion in the National Register of Historic Places. In addition, none of the building sites or remains warrant inclusion as historic archaeological sites due to a lack of specific historical or cultural preconditions that would be likely to produce a body of significant archaeological data.

Although none of the log buildings present are, in our opinion, eligible for the National Register, Exxon Nuclear should explore the possibilities

Mr. D. A. Brodnick
October 6, 1977
Page two

of making some of them available to civic or public agencies for use in interpretative exhibits. The Oak Ridge Children's Museum or the University of Tennessee public arboretum in Oak Ridge are two suggested contacts.

Four prehistoric period archaeological sites were investigated in the project area adjacent to the Clinch River. Three of these sites, 40RE125, 40RE139, and 40RE140, do not contain sufficient contextual information to make them eligible for inclusion in the National Register. The fourth, 40RE138, has not been tested sufficiently to allow a determination of eligibility to be made.

However, based on project information contained in the Environmental Report and other information supplied to this office by Exxon Nuclear, none of the recorded archaeological sites are located in areas that will be directly affected by construction activities that are included under the current license application. Site 40RE138 may be affected by future construction, but a determination of eligibility should be deferred until such time as a specific impact evaluation is prepared.

In summation, it is the opinion of the State Historic Preservation Officer, that there are no known historical, architectural, or archaeological properties located in the project impact area that possess the qualities required for eligibility to the National Register of Historic Places.

Thank you for your coordination with this office.

Yours for a better tomorrow,

ORIGINAL SIGNED BY

Herbert L. Harper

HLH:GFF:11



APPENDIX K. COMMENTS AND RESPONSES

K.1 INTRODUCTION

The Draft Environmental Impact Statement (DEIS), "Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site" (DOE/EIS-0109D), was issued by the U.S. Department of Energy (DOE) for public review and comment on August 17, 1984. Copies of the letters of comment received during the review period are reproduced in this Appendix K of the Final Environmental Impact Statement (FEIS). Appendix K contains comments, responses, and corrections and additions to the DEIS. A total of 42 letters were received; 22 people gave oral comments, of which 10 repeated these comments in letters. In addition, DOE has had further discussions with the U.S. Environmental Protection Agency and the state of New York. The substance of each additional comment is presented at the beginning of the response to the appropriate original written comment. Additional new comments are presented following all other responses to a particular comment letter.

Most commenters expressed preference for or against specific alternatives. Residents of New York were generally in favor of removing at least the residues to Tennessee. Residents of Tennessee and Washington were generally opposed to having any of the wastes or residues moved to their states.

Appendix K includes Topical Comments and Responses (Section K.2), Written Comments and Responses (Section K.3), Oral Comments and Responses (Section K.4), a list of references cited, and an index to topics receiving frequent comment. The topical comments have been summarized from various comments dealing with one particular area of concern, and the oral comments have been summarized from three public meetings held regarding the DEIS.

Each topical comment/response is identified by number--e.g., Topical Comment 1, Topical Response 1. Each letter or oral presentation has been assigned an identification (ID) designation as follows. The first part of the ID consists of either the first three to five letters of the surname of an individual or a three- to five-letter acronym of an organization that provided the written or oral comments. (For persons with the same surname, the first initial of the forename is included as the last initial of the ID.) The second part of the ID consists of one of the consecutive numbers assigned in each letter or oral presentation. For example, the letter received from John LaFalce, Congressman, 32nd District, has been identified by the ID designation LAFAL, and the individual comments are designated by LAFAL-1, LAFAL-2, etc. Where appropriate, a written response has been provided for each comment, and these responses are designated by the same IDs as the comments to which they refer--i.e., LAFAL-1, LAFAL-2, etc.

A list of the ID designations for all comments and responses is provided at the beginning of Sections K.3 and K.4.

K.2 TOPICAL COMMENTS AND RESPONSES

Two topics that received frequent comment are (1) other alternatives, and (2) groundwater impacts at NFSS. In this section, each of these topics has been summarized as a Topical Comment and this comment summary is followed by a Topical Response. The Topical Responses are also referred to in responses presented in Sections K.3 and K.4. The Topical Comment summaries are followed by a list of commenters who addressed the particular topic. (See tables at beginning of Section K.3 and K.4 for ID designations for commenters.)

TOPICAL COMMENT 1: OTHER ALTERNATIVES

Several commenters expressed the opinion that the near-surface methods for long-term management analyzed in detail in the EIS are not sufficient, not acceptable, or not suitable for long-term management of the NFSS contaminated materials, particularly for the residues. Others believe that some other alternatives should be given more consideration, such as (1) deep-well injection or hydrofracture grout injection, (2) storage in concrete modules or vaults, (3) an additional intruder barrier, and (4) the "French system". One reason given for these recommendations is the potential impacts to a resident intruder if controls ceased in the future. [NYDEC-8, -9; NYDH-1, -2, -5, -9; RAUCH-6; USEPA-4, -20, -28; WDEC-5; WEFS-4]

TOPICAL RESPONSE 1: OTHER ALTERNATIVES

The NFSS wastes and residues are both in the same category of "wastes contaminated with naturally occurring radionuclides" under Section IV of DOE Order 5820.2. For management of these materials, DOE

is using the EPA uranium mill tailings regulations (40 CFR 192) as guidance (see introduction to Section 4). It is explicitly stated in the preamble to these regulations that "institutional oversight is an essential backup to passive controls," that "it would not be safe to build habitable structures on the disposal sites," and that "Federal ownership of the site is assumed to preclude such inappropriate uses" (U.S. Environ. Prot. Agency 1983). DOE has explicitly stated in the introduction to Section 2 (p. 2-1) that it intends to take perpetual care of whatever site is used for long-term management of the NFSS wastes and residues.

If controls are effective, the resident-intruder scenario will not occur. Even if controls cease, the intrusion barrier (riprap layer) incorporated into the long-term cap of preferred Alternative 2 will deter the intruder and make the resident-intruder scenario unlikely to occur. However, to assess potential environmental impacts so that the DOE decision-maker has full knowledge of the potential consequences of the long-term management decision, the analysis in the EIS includes the potential impacts that could occur if maintenance, monitoring, and controls were to cease after 200 years. The resident-intruder scenario for the NFSS alternatives is based on several conservative assumptions, including: (1) both the 3-m (10 ft) earthen cap (which includes a 0.9-m [3-ft] riprap intrusion barrier) and the approximately 3-m (10-ft) layer of wastes overlying the residues are either completely eroded or have been removed, and (2) the intruder's house is constructed exactly over the residues. It is unlikely that an intruder would build a house on the exact spot on the mound of wastes/residues where the residues are buried. The results of the analysis indicate that a resident intruder would receive a very high radiation dose because the residues have an average radium-226 concentration of 67,000 pCi/g (they would need to be packaged and shielded for shipment to another site).

Because of the very high doses that are predicted and because many of the other potential long-term impacts are associated with the presence of the residues, DOE also identified possible modifications to the near-surface containment designs as well as optional design concepts (Section C.3)--some of which would reduce the likelihood of the resident-intruder scenario or reduce the impact to such an intruder (Tables C.3 and C.4). These other alternatives (options) are compared in terms of four key long-term factors (radon emissions, leaching to groundwater, erosion rates, and detrimental effects on a resident-intruder) relative to the conceptual designs for near-surface management analyzed in detail in the main body of the EIS. As noted in Section C.3.4, other factors--e.g., short-term impacts; costs; and the need for detailed subsurface investigations, laboratory testing, and engineering analyses--would also have to be considered if optional design concepts were to be considered further.

Following is a discussion of the four major alternatives that commenters mentioned as possibilities for further consideration: (1) deep well injection or hydrofracture/grout injection, (2) storage in concrete bunkers or vaults, (3) an additional intruder barrier, and (4) the "French system".

Deep Well Injection or Hydrofracture/Grout Injection

The U.S. Environmental Protection Agency suggested that DOE consider deep-well injection. However, deep-well injection is not technically feasible for the solid NFSS residues. Furthermore, no new permits for deep well injection of any hazardous materials are being granted by the state of New York.

A method called hydrofracture/grout injection has been suggested by the New York Department of Health. This option would entail drilling holes and forcing water under high pressure down into a shale rock or other low-permeability formation to create fractures. The residues would be mixed with cement and other additives to form a grout and then injected under pressure down the drill holes and into the fractures that have been created in the shale. The grout would then solidify in the rock formation.

This option was identified for the Oak Ridge Reservation (Table C.4) because there has been such a disposal operation for intermediate-level radioactive wastes at the DOE Oak Ridge Reservation (Nat'l. Res. Council. 1985). The hydrofracture/grout injection operations at Oak Ridge ceased after the state of Tennessee promulgated its new underground injection control regulations that require DOE to obtain a permit for DOE operations. DOE has decided not to apply for a permit to resume operations at this time. The National Research Council (1985) report concluded that disposal of certain types of radioactive wastes via the hydrofracture/grout injection method can be acceptable. However, the report also notes that an extensive research program would be necessary to support any future hydrofracture operations at Oak Ridge or other sites.

Hydrofracture/grout injection is not considered to be a viable option for the Niagara Falls area. This alternative was rejected for disposal of the high-level wastes at the nearby West Valley, New York, site because it has several serious shortcomings: "there are prospects for future drilling in the West Valley area for natural gas, and extensive drilling in the area near the shale beds could lead to eventual leakage of radioactivity from the shale beds; some question remains about the type of fractures that would be produced in the shale at West Valley (possibly extending beyond the impermeable shale into other types of water-bearing rocks); and if the disposal technique were judged to be inadequate for West Valley wastes at some future date, the wastes would be in an irretrievable form that would not allow corrective measures to be taken" (U.S. Dep. Energy 1982c). An extensive drilling

characterization and feasibility study would have to be undertaken to determine if the Niagara Falls area is suitable for hydrofracture/grout injection of the NFSS residues.

In addition, hydrofracture has several major disadvantages at whatever site such operations might take place, including: (1) the residues would be in an irretrievable form, and corrective actions could not reasonably be taken if unacceptable groundwater impacts were detected in the future, (2) there is some question about the type and extent of fractures that would be produced--possibly leading to injection of the residue grout beyond the intended formation or providing pathways for radionuclide migration into water-bearing rocks, and (3) future drilling (for hydrocarbons, water, etc.) could lead to leakage of radioactivity from the shale bed.

Storage in Concrete Bunkers or Vaults

Storage in above-grade concrete bunkers or vaults was not specifically analyzed in the EIS. Such storage would offer the following advantages: (1) the vaults would be more visible in the sense that they would look like buildings rather than mounds of dirt, thus possibly serving as a short-term reminder that the contaminated materials were "stored" or "managed" rather than disposed, and (2) they might afford a better opportunity to collect and monitor any leachate and might be easier to repair, if necessary. However, vaults could offer the following disadvantages: (1) they would not provide "passive" containment and would be more costly to construct and maintain, (2) airborne radioactive gaseous releases (radon) might be higher (unless a thick earthen cover was placed over the vaults or unless they were deeply buried--thus negating the possible advantages of visibility and leachate collection and increasing costs even more), (3) in the long-term, greater visibility could be a disadvantage because the likelihood of human intrusion might be increased if the vaults were above-grade and not covered with dirt (if they were below-grade and/or covered with dirt, intrusion might be delayed more), (4) because concrete is not expected to be any more durable over thousands of years than multilayered engineered earthen covers, the vaults would probably offer no significantly greater long-term containment relative to contamination of groundwater, and (5) if controls were lost and the vaults did not have an earthen cover, loss of containment due to physical forces (such as weathering) or human intrusion might occur sooner.

The preferred Alternative 2 is essentially a variation of a concrete vault/tumulus system. The residues (which account for 99% of the radioactivity) are buried in the basement of a reinforced-concrete building beneath a mound of wastes and a thick earthen cap. DOE is also considering an additional intruder barrier (e.g., a reinforced-concrete slab over the building--see later discussion).

Additional Intruder Barrier

As a result of further discussion with EPA and New York officials, DOE has given further consideration to an additional intruder barrier over the residues (in addition to the riprap layer in the cap). The engineering aspects and costs of several options have been investigated (Bechtel Natl. 1985). It is assumed that such a barrier would be constructed at the time of installation of the final cap. This would allow time for further consolidation of the residues that were transferred to Building 411 during 1984-1985 and are currently being dewatered. The interim placement of about 10 m (30 ft) of slightly contaminated wastes plus the interim cap over the residues will provide surcharge that will cause some settling of the residues. Prior to such settling, major extra costs would be required to construct an additional intruder barrier over Building 411 that could carry the unsupported weight of the overlying wastes and cap.

In order to install the additional barrier, the cap and wastes overlying Building 411 would have to be excavated and stored. A barrier could be constructed of reinforced concrete, asphalt, cement-stabilized sand, cement-stabilized fly ash, or stone. Reinforced concrete would provide the only practical means to tie the barrier into the building walls and would provide the most positive means of deterring an inadvertent intruder. Construction of such a barrier is estimated to cost an additional \$1.3 million (Bechtel Natl. 1985).

Radon emissions at the top of Building 411 are estimated using the same methodology and parameter values given in Section 4.1.2.2. These emissions are estimated to be at background levels, with or without a concrete barrier, primarily because of the intervening layer of approximately 4 m (12 ft) of damp wastes (mostly native clayey soils) and clay on top of the residues. This layer retards the radon emitted from the residues long enough for the radon to decay to solid decay products.

The "French System"

It was suggested by EPA that DOE consider the "French system". For contaminated materials similar to the NFSS wastes and residues (i.e., uranium mill tailings), the French use a management system that is similar to that recommended by the EPA for uranium mill tailings in the United States--specifically, containing the wastes in a large pile at their current locations (Pradel 1982). This is the alternative that DOE prefers for the NFSS wastes and residues (Alternative 2). For low-level wastes, the French use a tumulus system wherein the most hazardous wastes are placed in a solid form at the bottom of the containment system (Van Kote 1982). This is similar to NFSS Alternative 2b wherein the more hazardous residues would be solidified and replaced at the bottom of the containment system. DOE has not decided

whether or not the residues should be solidified. If DOE decides to implement Alternative 2, a later decision will be made at the time of implementation regarding whether or not the residues should be solidified. (See Figure 1.3 for details of the DOE decision-making process.)

Conclusions Regarding Other Alternatives

DOE will consider an additional intruder barrier over the residues. DOE has concluded, for the reasons discussed above, that the other suggested alternatives are not reasonable and do not warrant further detailed consideration at this time.

TOPICAL COMMENT 2. GROUNDWATER IMPACTS AT NFSS

Several comments were made concerning potential groundwater contamination at NFSS if the wastes and residues remain at NFSS. Commenters raised questions about the clay in the caps, the cutoff wall, and the gray clay layer beneath the containment area. Other commenters wanted more information regarding the geologic conditions at NFSS, the computer model used for the analysis, and the predicted groundwater contamination at the site boundary. [NYDEC-15, -17, -24, -25; USDOL-1, -6, -10; USEPA-21, -22, -23, -24, -25, -26, -27]

TOPICAL RESPONSE 2. GROUNDWATER IMPACTS AT NFSS

The layer of clay in the existing interim cap (Alternative 1, no action) and the additional clay in the preferred long-term cap (Alternatives 2a and 2b) are expected to reduce (but not eliminate) water infiltration into the buried wastes and residues (Section 4.2.2) and radon gas emissions from the buried materials (Section 4.1.2). The existing clayey soils beneath the containment area are expected to retard (but not eliminate) migration of radionuclides and other chemicals from the wastes and residues (Sections 4.2.2 and 4.3). Because the clay layers (including the so-called "gray clay layer") are known to contain sand lenses, the average hydraulic properties of the underlying clayey materials are assumed to be between the properties of clay and sand in this EIS (Table 4.39). Furthermore, it is conservatively assumed that over the long term, the average properties of the cutoff wall are the same as for the surrounding soils--i.e., that the cutoff wall offers no significant additional long-term barrier. The reasons for these assumptions are given in Section 4.2.2.

The clays are not chemically inert. They differentially adsorb the various chemicals and radionuclides. Hence, different distribution coefficients--the ratio of the concentration of a constituent adsorbed onto soil particles to the concentration of the dissolved constituent in water (or a measure of how tightly a substance is bound to the clay particles)--are used in the analysis (Table 4.48). Furthermore, for radium-226, the radionuclide of most concern with respect to groundwater contamination, the distribution coefficient used for the analysis is at least ten times less than laboratory tests have indicated for the soils at NFSS (footnote in Section 4.2.2.3)--thus leading to prediction of faster migration than may actually occur.

At NFSS, the near-surface soils are known to be seasonally saturated. Therefore, in the analysis, it is conservatively assumed that the wastes and residues are saturated and are sitting immediately on top of saturated soils throughout the year (assumed zero depth to groundwater for the hydrological modeling--Table 4.48). The analysis further assumes that the groundwater moves horizontally to a theoretical onsite well located immediately next to the contaminated materials.

Groundwater is used very little in the NFSS area, and most of the groundwater that is used is obtained from a geologic formation located south of the Niagara escarpment but not north of the escarpment where NFSS is located (Section 3.1.1). However, individuals are occasionally able to find sand lenses in the near-surface unconsolidated glacial deposits (in the clayey soils) that yield enough water to supply the needs of about one family. Sand lenses are known to occur in the containment area at NFSS. Because it cannot be ascertained whether or not there are large sand lenses next to the containment area without digging up the entire site, it is assumed for the EIS analysis that a large sand lens is located immediately adjacent to the containment area and that leachate from the NFSS wastes and residues will migrate into such a sand lens. It is furthermore assumed that a well will be drilled into this lens, that it will yield sufficient water, and that groundwater from this well will be used for drinking water in the future if controls cease.

The analysis indicates that the concentrations of radium-226 (Table 4.42) and some other chemicals (Tables 4.49 and 4.50) at the theoretical onsite well could exceed the current regulatory standards in the future (see Table 4.49 and text in Sections 4.2.2.3 and 4.4.3.1). Therefore, if the wastes and residues are to remain at NFSS, it will be necessary to prohibit the use of water from shallow wells on the NFSS site. If the large sand lens does not exist, if no one accidentally locates a well and uses the water from such a lens, or if the perpetual controls that DOE intends to exert continue, then there will be no impact on humans from drinking contaminated groundwater. If the average properties of the soils, wastes, and residues are better than those assumed in the analysis (e.g., lower hydraulic conductivity and higher diffusion coefficient), then the migration of contaminants will be slower.

As a result of comments on the Draft EIS, further analyses have been performed for preferred Alternative 2 at NFSS (Section 4.2.2.3). Using the same values for the input parameters as given in

the Draft EIS (e.g., distribution coefficient for radium of $100 \text{ cm}^3/\text{g}$ and average soil permeability of 10^{-5} cm/s), it is predicted that no offsite contamination will occur at a theoretical well located at the site boundary northwest of the containment area within the 1000-year design life of the containment system.

When less conservative values are used for the most sensitive parameters (i.e., distribution coefficient for radium of $500 \text{ cm}^3/\text{g}$ and average soil permeability of 10^{-7} cm/s), it is predicted that there will again be no offsite contamination for the 1000-year design life of the containment system and peak concentrations in the theoretical onsite well will decrease by a factor of about 5.

All available information on the geologic and hydrologic conditions at NFSS is summarized in Section 3.1. As required by CEQ regulations, only the details necessary to support the analysis are given and the rest of the information is incorporated by reference. Copies of the major references have been made available to the EPA, state of New York, DOE public reading rooms, and local libraries. Where there is uncertainty about the geologic and hydrologic conditions, conservative--but realistic--assumptions are made in the analyses, as described above.

Details regarding the computerized groundwater model are also given in reports that are incorporated by reference. As noted in Section 4.2.2.1, the two most sensitive parameters are distribution coefficient and hydraulic conductivity. Discussion of why the use of more sophisticated groundwater models is unwarranted and would not result in more accurate prediction of impacts is given in Section 4.2.2.1. DOE will conduct more groundwater modeling in conjunction with the development of detailed engineering designs for whatever alternative is selected. The results of this modeling will be incorporated or referenced in an engineering report on the detailed waste containment design for the alternative that DOE decides to implement (see Figure 1.3).

In this EIS, a three-dimensional transport model is used to project contaminant concentrations at specific locations in the aquifer (i.e., onsite well, nearest major surface water body, halfway between the two, and NFSS site boundary--Section 4.2.2). The results indicate that for the assumed modeling conditions, maximum contaminant concentrations would occur in a well located next to the waste/residue containment area. For Alternative 2a (modified containment at NFSS), radium-226 concentrations in the theoretical onsite well are expected to peak in 3,600 years. At the site boundary, no contamination is expected within the 1000-year design life of the containment system. At a point halfway to Lake Ontario (4,000 m), no contamination is expected for at least 32,000 years (the point at which the computer program was aborted).

K.3 WRITTEN COMMENTS AND RESPONSES

In this section, copies of the letters of comment received during the review period are reproduced in full. The letters have been arranged alphabetically under each state. The letters and specific responses are placed side by side as much as possible so that the reader can easily locate the specific response to a given comment. The IDs for the letters of comment are listed below in the order that they appear in the document:

Letter ID		Page
<u>New York</u>		
BROSS	Irwin D. Bross, Biomedical Metatechnology, Inc., Eggertsville	K-8
BURD	Cary and Henrietta Burdick, Youngstown	K-16
DALY	John B. Daly, Senator, 61st District	K-18
DEVAN	Edward C. DeVantier, Lewiston	K-20
LAFAL	John L. LaFalce, Congressman, 32nd District	K-24
LTB	Lewiston Town Board	K-30
NYDEC	New York Department of Environmental Conservation	K-34
NYDH	New York Department of Health, Office of Public Health	K-50
NCEMC	Niagara County Environmental Management Council	K-58
NCHD	Niagara County Health Department	K-60
NCPHC	Niagara County Legislature, Public Health Committee	K-62
PILLI	Joseph T. Pillittere, Assemblyman	K-64
PORT	Town of Porter, Youngstown	K-70

Letter ID		Page
<u>New York (cont.)</u>		
RAUCH	James Rauch, Williamsville	K-72
SIMON	Lee Simonson, Niagara County Legislator	K-78
<u>Tennessee</u>		
BEND	F. Delmar Bender, Oak Ridge	K-84
COOK	W.J. Cook, Sevierville	K-88
LUCKE	Ruby G. Luckey, Mayor, City of Kingston	K-90
PERD	P.T. Perdue, Oak Ridge	K-94
ROWL	Linda (Mrs. E. Bruce) Rowland, Norris	K-98
RULEY	Helen G. Ruley, Oak Ridge	K-100
RYMAN	Cyd Ryman, Oak Ridge	K-102
SHROP	Nellie Shropshire, Morristown	K-104
SPACH	Jean Spach, Oak Ridge	K-106
TDHE	Tennessee Department of Health and Environment, Nashville	K-108
TVA	Tennessee Valley Authority, Knoxville	K-116
TWAC	Tennessee Wilderness Action Council, Oak Ridge	K-118
WARR	Helen Scott Warren, Oak Ridge	K-120
YAGER	Kenneth E. Yager, Roane County Executive	K-122
<u>Washington</u>		
WDEC	Washington Department of Ecology	K-124
WDES	Washington Department of Emergency Services	K-132
WDSHS	Washington Department of Social and Health Services	K-134
WEFS	Washington Energy Facility Site Evaluation Council	K-138
WOAHP	Washington Office of Archaeology and Historic Preservation	K-144
WSPRC	Washington State Parks and Recreation Commission	K-146
<u>Other</u>		
ENCAN	Environment Canada, Environmental Protection	K-148
ISBH	Indiana State Board of Health	K-150
ONT	Ministry of the Environment, Province of Ontario	K-152
PDER	Pennsylvania Department of Environmental Resources	K-156
USDOI	U.S. Department of the Interior	K-158
USEPA	U.S. Environmental Protection Agency	K-166
USHR	U.S. House of Representatives, Committee on Science and Technology	K-190
VCE	Virginia Council on the Environment	K-192

BIOMEDICAL METATECHNOLOGY, INC.

109 MAYNARD DR., EGGERTSVILLE, NY 14226
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August 25, 1984

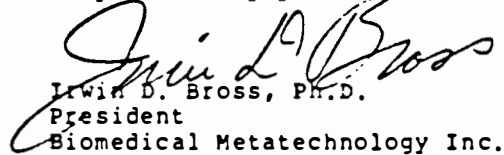
Mr. L. F. Campbell
Deputy Director, Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy
P.O. Box E
Oak Ridge TN 37830

Dear Mr. Cambell:

Enclosed is a copy of my comments on the August 1984 DEIR on the cleanup of the Niagara Falls Storage Site which I am submitting to you as per your memo of August 17, 1984.

In accordance with the attached instructions to your memo, I am requesting time at the meeting of September 19, 1984 in Lewiston, New York. I might wish to present or amplify the points in the enclosed comment.

Very sincerely yours,


Irwin D. Bross, Ph.D.
President
Biomedical Metatechnology Inc.

22480

BIOMEDICAL METATECHNOLOGY, INC.

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August 25, 1984

Mr. L. F. Campbell
Deputy Director, Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy
P.O. Box E
Oak Ridge TN 37830

Dear Mr. Cambell:

This comment on the DEIS of DOE's Niagara Falls Storage Site is in response to your memo of August 17, 1984. It reviews the health effects estimates in DOE/EIS-0109D (August 1984). It demonstrates that, when the DOE estimates are corrected for two serious errors, there are hundreds of "Potential Adverse Health Effects" in most options. This is far too many to be environmentally acceptable from a public health standpoint.

The basic issue here is "Official Science" vs. "normal science" estimates. "Official Science" is supported by DOE and other federal agencies and its estimates must be in line with the policies of these agencies irrespective of the facts. In contrast, "normal science" estimates are determined by the scientific facts, particularly by biostatistical-epidemiological studies of human populations actually exposed to low-level ionizing radiation.

Since 1955, the "Official Science" policy is that "low-level radiation is harmless". The policy was originally set by the Eisenhower Administration to protect the programs for atmospheric testing of nuclear weapons. As a direct result of this policy, hundreds of Atomic Veterans and Utah civilians suffered disabilities or deaths from the officially "harmless" fallout. DOE presented the same estimates used at Lewiston in a Utah federal court case to "prove" that the leukemia in Utah children could not have been due to the fallout. Judge Bruce Jenkins, after carefully considering the facts for more than a year, ruled that the leukemias were caused by the fallout and that the federal government was liable for damages. The negligence of DOE in failing to inform the public of the radiation risks in Utah is being repeated in the Draft Environmental Impact Statement (DEIR) under review.

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BROSS-1 { In the Yale Journal of Biology and Medicine (54, 317-328, 1981), my paper (with Deborah Driscoll) cites more than 30 studies of human populations actually exposed to low level radiation where serious health hazards were found in the data. As its title indicates ("Direct Estimates of Low-Level Radiation Risks of Lung Cancer at Two NRC-Compliant Nuclear Installations: Why Are the New Risk Estimates 20 to 200 Times the Old Official Estimates?") the DOE risk estimates must be corrected upward by a factor of 100 or more. It should be noted that these estimates by standard statistical methods of normal science, do not involve the extrapolations from animals to humans or from high doses to low doses that invalidate the Official Science estimates.

Official Science estimates of exposures are almost as bad. When NRC estimated the exposures from the clean-up at Three Mile Island Unit 2 (TMI-2), my critique of the EIS noted that Official Science habitually underestimates exposures by factors of 10 to 1000. In this instance, the original estimate of the lower limit had been reached by actual badge doses BEFORE the actual clean-up was even started. Hence NRC was forced to revise its estimates upward by a factor of 10 in a revised EIS. However this is still a gross underestimate. Conservatively, Official Science estimates of exposure need to be raised by a factor of 100 to be at all realistic.

BROSS-2 { "Total Health Effects" as estimated by Official Science have to be corrected by a factor of 100 for exposure and by another factor of 100 for health risks. This means that they must be corrected by a factor of 10000 if a realistic assessment of the environmental health effects is desired. Hence the DOE estimates of August 1984 can be corrected to be in line with normal science and the facts (rather than in line with Official Science and agency policies) by simply multiplying by 10000.

For example consider option 3b. From Table 4.31 there would be 660 "Total Health Effects" in the "General Public". From Table 4.32 there would be almost no additional health effects to the public during the maintenance and monitoring period. However from Table 4.34 there would be 1500 "Total Health Effects" to workers during the "Action Period". Thus by DOE's own estimates there would be 2160 "Total Health Effects". Since these are very serious effects such as cancers or genetic defects, this is unacceptable from a public health standpoint.

BROSS-1 The risk estimators used in the EIS are proposed by the major radiation protection organizations including the United Nations Scientific Committee on the Effects of Atomic Radiation; National Academy of Sciences, Committee on the Biological Effects of Ionizing Radiation; National Council on Radiation Protection and Measurements; and International Council on Radiological Protection. In preparing the recommended estimators, these organizations review and give thorough consideration to numerous related scientific investigations, including the work of those who propose significantly high risk estimators.

BROSS-2 The radiation exposure is estimated by computer modeling. The numerical simulation incorporates detailed site-specific information, e.g., meteorological conditions, population distribution, soil properties, work force and schedule, and characteristics of the radioactive wastes. The evaluation in this EIS is considered to be state-of-the-art and adequate as a basis for evaluation of impacts and comparison of alternatives. Some of the computer codes--UDAD or its simplified version, MILDOS (Momeni et al. 1979; Streng and Bander 1981)--have been used by the U.S. Nuclear Regulatory Commission for its generic environmental impact statement on uranium mill operations and by DOE in assessing environmental impacts of activities under DOE's Uranium Mill Tailings Remedial Action Program.

-3-

- BROSS-3 { In addition to the standard underestimation, other very serious health effects--particularly to the Canadian population--have been ignored in this DEIS. These include:
- BROSS-4 { (1) Only mutagenic effects causing mortality have been considered by Official Science. However normal science has also found a wide range of radiation-induced morbidity. Taking these other illnesses and disabilities into account might require multiplication by another factor of 10.
- BROSS-5 { (2) DOE has a long and disgraceful record of mismanagement of the difficult job of nuclear clean-ups. At the Niagara Falls Storage Site, spills will go directly into the drinking water for much of the Canadian population. The high levels of radon (and daughters) at
- BROSS-6 { this site mean that DOE mismanagement could easily produce an environmental catastrophe. Catastrophic risks have been ignored and only routine risks considered in the DEIS.
- BROSS-7 { (3) Toxic chemicals from the nearby Hyde Park dumpsite are leaking into the Niagara gorge. These toxics (and those of other leaky Niagara Falls dumpsites) are known to be mutagenic. My studies have shown striking synergistic effects when chemical and radiological mutagens are combined. This deadly synergism has been ignored by DOE in the DEIS. If it continues to be ignored in the management of the clean-up, the health effects could be disastrous in Canada.

- BROSS-3 Site-specific population distributions were used in calculating potential population doses. At NFSS, the Canadian population was included (see Sections 3.1.6 and 4.1).
- BROSS-4 Because of the characteristics of the NFSS wastes and residues, the radiation exposure to human beings is predicted to be a very small fraction of natural background radiation. With such low radiation exposures, no effects have ever been observed. For instance, the most sensitive acute effect due to radiation is blood changes. Although blood changes have been observed in individuals with gamma-ray doses as low as 14 rem, they usually do not appear until doses of 75-50 rem are experienced. By comparison, the maximum individual whole-body dose estimated for a member of the general public during long-term management of the NFSS wastes and residues is 0.001 rem (Section 4.1.2.2). As noted previously, the incremental radiation doses associated with any of the alternatives for management of the NFSS wastes and residues is a very small fraction of natural background doses.
- BROSS-5 Spills will not "go directly into the drinking water for much of the Canadian population." As discussed in Section 4.1.3, it is expected that spills of the solid wastes and residues (or the slurried residue in Alternative 2b) can be readily cleaned up. Workers involved in the cleanup are expected to receive the highest doses. Both onsite spills and transportation accidents are discussed in Sections 4.1.3.2 and 4.1.3.3. If a spill were for some reason not immediately cleaned up, the spilled material might be washed into the ditches. It is expected that the contaminated materials would not migrate very far down the ditches for several years because only about 3.2 km (2 mi) of the central ditch was contaminated after the R-10 residues were placed in an uncontrolled pile and exposed to weathering for about 30 years prior to the 1982-1985 interim remedial actions. Finally, as noted in Section 4.1.2.1, it is expected that there would have to be routine, controlled discharges in any of the alternatives involving removal of the wastes and/or residues. After the actions were completed, the sediments downstream of the site would have to be resurveyed and any contaminated sediments cleaned up. Therefore, dry releases of wastes or residues offsite, whether from spills or from routine discharges, would be cleaned up and impacts would be insignificant while the contaminants remained in the ditch that is under DOE control. (See also Responses RAUCH-9, USDO-3).
- BROSS-6 Both routine risks and accidents have been considered in the EIS (see Response BROSS-5). No catastrophic accidents are expected, nor have any specific catastrophic scenarios been identified by members of the public or other government agencies. The estimated radon releases given in the EIS are based on several conservative assumptions (Sections 4.1.2.1 and 4.1.2.2) and are expected to actually be lower than predicted. As can be seen in Section 4.1.2.1, the doses resulting from releases during the action period (when releases are expected to be highest) are insignificant compared to the doses either the general population or individuals will receive from natural background sources of radiation.
- BROSS-7 Synergistic effects (whether beneficial or harmful) of exposures to radiation and chemicals in the environment have not been studied extensively. However, there have been studies of the comparative effects of radiation and chemicals (Int. At. Energy Agency 1980; Alacevic 1980; DeSerres and Shelby 1981). Given the unknown kinds and extent of chemical mixtures in the environment, now or in the future, and the extremely low incremental radiation doses associated with the proposed actions (compared to natural background radiation), it is not reasonable to attempt any detailed analysis of potential synergistic effects associated with the various alternatives for long-term management of the NFSS wastes and residues at this time. (See also Responses USEPA-7, -31.)

-4-

In sum, this DEIS gives a completely unrealistic assessment of the actual environmental hazards of this extremely dangerous clean-up operation. DOE mismanagement can often be traced to its unrealistic view of the health hazards of low-level radiation. For instance, its failure to appreciate radiation hazards leads it to take shortcuts that endanger the health and safety of workers and the public. When the DOE estimates of health effects are corrected to make them more realistic, this DEIS shows that the options here have unacceptable public health risks.

BROSS-8

In this DEIS, DOE makes no attempt to deal with the specific and special hazards at this site or to produce a realistic environmental assessment that would protect the public health and safety. Unfortunately, if citizens reject this DEIS, DOE will simply ignore them (as it has ignored the rulings of Judge Jenkins). Since in practice there may be no way to appeal DOE decisions in U.S. courts, the only legal recourse may be for Canada to ask for an injunction from an international court. The DOE options will almost certainly result in serious contamination of international waters by radiological mutagens, a violation of treaties between the U.S. and Canada.

Very sincerely yours,



Irwin D. Bross, Ph.D.
President
Biomedical Metatechnology Inc.

BROSS-8 The specific hazards associated with the NFSS residues and wastes are analyzed in detail in Section 4 of the EIS. The major hazards are associated with direct human exposure to the contaminated materials concentrated within the containment system. Hazards associated with expected releases outside the NFSS site are expected to be insignificant and much less than the incremental radiation hazard that individuals would incur if, for example, they moved to Buffalo, New York (because of increased cosmic radiation at higher altitudes).

Suggested measures to mitigate potential impacts are identified throughout the document. Specific measures that could mitigate potential impacts to the public health and safety have been noted throughout the EIS. Those that DOE will be committed to for the specific alternative chosen will be identified in the Record of Decision.

October 2, 1984
1161 Pletcher Rd.
Youngstown, NY 14147

Mr. Lowell Campbell, Deputy Director
U.S. Department of Energy, Oak Ridge Operations
Technical Services Division
P. O. Box E
Oak Ridge, TN 37831

Dear Mr. Campbell:

BURD-1 { We found it quite difficult to digest all the material in the DOE/EIS-0109D and fully understand it. The one thing we know for sure is how it affects us--we are constantly in fear because our health and lives are at stake. Our property is also worthless and nobody in their right mind would buy a home next to a radioactive storage site. Unfortunately for us, we were not aware a problem existed at the time we purchased our home or else we would have made a different decision.

The report speaks of costs, but how can you put a dollar value on people's health and peace of mind. The government wastes money on many foolish things. Here, where we have a very critical situation the government worries about the clean up and maintenance costs. In this instance, money should not even be a factor in the decision making process.

BURD-2 { We strongly feel all the radioactive material and the residues should be moved to Oak Ridge, where the control and maintenance of that facility is equipped to handle this problem. We can't help but feel that the government has already made their decision and is just giving us this opportunity to speak because they have to follow certain steps to protect themselves legally. That's great for the government, but what recourse do people like us have? We are at the mercy of the decision-makers, who of course, do not live next door to constant threat.

Sincerely,

Cary & Henrietta Burdick

BURD-1 The concern about property values is noted. This subject is discussed in Section 4.6.2.2.

BURD-2 Recommendation for Alternative 3b is noted and is being considered. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.



JOHN B. DALY
SENATOR 81ST DISTRICT
CHAIRMAN COMMITTEE ON HOUSING
& COMMUNITY DEVELOPMENT
COMMITTEES
CHILD CARE
CONSERVATION & RECREATION
CORPORATIONS & AUTHORITIES
ENERGY
INSURANCE

THE SENATE
STATE OF NEW YORK

September 21, 1984

PLEASE RESPOND
11 ALBANY OFFICE
ROOM 413
CAPITOL BUILDING
ALBANY N.Y. 12247
(518) 455-2024
DISTRICT OFFICE
RAINBOW SECURITY CENTER
2201 PINE AVENUE
NIAGARA FALLS, NEW YORK 14301
(716) 262-7166

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
Oak Ridge Operations Office
Department of Energy
P. O. Box E
Oak Ridge, Tenn. 3783

Dear Mr. Campbell:

I would like to offer my comments on the Draft Environmental Impact Statement (DEIS) regarding the Niagara Falls Storage Site in Niagara County.

DALY-1 { Our county presently has the only two repositories in New York State for hazardous chemical waste. In addition, we must endure the existing radioactive waste stored for the past forty years at the Niagara Falls Storage Site. It seems to me that the citizens of the area bear an intolerable burden for the rest of society.

Your department can alleviate some of that burden by removing all of the radioactive material from the Lewiston site. Environmentally, I believe that this is the most appropriate measure. Over the long run, it will prove to be the most economical option.

However, considering the history of the Department of Energy activities at the storage site, I must realistically join the Lewiston Town Board to support alternate 4c of the DEIS.

I am hopeful that your department will carefully consider the impact that the storage site has had on our community. It seems appropriate at this time to heed the input from the community which has borne the brunt of a radioactive site for over forty years.

Sincerely,

John B. Daly
John B. Daly

JBD:jm

cc: Town of Lewiston Supervisor
Lewiston Councilmen

2071

DALY-1 Preference for Alternative 3a or 3b and recommendation for Alternative 4c are noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

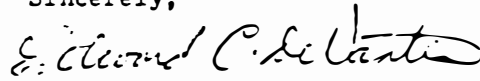
September 12, 1984
360 N. 7th Street
Lewiston, N.Y. 14092

Mr. L.F. Campbell
Dept. of Energy
Oak Ridge, TN 37830

Dear Mr. Campbell,

The attached letter was sent to the Niagara
Gazette to be used in their "Letters to the Editor". I am a board
DEVAN-1 { member of the Lewiston-Porter Board of Education, and the future
safety of our school is my main concern.

Sincerely,


Edward C. DeVantier

22054

DEVAN-1 Concern about the Lewiston-Porter School is noted. Potential radiation doses to an individual at the Lewiston-Porter school are given in Section 4.1.

An environmental impact study has been published concerning the Niagara Falls Storage Site (L.O.O.W.). Nine alternatives for the future use of this site have been suggested. Although these options can be debated at length, one major point must be kept in mind: If any radioactive wastes are allowed to remain, the L.O.O.W. will be permanently committed to radioactive waste management.

DEVAN-2 { To many, the L.O.O.W. site is an isolated and remote piece of property. In reality, within a 10 mile radius, there are over 100,000 residents. Also, 11 schools with 22,000 students lie within 7 miles of this site. More than just the Town of Lewiston will be affected.

DEVAN-3 { The report states that there are no plans to bring new wastes to the site. Although this may be the current view of the Department of Energy, it is a fact that the Oak Ridge, Tennessee dumpsite has a limited amount of room for radioactive disposal purposes. Sooner or later, the Government will need additional space.

The people of Niagara County have suffered long enough from the effects of our many dumpsites. It's about time we stopped being the dumping ground for the Nation.

Hopefully, the Department of Energy will realize our plight and see how we've suffered in the past. We should not be subjected to more condemnation of our land.

Edward C. DeVantier
Lewiston, N.Y.

DEVAN-2 Potential impacts to the local population and nearby individuals are discussed in Section 4.1.

DEVAN-3 Concerns are noted. DOE does not intend to bring new wastes to NFSS.



CONTACT: RICHARD T. LEE

FOR RELEASE: 9/19/84

COMMENTS ON DRAFT ENVIRONMENTAL IMPACT STATEMENT

BY

THE HONORABLE JOHN J. LaFALCE

AT SEPTEMBER 19, 1984 PUBLIC HEARING

IN 1978, THE NIAGARA FALLS STORAGE SITE BECAME A MATTER OF MAJOR CONCERN TO THE RESIDENTS OF THIS AREA AND MYSELF. I HAVE REPEATEDLY SOUGHT THE DECONTAMINATION AND DECOMMISSIONING OF THE SITE. THAT IS TO SAY THAT ALL RADIOACTIVE MATERIALS WOULD BE REMOVED AND THE SITE MADE SAFE FOR USE BY THE PUBLIC. DURING THE ENSUING YEARS, CONSIDERABLE EFFORT AND SIGNIFICANT FUNDS HAVE BEEN EXPENDED ON SURVEYS, DESIGN WORK AND CONTAINMENT OF THE RESIDUES AND WASTES. IN CONJUNCTION WITH THIS WORK, STUDIES HAVE BEEN CONDUCTED AND OPTIONS FORMULATED FOR THE LONG TERM MANAGEMENT OF THE SITE.

LAFAL-1

THE ALTERNATIVES RANGE FROM NO ACTION TO COMPLETE REMOVAL OF THE WASTES AND RESIDUES. WHILE VIRTUALLY ALL AREA RESIDENTS, INCLUDING MYSELF, WOULD PREFER COMPLETE REMOVAL, UPON REVIEWING THESE ALTERNATIVES (IN COLLABORATION WITH MY OVERSIGHT COMMITTEE), IT APPEARS THAT ALTERNATIVE 4C, WOULD ACCOMPLISH 99% OF OUR ORIGINAL GOAL AT A COST SIGNIFICANTLY SMALLER THAN THE COST OF TOTAL REMOVAL OF ALL WASTES AND RESIDUES. HOWEVER, THERE ARE CERTAIN ASPECTS OF ALTERNATIVE 4C THAT MUST BE ADDRESSED. CONSIDERATION MUST BE GIVEN TO MODIFICATION OF THE ALTERNATIVE FOR IT TO BE CONSIDERED AS A REASONABLE SUBSTITUTE FOR THE PREFERRED COMPLETE REMOVAL OF ALL WASTES AND RESIDUES.

LAFAL-1 Recommendation for Alternative 4c is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

-2-

LAFAL-2

I CONCUR WITH THE STATEMENT ON PAGE 4-88 OF THE DEIS WHICH SAYS THAT THE PROBABILITY OF MAINTAINING ACTIVE LAND USE CONTROLS MAY PROVE TO BE MORE DIFFICULT AT THE NIAGARA SITE THAN AT OAK RIDGE OR HANFORD. THIS LEADS TO MY CONCERN THAT THE R-10 RESIDUES WILL NOT BE PROPERLY STORED FOR THE LONG TERM. AS YOU KNOW, THESE RESIDUES HAVE BEEN INCLUDED IN THE WASTES THAT WOULD REMAIN ON THIS SITE. THE R-10 RESIDUES HAVE A MUCH HIGHER CONCENTRATION OF RADIUM AND OTHER LONGER HALF-LIFE MATERIALS THAN DO THE WASTES.

IT IS MY UNDERSTANDING THAT THE R-10 RESIDUES AS OPPOSED TO THE SOILS CONTAMINATED BY THE R-10 RESIDUES ARE LOCATED IN A STRATA OF A PARTICULAR AREA OF THE R-10 PILE. HENCE, IT IS POSSIBLE THAT THESE COULD BE SHIPPED OUT WITH THE OTHER RESIDUES. THIS WOULD RESULT IN THE REMAINING MATERIALS TRULY BEING IN THE WASTE CATEGORY AND BE COMPATIBLE WITH LONG TERM MANAGEMENT IN THE DIKED CONTAINMENT AREA.

IF, HOWEVER, IT IS NOT CONSIDERED FEASIBLE TO REMOVE THE R-10 RESIDUES FROM THE SITE, THEN I BELIEVE THAT CONSIDERATION MUST BE GIVEN TO A DEEP BURIAL BETWEEN GEOLOGICAL BARRIERS AT THE NIAGARA SITE. THIS COULD BE ACCOMPLISHED BY DIGGING A DEEP WELL WITHIN THE CLAY DIKE AREA. WE MUST REMEMBER THAT WE ARE LOOKING AT A 200 YEAR CONTAINMENT DESIGN AND A RESIDUE WITH A RADIOACTIVE HALF LIFE OF ALMOST 80,000 YEARS. WE MUST FULLY CONSIDER TAKING STEPS THAT WILL PROTECT FUTURE GENERATIONS.

LAFAL-3

FINALLY, THE PLANS FOR PERPETUAL MAINTENANCE OF THE DISPOSAL SITES MUST BE ELABORATED IN MUCH GREATER DETAIL. THE RELATIVELY SHORT HISTORY OF THIS SITE ALREADY DEMONSTRATES THAT THE PRIORITIES AND ATTENTION OF THE ATOMIC ENERGY COMMISSION AND ITS SUCCESSORS SHIFT OVER THE YEARS AND ADEQUATE PERPETUAL CARE OF SHALLOW BURIAL MOUNDS ON A SMALL ISOLATED SITE CANNOT BE GUARANTEED BY THE EXISTING GOVERNMENTAL INSTITUTIONS. THIS FURTHER REINFORCES MY CONCERN FOR CONSIDERATION OF REMOVAL OR DEEP BURIAL OF THE R-10 RESIDUES.

LAFAL-2 About 7,000 m³ of the original R-10 residues were placed on the ground north of Building 411 in 1946. Wind and rain erosion in subsequent years spread some of the R-10 residues to surrounding areas. A cleanup effort was carried out in 1972 that resulted in 11,000 m³ of contaminated soils being placed on the remaining residues. As of 1980, the R-10 pile was spread over an area of 1.6 ha (4 acres) and contained about 45,000 m³ of contaminated materials (including below-surface contamination) with an average radium-226 concentration of about 96 pCi/g and a total radium-226 inventory of 5.2 Ci (Section 3.1.7). In the EIS, the R-10 residues are considered to be part of the wastes.

The options proposed by Congressman LaFalce are: (1) shipping the R-10 residues to another site, or (2) burying the R-10 residues in a deep pit ("well") excavated within the clay diked area at NFSS. Following is a summary of the costs and benefits of these options. At this point in time, it is difficult to physically define the R-10 residues. Assuming that the volume is somewhere between 7,000 m³ (the original volume) and 45,000 m³ (the 1980 R-10 pile volume), removal of the R-10 residues could cost an additional \$2.9 to \$18 million for excavation, shipment, and reburial at Oak Ridge and \$5.8 to \$37 million for excavation, shipment and reburial at Hanford. This would result in a further reduction of the radionuclide inventory at NFSS by less than 1% (removal of the K-65, L-30/F-32, and L-50 residues would eliminate 99% of the radionuclide inventory from NFSS [see Table 1.1]). Shipment of the R-10 residues would increase transportation-related risks of injury and death by a factor of 2 to 5 over shipment of the other residues alone (shipment of 18,000-56,000 m³ vs 11,000 m³). These costs are probably underestimates because additional survey work would have to be done to locate and define the R-10 residues. Erosion and previous activities on and around the pile were such that it is probable that a distinct layer of R-10 residues could not be located. Excavation and control costs would also be higher if the R-10 residues were segregated from the rest of the wastes.

With respect to the suggested option of burying the R-10 residues in a deep pit, the costs are expected to be considerable, particularly if the pit is deep and must be lined. The benefits are insignificant. The major radiological impact of concern, release of radon gas, is expected to be insignificant if all the wastes (including the R-10 residues) are left at NFSS (Section 4.1). Deeper burial would simply reduce the already insignificant radon releases. This option poses an additional problem in that the deeply buried R-10 residues would be below the water table.

In conclusion, the two options proposed by Congressman LaFalce appear to offer little or no long-term environmental benefit but would markedly increase short-term costs and environmental impacts compared to either removal of the other residues from NFSS or containment at NFSS as described in the EIS. Management of the R-10 residues at NFSS by stabilizing them underneath a long-term cap is DOE's preferred alternative (2). This type of management is consistent with the management of uranium mill tailings under the EPA regulations (40 CFR 192) that DOE is using for guidance in the NFSS case.

LAFAL-3 The plans for perpetual monitoring and maintenance will be covered in more detail for the specific alternative chosen in the Record of Decision. (See also Responses NYDEC-5, -24; PEELE-3; USEPA-28.)

-3-

IN SUMMARY, WHILE I WOULD PREFER COMPLETE REMOVAL, I ALSO BELIEVE THAT A MODIFIED ALTERNATIVE 4-C WOULD BE AN ACCEPTABLE ALTERNATIVE TO MEET THE LONG TERM NEEDS OF OUR COMMUNITY. THIS MEANS, PREFERABLY, REMOVAL OF ALL THE RESIDUES, INCLUDING R-10, OR, IF THAT CANNOT BE DONE, REMOVAL OF ALL OTHER RESIDUES AND DEEP BURIAL OF THE R-10 RESIDUES.

The Lewiston Town Board, at a special meeting held August 27, 1984, reviewed the various alternatives available to it in the handling of radioactive residues stored at the Lake Ontario Ordnance Works (LOOW) in the Town of Lewiston.

LTB-1

Ideally, the Board would prefer Alternative 3a, which calls for complete removal of everything from the LOOW site. However, knowing that the cost of this alternative would be prohibitive, we have agreed to support Alternative 4c, which would eliminate most of the hazardous materials at a relatively low cost while securing the bulk of the remaining material safely and cost-effectively.

In its choice of Alternative 4c, the Town has the staunch support of a number of Niagara County agencies, including:

1. Niagara County Health Department
2. Niagara County Board of Health

We have also been assured of the firm backing of Niagara County Legislature.

In selecting Alternative 4c, the Lewiston Town Board also took into consideration the fact that resulting possible injuries and/or deaths are estimated at an absolute minimum.

LTB-2

The Town of Lewiston has suffered socially, economically, and health-wise by having dangerous material stored at the LOOW site. We want this threat to our citizens removed, and would urge the DOE to act immediately to clear up this life-threatening situation. It's hardly necessary to point out that decisions and actions taken now could affect Lewiston citizens a thousand years hence. Besides asking implementation of Alternative 4c, the Lewiston Town Board seeks assurance from the DOE that no other material will be brought to the LOOW site at some future date.

We would appreciate your assistance in complying with these requests -- in the interest of the health, safety and welfare of the townspeople of Lewiston.

LTB-1 Preference for Alternative 3a and support for Alternative 4c are noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

LTB-2 DOE does not intend to bring other material to NFSS.

HIGHLIGHTS OF MEETING RE DRAFT EIS FROM DOE ON LOOW SITE 8-27-84

1. VARIOUS COUNTY AND GOVERNMENTAL AGENCIES REPRESENTED. ALSO PRIVATE CITIZENS IN ATTENDANCE.
2. COUNTY SUPPORT GUARANTEED TO TOWN.
3. TOWN OFFICIALS STATE PREFERENCE FOR 3a WHICH CALLS FOR REMOVAL OF ALL MATERIAL FROM LOOW SITE. HOWEVER, DUE TO HIGH COST THEY FELT IT UNLIKELY THEIR REQUEST WOULD BE HONORED AND IT WAS BETTER TO SETTLE FOR LESS (4c) WHICH THEY FELT DOE WOULD AGREE TO.
4. DISCUSSION ON SERIOUS IMPACT STORAGE OF DANGEROUS MATERIALS HAS HAD ON TOWN -- ECONOMICALLY, HEALTH-WISE, SOCIALLY. COULD HAVE REPURCUSSIONS ON GENERATIONS TO COME.

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233-0001



Henry G. Williams
Commissioner

November 9, 1984

U.S. Department of Energy
Technical Services Division
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37830

Attention: E.L. Keller, Director

Subject: Draft Environmental Impact Statement
Long-Term Management of the Existing
Radioactive Wastes and Residues at the
Niagara Falls Storage Site
DOE/EIS-0109D, Dist. Category UC-70A

Gentlemen:

The State of New York has completed its review of the subject Draft Environmental Impact Statement (DEIS) as prepared by the Department of Energy and issued in August 1984. This Draft Environmental Impact Statement was distributed by the Department of Environmental Conservation to cognizant state agencies for review and comment. The enclosed comments comprise the coordinated reply for the State of New York.

NYDEC-1 { Alternate Number 1, the no action alternative, continues interim storage at the Niagara Falls Storage Site with a diked and capped containment area. Thus, radioactive material with a half-life of greater than 100,000 years will continue to be stored in a flood plain that will experience floods on a 200 year basis. This "Alternative" does not appear to be acceptable since it is contrary to federal criteria concerning shallow land burial within a flood plain.

NYDEC-2 { On a related issue, the DEIS fails to identify the preferred alternative. Since the Impact Statement process under NEPA is intended to open federal decisions affecting the environment to public review and since the DEIS should be written such that it is readily understandable by the general public, the preferred alternative should be identified in the DEIS and not circumvented till the final EIS is issued.

000273

NYDEC-1 In subsequent correspondence, the New York State Department of Environmental Conservation indicated that:

"In response to comments on the location of the proposed storage site, within the floodplain, and on the probability of erosion of the caps, the representatives of DOE stated that these circumstances have been recognized and will be corrected by a site maintenance program. The EIS for the subject project must contain specific wording indicating that the DOE is planning to maintain the site in perpetuity to correct the geological deficiencies of the site."

As shown in Section 3.1.1, NFSS is located on the flat and poorly drained Lake Ontario plain. Ditches were constructed in the 1940s to drain the NFSS area, and these ditches fill with water after precipitation events and snowmelt. As noted in Section 4.2.1.2, the flood level in the ditch near the containment area will depend on many factors, including the extent of the offsite drainage area that is or may be routed into the ditch and the maintenance of the culverts and ditches.

If DOE decides to manage the wastes and residues at NFSS under preferred Alternative 2, it will be necessary to reroute the central drainage ditch and to maintain the drainage system (ditches) above and below NFSS so that the containment system is not jeopardized (Section 2.1.2). Discussion of the potential impacts that will occur if the drainage system is not maintained is given in Section 4.2.1. These impacts will be taken into consideration in making the decision regarding where and how to manage the NFSS wastes and residues for the long term.

DOE is using the federal regulations for uranium mill tailings (U.S. Environ. Prot. Agency 1983) as guidance in deciding how to manage the NFSS wastes and residues. In the preamble to the EPA regulations, it is specifically stated that "diking or other flood protection control [should be] given first consideration rather than moving piles, when there is a risk from floods." The Probable Maximum Flood (PMF) event based on the Probable Maximum Precipitation (PMP) event is being determined and will be incorporated into a report on design of the interim containment system. The report will be available before the Record of Decision (see Figure 1.3). If the decision is made to implement the long-term Alternative 2, special consideration will be given to the design and relocation of the central drainage ditch as well as the design of the sides of the containment area. (See also Response USEPA-7).

NYDEC-2 The CEQ regulations state that the agency [DOE] shall "identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such preference" [40 CFR 1502.14(e)]. Now that the Draft EIS has been reviewed by federal, state, and local officials and the general public, DOE has selected Alternative 2 as the preferred alternative, and it is so identified in this Final EIS. (See also Response USEPA-1.)

NYDEC-3

A major general concern is whether or not the Department of Energy is embarking on a policy requiring that radioactive wastes, residues, etc. must remain within the boundaries of the particular state in which they are presently stored. Such a policy could impact unfairly against the smaller states. An Environmental Impact Statement pursuant to the National Environmental Policy Act is necessary before such a policy can be implemented since such a major federal action could have a significant impact on the environment.

Previous comments concerning the scoping of the subject Environmental Impact Statement were submitted to the Department of Energy by letter on March 11, 1983. Our comments were only partially addressed in the DEIS since two of the four comments submitted, numbers 2 and 4, do not appear to have been considered in the instant document.

Thank you for the opportunity to review this Statement. We request that you give our comments your utmost attention.

Sincerely,

G. A. Dancka' for

Louis M. Condra, Jr.
Director
Division of Regulatory Affairs

PN:djp
cc: Dr. Robert J. Stern

NYDEC-3 DOE has no policy requiring that radioactive wastes for which DOE is responsible must remain within the boundaries of the particular state in which they are currently stored. Removal to DOE sites in other states (e.g., Oak Ridge, Tennessee, and Hanford, Washington) are major alternatives considered in this EIS. The environmental impacts associated with removal to, and long-term management in, another state relative to the potential impacts associated with long-term management at NFSS are being considered in making the decision.

The interim remedial actions at NFSS were funded under two DOE programs: the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Surplus Facilities Management Program (SFMP). The DOE policy for FUSRAP waste disposal is outlined in a letter from Energy Secretary Hodel (1983) to Governor Evans (excerpt follows).

"FUSRAP waste does not typically qualify as low-level radioactive waste under the definition contained in the Nuclear Waste Policy Act of 1982. Rather, FUSRAP waste generally qualifies as byproduct material as defined in Section 11(e)(2) of the Atomic Energy Act of 1954, as amended. To the extent that certain FUSRAP waste may qualify as low-level waste, it is the policy of the Department of Energy (DOE) that its disposal remains the responsibility of the Department.

The Department normally will dispose of such wastes by stabilization in place, if technically and environmentally feasible, or at a DOE disposal site. However, the limited capacity of existing DOE disposal sites, the costs associated with transportation of bulky waste materials, and the resistance of individual States to receiving FUSRAP waste from another State is expected to limit the use of such disposal sites to only small quantities of FUSRAP waste material.

When neither stabilization in place nor use of an existing DOE disposal site is practical, the DOE will look to the States to select a location for establishment of a suitable DOE FUSRAP disposal site. At the discretion of the States, a regional low-level waste site could be considered for this purpose to avoid establishment of a separate, additional DOE site.

The Department is anxious to work closely with the States to develop satisfactory solutions for disposal of FUSRAP wastes."

Comment 2 from the March 11, 1983, letter is as follows:

2. The community impact of alternative 3 should consider SCA Chemical Services, Inc. as part of the community. Removal of the DOE site as a buffer between SCA and the public may reduce the desirability of SCA for continued hazardous waste disposal including future incinerator operation.

Comment 2 is addressed in Section 4.6.2 (Land Use and Property Values). As noted, surrounding land-use patterns are well established, and removal of the NFSS wastes and residues will probably not affect surrounding land use. Local zoning authorities could restrict uses of the NFSS site to those considered compatible with the existing use of the surrounding land for other waste management activities.

Comment 4 from the March 11, 1983, letter is as follows:

4. The following air issues should be addressed in the DEIS:
 - concentration/containment/mitigation of both radioactive and non-radioactive dust from the site from both remediation and storage activities;
 - concentration/containment/mitigation of radon emissions from the site from both remediation and storage activities; and
 - dispersion modeling of off-property impacts from airborne contaminants using appropriate model(s).

Comment 4 is addressed in Section 4.1 (Radiological Impacts). Radiological hazards from releases of radon and contaminated particles to the air are calculated using appropriate models for the action period, the maintenance and monitoring period, and the long-term period. Mitigative measures are also discussed. It is expected that the measures to control dust because of the potential radiological hazard will reduce dust levels to far below those normally encountered during similar construction activities. To the extent that the amount of dust is less than that assumed in this EIS, the impacts will be less than predicted.

Comments of the
State of New York
on the U.S. Department of Energy
Draft Environmental Impact Statement Related to
Long-Term Management of the Existing Radioactive
Wastes and Residues at the Niagara Falls Storage Site
(DOE/EIS-0109D) Dist. Category UC-70A, Published August 1984

November 9, 1984

1. General Comment

NYDEC-4 { The DEIS does not address what remedial work would be done at the NFSS. Should other storage alternatives be selected? The impact of such remedial work on ambient air levels should be discussed.

2. General Comment

NYDEC-5 { Engineering details of managing the materials on site should be discussed, including provisions for groundwater and air monitoring. The possibility of incorporating an impermeable plastic liner as part of the cap should be examined.

NYDEC-6 {

3. General Comment

NYDEC-7 { There should be consideration of whether uncontaminated clay suitable for cap construction can be obtained from within the existing 190 acre site. If suitable fill can be obtained on site, transportation impacts on local roads would be lessened.

4. General Comment

NYDEC-8 { Shallow land burial, and above-ground disposal are the only disposal options seriously considered in the EIS. While ocean disposal is discussed, it is not permitted at this time. The DEIS then compares costs and impacts of these disposal methods at three different sites. Since the wastes and residues are not homogeneous, 99% of the activity is concentrated in 6% of the volume. The DEIS should consider the NFSS wastes in two or three categories and examine various disposal methods for each category independently. Disposal alternatives which provide a higher degree of containment integrity, such as disposal via shale fracturing, should be considered.

5. General Comment

NYDEC-9 { The doses calculated for the resident intruder, 8,000 rem/year to the bronchial epithelium from breathing Rn-222 and up to 5 rem/year whole body equivalent from drinking contaminated water, imply that the shallow land or surface disposal burial options are not acceptable and that alternative disposal methods need to be examined.

- NYDEC-4 As noted in Section 1.1, the impacts associated with the interim remedial actions are not covered in this EIS. Potential impacts associated with the interim activities (such as release of radioactive particulates and gases to the atmosphere) were previously analyzed (U.S. Dep. Energy (1982a, 1982b, 1983a, 1983b). These potential impacts, including air quality impacts, were considered in making decisions regarding the interim remedial actions and were found to be "clearly insignificant". The EIS focuses on the decision to be made now--specifically, long-term management of the NFSS wastes and residues. The state of New York has been routinely informed of all interim remedial actions and has received copies of the above-mentioned DOE documents. (See also Summary and Responses NYDH-2, -8.)
- NYDEC-5 The details of the interim groundwater and air monitoring at NFSS (and general aspects of a program that is suggested if the preferred Alternative 2 is implemented) are being developed and will be available for the Record of Decision (Figure 1.3). The state of New York will continue to be apprised of the ongoing monitoring program and results, and will also be advised of any changes that are contemplated if DOE decides to leave the materials at NFSS. As required by the CEQ regulations [1505.2(c)], the Record of Decision will state "whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and if not, why they were not. A monitoring and enforcement program shall be adopted and summarized where applicable for any mitigation." (See also Responses LAFAL-3, NYDEC-24, PEELE-4, USEPA-28.)
- NYDEC-6 In the engineering evaluation report of alternatives (Bechtel Natl. 1984), a synthetic membrane (EPDM) on top of the wastes was considered. Such a membrane was dismissed from further consideration for several reasons: (1) it would serve as a major potential slippage plane (i.e., infiltrating water would saturate the overlying clay which would then tend to slip off the membrane), (2) it would offer no long-term (1000-year) advantage for either reducing water infiltration or radon emissions (such fabrics are guaranteed to last for only about 20 years), (3) it would offer little or no short-term advantage relative to radon emissions (the major source of radon--the residues--would be buried so deeply beneath the overlying wastes that the radon from the residues would decay to solid decay products before it had a chance to escape from the containment system (Section 4.1.2.2).
- NYDEC-7 Clay suitable for the 1-m (3-ft) clay layer in the interim cap (Alternative 1, no action) did not exist at NFSS and had to be obtained from offsite borrow areas. One borrow area was located between the site and Creek Road north of Pletcher Road, and the other was located south of Swan Road between Harold and Porter Center roads (Figure 3.2). If DOE decides to implement one of the long-term alternatives at NFSS, the additional clay for the long-term cap will also have to be obtained from offsite borrow sources.
- NYDEC-8 The NFSS wastes and residues are both in the same category of "wastes contaminated with naturally occurring radionuclides" under DOE Order 5820.2 (Section 4.7.1.1). Options for long-term management, particularly of the residues--which have higher activity than the wastes, are discussed in Appendix C, Section C.3. One optional design concept identified in Appendix C is disposal as a grout into fractured shale bedrock (hydrofracture) (Appendix C, Table C.4). (See more detailed discussion in Topical Response 1.)
- NYDEC-9 The opinion that the potential impacts to an intruder, if controls cease, warrant further consideration of alternative disposal methods is noted. DOE will consider the identified impacts to an intruder, the options that could lessen the likelihood of this particular kind of impact, all other potential impacts, costs, and other factors in making its decision. As discussed in Section 4.1.2.3 and Topical Response 1, DOE is considering an additional intruder barrier on top of Building 411. If a person were to intrude down to the top of Building 411 and no further, radon emissions at that point would be at background levels because the intervening layer of slightly contaminated wastes and clay is expected to retard the radon emanating from the residues long enough for the radon to decay to solid decay products. Thus, the impacts to such an intruder via the air pathway would be negligible.

6. General Comment

NYDEC-10 { The EIS uses an annual individual dose of 500 mrem/year as a basis for developing decontamination and decommissioning criteria. In view of the fact that criteria under consideration by EPA, NRC and DOE propose dose limits that range from 1 to 25 mrem per year, it appears that the proposed criteria are not consistent with current thinking on this issue. The use of the 500 mrem per year limit will only lead to future need for decontamination of the site (as happened previously in the case of Lake Ontario Ordnance Works excess properties).

7. General Comment

NYDEC-11 { The resident intruder scenario considers the K-65 residues as if they were blended uniformly into the entire volume of contaminated materials. Intrusion into the K-65 residues results in much higher doses to the intruder.

8. General Comment

NYDEC-12 { The DEIS makes reference to the New York's Radioactive Materials Transportation Act". While such legislation was proposed, it has not been enacted.

9. General Comment

NYDEC-13 { The K-65 residues should not be subject to several handlings, but packaged and transported elsewhere for disposal. The recent attempts to transfer these residues from the tower by water mining methods and slurry transfer indicate that this will be harder than originally envisioned. Use of the same techniques to later remove these residues from the mound structure will also be as difficult and further complicated by problems in managing the water flows created within the mound itself. Since the transfer will probably not be completed before winter, DOE should consider packaging and shipping the remaining residues in the tower to a DOE disposal site rather than transfer to the mound.

10. General Comments

NYDEC-14 { The DEIS contains many indications that the Niagara Falls site possesses characteristics that will adversely effect any long-term storage of radioactive wastes.

- NYDEC-10 The criteria for residual contamination and waste control (Appendix H) is a separate DOE decision and applies to many DOE sites, of which NFSS is only one. As noted in Appendix G (p. G-3), development of the various DOE orders is not part of the currently proposed action and is therefore beyond the scope of this EIS. The guidelines shown in Appendix H are included, as required by CEQ regulations, because they are applicable to all the alternatives that are being considered for long-term management of the NFSS wastes and residues. The residual contamination guidelines that would be applied if the wastes and residues were to be removed from NFSS are identical to the soil concentrations in the EPA regulations for residual contamination at mill tailings sites. (See also Responses NYDEC-26; USEPA-35, -36.)
- NYDEC-11 The resident-intruder scenario for the NFSS alternatives (1, 2a, and 2b) assumes that the house is constructed in the "hot spot" area where the residues are buried. For the resident-intruder scenario at NFSS, the average concentration of the residues provides a sufficiently conservative analysis (Table 4.24). It is not assumed that the residues are blended with the entire volume of contaminated materials or with each other. Most of the residues, including the K-65 residues, will be contained within the Building 411 foundation--which occupies only about 3,400 m² or 10% of the waste/residue area at NFSS (Table 4.16). The analysis is conservative because it assumes that the 1-m (3-ft) layer of rock riprap is breached. It is also unlikely that a resident-intruder would choose to build a house on the exact spot on the mound of wastes/residues where the residues are buried. It is even more unlikely that the intruder would choose the smaller spot where the K-65 residues are located. In the extremely unlikely event that a house were constructed on only the K-65 residues, the doses would be about four times larger than the doses given in Table 4.24. The resident-intruder scenario incorporates many conservative assumptions and leads to the conclusion that the impact to a resident-intruder would be significant. Thus, the need to maintain perpetual control of the site is very important and will be considered in making the decision on long-term management of the residues. An additional intruder barrier over the residues is also being considered. (See Topical Response 1.)
- NYDEC-12 The EIS has been corrected by addition of the word "proposed".
- NYDEC-13 Removal of the K-65 residues from the tower (Building 434) to the Building 411 foundation is complete. There are two basic methods by which these residues could be retrieved from Building 411 and packaged for transport to another site: conventional mechanical means and removal as a slurry (Appendix C, Section C.1.2). The advantages and disadvantages of these two methods are compared in Table C.1. Movement of the residues by conventional mechanical methods (not slurry) was the option selected for analysis in the EIS for alternatives involving removal of the residues to other sites.
- NYDEC-14 The characteristics of each of the sites considered for long-term management of the NFSS wastes and residues--as well as all potential impacts (short-term and long-term), costs, and other factors--will be taken into consideration in reaching a decision.

11. General Comment

NYDEC-15 { It is stated in many places in the DEIS that clay is the material that will contain the wastes. Are these wastes chemically inert with respect to clays?

NYDEC-16 { Mitigating measures for flood plain elevations and surface erosion should be described in the final EIS to address our concerns for this proposed action if the NFSS is adopted as the preferred permanent storage site.

12. Section 1.2

NYDEC-17 { It is stated that the clay layer under the 8.5 acre containment area is not known to be continuous. For use as a long-term storage facility that would indicate that it cannot be considered to act as a containment area.

13. Section 3.1

NYDEC-18 { The description of the Niagara Falls site states that the average elevation of the site is approximately 98 meters. It is also stated in this report that the 100-year flood plain is at 97 meters. This indicates a knowledge that the site will flood during the longer period flood events (i.e. the 500 and 1000 - year floods) as these flood plains are always at a greater elevation. In an area where 90% of the population depends on surface water, a flood will distribute the wastes to the public water supply.

14. Section 4.1.1.3

NYDEC-19 { The dose assessments are performed for only 1000 years as indicated in section 4.1.1.3. Due to the long half-lives of the radionuclides involved, the risk of harm from the residues will continue essentially unabated for more than 100,000 years.

15. Figure 4.2

NYDEC-20 { This graph illustrates that it will be at least 150,000 years before the radioactivity of the wastes and residues decay to background levels. In contrast with this decay period is the 200 year period of proposed institutional control. This period is much too short for waste of this type, particularly when disposed of on the surface at a location which was glaciated only 12,000 years ago.

- NYDEC-15 It is not stated that clay will contain the wastes. There is a layer of clay in the existing interim cap (Alternative 1, no action), and additional clay will be added if Alternative 2 is implemented. This layer is expected to substantially reduce (but not eliminate) water infiltration down into the buried wastes and residues (Section 4.2.2) and radon gas emissions (Section 4.1.2). The existing clayey soils beneath the containment area are expected to retard (but not eliminate) migration of radionuclides and other chemicals from the wastes and residues (Sections 4.2.2 and 4.3). Clays are not chemically inert, and they differentially adsorb the various chemicals and radionuclides. Hence, different distribution coefficients are used in the analyses (Section 4.2.2.3 and Table 4.48). (See more detailed discussion in Topical Response 2.)
- NYDEC-16 See Response NYDEC-1 for discussion of floodplain at NFSS. Mitigative measures for erosion are discussed in Section 4.2.1.
- NYDEC-17 Because the clay layer cannot readily be proven to be continuous, the EIS analysis of potential groundwater impacts at NFSS included two major conservative assumptions: (1) the average hydraulic properties of the underlying clayey material are between the properties of clay and sand (e.g., hydraulic conductivity is assumed to be 0.000011 cm/s), and (2) a large sand lens, capable of supplying sufficient flow to a well, is located immediately adjacent to the containment area (Section 4.2.2.3). As a result of further discussions with EPA, additional analyses were performed for the preferred Alternative 2 (Section 4.2.2.3). No offsite contamination is expected within 1000 years. (See also Topical Response 2.)
- NYDEC-18 See Responses NYDEC-1, USDO1-3, and USEPA-7.
- NYDEC-19 The EIS notes that the radionuclide concentrations will continue essentially undiminished for 100,000 years (Figure 4.2). The reasons for selecting the 1000-year time frame for analysis are consistent with EPA regulations and are given in the introduction to Section 4. (See also Responses NYDEC-20, -22; USDO1-2; USEPA-8; WDSHS-2.)
- NYDEC-20 The 200-year control period is used for purposes of analysis only. Because of the impacts that could occur if controls are lost, the federal government plans to take perpetual care of the NFSS wastes and residues (see footnote on p. 2-1). (See also Responses NYDEC-19, -22; USDO1-2; USEPA-8; WDSHS-2.)

16. Section 4.2.1.1 Erosion

NYDEC-21 { The evaluation of the long term effect of erosion at the Niagara Falls site is based on predictions calculated by the Universal Soil Loss Equation. This equation does not account for discrete events but only addresses average erosion rates that may be expected assuming predictable land uses. Long-term uniform erosion has never proven to be the major problem with cap integrity. The formation of cracks and gulleys, which the USLE does not address, would probably breach the cap before it is eroded.

17. Section 4.2.1.2 Flooding

NYDEC-22 { Again referring to the comment on Section 3.1 concerning the proximity to the long-period flood plain elevations, the report says "severe events occurring within the 1000-year period of analysis are likely to stress the integrity of the containment systems." If this is already known, why has this site been submitted for consideration? Clearly, the lack of long-term integrity of the containment system should be a disqualifying criteria in siting if it cannot be mitigated.

18. Section 4.2.1.3 Severe Erosion Events and Droughts

NYDEC-23 { It is stated in paragraph two "Unchecked, gully erosion will seriously jeopardize the integrity of the waste/residue pile." After the very short, 200 year duration of institutional control as compared to the waste's radioactive decay period, the wastes will be introduced to the environment by this process. Reanalysis is required.

19. Section 4.2.1.5 Seismic Activity

NYDEC-24 { It is stated "Damage to the subsurface clay cutoff wall at NFSS may not be noticed unless monitoring wells are fortuitously located...". A rigorous and thorough monitoring program is usually planned and included as a part of the environmental assessment to eliminate the need for reliance on fortune.

- NYDEC-21 The evaluation of long-term effects of erosion includes calculations based on the Universal Soil Loss Equation (USLE) and consideration of several nonquantifiable factors such as flooding, gully erosion, other severe erosion events, slope and cover failure, and seismic activity (Sections 4.2.1.2 through 4.2.1.5). The formation of cracks is taken into consideration by assuming conservatively low average moisture contents for the various layers of the cap (Section 4.1.2.2). The effects of gulleys are taken into consideration by applying the worst-case results of the USLE for erosive land use to the radiological analyses in Section 4.1, the hydrological analyses in Section 4.2.2, and the chemical analyses in Section 4.3. The estimates for perpetual-care costs (Appendix F) include costs for periodic maintenance to repair gully erosion. The perpetual-care costs for the no-action alternative (1) are higher than for the preferred containment alternatives (2a, 2b) because of the expected more frequent need for repairs due to erosion of the interim cap.
- NYDEC-22 Severe events are likely to stress the integrity of any near-surface containment system at any site. These factors will be taken into consideration in developing the detailed long-term containment design. The stresses on the containment system will have adverse impact only if controls cease and the site is not maintained (Section 2.10). Thus, DOE is committing to perpetual care. As noted in the introduction to Section 4, DOE is using the EPA mill tailings regulations as guidance in making the decision on long-term management of the NFSS wastes and residues. The EPA regulations require that control measures be carried out in a manner that provides reasonable assurance that they will last, to the extent reasonably achievable, up to 1000 years and, in any case, for a minimum of 200 years. (See also Responses NYDEC-1, -19, -20; USD01-2; USEPA-8; WDSHS-2.)
- NYDEC-23 The probability of gully erosion affecting the integrity of the containment systems at all sites (Section 4.2.1) will be taken into consideration in making the decision. As noted in Section 2.10, containment will eventually be lost at all sites--relative to the duration of the hazard--if controls cease. This is also true for all sites where long-lived radioactive wastes (e.g., uranium mill tailings) and chemical wastes (e.g., the adjacent SCA site) are managed near the earth's surface. If controls do not cease, containment systems can be repaired. DOE plans to take perpetual care of the containment system and to restrict site access.
- NYDEC-24 A monitoring program will be designed to provide reasonable assurance that migration of contaminants will be detected. Such a program will be part of whatever alternative is implemented. Conservative assumptions are made for the groundwater analysis in the EIS. (See also Responses LAFAL-3, NYDEC-5 [regarding monitoring], USEPA-28, and Topical Response 2 [regarding groundwater at NFSS].)

20. Page 4-60

NYDEC-25 { On page 4-60, a statement is made that the water table at NFSS approaches the ground surface at certain seasons of the year. The impact of this intrusion by groundwater into the mound and subsequent leaching and transport off site is not adequately addressed.

21. Appendix H

NYDEC-26 { Residual soil and surface contamination limits in Appendix H are not as restrictive as those being used elsewhere in New York by DOE, such as at the NL site in Colonie, where DOE agreed to a limit for U-238 of 35 pCi/gm averaged over the first 5 cm of soil. The same basis should apply in the table on H-2, and all entries should be adjusted to reflect the risks equivalent to those agreed to by DOE for U-238.

22. Table on p. H-3

NYDEC-27 { Residual surface contamination limits proposed in the table on H-3 are higher than those allowed in 10 NYCRR 16. We feel the Part 16 levels should apply.

- NYDEC-25 In the analysis in Section 4.2.2, it is conservatively assumed that the wastes and residues are saturated and are sitting immediately on top of permanently saturated soils (assumed zero depth to groundwater in the hydrological modeling). This results in a very conservative analysis. (See more detailed discussion in Topical Response 2.)
- NYDEC-26 The interim guidelines given in Appendix H of the EIS are not part of the current decision (see Response NYDEC-10). If DOE decides to implement one of the offsite alternatives, the site-specific application of then-current guidelines to determine acceptable residual contamination levels at NFSS will be discussed with the state of New York. The guidelines noted in Appendix H have been applied to cleanup of the vicinity properties near NFSS from 1982 to the present. The New York Department of Environmental Conservation has been informed of all these cleanup activities and the guidelines that are being used. As noted in these guidelines, generic cleanup criteria--consistent with EPA mill tailings regulations--are being used for the radium concentrations at NFSS. Because no generic concentration limits are available for the uranium found at Colonie, a concentration had to be derived from the risk limits as described in the Appendix H guidelines. (See also Responses NYDEC-10; USEPA-35, -36.)
- NYDEC-27 See Responses NYDEC-10, -26; USEPA-35, -36.
- NYDEC-28 In subsequent correspondence, the New York Department of Environmental Conservation indicated that:
"The K-65 residues require a separate treatment from the remainder of the waste on the site due to high concentration of radioactive material in these residues. The EIS should include options of utilizing different disposal methods for these residues."
See Appendix C and Topical Response 2.

STATE OF NEW YORK
DEPARTMENT OF HEALTH OFFICE OF PUBLIC HEALTH

CORNING TOWER
DAVID AXELROD, M.D.
Commissioner

THE GOVERNOR NELSON A. ROCKEFELLER EMPIRE STATE PLAZA

ALBANY, N.Y. 12237
LINDA A. RANDOLPH, M.D., M.P.H.
Director
WILLIAM F. LEAVY
Executive Deputy Director

November 2, 1984

Mr. Steven Woodbury
Environmental Protection Specialist
U.S. Department of Energy
1000 Independence Avenue, S.W.
Room 36092
Washington, D.C. 20585

Dear Mr. Woodbury:

Enclosed are comments I have prepared concerning the DEIS, "Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Site." Since the NYS Department of Environmental Conservation is lead agency for the State's response to the DEIS and there are many other issues being raised concerning specific content, it is not clear what form this review may eventually take when forwarded to DOE.

The issues I raise, I believe are much more serious than those which address content of the DEIS. Because of what DOE has omitted from its regulations and its choice of alternative strategies for the DEIS, there is doubt that DOE has met its NFPA obligations.

NYDH-1

Firstly, the omission from the final version of DOE Order 5820.2 of a waste classification system (one was proposed in early drafts) raises questions of DOE's probity. Did DOE make its Order 5820.2 less restrictive than either NRC's 10CFR Part 61 or EPA's 40CFR Part 193, because it sought to avoid actions of the type which would be mandated for the residues at NFSS, especially for the K-65 residues?

Secondly, don't the inordinately high doses from the residues to the inadvertent intruder (whether at NFSS, Hanford or Oak Ridge) mandate consideration of other alternatives for long-term disposal regardless of DOE Order 5820.2?

NYDH-2

Thirdly, why was the document, "Comparative Analysis of Various Interim Handling Alternatives of K-65 Residues at the Niagara Falls Storage Site, July 1981", prepared separately from the DEIS, even though actions proposed in 1981 markedly affect the alternatives later selected? Was this merely a subterfuge to avoid incorporating the K-65 residues at NFSS with those at Fernald? Or was it a subterfuge to avoid full

NYDH-1 EPA regulations under 40 CFR 193 are not yet available (see Response NYDH-6). DOE orders are developed for general application to DOE operations and are beyond the scope of this EIS (Appendix G). DOE Order 5820.2 allows for site-specific considerations to be taken into account in deciding how to manage the radioactive wastes for which DOE is responsible. For management of wastes contaminated with naturally occurring radionuclides such as the NFSS wastes and residues, DOE is using the EPA uranium mill tailings regulations (40 CFR 192) as guidance. In the preamble to these regulations, it is explicitly stated that "institutional oversight is an essential backup to passive controls," that it "would not be safe to build habitable structures on the disposal sites," and that "Federal ownership of the site is assumed to preclude such inappropriate uses." If controls are effective, the resident-intruder scenario will not occur. However, to assess potential environmental impacts so that the DOE decision-maker has full knowledge of the potential consequences of the long-term management decision, the resident-intruder scenario was analyzed. This scenario is based on several conservative assumptions, including: (1) both the 3-m (10-ft) earthen cover (which includes a 0.9-m [3-ft] riprap intrusion barrier) and the approximately 3-m (10-ft) layer of wastes overlying the residues at NFSS are either completely eroded or have been removed, and (2) the intruder's house is constructed exactly over the residues (which is only a small part of the containment area). Because of the extremely high doses that are predicted, DOE further considered modifications to the containment designs as well as completely different design concepts--some of which might reduce the likelihood of the resident-intruder scenario or reduce the impact to such an intruder (Appendix C, Section C.3). An additional barrier over the residues is being considered (Topical Response 1). The potential resident-intruder impact--as well as all other impacts (short-term and long-term), costs, and other factors--will be taken into consideration in making the decision.

NYDH-2 The referenced document, whose scope was restricted to the interim handling of the K-65 residues, concluded that this interim action would not markedly affect or effectively preclude from further consideration the alternatives for long-term management of the K-65 residues. The state of New York has been regularly informed about the interim remedial actions, the results of environmental analyses of the interim remedial actions, and the reasons for the interim remedial actions (see Response NYDEC-10). In keeping with CEQ regulations and having already studied and performed the majority of the interim remedial actions at the site, DOE is now focusing on long-term management of the NFSS wastes and residues because this is the issue that is "ripe" for a decision at this time.

Planning and analysis to support DOE decision-making for the Fernald residues has recently begun. However, DOE does not see any reason for treating the Fernald and NFSS residues together. DOE believes that the most reasonable alternative for management of the Fernald residues and all the other contaminated materials at Fernald is independent of what is the most reasonable alternative for the NFSS residues.

Mr. S. Woodbury

-2-

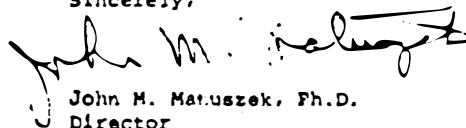
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NYDH-2 { NEPA review for the actions now in progress at NFSS?

NYDH-3 { Fourthly, our concern that DOE may seek to dilute the K-65 residues must be mentioned again. Doses to the inadvertent intruder would be even greater than those obtained in the DEIS (which even now are unacceptably great) should he encounter only the K-65 residues. But throughout the DEIS, disposal alternatives are evaluated on the basis of having all residues as a single unit. Does such an approach to dose assessment indicate that DOE plans eventually to blend the residues?

Thank you for your considerate attention to these questions.

Sincerely,



John M. Matuszek, Ph.D.
Director
Radiological Sciences Laboratory

Encl.

NYDH-3 It is not assumed in the EIS that the K-65 residues are diluted, and DOE does not intend to blend the residues. For the estimates of radon emissions, transportation impacts (e.g., the need for packaging and shielding), and doses to workers, it is specifically assumed that the K-65 residues are distinct and separate from all other residues and wastes. As discussed in Topical Response 1 and NYDEC-11, a reasonably conservative intrusion scenario was analyzed. Because of the unacceptable impact that would occur if someone intruded into the residues (or uranium mill tailings), perpetual control of such sites is a necessity. (See also Responses NYDEC-11, NYDH-1.)

REVIEW OF PROPOSED ALTERNATIVES FOR DISPOSAL OF NFSS RESIDUES

A review of recent and proposed regulatory actions shows that the U.S. Department of Energy (DOE) has not performed an adequate evaluation of alternative disposal options for all the residues at NFSS. In addition to the deficiencies found from a regulatory standpoint, DOE has failed to include as disposal alternatives for the K-65 residues at NFSS any consideration of its developing plans to decommission the DOE facilities at Fernald, Ohio where the bulk of the K-65 residues are stored. The two issues are discussed below in more detail.

Alternative Disposal Options for Residues

NYDH-4

Although new U.S. Nuclear Regulatory Commission (NRC) regulations, 10CFR Part 61, for disposal of low-level wastes generated by NRC licensees are not binding on DOE, they will be used extensively nationwide to meet the requirements of the Low-Level Waste Policy Act of 1980. Thus, all three of the recipient states considered in the DEIS are likely to evaluate DOE's disposal plans in the context of NRC's regulations.

The NRC requires that all radioactive waste other than high-level waste (which must be disposed in a deep geologic repository) be classified into one of five categories -- "non-radioactive", Classes A, B, or C, and "greater-than-Class C". Furthermore, the NRC considers inapplicable the use of dilution as a mechanism for achieving a lower classification for categorized wastes. The NRC regulations do not at this time contain reference to ²²⁶Ra, the predominant radiological hazard in the NFSS residues, but such a reference is being developed in response to numerous requests from the states.

Applying the classification system in 10CFR Part 61, the K-65 residues at NFSS would be "greater-than-Class C" waste, while the L-30 and L-50 residues would be Class C waste. As "greater-than-Class C" waste, the K-65 residues require greater-confinement disposal and to not appear to be acceptable for shallow-land burial or above-ground disposal, the only alternatives evaluated in the DEIS. Even the L-30 and L-50 residues would be improperly packaged if disposed under the alternatives proposed in the DEIS.

NYDH-5

Therefore, we believe that none of the permanent disposal alternatives considered in the DEIS adequately addresses disposal of the residues, especially the K-65 residues. Furthermore, the State considers inappropriate any interim storage methods which will dilute any of the residues to a lower classification. DOE's use in the DEIS of blended residues as a source term for dose assessment heightens our concern that DOE is planning to use dilution to reduce its obligations.

NYDH-4 In subsequent correspondence, the New York Department of Health indicated that:
"Although the waste classification system of 10 CFR 61 does not include Ra-226, advice of the USNRC for comment on that radionuclide has been sought. The USNRC has assured that the amended 10 CFR 61 will include reference to Ra-226. DOE has previously been provided the results of NRC's recommended method of classification of Ra-226 until amended 10 CFR 61 is published. It appears that DOE has chosen to ignore that earlier correspondence. ... DOE appears to have created a dichotomy when we compare this comment [USEPA Response 29] to that [DOE's draft response] for NYDH-4 In NYDH-4, DOE does not choose to use 10 CFR 61 (which does apply to byproduct material) but here decides to not use RCRA, because NFSS wastes are byproduct material. In a response to earlier comments by NYDH staff, DOE stated that 'NRC does not have the authority to regulate Radium-226'. NYDH staff is under the impression that NRC does indeed regulate byproduct material. NYDH staff does not believe that DOE can have it both ways."

DOE is using the EPA uranium mill tailings regulations (40 CFR 192) as guidance in making a decision regarding long-term management of the NFSS wastes and residues. The low-level waste regulations (10 CFR 61) do not provide guidance for management of the NFSS wastes and residues. Regulation 10 CFR 61 does not apply to byproduct material.

NYDH-5 See detailed discussion of other alternatives in Topical Response 1. DOE has not stated that it will dilute the residues and does not intend to do so.

NYDH-6 The State's position on this question appears to be bolstered by our understanding that the U.S. Environmental Protection Agency (EPA), under its broad Congressional mandate for setting applicable environmental standards, intends within the next year to promulgate standards for low-level radioactive waste disposal (40CFR Part 193). The new EPA standards are likely to apply to naturally-occurring and accelerator-produced radioactive materials (NARM) as well as to NRC-licensed low-level waste in much the same way as do both the existing and forthcoming NRC regulations.

Failure by DOE to include a comparable waste classification system in Order 5820.2 invalidates the disposal alternatives presented in the DEIS.

Origin and Disposal of K-65 Residues

NYDH-7 The K-65 residues at NFSS were not generated by Manhattan Engineering Division programs in New York. Instead, they were shipped from Mallinkrodt Chemical Company operations in St. Louis, Mo. and are only a small fraction of the total amount of K-65 residues now in storage. The bulk of the K-65 residues are now stored at DOE's Fernald, Ohio site (748 Ci of ²²⁶Ra in 3,891 tons of residues at NFSS and 1,652 Ci in 9,690 tons at Fernald). We understand that DOE intends to decommission the Fernald site in the near future.

NYDH-8 DOE chose to transfer and stabilize the K-65 residues at NFSS on the basis of an internal evaluation report rather than including those operations in the DEIS. The configuration of the K-65 residues once the interim storage operation is complete severely affects the future considerations of disposal alternatives. For example, once the K-65 residues are in Building 411, among and under the other residues and wastes, the likelihood is greatly diminished that they might be treated and disposed with their sister wastes at Fernald.

NYDH-9 Thus, the State believes that the alternatives considered in the DEIS for disposal of the K-65 residues at NFSS have been improperly selected by DOE. The fiscal costs and radiation risks of the disposal alternatives in the DEIS are critically influenced by the option selected for interim storage, yet the storage options were not made a part of the NEPA process. The fiscal costs and radiation risks of the disposal alternatives for NFSS residues will be markedly affected by the disposal method selected for the K-65 wastes at Fernald, but such a consideration may be proscribed by the form in which the K-65 residues are stored at NFSS -- again a process which violates the spirit, if not the letter, of the NEPA process.

The State requests that DOE withdraw from its plans for temporary entombment the K-65 residues at NFSS, at least until it completes its plans for the K-65 residues at Fernald.

NYDH-6 DOE is using the mill tailings regulations (40 CFR 192) as guidance in deciding how to manage the NFSS wastes and residues for the long term. The EPA's rules on low-level radioactive wastes (40 CFR 193) have not yet been proposed. When standards are promulgated, DOE will review the possible applicability to the NFSS wastes and residues. DOE Order 5820.2 is not the subject of this EIS or this decision. (See also Response NYDH-1.)

NYDH-7 The residues at both NFSS and Fernald were generated as a result of support for the national war effort. As noted in Response NYDH-2, DOE considers any future decisions about the Fernald site to be independent of the decision about the NFSS site. DOE does not yet have any definite plans or proposals for the Fernald site. (See also Response NYDH-2, -9.)

NYDH-8 In subsequent correspondence, the New York Department of Health indicated that:
 "here, and in other parts of the DOE document, reference is made to how DOE has 'routinely informed' state agencies 'about the interim remedial action'. DOE fails to note that the State has objected each time to DOE's plans for the interim remedial action, and that DOE has chosen to ignore the state's protests to interim remedial storage."

As discussed in Response NYDH-2, DOE concluded that the interim handling of the K-65 residues would not markedly affect or effectively preclude from future consideration options for the long-term management of the K-65 residues. When DOE makes a decision regarding the long-term disposition of the NFSS K-65 residues, the Record of Decision will note the factors, including consideration of the potential environmental impacts delineated in this EIS, that led to the decision. The New York Department of Health has been routinely informed about the interim remedial actions.

NYDH-9 See Responses NYDH-2 and -8 and NYDEC-13.

NYDH-10 In subsequent correspondence, the New York Department of Health indicated that:
 "A [NYDH] staff member who serves on a National Academy of Science Panel studying burial practices at Oak Ridge National Laboratory has had occasion to review the data concerning hydrofracture experiments at ORNL. He states that there is nothing in the results of those tests which would cause the degree of alarm towards hydrofracture that DOE seems to project in its comments. The advice of three geohydrologists who were panel members has been sought, but further comment can only be made after the NAS report has been submitted to DOE"

See Topical Response 1.



NIAGARA COUNTY

ENVIRONMENTAL MANAGEMENT COUNCIL
4187 LAKE AVENUE
LOCKPORT, NEW YORK 14094

September 14, 1984

Mr. Lowell Campbell, Deputy Director
 Technical Services Division
 U.S. Department of Energy
 Oak Ridge Operations
 P.O. Box E
 Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

The Niagara County Environmental Management Council has reviewed the Draft Environmental Impact Statement for the Department of Energy's Niagara Falls Storage Site and provides the following comments, which we would like to present at the Public Hearing - September 19th, 1984, 7:30 p.m. in Lewiston.

- NCEMC-1 { We support alternative 4c for the long-term management of the existing radioactive wastes and residues at the Niagara Falls Storage Site, which is in support of the Town of Lewiston's position. However, in reviewing the report we question why a combination of the alternatives cannot be utilized in attaining the management objectives. We suggest that the processing to extract valuable constituents from the wastes and residues by physical and chemical modification (Alternative 2b) be utilized in combination with Alternative 4c to reduce the amount of material to be transported off site, thus minimizing potential transportation problems.
- NCEMC-2 {
- NCEMC-3 { We have a concern that the estimates of deaths and injuries resulting from transportation and construction accidents are misleading. These figures are derived from general accident statistics for the United States, not data on radioactive materials/waste transportation and construction which should be readily available. We believe that with the implementation of a sound construction and transportation plan inclusive of extra precautions and safety measures, that the accident statistics attributed to directly working with the radioactive waste will be much lower than estimated.

Sincerely,

Bonnie W. Soley, Chairman
 Niagara County Environmental Management Council

cc: James Lombardi, Town of Lewiston Supervisor
 Richard Shanley, Niagara County Legislator, Chairman
 Ronald Perry, Niagara County Legislator
 James Sacco, Niagara County Legislator
 Lee Simonson, Niagara County Legislator
 Philo Brooks, Niagara County Legislator

mmc



BONNIE W. SOLEY
 Chairman
RONALD L. PERRY
JAMES A. SACCO
 Legislative Representatives
JOSEPH S. URSO
 Executive Director
 (716) 433-6721

- NCEMC-1 Support for Alternative 4c is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- NCEMC-2 If management at another site were preferred, the suggested processing of the residues prior to shipment could reasonably be considered. An engineering assessment of this option can be found in a report of Bechtel National (1984). The environmental impacts during the action period are expected to be similar to those for Alternative 2b. During the long-term period, impacts at the Hanford site would be reduced to the extent that solidification of the residues would result in reduced radon emissions. At the Oak Ridge site, impacts are expected to be similar to those for Alternative 4c because the overall radon emission from the containment area would not be appreciably affected, if at all. Such a combination alternative would be more costly than 4c and the "valuable constituents" might be worthless (as in Alternative 2b) if residual radioactivity precluded sale of the recovered materials (Section C.2.1.2). (See also Responses KADR-1, RAUCH-7.)
- NCEMC-3 For the alternatives involving transport of both the NFSS wastes and residues (Alternatives 3a, 3b, 4b, and 4d), it is believed that the transport injury and death rates are fairly accurate because the wastes account for 90% of the transportation and would be transported as nonradioactive material in bulk form similar to construction materials. For those alternatives involving transport of the residues only (Alternatives 4a and 4c), extra precautions taken because of the radioactive nature of the residues could possibly reduce the death and injury rates. However, data are lacking to predict what percentage reduction in deaths and injuries might occur. (See also Responses USDO1-7; VCE-1, -2; WDES-1; WEFS-5.)



NIAGARA COUNTY

HEALTH DEPARTMENT
5467 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK 14094

FRANCIS J. CLIFFORD, M.D.
Commissioner

GEORGE J. NEEDLE
Public Health Administrator
(716) 439-6123

JOHN A. KEHOE
Assistant Commissioner
(716) 284-3177

September 4, 1984

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
Oak Ridge Operations Office
Department of Energy
Post Office Box E
Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

The Niagara County Board of Health has received and discussed at length, the Draft Environmental Impact Statement; Long Term Management of the Existing Radioactive Waste and Residues at the Niagara Falls Storage Site, dated August 1984.

- NCHD-1 { Ideally, and preferably, alternative 3-a; removal of all residues and wastes with long term management at Hanford, Washington, would be carried out. The Board of Health, realizing that this is simply not economically practical, strongly urges that alternative 4-c: "off site storage of residues at Oak Ridge, Tennessee, long term management of waste at Niagara Falls Storage Site" be designated by D.O.E. as the long term management program for the radioactive residues and wastes at the Niagara Falls Storage Site.
- NCHD-2 { With our recognized vast amounts of industrial wastes, the notorious Love Canal, and the Lake Ontario Ordinance Works, now called the Niagara Falls Storage Site, we in Niagara County have had far more than our share of ecologic and environmental insults. The Board unanimously feels that designation and implementation of alternative 4-c is imperative.

Very truly yours,

Patricia M. Powell

Patricia M. Powell
Public Health Director &
Secretary, Board of Health

PMP...pal
Distribution sheet attached

NCHD-1 Preference for Alternative 3a and recommendation for Alternative 4c are noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

NCHD-2 Opinion is noted. DOE will consider it in making a decision.

NIAGARA COUNTY LEGISLATURE

FROM: PUBLIC HEALTH COMMITTEE **DATE:** SEPT. 04, 1984 **RESOLUTION #** 351-E

APPROVED AS TO FORM
NIAGARA CO. ATTORNEY

LEGISLATIVE ACTION

Approved: Ayes Noes 0

Rejected: Ayes Noes

Referred:

COMMITTEE ACTION

PH- 2.29.84

By

WHEREAS, the United States Department of Energy has released a draft Environmental Impact Statement regarding the long term management of existing wastes and residues stored at the Niagara Falls Storage Site (otherwise known as the Lake Ontario Ordinance Works) located in the Town of Lewiston, and

WHEREAS, several alternatives were presented in this statement, ranging from taking "no action" to complete removal of the wastes, and

WHEREAS, it appears that the alternative known as "4c" offers a reasonable and acceptable solution to the waste storage problem presently existing at the Niagara Falls Storage Site, since it proposes to remove the most toxic residues from the Site while safely covering and maintaining the remaining wastes at the Site, now, therefore, be it

NCPHC-1

RESOLVED, that upon considering the health and economic implications of each alternative presented in the DOE draft Environmental Impact Statement, the Niagara County Legislature formally supports the adoption of Alternative "4c", and be it further

RESOLVED, that the Niagara County Legislature state its position at the public hearing to be held on September 19, 1984, at 7:30 p.m., at the Lewiston-Porter Senior High School, and be it further

RESOLVED, that the Niagara County Legislature seek a wide and united effort in gaining approval for Alternative "4c" and respectfully urges participation at the hearing in support of Alternative "4c" by U. S. Senators Moynihan and D'Amato, Congressman LaFalce, State Senator Daly, Assemblymen Pillittere and Murphy, the Town of Porter, the Lewiston-Porter Board of Education, United States and Canadian environmental groups and all other interested parties, and be it further

RESOLVED, that copies of this resolution be sent to all of the above mentioned parties, other interested parties whom the Clerk of the Legislature feels should be advised of same, the President of the United States, the Secretary of Energy and to the Town of Lewiston, New York.


PUBLIC HEALTH COMMITTEE

LS:pan

NCPHC-1 Support for Alternative 4c is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

ASSEMBLYMAN JOSEPH T. PILLITTERE
STATEMENT GIVEN BEFORE THE DEPARTMENT OF ENERGY REGARDING
THE DRAFT ENVIRONMENTAL STATEMENT ON THE NIAGARA FALLS
STORAGE SITE.

SEPTEMBER 19, 1984

THANK YOU FOR THIS OPPORTUNITY TO SPEAK AT THIS PUBLIC HEARING REGARDING LONG-TERM MANAGEMENT OF EXISTING RADIOACTIVE WASTE STORED AT THE FORMER L.O.O.W. SITE ON BALMER ROAD IN LEWISTON.

IN ITS AUGUST 1984, DRAFT ENVIRONMENTAL IMPACT STATEMENT, THE D.O.E. PROPOSED NINE ALTERNATIVES FOR LONG-TERM MANAGEMENT OF THE SITE. THE ALTERNATIVES RANGED FROM NO ACTION, TO THE TOTAL REMOVAL OF THE RADIO-ACTIVE WASTES AND RESIDUES.

THE LEWISTON TOWN BOARD AND THE NIAGARA COUNTY LEGISLATURE AND COUNTY DEPARTMENT OF HEALTH HAVE EACH RECOMMENDED THAT ALTERNATIVE 4-C BE IMPLEMENTED.

I WOULD LIKE TO OFFER MY POSITION REGARDING THIS CHOICE.

IN PREVIOUS TESTIMONY, ON A NUMBER OF OCCASIONS BEFORE THE UNITED STATE DEPARTMENT OF ENERGY, THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, I HAVE CONSISTENTLY REPEATED MY SUPPORT FOR THE TOTAL CLEAN-UP OF THE L.O.O.W. SITE AND THE COMPLETE REMOVAL OF ALL CONTAMINATED MATERIALS.

THIS POSITION I HAVE BASED UPON THE PROXIMITY OF THE SITE TO THE LEWISTON -PORTER CENTRAL SCHOOL, RESIDENTIAL AREAS, 4,6 & 12 MILE CREEKS, THE NIAGARA RIVER AND THE GREAT LAKES WATERSHED.

IT IS CLEAR THAT THIS SITE SHOULD NEVER HAVE BEEN CHOSEN FOR THE STORAGE OF RADIO-ACTIVE MATERIALS IN THE FIRST PLACE.

HOWEVER REALIZING THE D.O.E. WILL PICK ON A COST BASIS RATHER THAN THE MOST ENVIRONMENTALLY SOUND BASIS, THE LEWISTON TOWN BOARD, AND THE NIAGARA COUNTY LEGISLATURE HAVE SOUGHT MY SUPPORT FOR ALTERNATIVE 4-C.

THIS ALTERNATIVE WOULD REMOVE 99% OF THE MOST RADIOACTIVE RESIDUES TO OAK RIDGE AND HOPEFULLY END 40 YEARS OF FEDERAL GOVERNMENT NEGLECT.

PILLI-1

IN ADDITION TO THE ABOVE MENTIONED REASONS THE FEDERAL GOVERNMENT'S 40 YEARS OF MISMANAGEMENT OF THE SITE LEAVES ME LITTLE CONFIDENCE IN ANY PROPOSALS PUT FORTH BY THE D.O.E. FOR MANAGEMENT OF THEIR FACILITY ON A LONG TERM BASIS.

IT IS OBVIOUS BY STUDYING THE EXAMPLE OF THE LOOW SITE THAT EXPEDIENCY AND ECONOMY WERE ALWAYS THE PRINCIPAL DETERMINANTS OF THE FEDERAL RADIO-ACTIVE WASTE STORAGE AND DISPOSAL PROGRAM.

AS A RESULT, OUR ENVIRONMENT HAS CONTINUED TO SUFFER.

IT IS MY EXPECTATION, THAT THE D.O.E. WILL CHOSE FROM ITS PROPOSALS ON A COST-EFFECTIVE BASIS, RATHER THAN THE MOST ENVIRONMENTAL SOUND BASIS.

PILLI-2

IN CONCLUSION, I PERSONALLY CONTINUE IN MY BELIEF THAT COMPLETE REMOVAL OF ALL RADIO-ACTIVE WASTES AND RESIDUES IS THE ONLY DESIREABLE, ENVIRONMENTALLY SOUND ALTERNATIVE, HOWEVER THE LEWISTON TOWN BOARD AND THE NIAGARA COUNTY LEGISLATURE HAVE GIVEN THEIR SUPPORT TO ALTERNATIVE 4-C.

PILLI-1 Lack of confidence is noted. DOE will take this into consideration in reaching a decision.

PILLI-2 Support for Alternatives 3a and 3b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

I MUST ACKNOWLEDGE THE LOCAL JURISDICTION OF THESE MUNICIPALITIES
IN THIS MATTER.

THANK YOU.....

TOWN of PORTER
120 LOCKPORT ST.
YOUNGSTOWN, N. Y. 14174

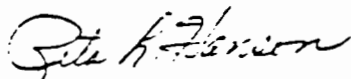
September 13, 1984

Niagara County Legislature
Courthouse
Lockport, New York 14094

Dear County Legislators:

PORT-1 { In reference to Resolution #351-84 adopted by the Niagara County Legislature
pertaining to the Lake Ontario Ordinance Works and supporting the adoption
of Alternative "4c", the Town Board of the Town of Porter has gone on record
in giving its full support to this resolution at its regular meeting held on
September 10, 1984.

Very truly yours,



PETA L. HANSON
TOWN CLERK

cc: Town of Wilson
Town of Lewiston ✓
Village of Youngstown
Village of Lewiston

Copy 9/17/84
In Bd.

PORT-1 Support for Alternative 4c is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

345 Hopkins Road
 Williamsville, N.Y. 14221

9/19/84

Mr. Lowell Campbell
 Technical Services Division
 US Dept. of Energy, Oak Ridge Operations
 PO Box E
 Oak Ridge, Tenn. 37831

Dear Deputy Director Campbell:

- These comments concern the Niagara Falls Storage Site and the usefulness of the draft document, DOE/EIS-0109D, in arriving at a scientifically valid resolution of the issues involved. It would appear that the mere issuance of a DEIS satisfies the requirements of NEPA (National Environmental Policy Act, 1969) for you people at DOE. I don't believe the document fulfills the intent of NEPA for the specific reasons outlined below. Furthermore, your self-serving dismissal of several important issues (App. G-3) as being 'beyond the scope of this EIS' is not valid. For example, your determination that the politically expedient settlement of the Afrimet leases (for 8 million dollars) is an action having a 'clearly insignificant impact on the quality of the human environment' and requiring no further NEPA compliance is ridiculous. It should be the subject of a court action by New York State (see enclosures).
- Another issue improperly ruled out is the impacts of past operations at NFSS and Oak Ridge. This issue is intimately related to the public's distrust of federal officials and lack of public participation in the DOE decision-making process (issue 10, also ruled out). From what we do know of DOE's and its predecessors past actions, they have been characterized by recklessness both in regard to worker and public protection as well as environmental protection measures. It is quite clear to me that the form of the interim remedial actions will have an effect on the long-term management options, and yet this subject is ignored. For example, as a result of the 1972 'remedial actions' it has now been determined to be 'not practicable' to separate the R-10 residues from other wastes in the north diked area. I contend that this action is a deliberate attempt on the part of DOE to downgrade the classification of 5.4×10^7 kg of residues (containing substantial amounts of radium, thorium, and 605 lbs of U-238, among others) to a classification of 'waste', thereby enabling (according to DOE guidelines) a more expedient, less secure disposal method to be used.
- Global impacts of ocean disposal is another area incorrectly dismissed. Recent findings of plutonium bio-accumulation in fish in the Pacific Ocean off San Francisco are alarming and call to question the validity of the theoretical machinations used in appendix E.
- The following are specific comments on the deficiencies of the DEIS.

- RAUCH-1 Opinion about NEPA compliance on the transfer of the Afrimet residues to federal ownership is noted. The determination to place the Afrimet residues in interim storage in Building 411 was done for the purpose of getting the residues in a more controllable configuration (rather than storage in the tower or in the open). This determination was not influenced by "ownership." As noted in Appendix G, DOE has determined that settlement of the Afrimet leases was an action that, in and of itself, will have a clearly insignificant impact on the quality of the human environment and that no further NEPA compliance is necessary.
- RAUCH-2 As stated in Section G.3, the U.S. Supreme Court has ruled that "NEPA is not directed at the effects of past accidents and does not create a remedial scheme for past federal actions" (U.S. Supreme Court 1983).
- RAUCH-3 Opinion is noted. The potential impacts associated with the interim remedial actions are discussed in reports of the U.S. Department of Energy (1982a, 1982b, 1983a, 1983b).
- RAUCH-4 Potential bioaccumulation of the radionuclides from the NFSS wastes are addressed in Sections 4.1.2.1, 4.5, and Appendix E. Based on worst-case analyses, it is concluded that the concentrations of naturally occurring radionuclides could theoretically be raised by an insignificant amount in the bodies of only a few fish. No evidence for potential global impacts is indicated.

-2-

- RAUCH-5 (1) Waste Characterization and Classification:
 The wastes and residues are inadequately characterized as to their contents. 'No information is available regarding the thorium-230 content of the residues' states page 3-11. Thorium has a half-life of 77,000 years and yet there is no description of its quantity or physical properties, such as water solubility. Page 3-11 continues 'The residues contain small amounts of other radionuclides resulting from decay of the small amount of U-235'. Just what are these small amounts? Is the one percent of the world's known supply of radium (the amount contained in NFSS wastes), the amount being considered for ocean disposal, a small amount?
- RAUCH-6 This calls to question the whole waste classification system. A law unto itself, the DOE issued order 5820 on February 6, 1984. This order states that the NFSS wastes and residues will be classified as 'wastes contaminated with naturally occurring radionuclides,' and further, that these wastes may be disposed of at existing DOE low-level waste-disposal sites. In addition, 'DOE field offices are assigned responsibility for developing project-specific or site-specific management criteria.' This is a capricious attempt by DOE to re-classify uranium and thorium tailings and wastes as low-level wastes. Low-level radioactive waste (LLRW) as defined in NRC 10CFR61 specifically excludes by-product material as defined in section 11e(2) of the Atomic Energy Act, i.e. uranium or thorium tailings and waste. The New York State LLRW Management Study, April, 1984, states that 'Uranium mill tailings, along with Formerly Utilized Site Remedial Action Program (FUSRAP) wastes are sufficiently different in hazard, regulation and volume to be excluded from the focus of this report.' The study further states that the 'State Energy Office does not believe the terminology is completely appropriate.... Some LLRW can be more radioactive than some HLW, and can be longer lived. We believe the term 'low-level' radioactive waste is misused in this context and Congress and the NRC should give serious consideration to developing new terminology which more appropriately reflects the hazards involved.' (page 7, Executive Summary) I heartily concur with this assessment. Uranium/thorium tailings, transuranics, radium, Cs-137, Sr-90 ... do not belong in a low level waste category, in any amount. Nor do they belong in a land burial site. Once again, (see letter of 3/25/84) I call upon the state officials to intercede in this matter on behalf of the residents of New York.
- RAUCH-7 (2) Groundwater impacts:
 Page 2-11 states that modification of the residues (i.e. vitrification) will not markedly reduce groundwater impacts, and yet results reported in C-7 indicate a 1000-fold decrease in radon release after vitrification. Should one assume a similar decrease in radium leaching following vitrification, could one not also assume a significant decline in groundwater contamination, especially if such masses were stored in engineered modules? Page 2-25 states that groundwater will be contaminated eventually in all alternatives, but 'prediction of how and when this will occur, and the resulting environmental impact, is beyond current predictive capabilities.' I do not think it unreasonable, with the foregoing in mind, to request an alternative to the alternatives presented in the DEIS, which would provide a substantially greater degree of isolation of the residues. I find the description, on page 4-15, of allowable radium releases during operations particularly cavalier and repugnant.
- RAUCH-8
- RAUCH-9

- RAUCH-5 For purposes of analysis (Section 4, p. 4-1), it is conservatively assumed that all radionuclides from thorium-230 through polonium-210 are present and in secular equilibrium (lead-206 is stable). This assumption accounts for the continued presence of radium-226 at undiminished concentrations for hundreds of thousands of years (Figure 4.2). During transfer of the K-65 residues (the primary source of radioactivity at NFSS) from the tower to Building 411, samples were taken. These samples were analyzed for radionuclides in the uranium-238 decay series. The results are not yet available. To the extent that the K-65 residues are depleted in thorium, the analysis of impacts in the EIS is conservatively high.
- Thorium is much less soluble than radium; therefore, the groundwater analysis focuses on the movement of radium.
- The small amounts of uranium-235 and its decay products result from the typically small amount of uranium-235 found in the ore. Anderson et al. (1981) indicate that the uranium-235 decay chain accounts for less than 1% of the total radioactivity.
- RAUCH-6 As noted in Appendix G, development of DOE Orders is not part of the currently proposed action and is therefore beyond the scope of this EIS. The NFSS wastes and residues are not placed in the low-level waste category; rather they are placed in the category of wastes contaminated with naturally occurring radionuclides (Section 4.7.1). The commenter's opinion about the unsuitability of land disposal for these types of wastes is noted. There are many sites that have the same kinds of wastes (mill tailings sites), and DOE is managing NFSS in the same manner that EPA has recommended for mill tailings sites. (See also Topical Response 1.)
- RAUCH-7 As discussed in Section C.2, there are several uncertainties about the resource recovery/residue solidification process, including radioactive content of the residue slag and lime precipitate and leachability of the slag and precipitates. As noted in the analyses (Section 4.1.2), reduction of radon emanation from the residues gains nothing in terms of radon emissions from the containment area. Reduction of leachability of the residues reduces the concentration in groundwater. A tenfold reduction was assumed for the analysis. The actual reduction could be higher if most of the radioactivity is in the slag and if the long-term behavior of the slag (over hundreds of thousands of years) is similar to other vitrified products. The actual reduction could be less if a significant portion of the radioactivity was in the precipitates and/or if the vitrified slag broke down significantly over the long term. (See also Responses KADR-1, NCEMC-2.)
- RAUCH-8 Several options involving substantially greater degrees of isolation of the residues are discussed in Section C.3.
- RAUCH-9 The discussion in Section 4.1.2.1 notes that a water treatment system, similar to the filtration/ion-exchange system currently used during the interim remedial actions, will be used at all sites during the action period to keep releases as low as reasonably achievable and within applicable regulations and standards. (See also Response BROSS-5.)

-3-

- RAUCH-10 { Dilution and release rates in pCi/L are glibly outlined, but no indication of total activities released to surface waters is given. No total volume figures are given.
- RAUCH-11 { (3) Radiological Assessment:
Throughout the DEIS, radiological effects attributable to radium and radon exposure are discussed. But no discussion is given of the public health and environmental effects attributable to the thorium and other radionuclide content of the wastes and residues. Or has DOE determined the effects of say thorium-230 ($t_{1/2}$, 77,000 years) to be negligible?
- RAUCH-12 { (3) Vitrification:
It would appear from the analysis given on C-6 that vitrification employing the electric furnace results in the most uniform, stable product at a cost of approximately 3.6 million KWH. This should be the method of choice. In-situ process would consume 20 million KWH with little guarantee of producing a stable product.
- RAUCH-13 { In conclusion, as a health professional whose sole interest in this matter is the maintenance of public health and prevention of environmental degradation, I make the following recommendations. The residues, including the R-10 pile, should be fused in an electric furnace and stored in engineered storage facility dedicated to long-term institutional control. The contaminated soils, wastes, should be packaged and stored in a similar facility or at a site such as Hanford in a manner ensuring long-term environmental isolation. No further consideration should be given to ocean dumping of the wastes or land burial of the residues.

Sincerely,



James Rauch

Enclosures

- RAUCH-10 It is expected that most of the water released will result from controlled collection of precipitation runoff water from the areas of exposed wastes and residues. The volume released during the interim remedial actions has been about 16 million L/yr (4.5 million gal/yr). Radionuclide concentrations have been well below DOE operating limits.
- RAUCH-11 See RAUCH-5. Thorium-230 is included in all calculations.
- RAUCH-12 Opinion on electric furnace vitrification is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- RAUCH-13 Recommendations on vitrification of the R-10 residues, packaging of the remaining wastes, and no further consideration of ocean disposal of the wastes or land burial of the residues are noted. No response necessary.

SEPT. 19, 1984

STATEMENT BY LEE SIMONSON
NIAGARA COUNTY LEGISLATOR AND DESIGNATED SPOKESMAN FOR
THE NIAGARA COUNTY LEGISLATURE

GOOD EVENING:

MY NAME IS LEE SIMONSON AND I'M THE COUNTY LEGISLATOR FOR THIS AREA -- I HAVE ALSO BEEN DESIGNATED BY THE NIAGARA COUNTY LEGISLATURE TO BE ITS SPOKESMAN HERE TONIGHT.

-SIMON-1 / THE NIAGARA COUNTY LEGISLATURE WHOLEHEARTEDLY SUPPORTS ALTERNATIVE 4c AS DESCRIBED IN THE DRAFT ENVIRONMENTAL IMPACT STATEMENT.

TO VERY BRIEFLY SUMMARIZE OUR OPINION, ALTERNATIVE 4c OFFERS A REASONABLE AND ACCEPTABLE SOLUTION TO THE PROBLEMS WE HAVE FACED AS A COMMUNITY IN REGARD TO THE RADIOACTIVE STORAGE SITE. WHILE 4c DOES NOT OFFER US THE IDEAL SITUATION OF HAVING THE CONTAMINATED MATERIALS COMPLETELY AND PERMANENTLY REMOVED FROM THE SITE, IT DOES PROVIDE FOR THE ELIMINATION OF THE MOST HAZARDOUS WASTES AT THE MOST REASONABLE COST TO THE FEDERAL GOVERNMENT.

REALISTICALLY, THERE MAY BE SOME IN THE FEDERAL GOVERNMENT THAT FEEL THAT ALTERNATIVE 4c IS THE MOST THAT LEWISTON AND NIAGARA COUNTY CAN HOPE FOR -- HOWEVER, FOR THE RECORD, WE DO NOT VIEW ALTERNATIVE 4c AS THE MOST WE CAN HOPE FOR -- WE VIEW IT AS THE LEAST WE EXPECT. ANY ALTERNATIVE THAT PROVIDES NIAGARA COUNTY WITH LESS IS TOTALLY UNACCEPTABLE.

SIMPLY, WE ARE NOT HERE THIS EVENING ASKING THE FEDERAL GOVERNMENT FOR THE MOON, THE SUN AND THE STARS. WE HAVE TRIED TO PUT OURSELVES IN SHOES OF THE FEDERAL GOVERNMENT AND HAVE TRIED TO BE REALISTIC IN OUR ENDORSEMENT OF 4c.

SIMON-1 Support of Alternative 4c is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

-2-

SIMON-1

THIS COMMUNITY WOULD LIKE TO SEE ALL THE RADIOACTIVE MATERIALS REMOVED -- POSSIBLY THERE ARE THOSE IN THE FEDERAL GOVERNMENT THAT WANT ALL THE RADIOACTIVE MATERIALS TO STAY. IN EFFECT, WE SEE 4c AS AN ACCEPTABLE COMPROMISE.

WE HAVE COMPROMISED OUR POSITIONS IN AN EFFORT TO EXPEDITE THE DISPOSITION OF THESE HAZARDOUS WASTES. FRANKLY, WE ARE NOT IN THE MOOD TO DRAG THIS ISSUE OUT -- WE HAVE NO DESIRE TO HAGGLE IN THE COURTS -- WE HAVE NO INTEREST IN MOUNTING A PUBLIC CAMPAIGN TO PUT PRESSURE ON THE FEDERAL GOVERNMENT TO ACCEPT AN ALTERNATIVE THAT IT SIMPLY DOES NOT WANT TO ACCEPT. RATHER, THE COUNTY LEGISLATURE WOULD LIKE TO SEE THIS ISSUE BEHIND ALL OF US AND WE BELIEVE ALTERNATIVE 4c IS THE FASTEST, SAFEST, MOST ECONOMICAL AND BEST WAY TO DO JUST THAT. WE LOOK UPON ALTERNATIVE 4c AS SOMETHING WE CAN LIVE WITH AND SOMETHING THE FEDERAL GOVERNMENT CAN LIVE WITH.

WE URGE THE FEDERAL GOVERNMENT TO IMPLEMENT 4c AT THE EARLIEST POSSIBLE DATE AND PLEDGE OUR COOPERATION.

THE NIAGARA COUNTY ENVIRONMENTAL MANAGEMENT COUNCIL, OUR ENVIRONMENTAL ADVISORS FOR THE COUNTY LEGISLATURE, HAS SOME ADDITIONAL COMMENTS THAT WILL BE ADDRESSED THIS EVENING.

MEANTIME, PLEASE ACCEPT OUR APPRECIATION FOR YOUR ATTENTION TO THIS MATTER, AND AGAIN, WE LOOK FORWARD TO A QUICK AND SUCCESSFUL COMPLETION OF THE PROJECT AS DESCRIBED IN 4c.

-3-

ATTACHED TO THIS STATEMENT, PLEASE FIND A COPY OF THE
RESOLUTION PASSED BY THE NIAGARA COUNTY LEGISLATURE WHICH IS
UNANIMOUS IN ITS POSITION.

THANK YOU.

Lee Simonson
Niagara County Legislator
Box 57
Lewiston, New York 14092

Copy: SIMONSON

NIAGARA COUNTY LEGISLATURE

FROM: PUBLIC HEALTH COMMITTEE DATE: SEPT. 04, 1984 RESOLUTION # 351-E

APPROVED AS TO FORM
NIAGARA CO. ATTORNEY

LEGISLATIVE ACTION

Approved: Ayes _____ Noes 0

Rejected: Ayes _____ Noes _____

Referred: _____

COMMITTEE ACTION

PH- 229-24

By _____

WHEREAS, the United States Department of Energy has released a draft Environmental Impact Statement regarding the long term management of existing wastes and residues stored at the Niagara Falls Storage Site (otherwise known as the Lake Ontario Ordinance Works) located in the Town of Lewiston, and

WHEREAS, several alternatives were presented in this statement, ranging from taking "no action" to complete removal of the wastes, and

WHEREAS, it appears that the alternative known as "4c" offers a reasonable and acceptable solution to the waste storage problem presently existing at the Niagara Falls Storage Site, since it proposes to remove the most toxic residues from the Site while safely covering and maintaining the remaining wastes at the Site, now, therefore, be it

RESOLVED, that upon considering the health and economic implications of each alternative presented in the DOE draft Environmental Impact Statement, the Niagara County Legislature formally supports the adoption of Alternative "4c", and be it further

RESOLVED, that the Niagara County Legislature state its position at the public hearing to be held on September 19, 1984, at 7:30 p.m., at the Lewiston-Porter Senior High School, and be it further

RESOLVED, that the Niagara County Legislature seek a wide and united effort in gaining approval for Alternative "4c" and respectfully urges participation at the hearing in support of Alternative "4c" by U. S. Senators Moynihan and D'Amato, Congressman LaFalce, State Senator Daly, Assemblymen Pillittere and Murphy, the Town of Porter, the Lewiston-Porter Board of Education, United States and Canadian environmental groups and all other interested parties, and be it further

RESOLVED, that copies of this resolution be sent to all of the above mentioned parties, other interested parties whom the Clerk of the Legislature feels should be advised of same, the President of the United States, the Secretary of Energy and to the Town of Lewiston, New York.


PUBLIC HEALTH COMMITTEE

LS:pan

114 Monticello Road
Oak Ridge, Tennessee 37830

October 3, 1984

Mr. L. F. Campbell
Deputy Director, Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy
P.O. Box E
Oak Ridge, Tennessee 37830

Dear Mr. Campbell:

BEND-1 { The Oak Ridge area is not suitable or desirable for the storage of any radioactive waste. Oak Ridge is surrounded by water. Poplar Creek is on the north, the Clinch River is on the other three sides. Smaller streams drain from within the area. This water eventually flows into the potable water supply for cities downstream. The Environmental Statement agrees that Oak Ridge has a humid climate with a 53-inch annual rainfall. To quote the Environmental Statement: "ground water will eventually be unavoidably contaminated ...in all alternatives."

BEND-2 { Let us realize that nuclear wastes are generated in specific locations in the production of goods and materials for the entire nation, not for the benefit of one location. Therefore, it benefits us all to store, if we must store, the wastes in locations which will be best for us all.

BEND-3 { I submit that DOE's Nevada Operations Office is interested in storing wastes and is currently storing wastes at its 800,000-acre Nevada Test Site. From their pamphlet we learn that "large isolated areas make NTS suitable for the disposal of low level radioactive wastes from the nation's defense programs. Low Nevada rainfall prevents percolation of the radioactivity to the water table several hundred feet below." Also, "The NTS has potentially suitable geologic formations available with deep water tables, low water flow and long flow paths to eventual discharge areas. The NTS land is controlled by DOE, and already requires long-term radiological monitoring because of past nuclear weapons testing. The NTS has a substantial work force experienced in drilling and mining."

When we compare the 35,000 acres at Oak Ridge, only part of which is "reservation," with the 800,000 acres at NTS, we realize how limited our choices of storage sites here are. NTS has a large area with low population density around it. DOE has a commitment to maintain control of the area contaminated by weapons testing, so storage of more waste would not impose an additional burden.

10075

- BEND-1 Opinion against Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- BEND-2 Opinion about national responsibility for the radioactive wastes generated is noted. DOE will take this into consideration in reaching a decision.
- BEND-3 Opinion about the suitability of DOE's Nevada Test Site for long-term management of the NFSS wastes and residues is noted. It is expected that the potential impacts and costs for implementing long-term management at the Nevada Test Site would be similar to those for the Hanford alternatives analyzed in detail in the EIS. A Nevada Test Site alternative would have the same shortcomings as those associated with the Hanford alternative, including high transportation risks and higher radiation risks associated with higher radon emissions in an arid environment. DOE determined that, because of these similarities, it was unreasonable to assess disposal at the Nevada site as a separate alternative. (See also Response KLAB-1.)

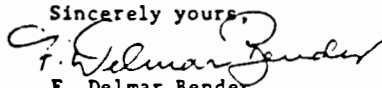
Mr. L. F. Campbell

2

October 3, 1984

We, as residents of Tennessee, do not want our beautiful, healthy, surroundings further degraded. We see no necessity to store any wastes, chemical, radioactive, whatever, in our area with the knowledge that such storage would detrimentally affect us all.

Sincerely yours,


F. Delmar Bender

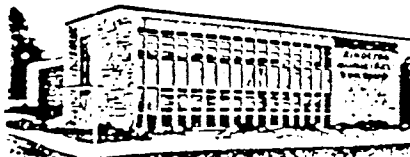
THIS IS A RETYPED VERSION OF THE ORIGINAL HANDWRITTEN LETTER OF COMMENT FROM W.J. COOK. IT HAS BEEN RETYPED TO PROVIDE BETTER CLARITY FOR PRINTING. THIS IS A VERBATIM COPY.

COOK-1 { Your record on the disposal of hazardous waste (i.e. the mercury contamination of important watersheds in east Tennessee) has not been satisfactory. You should not consider the use of the facility for radioactive hazardous waste. Do not dump hazardous nuclear waste in our ecosystems. I will continue to halt any attempts to increase waste disposal in our area.

WJ Cook
Rt 8 Box 202
Sevierville, TN 37862

COOK-1 Opinion against Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

Vice Mayor
Roy Gullett



Councilmembers
Walter Ford
Curtis Leffew
Martin Skinner
Don Woody
Martha Wyatt

KINGSTON MUNICIPAL BUILDING

CITY OF KINGSTON

Ruby Luckey, Mayor
Cumberland Street, Kingston, TN 37763
(615) 376-6584 or 376-6981

September 20, 1974

Comments opposing additional storage of radioactive waste at the Oak Ridge Reservation

RADIOACTIVE WASTES, A NECESSARY EVIL! NO ONE WANTS IT - IN THEIR STATE OR IN THEIR NEIGHBORHOOD. THE MAYOR AND CITY COUNCIL OF THE CITY OF KINGSTON, ON

LUCKE-1 [SEPTEMBER 11, 1974, PASSED A RESOLUTION AS FOLLOWS IN PART: " BE IT RESOLVED THAT THE CITY COUNCIL GO ON RECORD AS "OPPOSING ANY AND ALL EFFORTS TO BRING RADIOACTIVE WASTE MATERIALS FROM OUTSIDE THE STATE OF TENNESSEE TO STORE IN ROANE COUNTY, TENNESSEE." end quote. IT IS RECOGNIZED BY EVERYONE THAT THE DEPARTMENT OF ENERGY IS CONFRONTED WITH A MOST DIFFICULT DILEMMA, THAT OF PROVIDING STORAGE SITES FOR RADIOACTIVE WASTES. RADIOACTIVE WASTE STORAGE IS A FRIGHTENING PROSPECT. IT PRESENTS POTENTIAL DANGER TO THE HEALTH AND LIFE OF HUMANS AND OTHER INHABITANTS OF THE AIR, WATERS, AND EARTH. IT IS MY FEAR THAT MANY OF US, INCLUDING MY FAMILY, WHO HAVE LIVED AND WORKED IN AND AROUND OAK RIDGE FOR OVER FORTY YEARS, HAVE BECOME COMPLACENT ABOUT THE DANGERS OF RADIOACTIVE MATTERS. MANY OF THE DANGERS ARE YET TO BE DISCOVERED - OTHERS ARE ALREADY KNOWN. MY CONCERNS HAVE INCREASED IN THE LAST TEN DAYS AS I HAVE STUDIED THE DOE'S REPORT ON THE ENVIRONMENTAL IMPACT FOR THE PROPOSED CONSTRUCTION OF A FACILITY FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE IN THE OAK RIDGE RESERVATION. IF BUILT, IT COMPOUNDS THE PROBLEMS TO BE REALIZED FROM THE ADDITIONAL DANGERS OF TRANSPORTING RADIOACTIVE WASTES FROM THE STATE OF NEW YORK, THE NIAGARA FALLS STORAGE SITE.

LUCKE-1 Resolution against Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

IN ADDITION TO THE PRESENT HOLDING PONDS AND OTHER STORAGE SITES IN THE OAK RIDGE RESERVATION, FIVE STATES PRESENTLY HAVE RADIOACTIVE WASTE FACILITIES(DOE), AND THREE STATES SUPPORT COMMERCIAL FACILITIES. MY QUESTION IS, "IS IT FEASIBLE THAT THE EXISTING FACILITIES BE UTILIZED IN THE STORAGE OF THE LOW-LEVEL RADIOACTIVE WASTES AND FOR THE FUTURE BUILD THE NECESSARY STORAGE SITES IN AREAS WHICH ARE NOT LOCATED NEAR CITIES AND OUR WATERWAYS?

IN CLOSING, I WOULD LIKE TO QUOTE TWO STATEMENTS TAKEN FROM THE CWDF ENVIRONMENTAL IMPACT STATEMENT.

THE TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT IN 1983, STATES, "THE PRESENT HOLDING PONDS IN OAK RIDGE ARE LEAKING INTO BEAR CREEK, THEREBY RESULTING IN DISCHARGES TO THE WATERS OF THE STATE OF TENNESSEE."

SECOND QUOTE: "

4.5 CUMULATIVE IMPACTS "ALTHOUGH NOT PLANNED, THERE IS A POTENTIAL FOR OVERLAP WITH ANOTHER PROJECT, THE DISPOSAL OF NIAGARA FALLS STORAGE SITE WASTES AT THE PINE RIDGE KNOLLS SITE (U.S. DEPARTMENT OF ENERGY 1984). IF THE NFSS PROJECT IS IMPLEMENTED WITH DISPOSAL OF THE WASTES AT THE OAK RIDGE RESERVATION, ONE TRUCK HAULING RADIOACTIVE WASTES WILL BE BROUGHT INTO ORR EVERY 15-MINUTE DURING TWO SUMMERS (THE CWDF PROJECT WOULD INVOLVE ABOUT 2 TRUCKS PER HOUR PER 8-HOUR SHIFT FOR THE FIRST 4 YEARS. THUS, THE CUMULATIVE TRANSPORTATION IMPACT WOULD RESULT IN INCREASED TRAFFIC CONGESTION, INCREASED ACCIDENTS, AND ACCELERATED DETERIORATION OF THE ROADS, PRIMARILY DUE TO THE NFSS (NIAGARA FALLS STORAGE WASTE) PROJECT"

AS STATED IN THE BEGINNING, NO ONE WANTS IT, BUT PLEASE DON'T MAKE US THE GARBAGE HEAP FOR THE WHOLE COUNTRY.

Respectfully submitted,

Ruby G. Luckey, Mayor, City of Kingston, TN



RESOLUTION NO. 84-9-11-3

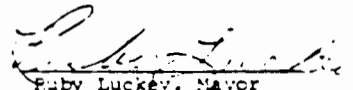
WHEREAS it has been reported that a proposal has been made to bring radioactive waste material from Niagra Falls, New York and store such materials in the Grassy Creek area of Roane County, Tennessee; and,

WHEREAS Grassy Creek empties into the Clinch River above Kingston and the Council is concerned that such storage will create an environmental hazard which will adversely affect this community

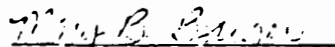
NOW THEREFORE be it resolved that the City Council go on record as opposing any & all efforts to bring radioactive waste materials from outside the State of Tennessee to store in Roane County, Tennessee

Copies of this resolution are to be forwarded to proper governmental bodies and elected officials.

This 11 day of September 1984


Ruby Luckey, Mayor

ATTEST:


City Clerk

103 Oak Lane
Oak Ridge, Tn. 37830
3 September, 1984

Mr. L.E. Campbell, Deputy Director
Technical Services Division
Oak Ridge Operations Office
U.S. Department Of Energy, P.O. Box E
Oak Ridge, Tn. 37830

Dear Sir:

PERD-1 I have read the Draft Environmental Impact Statement (DOE/EIS-0109D) and wish to comment on some of the provisions. The temporary storage provided at Lewiston, N.Y. is sufficient for the immediate future, but appears to have objections for a permanent storage. The various anti-nuclear groups insist on assurances of zero migration under all foreseeable conditions. In the case of uranium and radium, in particular, this assurance could not be given. Further, this site, in common with all land disposals, would require perpetual care and surveillance to prevent diversion at some future time. The principal real hazard to storage of these materials is their employment in the construction of human habitations, either as construction materials or as fill under buildings.

PERD-2 The second alternative, the removal of the materials to the deep ocean, off the continental shelf, is by far the safest approach to permanent storage. The radiochemistry of the sea has been carefully documented by Oak Ridge's famous Hungarian-Dr. Elizabeth Bona, among others. For the isotopes of uranium and thorium alone, the sea is the safest repository. The small amount of uranium still present in the residues is quite soluble in sea water and will make an insignificant contribution to the amount already there. The thorium family (including the thoriums in the uranium family) are insoluble in sea water and will, like the thoriums created in the decay of uranium, precipitate to the bottom of the sea, where it will decay, by the route of radium, to lead. Radium is virtually insoluble in sea water, and any amount added from the land would be insignificant to the amount, at near saturation, present in sea water.

PERD-3 The foregoing method is the most logical of the methods described, but politics is not logical. There are a lot more people in New York State than there are in the State of Tennessee, and in the world of politics, this is relevant. The second removal option, to a preselected site in Oak Ridge, must be considered a viable option. With provisions similar to those made for temporary storage at NFSS, these clay hillsides can be made to store these uranium residues at least as long as their

- PERD-1 This potential hazard is analyzed in Section 4.1 (resident-intruder scenario). As discussed in the EIS, this scenario leads to the greatest potential radiological impact. (See also Topical Response 1.)
- PERD-2 Recommendation for ocean disposal (Alternatives 4b and 4d) is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- PERD-3 Opinion about Oak Ridge being as suitable as NFSS for long-term management of the NFSS wastes and residues is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

- PERD-3 { present repository. As I tried to point out at a meeting of Oak Ridge City Council earlier in the year, these materials would require permanent isolation. The half-life of radium-226 is 1600 years and since the thorium-230 parent is nearly in equilibrium, there will be about 2 kilograms of radium equivalent in the repository for about half a million years. Should the Oak Ridge site be chosen, the City should be compensated for about 16 acres taken out of the tax base permanently. Further, since permanent security is required, provision should be made for an adjacent commercial low-level repository owned by the city, and controlled by the U.S. Government. There are presently about 10 radioactive waste repositories in the city, containing all members of the uranium family and all known fission products. There should be one that is legal and under control of the City. Unless something is done in this country soon, the city fathers of a good many U.S. cities will come to realize with a shock that the city dump is radioactive !
- PERD-4 {
- PERD-5 {
- PERD-6 { The Hanford option is the least attractive, because of the sheer volume of waste that would need to be transported across the U.S. In this respect, Oak Ridge has relatively direct rail connections and would thus be more attractive. Of the land repositories, the high elevation above the water table and desert conditions make the storage at Hanford attractive.

The radiochemistry has been worked out for many years for the proper storage of these radioactive materials, including fission products. It is politics that is preventing the safe storage of these products and residues.

Sincerely Yours,



P. T. Perdue

Copy: Oak Ridge City Council

- PERD-4 Opinion is noted regarding the need to compensate the city of Oak Ridge if Alternative 3b, 4c, or 4d is selected. DOE will take this into consideration in reaching a decision.
- PERD-5 Opinion about providing for an adjacent commercial low-level repository is noted. DOE will take this into consideration in reaching a decision.
- PERD-6 Opinion is noted that the Hanford alternatives (3a, 4a, and 4b) are the least attractive. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

THIS IS A RETYPED VERSION OF THE ORIGINAL HANDWRITTEN LETTER OF COMMENT FROM LINDA ROWLAND. IT HAS BEEN RETYPED TO PROVIDE BETTER CLARITY FOR PRINTING. THIS IS A VERBATIM COPY.

Mrs. E. Bruce Rowland
142 W. Norris Road, Box 639
Norris, Tennessee 37828

Sept. 23

Dept. of Energy,

ROWL-1

As a resident of Anderson County and mother of 2 children I would like to voice my sincere and strong objection to bringing anymore nuclear waste into the Oak Ridge area. Bringing nuclear waste that is already stored in the Niagara Falls area to Anderson County is much too costly and dangerous.

One of my objections to the use of nuclear power plants is that no fool-proof method of waste storage has been devised.

Please do not consider the Oak Ridge area for any more nuclear storage.

Sincerely,

Linda Rowland

ROWL-1 Objection to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

September 20, 1984

Mr. Lowell F. Campbell
U. S. Dept. of Energy
Oak Ridge, Tn 37830

Dear Mr. Campbell:

- RULEY-1 { After reviewing the August 1984 DEIS re NFSS I wish to go
on record as opposing the storage of the NF waste in Oak Ridge,
Tn. from the financial, health and traffic standpoint. Such a
consideration to make the deposit here is incomprehensible.
- RULEY-2 { My thought is that each state should assume the responsibility
of its own nuclear waste and using the ocean as a dump site
should be an absolute no. It should occur to our scientists
that the inhabitants of this globe have been here for a long
time and should expect to continue living on this earth for gen-
erations to come. They should take that into consideration
before creating the hazards that they persist in doing.
- RULEY-3 {

Helen G. Ruley
Helen G. Ruley
344 Louisiana Ave.
Oak Ridge, Tn. 37830

- RULEY-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- RULEY-2 Opinion about each state being responsible for its own waste and opposition to ocean disposal are noted. DOE will take this into consideration in reaching a decision.
- RULEY-3 Opinion about considering the hazards that are being created is noted. DOE will take this into consideration in reaching a decision.

THIS IS A RETYPED VERSION OF THE ORIGINAL HANDWRITTEN LETTER OF COMMENT FROM CYD RYMAN. IT HAS BEEN RETYPED TO PROVIDE BETTER CLARITY FOR PRINTING. THIS IS A VERBATIM COPY.

I make this statment as an individual, not as a member or representative of EQAB (Environmental Quality Advisory Board to the city of Oak Ridge).

Over all the DEIS regarding the NFSS is very good. I thank you (DOE) for the time and effort made to compile even the Draft EIS.

I make only minor points.

Several options were considered. Among these were depositing the mine tailings & other low level wastes in the ocean, site 106, with negligible effect. The option of resourse recovery and modification of form were also considered. However neither of these were considered for Oak Ridge--in combination.

- RYMAN-1 { I suggest you consider depositing the low level rad wastes in the ocean, thus, taking care of 96% or most of the volume.
- RYMAN-2 { Then I suggest that we try some resourse recovery before form modification by vitrification for the remaining higher level rad-wastes.
- { Unfortunately, I have no facts to support my belief that resourse recovery can be done. How much, if anything, was recovered before vitrification of some rad wastes & storage in the old salt mines near Kansas City? If it were to happen, where would form modification take place?
- RYMAN-3 { I was astounded by the costs of perm-care at Niagara Falls. Are costs so high because someone would need to check on the site periodically and the government has no one there?
- RYMAN-4 { Concerning the selected Oak Ridge site--Who chose it? Why? Was it merely because there was sufficient data on that land site?
- RYMAN-5 { The argument that wastes would be deposited on only 40% of the land of the site and that the rest of the site would be useable is faulty, because of irregular configuration of the deposits and the need for buffers (Figure 3.14). Thus most, or all, of the Pine Ridge Knolls site would not be suitable for other commerical interests.

Thank you.

Sincerely,

Cyd Ryman
443 East Drive
Oak Ridge

- RYMAN-1 Opinion for ocean disposal (Alternatives 4b and 4d) is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- RYMAN-2 Opinion for resource recovery followed by vitrification of the residues is noted. The technical aspects and environmental implications of this alternative are discussed in more detail in Appendix C, Section C.2. The Kansas City operation dealt with high-level wastes containing radionuclides that are different than the naturally occurring radionuclides in the NFSS residues.
- RYMAN-3 The estimated costs of permanent care at NFSS (for the preferred Alternative 2) would be the same as at Oak Ridge or Hanford (Table F.1)--amounting to about \$85,000/yr. This amounts to about 9 person-months of effort and is primarily for monitoring, periodic surveillance, and occasional maintenance.
- RYMAN-4 As noted in Section 2.5.1, the Pine Ridge Knolls site was identified by the DOE Oak Ridge Operations Office as being a site that is reasonable to assume for purposes of analysis and comparison of alternatives in this EIS. It is potentially available for disposal of the NFSS wastes and residues and site-specific information is available on this site so it can be analyzed.
- RYMAN-5 There is no statement in the EIS that only 40% of the land would be used at the Pine Ridge Knolls site and that the rest of the area could be used for other purposes. As shown in Table 4.58, about half of the acreage needed would be for a buffer zone and service area. (See also Responses TDHE-5; USEPA-32; WALK-1, -3; YAGER-2.)

THIS IS A RETYPED VERSION OF THE ORIGINAL HANDWRITTEN LETTER OF COMMENT FROM NELLIE SHROPSHIRE. IT HAS BEEN RETYPED TO PROVIDE BETTER CLARITY FOR PRINTING. THIS IS A VERBATIM COPY.

Sirs

SHROP-1

I feel we have more than our share of polution and do not need any transported from other locations. We have the right to preserve our enviroment here in Tennessee the same as any other state.

Nellie Shropshire
834 Lincoln Ave
Morristown TN 37814

SHROP-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

THIS IS A RETYPED VERSION OF THE ORIGINAL HANDWRITTEN LETTER OF COMMENT FROM JEAN SPACH. IT HAS BEEN RETYPED TO PROVIDE BETTER CLARITY FOR PRINTING. THIS IS A VERBATIM COPY.

September 23

Dear Sirs,

SPACH-1 { I want to be counted among those opposed to storing any extra nuclear waste in Oak Ridge. We are already doing a poor job with our local by products. We don't need anyone else's waste.

Jean Spach

ADDRESS ON ENVELOPE:

Spach
226 Hendrix Dr.
Oak Ridge, TN 37830

SPACH-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.



TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

Bureau of Environment
T.E.R.R.A. BUILDING
150 NINTH AVENUE, NORTH
NASHVILLE, TENNESSEE 37203

October 5, 1984

Mr. L. F. Campbell
Deputy Director, Technical Services Division
Oak Ridge Operations Office
U. S. Department of Energy
P.O. Box E
Oak Ridge, Tennessee 37830

Re: Long-Term Management of the Existing Radioactive Wastes and Residues at
the Niagara Falls Storage Site - Draft Environmental Impact Statement
(DEIS)

Dear Mr. Campbell:

Detailed comments on the above referenced document by our Divisions of Radiological Health and Air Pollution Control are attached. As of this writing, two other Divisions have not completed their review. However, because previous obligations will keep the person coordinating our review and comments out of town until October 9, we wish to document the current position of the Tennessee Department of Health and Environment with this letter. Any additional detailed comments will be forwarded at the very first opportunity.

TDHE-1 { We have noted the positions of local residents and officials as delivered at the September 20, 1984, public hearing in Oak Ridge. With empathy and due respect for the apparent concerns of residents in the Niagara Falls Storage Site area, we must agree with Oak Ridge area residents. Events of the past few months have revealed that the Department of Energy (DOE) at its Oak Ridge site already has a sufficient number of waste disposal problems to deal with for the foreseeable future.

TDHE-2 { The problems that we, the U. S. Environmental Protection Agency, and DOE's Oak Ridge staff currently face are of considerable complexity and magnitude. We are convinced that DOE is committed to cleaning up "sins of the past" and to compliance with existing environmental statutes now and in the future in Oak Ridge. However, this effort will involve continuing dedication to the task, hard work, and time from DOE, government officials at all levels, local residents, and the news media. Furthermore, this effort will take millions of dollars. The DEIS estimates that the costs of alternatives involving Oak Ridge or Hanford are at least an order of magnitude higher than for those involving Niagara Falls. We would prefer that the monies in the differential be used to research and address known

22892

TDHE-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

TDHE-2 Preference for spending money to solve the problems at Oak Ridge rather than moving the NFSS wastes and residues is noted. DOE will take this into consideration in reaching a decision.

Mr. L. F. Campbell
October 5, 1984
Page Two

and potential problems in Oak Ridge. We also must acknowledge and point out the increased risk to public health and safety posed merely by the transport of this material away from its present location to another distant location.

TDHE-3

We feel strongly that DOE's preferred option should not involve any of the alternatives proposed at Oak Ridge. In fact, in the best interests of Tennesseans, we feel that legal action would have to be one of our considerations in the event that DOE should decide in favor of one of the Oak Ridge alternatives.

The opportunity to offer comment in this important matter is most certainly appreciated. Should further discussion be needed please feel free to contact this office.

Sincerely,



Michael T. Bruner, Dr. P. H.
Assistant Commissioner
Bureau of Environment

MTB/TKC/ca/1/3

Attachments

TDHE-3 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

DRH Comments on review of DRAFT EIS
(DOE/EIS-0109D) Long-term Management of
the Existing Radioactive Waste and Residues
at the Niagara Falls Storage site

TDHE-4 { Summary, Page vi - Pine Ridge Knolls are proposed as site for above ground storage in mounds. Why not the Central Waste Disposal Facility on West Chestnut Ridge or, if the Knolls are better, use that site for CWDF.

TDHE-5 { Page 1 - 1, Item 1.2 - Radium -226 appears to be the primary source of the radioactivity. Oak Ridge was not established and to our knowledge has not been used, for naturally occurring radioactive material waste handling. Why start now??

TDHE-6 { Page 2-15, Item 2.5.2 - Impact of erosion of Knoll when trees are removed is not discussed.

TDHE-7 { 2. Why are there to be no Radium-222 releases at Oak Ridge if caps are similar to those proposed for alternative 1, at NFSS?

TDHE-8 { 3. Migration of contaminants is controlled by a great number of factors apparently not considered here. A conclusion of slow migration is not supported at this point and should not be made.

TDHE-9 { I did not recognize anything in this document that presented a compelling reason to do anything with this material, i.e, alternative 1, or at most alternative 2a is the option to take. All of them presented some degree of hazard. These seemed to have the least.

TDHE-10 { On page 3-30 of the Niagara Falls DEIS it says, "The Pine Ridge Knoll site is underlain by the Rome formation and the Conasauga Group (Figure 3.15). About 230 m (740 ft) of continuous Rome Formation . . . has been observed at the site."

However, on page 2-8 of the Chestnut Ridge DEIS (DOE/EIS-0110-D) it says, "Of the four major strata—Conasauga Group, Knox Group, Chicamauga Group, and Rome formation--only the Knox Group and the Conasauga Group have characteristics that are considered suitable for placement of a waste-disposal facility (Lee et al. 1983; Lominick et al. 1983)."

The Niagara Falls DEIS does not have either reference in any chapter.

The full references are:

Lee, D. W., R. H. Ketelle, and L. H. Stinton. 1983. Use of DOE Site Selection Criteria for screening Low-Level Waste Disposal Sites on the Oak Ridge Reservation. ORNL/TM-8717. Prepared by Oak Ridge National Laboratory, Oak Ridge, TN, for the Low-Level Waste Management Program, U. S. Department of Energy. September 1983

Lominick, T. F., D. W. Byerly, and S. Gonzales. 1983. Evaluation of the ORNL Area for Future Waste Burial Facilities. ORNL/TM-8695. Oak Ridge National Laboratory.

This must be addressed if alternative 3b, 4c, or 4d is developed further.

- TDHE-4 Because of the large volume of wastes to be generated at Oak Ridge and the large volume of the NFSS wastes and residues, DOE believes that two sites would be needed.
- TDHE-5 Oak Ridge is being considered as an alternative because it is a DOE site and the NFSS wastes and residues are a DOE responsibility. It is not the preferred alternative. (See also Responses RYMAN-4; USEPA-32; WALK-1, -3; YAGER-2.)
- TDHE-6 The impact of erosion when trees are removed is discussed in Sections 4.2 and 4.3.
- TDHE-7 The cap at Oak Ridge is similar to the long-term cap at NFSS (Alternatives 2a and 2b), not the Alternative 1 (no-action) cap. Radon-222 releases are discussed in detail in Section 4.1.2.2).
- TDHE-8 Many factors affecting the long-term migration of radionuclides into groundwater at Oak Ridge are discussed in detail in Section 4.2.2. As noted in Section 4.2.2.1, the most sensitive parameters are hydraulic conductivity and distribution coefficient. (See also Responses USEPA-38, -40.) Using a conservatively high number for the average hydraulic conductivity and conservatively low numbers for distribution coefficients, slow migration is predicted (Section 4.2.2). Based on all available information, the conclusion of slow migration is supported.
- TDHE-9 Opinion for Alternatives 1 and 2a is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- TDHE-10 The information given in the two additional references, which are site-screening studies for the Oak Ridge Reservation, was considered by DOE Oak Ridge Operations in selecting the alternative site for consideration in this EIS.

APC Comments on review of DRAFT EIS
(DOE/EIS-01090) Long-term Management of
the Existing Radioactive Waste and Residues
at the Niagara Falls Storage site

It appears the only real possibility of air impact from the option of storage of DOE Niagara Falls waste at Oak Ridge could be fugitive emissions from handling cover materials (rock and dirt). This handling includes excavation loading, transport unloading and placement. Although the draft statement does not specify what precautions will be taken to assure a negligible impact, the statement mentions that truck traffic will increase during the project; DOE recognizes there will be some impact.

TDHE-11 { I expect that if reasonable precautions are taken in the rock and dirt handling there will be negligible air impact. I believe it is appropriate for the Division to comment that we do not anticipate a problem developing but want to assure that the matter of reasonable fugitive dust control be considered even if not comprehensively addressed.

TKC/ca/1/2

TDHE-11 Radiological impacts are estimated assuming typical construction activities and associated particulate releases (Section 4.1.2). As noted, dust control measures would be employed, such as periodic watering and minimization of exposed surfaces, and actual particulate releases might be lower than those assumed in the EIS analysis. (See also Response USEPA-13).

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE 37902

SEP 20 1984

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
U.S. Department of Energy
Oak Ridge Operations
Post Office Box E
Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

TVA-1

The Tennessee Valley Authority has reviewed the Department of Energy Draft Environmental Impact Statement, Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site (NFSS). We believe that long-term radioactive waste management at NFSS is preferred over the alternatives of no action and those involving transportation of wastes (including ocean dispersal). Specifically, we believe that alternative 2a, long-term management at NFSS with modified containment, will be the most cost-effective method to minimize short-term impacts and provide adequate long-term protection to the public and environment.

Thank you for the opportunity to review and comment on the document. If you have questions or comments, please contact John R. Thurman at (615) 632-6656 (FTS 856-6656).

Sincerely,



Martin E. Rivers, Director
Environmental Quality

TVA-1 Opinion for Alternative 2a is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

Tennessee Wilderness Action Council

KENNETH S. WARREN, Chairman
105 Evans Lane
Oak Ridge, Tennessee 37830
Phone (615) 483-1027

483-1027

October 4, 1984

Mr. L. F. Campbell
Deputy Director, Tech Serv. Div.
Oak Ridge Operations Office, U. S. DOE
P.O.Box E, Oak Ridge, TN 37830

Dear Mr. Campbell:

We wish to make a few comments on the draft Environmental Impact Statement, Long-term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site, Lewiston, New York. Our remarks will be confined generally to the plan which would involve using a site near Oak Ridge, Tennessee as the final dumping ground for the NFSS radioactive wastes.

TWAC-1

A number of health problems presently exist in the environs of Oak Ridge, Tennessee. These are:

- (1) 2.4 million pounds of mercury are been lost to the environment and is now contaminating local ground waters.
- (2) Radionuclides in the air near Oak Ridge are currently above EPA standards.
- (3) The Oak Ridge plants currently serve as a dumping ground for over 7,570,000 cubic feet of low-level military wastes.
- (4) Although the Safe Drinking Water Law prohibits injection of contaminants into an underground source of drinking water, now EPA has released permits to three chemical industries for injecting chemical wastes into the entire Knox aquifer, comprising about 124 cubic miles in volume.
- (5) Inventory personnel have disclosed that 100 pounds of uranium are missing, according to their records. Until this uranium is located, we must assume that it may eventually show up in the environment, also. The tendency to suppress pertinent information must be acknowledged.

The history of radioactive waste practices reveals universal off-site migration of radioactivity and shoddy burial techniques. Borings cannot adequately characterize a proposed burial site. Migration of wastes is poorly understood, and there is no way to permanently control slumping and shifting in a burial ground. In view of the problems that already exist, wastes should be preserved at the NFSS rather than brought to Oak Ridge.

Sincerely yours,
Kenneth S. Warren
for - TWAC

TWAC-1 Opinions regarding existing health problems at Oak Ridge and preference for Alternative 1, 2a, or 2b are noted. These comments, along with those from other commenters, were taken into consideration in determining the preferred alternative.

105 Evans Lane
Oak Ridge, TN 37830
October 5, 1984

Mr. L.F. Campbell
Deputy Dir., Tech Services Div.
Oak Ridge Operations Office, D.O.E.
P.O. Box E, Oak Ridge, TN 37830

Dear Sir:

WARR-1

After perusal of the DEIS on a Disposal Facility for Low-Level Radioactive Waste (DOE/EIS-0110-D) and attendance at the September public hearing, I would like to express my protest to the concept of moving wastes and residues from the NRSS for the following reasons:

1. Hazard to the workers and to the public which would develop during the moving.
2. Expense, which will eventually be billed to the taxpayer.
3. Contamination of ocean waters, a valuable resource, which is already being contaminated much too rapidly.

Please include this letter with other testimony which may be published in the future on this subject. Thank you for the opportunity to submit a written comment.

Very truly yours,

Helen Scott Warren

Helen Scott Warren

22893

WARR-1 Opposition to Alternatives 3a, 3b, 4a, 4b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

Executive Offices
376-8878

Accounting & Purchasing Dept.
376-8883

Office of the County Executive

ROANE COUNTY COURTHOUSE
KINGSTON, TENNESSEE 37763

September 20, 1984

COMMENTS OF KENNETH E. YAGER, ROANE COUNTY EXECUTIVE, RELATIVE
TO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)/LONG
TERM MANAGEMENT OF EXISTING RADIOACTIVE WASTE AND RESIDUE
AT THE NIAGARA FALLS STORAGE SITE (DOE:1984).

YAGER-1

I oppose storing in Oak Ridge (Roane County) any of the
waste or residue presently found at the Niagara Falls Storage Site
(NFSS).

YAGER-2

The proposed site for the storage of any NFSS waste and/or
residue, is drained by tributaries of the Clinch River, principally
Grassy Creek, Bear Creek, and the East Fork of Poplar Creek. The
Clinch River flows through Roane County to Kingston, where it merges
into the Tennessee River. The Tennessee River provides water for
Kingston, and recreational opportunities for thousands of swimmers
and fishermen.

It is easy to see why many people throughout Roane County
who depend on the Tennessee River for water, or for recreational
purposes would be affected by the radioactive contamination.

Moreover, this particular site is suitable for industrial
development, and the location of the proposed site in Roane County
would completely take the property out of consideration by
industrial prospects.

YAGER-3

It is the Department of Energy's stated goal that Roane
County become self-sufficient to a point that it no longer would
depend on DOE's federal assistance payments. A policy of taking
the NFSS waste and dumping it in Roane County is contrary to that
goal and would make it more difficult to become truly self-sufficient.

I do not support any effort that would make Roane County
the "dumping ground" for waste already located at the Niagara Falls
site. Leave the waste where it is rather than contaminate other
areas of the country, and increase the risk of contamination in five
other states, by transporting it almost a thousand miles, from New
York to Tennessee.

Thank you.

- YAGER-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- YAGER-2 These subjects are discussed in Sections 4.1, 4.2.2, 4.3 (water contamination), and 4.6 (industrial land use). (See also Responses RYMAN-5; TDHE-5; USEPA-32; WALK-1, -3.)
- YAGER-3 Opinion that management of the NFSS wastes and residues at Oak Ridge would be contrary to the goal of making Roane County self-sufficient is noted. DOE will take this into consideration in reaching a decision.

JOHN SPELLMAN
Governor



DONALD W. MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

Air Mail Stop PV-11 • Olympia Washington 98504 • (206) 459-6000

October 4, 1984

Mr. Lowell Campbell
Deputy Director
Technical Services Division
U.S. Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

Thank you for the opportunity to review the draft Environmental Impact Statement (EIS) for "Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site".

In accordance with the state's responsibilities under NEPA, this agency has coordinated the review of your document with other state agencies. This letter, along with the enclosed agency comment letters, constitutes the State of Washington response to your EIS.

WDEC-1 {

To briefly summarize the state's position, there are a number of issues identified in the enclosed letters which have not been adequately addressed in the draft EIS. These issues need to be discussed in the final EIS. The state's review of potential impacts and alternatives leads us to conclude that none of the alternatives involving disposal at Hanford should be selected.

We look forward to receiving the final EIS when it is issued. If you have any questions, please contact Ms. Carol Jolly (206/459-6224).

Sincerely,

Donald W. Moos
Director

DWM:pk

Enclosures

cc: Governor John Spellman
State Agencies
Carol Jolly, WDOE, Low Level Nuclear Waste
Greg Sorlie, WDOE, Environmental Review

WDEC-1 Opinion against Alternatives 3a, 4a, and 4b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

JOHN SPELLMAN
Governor



DONALD W. MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

Mail Stop PV-11 • Olympia, Washington 98504 • (206) 459-6000

October 3, 1984

Mr. Lowell Campbell
Deputy Director
Technical Services Division
U.S. Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37830

Dear Mr. Campbell:

The Washington Department of Ecology (WDOE) appreciates the opportunity to comment on the Draft Environmental Impact Statement (DEIS) on Long-Term Management of the Radioactive Wastes and Residues at the Niagara Falls Storage Site (NFSS).

In light of the inclusion of three alternatives that would entail burial of part or all of the wastes and residues on the U.S. Department of Energy's Hanford Reservation near Richland, WDOE has a strong interest in the evaluation of the impacts described in the DEIS. Our review of the impacts, as described in the document, leads us to conclude that none of the alternatives reflecting Hanford disposal should be selected by U.S.DOE as its preferred alternative.

WDEC-2

In virtually every category of effect, Hanford is the least supportable alternative discussed:

- "During the action period, the risk is highest for workers if all wastes and residues are moved to Hanford: (Page i).
- "Long-term radiological risks to the general public are expected to be highest for Alternatives 3a, 4a, and 4b [those involving Hanford disposal] primarily because of the much higher releases of radon gas from the residues in the arid climate at Hanford" (Page vii).
- "Initial commitments for the action alternatives range from about \$3.2 to \$6.3 million for Alternative 2a (modified containment at NFSS) to about \$130 to \$260 million for

WDEC-2 Opinion against Alternatives 3a, 4a, and 4b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

Mr. Lowell Campbell
 October 3, 1984
 Page 2

- WDEC-2 | Alternative 3a (move all wastes and residues to Hanford)"
 (Page 2-25).
- Total one-way distance to transport wastes and residues range from zero if they remain at NFSS to 4100 km (through 12 states) if they are moved to Hanford (Page 3-42).
 - "The largest bronchial epithelium and bone doses, however, will be associated with transport of the residues and wastes to Hanford, primarily because of the radon-222 and particulate releases and the longer distance involved" (Page 4-21).
 - "Implementation of any of the Hanford alternatives will, however, result in a greater net contribution to general air quality degradation in the United States because total emissions will be greater as a result of the greater distance involved" (Page 4-94).
- WDEC-3 | The Department of Ecology is aware of the substantial quantity of low-level radioactive waste from U.S.DOE's Surplus Facilities Management Program that is already projected for Hanford disposal. According to DOE/NE-0017/2, "Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics," 3,171 m³ of low-level waste from California and over 58,280 m³ of waste from Washington are to be added to the 15,400 m³ of waste from Pennsylvania's Shippingport reactor buried at Hanford. It seems to us not only environmentally unsound, but also inequitable, to add the 190,000 m³ of Niagara Falls wastes and residues to this total.
- WDOE also wishes to emphasize a deficiency in the DEIS that we believe will require attention in the Final Impact Statement. On Pages 4-103 and 4-104, the DEIS addresses the issue of federal facilities being subject to the Resource Conservation and Recovery Act (RCRA). It states that "U.S. DOE will implement all applicable requirements of RCRA for whichever NFSS alternative is implemented."
- WDEC-4 | It is our view that--based on the information in Tables 3.7, 3.8, and 3.9--the residues could be classed as Extremely Hazardous Wastes and the wastes as Dangerous Wastes under Washington's hazardous waste regulations. However, the information in the DEIS is insufficient to make such a determination. Verification of waste hazard will require testing for EP Toxicity and corrosivity and analysis of organic and carcinogen content. Such data should be included in the Final EIS.
- WDEC-5 | We are aware that U.S.DOE and the U.S. Environmental Protection Agency (U.S.EPA) are currently attempting to define the types of mixed hazardous and radioactive waste that will be subject to RCRA regulation. Should the Niagara Falls residues and/or wastes be classed as "byproduct" wastes and excluded from state dangerous waste regulation, it is our view that the

- WDEC-3 Opinion about the addition of the NFSS wastes and residues to the Hanford Reservation being inequitable is noted. DOE will take this into consideration in reaching a decision.
- WDEC-4 As noted in Section 4.7.1.2, DOE is analyzing the NFSS materials. Results of the EPA toxicity test (EAL Corp. 1984) indicate that the residues fail this test, particularly with respect to lead (see lead concentrations in Table 3.7). However, because the NFSS materials are classified a "byproduct" material under the Atomic Energy Act of 1954, as amended, they are exempt from RCRA under 40 CFR 261.4(4). The chemical constituents of the NFSS wastes and residues are defined and analyzed in Section 3.1.8. Based on this analysis, it is not necessary to conduct corrosivity tests or to analyze the organic and carcinogenic content of the wastes and residues. Potential impacts associated with the chemicals in the residues are addressed in Section 4.4 and will be considered in making the decision regarding long-term management of the NFSS materials. (See also USEPA-2, WDSHS-3.)
- WDEC-5 Opinion about the level of management of the residues/wastes not being commensurate with the hazard is noted. If a decision is made to manage the NFSS wastes and residues at Hanford, DOE will have discussions with the state of Washington to clarify the state's views on acceptable levels of protection for the residues and wastes and the conceptual design. (See also Topical Response 1.)

Mr. Lowell Campbell
October 3, 1984
Page 3

WDEC-5 | level of protection afforded by the intended disposal technique will not be commensurate with the waste's inherent hazard.

We trust that other state agencies' comments will complement the preceding statements and help U.S.DOE prepare a Final EIS that lays a firm foundation for making a sound decision.

Sincerely,



Lynda L. Brothers
Assistant Director
Office of Hazardous Substances
and Air Quality Control

LLB:bh

JOHN SPELLMAN
Governor



DEPARTMENT OF
Ecology

STATE OF WASHINGTON

DEPARTMENT OF EMERGENCY SERVICES

4220 E. Martin Way • Olympia, Washington 98504 • (206) 454-9191 • (SEA) 244-5255

September 7, 1984

RECEIVED

SEP 11 1984

DEPARTMENT OF ECOLOGY
ENVIRONMENTAL REVIEW

Ms. Barbara Richie
NEPA Coordinator
Environmental Review Section
Department of Ecology
Mail Stop PV-11

Dear Ms. Richie:

The Department of Emergency Management has reviewed the draft Environmental Impact Statement (DOE/EIS-0109D) for long term management of radioactive wastes and residue currently stored at the U.S. Department of Energy's Niagara Falls storage site. This agency's comments on the draft statement are limited to the Hanford disposal options.

WDES-1

The Department of Emergency Management acknowledges that the U.S. Department of Energy has outlined the transportation risks connected with moving wastes and residues from Niagara Falls to Richland, Washington. However, we believe that if any of the Hanford options are chosen as the long term management strategy, the Department of Energy should carefully spell out in detail in the final impact statement what means it will utilize:

- 1) to mitigate transportation accidents involving any vehicles carrying waste or residues, and
- 2) to interface with state and local governments on emergency response to any transportation accident involving such waste or residues.

These concerns are not adequately addressed in the draft statement and need to be discussed in detail in the final impact statement.

Sincerely,

James M. Thomas
Assistant Director
Plans and Preparedness Division

JMT:cb

WDES-1 DOE has now determined that the preferred alternative is to leave both the wastes and residues at NFSS (Alternative 2). If DOE decides to implement one of the alternatives involving transport of the contaminated materials to Hanford or Oak Ridge, measures to mitigate transportation accidents and to interface with local governments regarding emergency response will be summarized in the Record of Decision. (See also Responses NCEMC-3; USDO1-7; VCE-1, -2; WEFS-5.)

JOHN WILLIAMS
GovernorKARL E. RAY
Secretary

STATE OF WASHINGTON
DEPARTMENT OF SOCIAL AND HEALTH SERVICES
Olympia, Washington 98504

September 24, 1984

TO: Nancy P. Kirner, Supervisor
Radioactive Materials Unit

FROM: Joe Stohr, Manager JS
Uranium Mills Program

SUBJECT: COMMENTS ON DEIS FOR NIAGARA FALLS STORAGE SITE

The DEIS issued by the U.S.D.O.E. attempts to evaluate nine alternatives for disposal of radioactive waste and residues resulting from the processing of uranium ores. There are approximately 11,000 m³ of residues and 180,000 m³ of contaminated wastes. The residues contain uranium daughters in equilibrium with average Ra-226 concentrations of 67,000 pCi/g. The wastes include soils contaminated by pitchblende ores and sediments from dikes surrounding the stored residues. The average Ra-226 concentration is 36 pCi/g in these wastes.

A brief description of the nine alternatives evaluated in the DEIS includes:

- 1) No action.
- 2a) Long-Term Management at NFSS: Modified Containment.
- 2b) Long-Term Management at NFSS: Modified Containment plus Modified Form.
- 3a) Long-Term Management at Hanford.
- 3b) Long-Term Management at Oak Ridge.
- 4a) Long-Term Management of Residues at Hanford, Waste at NFSS.
- 4b) Long-Term Management of Residues at Hanford, Ocean Dispersal of Wastes.
- 4c) Long Term Management of Residues at Oak Ridge, Waste at NFSS.
- 4d) Long-Term Management of Residues at Oak Ridge, Ocean Dispersal of wastes.

WDSHS-1

After reviewing the estimated potential environmental and economic impacts each of these alternatives represent, I would recommend Alternative 2a or 2b. With the exception of the no action alternative, these two plans are the least expensive and present the lowest probability of hazard to workers and the

WDSHS-1 Recommendation for Alternative 2a or 2b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

Nancy P. Kirner
 September 24, 1984
 Page 2

general public. In both of these alternatives there will be at least 3 meters of cover including 1.5 meters of clay used as an impermeable cap over the wastes stored at NFSS. This should provide adequate stabilization while retarding contaminant migration through groundwater and radon emanation from the tailings. In addition, Alternative 2a could be accomplished within the next several years because of the availability of funding. The other alternatives would require obtaining additional funds and could take five to ten years.

- The 180,000 m³ of contaminated wastes show concentrations of nonradiological elements at levels similar to natural soils. The low concentrations of uranium daughters are the primary contaminants. The residues however, contain high concentrations of toxic metals such as copper, nickel and lead as well as the high concentrations of radioisotopes. Analysis of both types of wastes for organic chemicals resulted in estimated average concentrations less than 26 parts per billion or below detection limits. Therefore,
- WDSHS-2 { because these wastes and residues were the direct result of the processing of uranium ores, they should be disposed of in a manner as consistent with the standards of 40 CFR 192 as site-specific conditions allow.
- WDSHS-3 { In reference to my last comment, the DEIS does not address specifically the requirements of RCRA for groundwater monitoring, lined impoundments or the measurement of 375 hazardous constituents which are all part of the 40 CFR 192. They do however, estimate impacts over 1000 years and design the cover for maintenance of integrity over 1000 years, both of which are parts of 40 CFR 192.
- WDSHS-4 { The DEIS estimates that in carrying out any of the alternatives presented, the short-term risks of occupational and transportation related injuries and death are larger than the long-term radiological health impacts, (cancer risks). This is an important argument for leaving the wastes where they are and expending efforts towards stabilization on site at the NFSS Facility.
- WDSHS-5 { Also, under "Major Laws . . . Applicable to the various alternatives on pages 1-6 and 1-7 there is no mention of RCW 70.98.
- JS:pm

- WDSHS-2 As stated in the EIS, DOE is using the 40 CFR 192 standards as guidance in making the decision about the NFSS wastes and residues. (See also Responses NYDEC-19, -20, -22; USDO1-2; USEPA-8.)
- WDSHS-3 New information indicates that the residues fail the EPA EP toxicity test (EAL Corp. 1984). Potential impacts associated with the chemicals in the NFSS materials are addressed in Section 4.4 of the EIS and will be considered in making the decision on long-term management of the NFSS materials. (See also Responses USEPA-2; WDEC-4, -5.)
- WDSHS-4 The reference to the results of the impact analysis in the EIS and the opinion about the preferability of Alternative 1, 2a, or 2b are noted. No response necessary.
- WDSHS-5 RCW 70.98 (Revised Code of Washington, Title 70, Section 98) is not applicable to DOE, per the Atomic Energy Act.

JOHN SPELLMAN
Governor



NICHOLAS D. LEWIS
Chairman

STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

Mail Stop PY-11 • Olympia, Washington 98504 • (206) 459-6490 • (SCAN) 585-6490

October 1, 1984

Ms. Barbara Ritchie, NEPA
Coordinator
Department of Ecology
Mail Stop PV-11
Olympia, WA 98504

Dear Ms. Ritchie:

The following constitutes my comments concerning the Draft Environmental Impact Statement prepared by the U.S. Department of Energy (August, 1984) on the Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site.

WEFS-1

- (1) The sweeping assumptions throughout the DEIS that the Hanford Reservation is a waste disposal facility are open to serious question. At section F.1 the DEIS states that because Hanford has a "large waste disposal facility" it will not require much expansion and thus be less costly. My question is, What large waste disposal facility? Simply because there is a large land area at Hanford does not automatically make it a waste disposal facility.

The Hanford Reservation was established as a research and production facility. There are wastes which these processes create and which must be disposed of in some acceptable manner. That is quite another matter than designating Hanford as a "large waste disposal facility." At the minimum, such a significant change would require an extensive evaluation and consultation process before it could be implemented; certainly it cannot be accomplished by a unilateral declaration in a DEIS.

WEFS-2

- (2) At repeated points in the DEIS reference is made to Hanford as an arid site which constitutes a positive condition for waste disposal. Arid sites have many fragile characteristics; the fact that you have only

- WEFS-1 The existing large waste disposal facilities at Hanford are shown in Figure 3.12, and the amounts of existing wastes are summarized in Section 3.2.7. The addition of the NFSS wastes and residues, which resulted from federal activities similar to those at Hanford, would not add significantly to the existing waste inventory on the Hanford Reservation.
- WEFS-2 As noted in the EIS, the arid conditions at Hanford offer a potential advantage in terms of groundwater contamination (Section 4.2.2) but a disadvantage in terms of airborne radioactive releases (Section 4.1.2).

Barbara Ritchie
October 1, 1984
Page 2

- WEFS-2 { a little water makes it all the more valuable.
- WEFS-3 { (3) Ongoing intensive investigations of ground water movement, surface water, seismic and other similar issues in connection with the high-level radioactive waste repository program lead me to believe that there is much more to learn about these issues. The assumptions on these points which are expressed in the DEIS and which appear to be passed on from one federal environmental analysis to another, require careful reexamination in the light of these more recent studies.
- WEFS-4 { (4) I am disappointed to note the failure of the DEIS to carefully consider alternate storage methods for wastes at Hanford. The use of vaults or other devices should be given a great deal of serious attention. The use of trenches for waste disposal, allowing pollutants to reach the accessible environment even in any quantity simply because it's a less costly solution, is open to serious question.
- WEFS-5 { (5) The section of the DEIS on transportation is seriously deficient. Transportation of large volumes of waste from one side of the country to another is a serious matter and requires a great deal of careful attention. Transportation appears to be dealt with as a side issue when, in fact, if Hanford is to be considered it constitutes a major issue.
- WEFS-6 { (6) The DEIS sections on economics, community impacts and similar matters are very deficient with regard to the Hanford site. Sweeping assumptions in the document that because nuclear materials and radioactive wastes are presently at Hanford, a large increase in waste disposal would not create a negative impact are simply not acceptable. As noted above, a substantial shift in the program mission of Hanford from research and production to waste disposal may have profound impacts on the community and state which require careful analysis.
- WEFS-7 { (7) The failure to consider other sites (G.3) because Hanford and Oak Ridge are considered typical is unacceptable. Given the prominence with which these

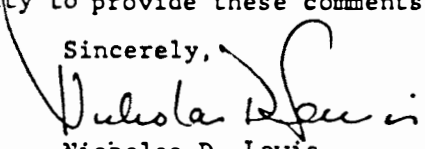
- WEFS-3 Recent studies at Hanford do not contradict the basic assumptions in the EIS, such as the relatively great depth to groundwater and the small amount of precipitation, which lead to the conclusion that groundwater contamination at Hanford will occur much later than at the humid Niagara Falls and Oak Ridge sites.
- WEFS-4 Design options at Hanford are discussed in Appendix C, Section C.3. Although vaults are not specifically mentioned, they would offer the following disadvantages: (a) airborne gaseous radioactive releases might be higher unless a deep earthen cover was placed over the vaults, (2) long-term contamination of groundwater would not be significantly affected because the vaults would not exclude infiltrating water for thousands of years, (3) the likelihood of human intrusion might be increased if the vaults were above-ground structures or decreased if they were below-ground structures, and (4) costs would be higher. Given that the Hanford alternative is the most costly, has the largest potential for environmental impact, and is not preferred, more detailed analysis of management of the residues in vaults at Hanford is not reasonable at this time. (See also Topical Response 1.)
- WEFS-5 No specific deficiencies in the transportation analysis are noted. The radiological impacts are analyzed in detail in Section 4.1, the nonradiological impacts are discussed in Section 4.6, and other transportation considerations are detailed in Appendix D. In the summary comparison of alternatives in Section 2, it is noted that implementation of Alternative 3a (all wastes and residues removed to Hanford) is expected to result in significant risk of injury and death (p. 2-12). (See also Responses NCEMC-3; USD0I-7; VCE-1, -2; WDES-1.)
- WEFS-6 There is no statement in the EIS that because nuclear materials are currently at Hanford, a large increase in waste disposal would not create a negative impact. The commenter's statement about profound impacts on the community and state are not supported.
- WEFS-7 DOE has not selected either Oak Ridge or Hanford. The preferred alternative is to leave both the wastes and residues at NFSS (Alternative 2).

Barbara Ritchie
October 1, 1984
Page 3

two sites are treated in the DEIS, one can only assume that they in fact constitute the sites under active consideration. It is difficult to see how the federal government could select an alternate site without an extensive environmental analysis.

Thank you for the opportunity to provide these comments.

Sincerely,



Nicholas D. Lewis
Chairman

NDL:lm

JOHN SPELLMAN
Governor



JACOB THOMAS
Director

STATE OF WASHINGTON
OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
111 West Twenty-First Avenue, KL-11 • Olympia, Washington 98504 • (206) 753-4011

September 4, 1984

Ms. Barbara Ritchie
NEPA Coordinator
Dept. of Ecology
Mail Stop PV-11
Olympia, WA 98504

Log Reference: 556-F-DOE-01

Re: Long-Term Management of the
Existing Radioactive Wastes
and Residues at the Niagara
Falls Storage Site DEIS

Dear Ms. Ritchie:

WOAHP-1 { A staff review has been completed of the above referenced draft environmental impact statement. We will reserve specific comments until we have received and reviewed the results of the on-the-ground survey of the project impact area.

Thank you for this opportunity to comment.

Sincerely,

A handwritten signature in dark ink, appearing to read "Whitlam".

Robert G. Whitlam, Ph.D.
State Archaeologist
(206) 753-4405

dw

WOAHP-1 DOE does not prefer the Hanford alternatives. As noted, if DOE decides to implement one of the Hanford alternatives, an archaeological survey would be performed and reviewed by the State of Washington Office of Archaeology and Historic Preservation.

JOHN SPELLMAN
Governor



JAN TVEITEN
Director

STATE OF WASHINGTON

WASHINGTON STATE PARKS AND RECREATION COMMISSION

7150 Cleanwater Lane, KY-11 • Olympia, Washington 98504 • (206) 753-5755

September 10, 1984

RECEIVED

SEP 11 1984

DEPARTMENT OF ECOLOGY
ENVIRONMENTAL REVIEW

TO: Barbara Ritchie, NEPA Coordinator
Department of Ecology - PV-11

FROM: David W. Heiser, E.P. *Dave*
Chief, Environmental Coordination

SUBJECT: 35-2650-1820
Department of Energy Draft EIS
"Long-Term Management of the Existing Radioactive Wastes and
Residues at the Niagara Falls Storage Site" (E-2707)

WSPRC-1 [The staff of the Washington State Parks and Recreation Commission has reviewed the above-noted document and does not wish to make any comment.

Thank you for the opportunity to review and comment.

at

WSPRC-1 No response necessary.



Environment
Canada
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Environmental
Protection
Protection de
l'environnement

25 St. Clair Avenue East
7th Floor
Toronto, Ontario M4T 1M2
Telephone: (416) 966-5840

Your file Votre référence

Our file Notre référence

4359-1

September 13, 1984

Mr. Robert I. Stern
Director
Office of Environmental Compliance
Department of Energy
Washington, D.C. 20585
U.S.A.

Dear Mr. Stern:

Re: Long-Term Management of the Existing Radioactive
Wastes and Residues at the Niagara Falls Storage Site

Thank you for providing this office with a copy of the above referenced draft Environmental Impact Statement. The information provided has been reviewed with particular attention to potential for transboundary impacts.

- ENCAN-1 { From this perspective, we would have no objection to the removal of all or part of the contaminated material for transfer to either the Hanford or Oak Ridge sites (alternatives 3a and 3b). As both Canada and the U.S.A. are signatories of the London Dumping Convention, we would anticipate receiving additional information should a decision be made to further pursue options involving ocean disposal (alternatives 4b and 4d).
- ENCAN-2 {
- ENCAN-3 { We are confident that long term management at the Niagara Falls Storage Site, of 180,000 m³ wastes as defined in the report, is unlikely to pose any significant threat to the Canadian environment (alternatives 4a, 4b, 4c and 4d). However, should any alternative involving the long term on site management of the 11,000 m³ of residues at the NFSS be selected by US-DOE for further consideration (alternatives 1, 2 and 2b), we would request that this office be given an opportunity to conduct a more detailing review of the pathways analysis work.

Yours truly


Shikaze
Regional Director
EPS-Ontario Region

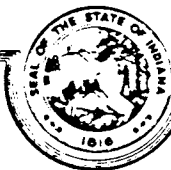
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and resources, this paper
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de l'énergie et des ressources,
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- ENCAN-1 No objection to Alternatives 3a, 3b, 4a, 4b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- ENCAN-2 Ocean disposal is not DOE's preferred alternative at this time. If ocean disposal is selected, Canada will be kept informed.
- ENCAN-3 Long-term management at NFSS (Alternative 2) is now DOE's preferred alternative. The pathways analysis is presented in Section 4.1. If any further analysis is conducted, Environment Canada will be provided with copies of any reports. (See also Responses ONT-1 to -6.)

STATE OF INDIANA



INDIANAPOLIS

STATE BOARD OF HEALTH
AN EQUAL OPPORTUNITY EMPLOYER

Address Reply to:
Indiana State Board of Health
1330 West Michigan Street
P. O. Box 1964
Indianapolis, IN 46206-1964

September 11, 1984

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
U.S. Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37831

Dear Mr. Campbell:

Re: Comments on Draft Environmental
Impact Statement

ISBH-1

A detailed review by myself and my staff reveals that the problem involved with "Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site" is social or political and not technical. There is overwhelming evidence that the waste could be stored where it is for 200 years with a near zero chance for any individual to incur any measurable radiation dose. The solution to this problem is not by moving the waste elsewhere, thereby incurring far greater risks than those involved in leaving it in place, but in implementing an effective public education program that would reduce the emotionalism involved in this and all other radioactive and toxic waste sites.

Sincerely,

Ralph C. Pickard
Assistant Commissioner for
Environmental Health

00002

ISBH-1 Preference for Alternative 1, 2a, or 2b and opinion about the need for public education programs are noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.



Ministry
of the
Environment

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de
l'Environnement

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Central
Region

Region
du
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416/521-7640

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Hamilton (Ontario)
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416/521-7640

February 5, 1985

Mr. Lowell F. Campbell
Deputy Director
Technical Services Division
US Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee
37830

Dear Mr. Campbell

Re: Long-Term Management of Existing Radioactive Wastes and
Residues at the Niagara Falls Storage Site.

From discussions with Mr. J. Alexander of your staff on
January 31, 1985, I understand that the final Environmental
Impact Statement is not yet completed. Therefore, I would
like to raise a few points which could be addressed.

- ONT-1 { At the public meeting of September 19, 1984, I obtained a
copy of the draft, "Environmental Impact Statement for the
Niagara Storage Site". The concern I have relates to the
possibility of contaminants migrating transboundary through
air, direct run-off and indirect migration through the
shallow groundwater to local streams and eventually to Lake
Ontario and/or the Niagara River.
- ONT-2 { In the summary of the Draft EIS on page vii, it is stated
that "groundwater will eventually be unavoidably contaminated
to some extent in all alternatives". This acknowledges the
potential for contamination but does not describe the extent.
The extent of the contamination and degree should be
evaluated.
- ONT-3 { Further, at the bottom of page 4-60 in the DEIS, it is
speculated that "there is probably little potential for
undetected underground piping to facilitate the migration of
contaminated groundwater from the wastes/residues at NFSS".
This emphasises the minimal likelihood but still leaves the
possibility open for contamination to migrate from the site.
Again, the extent and degree of contamination should be
assessed.



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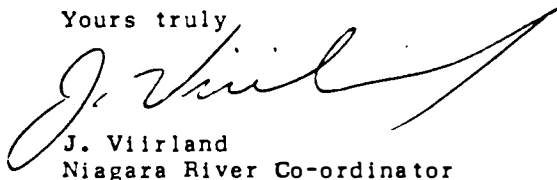
- ONT-1 The concerns about potential migration of contaminants into Canada are noted. This subject is discussed more extensively in Section 4.1, in Topical Response 2 (groundwater), and in Response USD01-3 (surface water). As noted in Section 4.1, the major pathway for potential exposure of the Canadian population is the air pathway. The expected radiation doses are insignificant compared to the doses from natural background sources of radiation. The various pathways are addressed in detail in Section 4 and are summarized in Section 2. DOE intends to take perpetual care of the site and no offsite releases of contaminants to surface waters or groundwaters are expected. Releases of radioactive substances to the air are expected to be insignificant, whether from the containment area under interim conditions (no action--Alternative 1) or the preferred alternative (improved containment--Alternative 2) as discussed in Section 4.1.
- ONT-2 The extent and degree of predicted groundwater contamination at NFSS is discussed in detail in Sections 4.2.2 and 4.4.3.1. This analysis is based on several conservative assumptions (see Topical Response 2). Even with these conservative assumptions, no contamination beyond the site boundary is expected within 1,000 years for preferred Alternative 2. Furthermore, the upper soil aquifer has limited potential use.
- ONT-3 Discussion of the underground pipes relative to potential for groundwater contamination is given in Section 4.2. During the interim remedial actions within the past few years, all known pipes were removed or grouted so that there is no known penetration through the waste containment system. Any undetected pipe would have to discharge into a sand lens that would have to be tapped by a well in order for these to be a potential risk to humans. DOE intends to continue controlling the site to preclude any drilling of drinking water wells into the near surface aquifer near the containment area.

- 2 -

- ONT-4 { There is a finite statement made on page 4-73, "Leachate from the NFSS wastes and residues will eventually contaminate the groundwater.", this sentence is followed by a qualifier which states "this contamination will occur sooner and reach higher levels if the caps are not maintained and infiltration ----increases". The question arises as to what steps are proposed to prevent this infiltration from occurring and preventing or reducing the contamination potential.
- ONT-5 { Considering all of the potential water contamination inferences, we would appreciate being kept informed of the DOE's choice of alternatives and monitoring, for the long term management of the existing radioactive wastes and residues at the Niagara Falls Storage Site. We would like to know the monitoring installation details, sampling frequency and other control measures proposed to make this a safe site and thus prevent contaminants from migrating from the site to Lake Ontario or the Niagara River.
- ONT-6 { In reviewing material for the NFSS, I have been led to believe that as part of the Manhattan project and subsequent activities, there was some refining done at facilities in the Tonawanda area. At that location, some radioactive wastes were apparently disposed. I would like to know the impact that radioactive waste disposal has had on the sub-surface environment, as well as the potential for radioactive waste and other waste to migrate through the surface or the ground-water system to the nearby Niagara River.

I trust that your office will address the concerns outlined above and describe the control measures proposed at the NFSS site as well as the impact of the Tonawanda operation on the Niagara River. I would also appreciate comments on any other site containing radioactive materials which may be located on the Niagara Frontier and which may have the potential for trans-boundary migration of contaminants.

Yours truly



J. Viirland
Niagara River Co-ordinator

cc: Environment Canada
John Spagnoli, Regional Director, New York DEC
Norman Nosenchuck, Director, Solid and Hazardous Waste,
New York DEC

JV/kt

- ONT-4 Although infiltration cannot be prevented, it is expected that a multilayered cap as designed for preferred Alternative 2 will minimize infiltration. DOE intends to provide perpetual care and maintain the cap. Even if it is conservatively assumed that the cap is not maintained, no offsite contamination is expected for at least 1000 years (Section 4.2).
- ONT-5 Details of the monitoring program are not yet available. They will be summarized in the Record of Decision. The Ontario Ministry of the Environment has been placed on the mailing list for the Final EIS, the Record of Decision, and the annual monitoring reports.
- ONT-6 The site at Tonawanda, New York (now occupied by the Linde Air Products Division of Union Carbide Corporation), is being dealt with as a separate project under DOE's Formerly Utilized Sites Remedial Action Program. The Ontario Ministry of the Environment will be informed of any DOE plans to take remedial actions at that site. From 1943 to 1946, a uranium extraction process was operated by the Linde Air Products Company (now Linde Air Products Division of Union Carbide Corporation), Tonawanda, New York. Onsite wells and sewers were used for disposing of effluents containing above-background concentrations of radionuclides. There is no indication that the discharge resulted in any radiation-associated hazards during or following the operation of the facility. Radiological surveys of the disposal pathways at the facility and vicinity properties did identify some above-background concentrations of uranium, radium, and thorium and their decay products. However, the concentrations are so low that any incremental radiation exposure to workers or the general public, as well as any added health risk, is negligible.



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
P.O. Box 2063
Harrisburg, PA 17120



September 28, 1984

Lowell F. Campbell
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

PDER-1 { We have reviewed the Draft Environmental Impact Statement for the Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site.

{ We have no comments on the Draft EIS at this time. Thank you for allowing us to review this project.

Sincerely,

A handwritten signature in dark ink, appearing to read "W. A. Cook".

William A. Cook
Acting Director
Secretary's Office of Policy

PDER-1 No response necessary.



ER 84/1104

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

NOV 2 1984

Lowell F. Campbell, Deputy Director
Technical Services Division
U.S. Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

Thank you for your letter of August 17, 1984, transmitting copies of the draft environmental impact statement for Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site, Niagara County, New York, for review. Our comments are presented according to the format of the statement or by subject.

Summary Description

- USD01-1 { The extent of the "gray clay layer" under the Niagara Falls Storage Site (NFSS), and into which the subsurface cutoff wall is keyed, should be determined in evaluating impacts from the use of the site. The effects from possible gaps in the impermeable layer should be evaluated, and appropriate mitigation should be presented elsewhere in the document.

Fish and Wildlife

- USD01-2 { The fish and wildlife resources at the NFSS, the Hanford Reservation, the Oak Ridge Reservation, and the Ocean Disposal Site are described briefly in the statement. As acknowledged in the draft statement, the radioactive materials to be disposed are also toxic and will remain dangerously radioactive for thousands of years. The disposal methods discussed in the document will not isolate these hazardous wastes from the environment, and contaminated materials will likely be dispersed from the sites via both physical (e.g., leaching, groundwater contamination, erosion) and biological (e.g., plant roots, burrowing animals, uptake by microorganisms) transport pathways. Once taken up by living organisms, these wastes are likely to become incorporated in a variety of food webs, where bioaccumulation may occur. Numerous fish and wildlife species, as well as man, could be adversely affected through these pathways. Burrowing animals and plant roots are briefly mentioned as possible agents penetrating the storage sites. Although section 4 contains a general discussion of the problem, it is not clear that this issue has been considered in the risk calculations. Further consideration is needed in this area, including better information on species likely to penetrate each site, and an assessment of the likely dispersal of the radioactive materials from these species.
- USD01-3 { The Niagara River and Lake Ontario are in close proximity to the Niagara Falls site and could receive contaminated surface and groundwater flows from the site. The Niagara River and Lake Ontario contain significant international fish and wildlife resources that

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- USDOI-1 As noted in Section 4.2.2, the cutoff wall is conservatively assumed to have no beneficial effect relative to long-term migration of contaminants. It is also conservatively assumed that the average hydraulic properties of the existing clayey soils beneath the containment area are between the properties of clay and sand (Table 4.39). The effect of a possible "gap" in the clay layer is analyzed by assuming that there is a large sand lens immediately adjacent to the containment area and that a well is drilled into that lens. Impacts will be less than predicted if the properties of the wastes and underlying geological formations are better than those assumed for the analysis (e.g., lower hydraulic conductivity or higher distribution coefficient), the sand lenses are small or do not exist, or no one drills such a well. (See also Topical Response 2.)
- USDOI-2 As noted in the introduction to Section 4, uncertainties increase significantly beyond 1000 years. At this time, it is not possible to predict the impacts of eventual dispersion into the environment. The future meteorological conditions, rate of dispersion, nearby population size and distribution, and other critical factors cannot be estimated with any accuracy for thousands of years into the future. The worst-case resident-intruder scenario is analyzed in Section 4.1.2.3. (See also Responses NYDEC-19, -20, -22; USEPA-8; WDSHS-2.)
- USDOI-3 Even if the NFSS wastes and residues were exposed, no impact on the fish and wildlife resources of the Niagara River and Lake Ontario are expected. If the rate of erosion of the NFSS wastes and residues is similar to the rate of erosion of the natural soils in the Lake Ontario watershed, the incremental contribution of the naturally occurring radionuclides from the NFSS wastes and residues would be equal to that normally contributed by the soil eroded from 65 km² (25 mi²)--or that naturally contributed by erosion from the Town of Lewiston. The contribution from the same area of the granitic-derived soils in Canada (which have a higher concentration of the naturally occurring radionuclides than the soils in the Niagara Falls area) would be higher than the contribution from the eroded NFSS wastes and residues. The total load of naturally occurring radionuclides on Lake Ontario would not be significantly increased if the NFSS wastes and residues were exposed and eroded into the lake. (See also Response BROSS-5.)

Lowell F. Campbell, Deputy Director

2

USDOI-3 { are protected by the Migratory Bird Treaty Act, the Great Lakes Fisheries Act, the Endangered Species Act, and by other international acts.

USDOI-4 { At Oak Ridge, the Clinch River is the major water body draining the Reservation, and the area of this river just below Melton Hill Dam near Oak Ridge is a significant spawning area for striped bass. Migratory birds frequenting the Oak Ridge Reservation include Canada geese, wood ducks, mallards, and canvasbacks.

USDOI-5 { Similar problems exist at the Hanford site. We note that even less attention is given to wildlife resources at this site than at the other two. The draft statement suggests that this might be the safer site for storage because of its lower rainfall, but that the cost and safety problems of transferring material to the site might make it a less likely choice. A brief discussion of previous dispersal of stored radioactive wastes at this site by burrowing animals, is found on page 3-24. Should further consideration be given to the Hanford site, it is essential that coordination be carried out with the FWS Field Supervisor at Olympia, Washington.

Mitigating Measures

USDOI-6 { The discussion of mitigating measures on page 4-64 should include engineering or other remedial methods that could be used in the event that movement of contaminants in the shallow aquifers exceeds predictions.

USDOI-7 { The possibility of a transportation accident leading to exposure of the radioactive wastes/residues may be low as noted on Table 3.5 and the dispersal of such materials to surface water from burial even lower, but the mechanisms to deal with the possibilities should be discussed.

Alternatives

USDOI-8 { All alternatives could involve dispersion of wastes/residues to surface water through erosion, runoff, and sedimentation by natural processes occurring while the interim cap is off or as the result of a transportation accident. It is stated on page 4-15 that "Effective implementation of erosion, runoff, and sedimentation controls can mitigate" the adverse impacts of exposure particularly for a thunderstorm during interim cap removal. These controls should be identified.

USDOI-9 { We also recommend that serious attention be given to transportation by rail, which would minimize truck transportation of the radioactive materials.

Groundwater

USDOI-10 { It is assumed on page 4-62 that no shallow wells will ever be allowed near the NFSS. However, under alternatives 2a, 2b, 4a, and 4c the NFSS site, including a buffer area, will be reduced to 39 acres as noted on Table 4.58. The other portions of the property would then be released (pages 4-86 and 4-87). The final statement should include a worst-case analysis to indicate the time required for hazardous or maximum

- USDOI-4 The information is noted. If one of the Oak Ridge alternatives is selected (not preferred at this time), DOE will further coordinate with the Asheville FWS Field Office.
- USDOI-5 If one of the Hanford alternatives is selected (not preferred at this time), DOE will further coordinate with the Olympia FWS Field Office.
- USDOI-6 The only mitigative measure contemplated at this time is to prohibit the use of groundwater from shallow wells located onsite near the containment area. A monitoring program is intended to detect movement of contaminants in groundwater. If unexpected movement is found, appropriate mitigative measures will be taken. (See also Topical Response 2.)
- USDOI-7 Transport of the contaminated materials to another site is not preferred at this time. If DOE decides to implement such an alternative, detailed plans for dealing with transportation accidents will be developed. Likewise, plans for surveying, cleanup, and dispersal to surface water sediments will be developed. (See also Responses NCEMC-3; VCE-1, -2; WDES-1; WEFS-5.)
- USDOI-8 Identification of specific erosion-control measures would be part of the detailed engineering effort prior to actual implementation of one of the removal alternatives. It is expected that the controls would be similar to those that have been effective during the interim remedial actions at NFSS (U.S. Dep. Energy 1982a, 1982b, 1983a, 1983b). Removal of the wastes and residues to another site is not the preferred alternative at this time. (See also Response PEELE-4.)
- USDOI-9 Detailed consideration of rail transportation is given in Appendix D, Section D.5.
- USDOI-10 A conservative analysis, assuming a well is located immediately next to the containment area, is presented in Section 4.2.2 (see Tables 4.40 and 4.42). Concentrations of radium-226 (the radionuclide of most concern with respect to groundwater contamination) at various locations downstream of NFSS are shown for each alternative in Table 4.41. For preferred Alternative 2, radium-226 concentrations in the onsite well are expected to peak in 3,600 years. At a point halfway to Lake Ontario (4,000 m), no contamination is expected for at least 32,000 years (the point at which the computer program was aborted). At 1,000 years, the time for which EPA has determined it is reasonable to design the containment system, it is predicted that contaminants will not have migrated to the site boundary. (See also Topical Response 2.)

Lowell F. Campbell, Deputy Director

3

- USDOI-10 concentrations of radionuclides and other contaminants to reach the revised boundary. We suggest that at least representative analyses from the existing monitoring wells should be included in the final impact statement to aid in evaluation of impacts from the proposal.

Endangered Species Act

- USDOI-11 Except for occasional transient species, no federally listed or proposed endangered or threatened species under our jurisdiction are known to exist in the Niagara Falls Storage Site area. Therefore, no Biological Assessment or further Section 7 consultation under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) is required with the U.S. Fish and Wildlife Service (FWS) for work at that site. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

- USDOI-12 As noted on page 3-36 of the draft statement, endangered species observed on or near the Oak Ridge Reservation include the Indiana bat, gray bat, bald eagle, peregrine falcon, and red-cockaded woodpecker. Two status review plant species potentially occurring on the site are the Appalachian bugbane (*Cimicifuga rubifolia*) and Carey's saxifrage (*Saxifraga careyana*). Information contained in the draft statement is insufficient to meet the requirement for a Biological Assessment for the Oak Ridge site, as described in the letter of September 28, 1983 (pages J-4 and J-5) from our Endangered Species Field Office in Asheville, North Carolina. For further consideration of this site, it is essential that you prepare a Biological Assessment and consult further with the Supervisor, Endangered Species Field Office, Plateau Building, Room A-5, 50 South French Broad Avenue, Asheville, North Carolina 28801 (phone 704 258-2850, ext. 321; FTS 672-0321).

- USDOI-13 On page 4-67 is the statement that "There are no endangered or threatened species at the NFSS or Hanford sites." This conflicts with the observation on page 3-26 that "some endangered or threatened raptors use the [Hanford] site." In addition, certain plant species that are being reviewed for potential listing may occur on or near the Hanford site. Appendix J contains letters from FWS concerning endangered species at the other two sites, but none for the Hanford site. Should the Hanford site continue to be considered seriously for this project, you will also need to meet the Biological Assessment requirement for that site. For a list of species that may be present in the action area, and for guidance on the Biological Assessment requirement and other possible requirements, it is essential that you consult directly with the Supervisor, Endangered Species Field Office, Building A, 2695 Parkmont Lane, Olympia, Washington 98502 (phone 206 753-9444; FTS 434-9444).

Fish and Wildlife Coordination Act

- USDOI-14 During the construction phase of this project, adverse impacts on fish and wildlife resources should be minimized as much as possible, and appropriate mitigation should be provided for unavoidable adverse impacts. Strict erosion, sedimentation and air quality control measures should be utilized during construction. A carefully designed monitoring program should be followed throughout the project, including the monitoring of fish and wildlife resources prior to, during, and after construction. The FWS should be involved in the development and implementation of this program.

USDOI-11 Information is noted. No response necessary.

USDOI-12 DOE agrees that the information contained in the EIS is insufficient to meet the requirement for a Biological Assessment at Oak Ridge. As noted in Section 4.3.1, before DOE could implement any of the Oak Ridge alternatives, surveys would have to be conducted to determine the presence of threatened or endangered species. The Oak Ridge alternatives are not preferred at this time.

USDOI-13 The Olympia FWS Field Office was contacted during the scoping process, both by letter and by phone, and had no comments to offer regarding endangered species at the Hanford site. The particular site considered in the EIS is an extension of an existing waste-burial area on a large plateau. No existing impacts on endangered species, including the bald eagle, have been identified by either FWS or DOE. The Hanford alternatives are not preferred at this time. If DOE decides to implement one of the Hanford alternatives, the Olympia FWS Field Office will be contacted again.

USDOI-14 If DOE decides to implement any of the removal alternatives where there would be potential for impacts on fish and wildlife at other sites, the Department of the Interior will be contacted relative to detailed planning and mitigation. These alternatives are not preferred at this time.

Lowell F. Campbell, Deputy Director

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USDOI-15 { While the draft statement does indicate the possible need for other interrelated Federal actions, such as U.S. Army Corps of Engineers Section 404 permits, insufficient information, including site-specific location, design, and measures to minimize harm, is provided for a full understanding and an evaluation of how the proposed action and interrelated Federal actions may affect fish and wildlife resources. The FWS will evaluate and report on each of the permit applications pursuant to the Fish and Wildlife Coordination Act. During the review of these applications, the FWS would most likely recommend that adverse environmental impacts be avoided as much as possible. Strict erosion and sedimentation control measures and time-of-year construction restrictions may be recommended. Because of these concerns, you are urged to further coordinate project planning with the Field Supervisor, U.S. Fish and Wildlife Service, 100 Grange Place, Room 202, Cortland, New York 13045 (phone 607 753-9334; FTS 882-4246). Further planning at the Oak Ridge site should be coordinated with the Field Supervisor, U.S. Fish and Wildlife Service, P.O. Box 845, Cookeville, Tennessee 38 502 (phone 615 528-6481; FTS 852-5057), and at the Hanford site with the Field Supervisor, U.S. Fish and Wildlife Service, Building B-3, 2625 Parkmont Lane, Olympia, Washington 98 502 (phone 206 753-9440; FTS 434-9440).

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,


Bruce Blanchard, Director
Environmental Project Review

USD0I-15 See Responses USD0I-5, -8, -12, -13, and -14.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II
26 FEDERAL PLAZA
NEW YORK NEW YORK 10278

23 OCT 1984

Mr. Lowell F. Campbell, Deputy Director
Technical Services Division
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37831

Dear Mr. Campbell:

We have reviewed the draft environmental impact statement (EIS) for the Long-Term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site (NFSS), located near Lewiston, New York. In the interest of providing a comprehensive review of the draft EIS, the Environmental Protection Agency's (EPA's) Office of Federal Activities in Headquarters has requested that we coordinate our response with EPA's Region IV and Region X offices since the draft EIS proposes different disposal options at the Department of Energy (DOE) Oak Ridge Reservation near Oak Ridge, Tennessee, and the DOE Hanford Reservation near Richmond, Washington. Comments from EPA Region's II, IV, and X are provided on the draft EIS and included as attachments for your consideration.

USEPA-1 { The draft EIS defines and analyzes nine potential alternatives for the long-term management of radioactive residues (produced from the processing of uranium ores) and wastes (primarily existing in the form of contaminated soils). However, the draft EIS does not present a selected or preferred alternative(s). According to the Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA), a preferred alternative(s) should be identified by the lead agency in the draft EIS [40 CFR Part 1502.14(e)].

However, when an agency fails to identify a preferred alternative in the draft EIS, EPA rates each alternative according to the analyses provided. The rating for each of the nine alternatives are discussed below. Specific technical comments regarding each of the alternatives are provided in separate attachments.

USEPA-2 { In general, we would recommend that a cost-effectiveness screening procedure be used to eliminate certain alternatives as described in section 300.68 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Oil and Hazardous Substances Contingency Plan. The procedure eliminates alternatives that are an order to magnitude more costly through a least-cost analysis where significant environmental or public health protection can not be distinguished. EPA is currently developing guidance for implementing this procedure. Although unpublished, Region II has had experience in utilizing

See 000073

USEPA-1 In subsequent correspondence EPA indicated that:

"In general, we are encouraged by DOE's decision to identify its preferred alternative in the final EIS for NFSS. We believe that making its recommendations known prior to the Record of Decision will enhance the National Environmental Policy Act (NEPA) review process for this project."

The CEQ regulations state that the agency [DOE] shall "identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such preference" [40 CFR 1502.14(e)]. DOE did not have a preferred alternative at the time of publication of the Draft EIS. Now that the Draft EIS has been reviewed by federal, state and local officials and the general public, DOE has selected Alternative 2 as the preferred alternative, and it is so identified in this Final EIS. (See also Response NYDEC-2.)

USEPA-2 DOE appreciates EPA's offer to informally apply its CERCLA 300.68 screening procedure to the range of possible project alternatives at NFSS. If this project were in the early phases of development, EPA's assistance in applying the screening procedure would be considered. However, it is believed that the information and analyses currently contained in the EIS, along with other information available to the Department, are sufficient to support identification of the preferred alternative in this Final EIS. (See also Responses WDEC-4, WDSHS-3.)

USEPA-2 | draft guidance to carry out similar analyses at other complex, hazardous waste sites. Our Emergency Response and Remediation Division has offered to assist the DOE in applying this screening procedure for this aspect of the project.

Rating of each Alternative

USEPA-3 | Alternative 1: No Action - Class EC-2.

- Alternative 1 involves the continued storage of all residues and wastes within the diked containment area in the southwest corner of NFSS. The containment areas is surrounded by a dike and subsurface clay cutoff wall and is capped with 1.5 m (5 ft) of clay, sand, and soil. The entire NFSS site will remain under DOE ownership and control.

Alternative 2a: Long-Term Management at NFSS, Modified Containment - Class EC-2.

- Under Alternative 2a, further actions will be taken to improve the long-term containment of the wastes and residues at NFSS. Such actions include removal and temporary storage of the upper layers of the interim cap and construction of a long-term cap. The long-term cap is 1.7-m (5.5-ft) thicker than the interim cap and will have extra clay and a layer of riprap (graded layers of gravel and rock). Only the containment area and a small buffer zone will be retained under DOE ownership and control.

Alternative 2b: Long-Term Management at NFSS, Modified Containment Plus Modified Form - Class EC-2.

- Under Alternative 2b, in addition to the improved containment system described for Alternative 2a, the residues will be modified physically and chemically to reduce the rate of long-term migration of contaminated materials from NFSS. The residues will be removed from the containment area and processed to extract valuable constituents (e.g., uranium, cobalt, nickel, molybdenum, and lead). Once processed, the vitrified (glass) residue slag and some pre-precipitates will be reburied in the diked containment area, the processing facilities will be decontaminated and demolished, and the entire waste-containment area will be covered with the long-term cap. Only the containment area and a small buffer zone will be retained under DOE ownership and control.

Alternative 3a: Long-Term Management at an Arid Site (Hanford) - Class EO-2

- Under Alternative 3a, both the residues and the wastes will be excavated from the containment area at NFSS and transported by truck to a radioactive waste-management site (218W5 Area) on the DOE Hanford Reservation near Richland, Washington. The residues will be packaged in large metal containers and transported on either flat-bed trailers or in shielded vans. The wastes are classified as non-radioactive under current transportation regulations and will be shipped in large dump trucks. About 16,000 truckloads will be needed to transport the wastes and residues over 4000 km (2500 mi) to Hanford. Following transport of the wastes and residues to the Hanford site, the excavated areas will be filled and regraded and NFSS will be released for other

USEPA-3 The EPA has identified environmental concerns for Alternatives 1, 2a, and 2b and environmental objections for Alternatives 3a, 3b, 4a, 4b, 4c, and 4d. The primary reason for the ratings is the potentially significant environmental impacts if the wastes and residues are transported offsite. These impacts are discussed in the EIS and DOE will take them into consideration in making the decision on long-term management of the NFSS wastes and residues. Only the residues would be classified as radioactive for transportation purposes (Sections 4.7.3 and D.2). DOE agrees with EPA's concern about the risk of transporting 16,000 truckloads of wastes and residues. The EPA's environmental ratings were taken into consideration in deciding to identify Alternative 2 (leave contaminated materials at NFSS) as the preferred alternative.

In subsequent discussions with EPA, it became clear that EPA believes that more information than is available in the EIS is necessary to ensure that all reasonable steps will be taken to ensure the continued integrity of the containment system at NFSS and to minimize the potential for release of contaminated materials to the environment. DOE will send EPA the additional documents noted in Figure 1.3 (Niagara Falls Storage Site: DOE Decision-Making Process) when such documents are available.

USEPA-3

use. At Hanford, the contaminated materials will be buried in 42 burial trenches in a manner similar to current practices for burial of other types of solid radioactive wastes at the Hanford Reservation. The residues and wastes will be covered with 3 m (10 ft) of local earthen materials, including a layer of riprap.

Alternative 3b: Long-Term Management at a Humid Site (Oak Ridge) - Class EO-2

- Under Alternative 3b, all the NFSS wastes and residues will be excavated and transported by truck to the Pine Ridge Knolls site on the DOE Oak Ridge Reservation near Oak Ridge, Tennessee. About 16,000 truckloads will be required, with a transportation distance of about 1200 km (750 mi). Following transport of the wastes and residues to the Oak Ridge site, the excavated areas at NFSS will be filled and regraded and NFSS will be released for other use. At Oak Ridge, the wastes and residues will be stabilized in several mounds. The mounds will be covered with a long-term cap similar to the cap at NFSS for Alternatives 2a and 2b.

Alternative 4a: Storage of Residues at Hanford/Long-Term Management of Wastes at NFSS - Class EO-2

- Under Alternative 4a, the residues will be excavated, packaged, and transported to Hanford as in Alternative 3a. About 1,600 truckloads will be needed. The residue packages will be buried in 10 trenches at Hanford. The wastes will remain at NFSS and will be covered with a long-term cap identical to that described for Alternative 2a. The containment areas and small buffer zones at NFSS and Hanford will be maintained and monitored.

Alternative 4b: Offsite Storage of Residues at Hanford/Ocean Disposal of Remaining Wastes - Class EO-2

- Under Alternative 4b, the residues will be excavated, packaged, and transported to Hanford as described for Alternative 4a. All remaining wastes will be excavated, transported in bulk in dump trucks to a dock in the New York/New Jersey harbor area, loaded onto barges, and transported to the 106-Mile Ocean Waste Disposal Site (Site 106) for dispersal. After removal of all wastes and residues from the site, NFSS will be released for other use. Only the residue containment area and a small buffer zone at Hanford will be maintained and monitored.

Alternative 4c: Offsite Storage of Residues at Oak Ridge/Long-Term Management of Waste at NFSS - Class EO-2

- Under Alternative 4c, the residues will be excavated, packaged, and transported to Oak Ridge as in Alternative 3b. About 1,600 truckloads will be needed. The residue packages will be stabilized in mounds and covered with a long-term cap similar to that described for Alternative 3b. The wastes will remain at NFSS and will be covered with a long-term cap identical to that described for Alternative 2a. The containment areas and small buffer zones at NFSS and Oak Ridge will be maintained and monitored.

USEPA-3 | Alternative 4d: Offsite Storage of Residues at Oak Ridge/Ocean Disposal of
Remaining Wastes - Class EO-2

- Alternative 4d is identical to Alternative 4c except that the NFSS wastes will be disposed in the ocean instead of remaining at NFSS. Ocean disposal will be the same as for Alternative 4b. After removal of all wastes and residues from the site, NFSS will be released for other use. Only the residue containment area and a small buffer zone at Oak Ridge will be maintained and monitored.

Explanation of Ratings

USEPA-4 | In accordance with EPA policy, we have rated alternatives as either EC-2 or EO-2, indicating that we have either environmental concerns (EC) or environmental objections (EO) to the proposed actions and that in all cases that we require more information (2) to better evaluate potential environmental impacts. The primary reason that EPA has differentiated between the EC and EO ratings is that significant environmental impacts may result if any of this material is transported off-site. Sufficient information has not been provided which justifies the potential risk of transporting 16,000 truckloads of radioactive material to the Hanford or Oak Ridge facilities or an ocean dumping site. Please be advised that we also maintain concern for the proposed NFSS alternatives (2a & 2b). Additional variations of these alternatives should also be examined in depth, including deep-well injection and above-ground storage using concrete modules.

At this time I would like to thank you for this opportunity to comment and if you have any questions please feel free to contact me or Mr. Christopher Militischer of my staff at (212) 264-1892 or 264-0522, respectively.

We have also included a list of EPA contacts should you have questions concerning the specific comments that have been provided in the attachments.

Sincerely yours,


Richard M. Walka, Chief
Environmental Impacts Branch

Attachments

cc: Mr. Edward G. Delaney, DOE
Mr. Jake Alexander, DOE

USEPA-4 In subsequent correspondence, EPA indicated that:

"EPA remains concerned that DOE has not yet adequately demonstrated that any of the containment alternatives evaluated to-date present the most environmentally acceptable management option. All of the on-site alternatives identified in the draft EIS would result in adverse impacts to groundwater from migration of radioactive contaminants into the underlying aquifer(s). For this reason, we strongly recommend that DOE evaluate additional engineering enhanced disposal options (e.g., the 'French' system) which have the potential to reduce groundwater and radiological impacts. Additional engineering-enhanced barriers such as a concrete bunker should also be evaluated."

EPA provided the following comments in this correspondence.

"Hydrofracture for the purpose of injecting hazardous material is a relatively new technique. Hydrofracture, when used for injection purposes, must be carefully evaluated and engineered in order to avoid fracturing confining zones. If this alternative were selected, future drilling activities for hydrocarbons, wellwater, etc., would have to be banned in the immediate area of the injection site at NFSS. Existing wells in the area of the injection site would also have to be inventoried, monitored, and tested periodically for mechanical integrity. Any wells which were found to be potential conduits for the migration of contaminants would have to properly plugged and abandoned. ... Upon review, we concur with DOE that hydrofracturing and grout disposal has several disadvantages (e.g., residues would be in an irretrievable form). Site-specific geologic and seismic activity considerations increase the inappropriateness of using this method at NFSS. The proximity of the NFSS to a public drinking water supply (i.e., the Niagara River) also makes this disposal method less acceptable because of the potential for contamination resulting from leakage of a shale bed. ... In the context of the above discussion, EPA recommends that hydrofracture be addressed in the final EIS as an alternative that was considered during the EIS process. However, we would concur with DOE's determination that this alternative does not appear to be feasible because of the reasons discussed above and in Topical Response 2.

Although deep-well injection does not appear to be a feasible alternative for semi-solid and solid radioactive wastes at NFSS, injection of the wastes in a fluid form into a formation underlying a competent confining zone may be a potentially viable alternative. The EIS should discuss whether an underlying competent confining zone is present at NFSS and should identify whether, from a strict hydrogeologic standpoint, this option is feasible. This issue should be discussed in the final EIS. ... In general, we recognize that permanent disposal of these alternative wastes and residues may make retrieval infeasible or impractical if leakage is detected at some point in the future. ... However, deep-well injection of the radioactive wastes may be a more viable disposal option in the future as the technological aspects of retrievability become better known. The final EIS should discuss the deep-well injection alternative in light of its present and future viability, and provide a cost-risk assessment if it is selected as the preferred alternative.

Storage in concrete bunkers or vaults is a method of long-term management that offers several important advantages, as outlined in Topical Response 2. The ability to collect and monitor leachate from the vaults or bunkers makes it attractive from the standpoint of limiting migration of radionuclides off-site. One important disadvantage, also discussed, is the increased potential for airborne release of radioactive gases (radon). However, if the vaults were covered with a thick clay/soil layer, as shown on page 6-15 of the Engineering Evaluation Report [Bechtel Natl. 1984], this potential release could be minimized. ... The suggested disadvantage of higher costs to construct and maintain this disposal method has not been documented in detail. The disadvantage of increased likelihood of human intrusion is reasonable, provided that the vaults are above ground. ... One possible variation on this option, which was not discussed in the engineering report or in DOE's draft response to EPA's comments, is the alternative of a modified concrete containment structure with an earthen cap. This structure could be constructed below ground level, such that the top is at ground level and capped with the clay/soil layer, as described for the other on-site containment options in the draft EIS. We believe that this alternative could reduce, and possibly eliminate, vertical migration of contaminants from the waste containment area; it would also provide for a more permanent, resistant structure. Other advantages include the ability to collect and monitor leachate, and the fact that containment of the wastes and residues in the concrete would prevent increased volumes of soil/material from becoming contaminated. The final EIS should provide a cost-risk assessment for this variation of on-site containment.

EPA believes that of all the material stored at NFSS, K-65 residues present the most significant environmental threat to human health. Furthermore, we maintain our concern that DOE has not yet adequately demonstrated that any of the on-site containment alternatives are environmentally acceptable. As suggested at the EPA/DOE meeting on March 25, 1985, a more acceptable on-site containment system may be provided at NFSS by employing

Attachment No. 1

EPA Region II Comments

EPA Region II has reviewed the Niagara Falls Storage Site Draft Environmental Impact Statement (DEIS) and we offer the following comments.

- USEPA-5 { 1. The DEIS gives no historical background of the site at NFSS. As of late spring 1984, much of the residue was still contained in a concrete silo on the site. Part of the ongoing interim remedial action involves relocating these residues to the bottom of building 411. The silo will then be demolished and the rubble moved inside the containment area. The wastes will then be used to cover building 411 and the ground in the diked area. The interim cap of clay, sand, soil, and grass will then be put in place. Information concerning these ongoing interim actions should be provided in the final EIS.
- USEPA-6 { 2. Several of the long-term management alternatives include disturbing the cap for movement of material or vitrification of residue. Even long-term management at NFSS with modified containment (alt. 2a) includes removing the upper layers of the interim cap. The cap material is stored temporarily while additional barrier layers are added and the site work completed. A rationale should be included which would indicate why this extra movement of materials is warranted in view of the potential for dust and worker exposure with each movement.
- USEPA-7 { 3. The properties bordering the NFSS include two landfills and a hazardous waste disposal facility. The EIS contains no determination of what effect these facilities and their operation might have on the integrity of NFSS site or vice versa. The possible synergistic effects of chemicals involved in these areas should be covered in the final EIS. That document should also address the effect that an emergency at one of these sites would have on the other. The EIS should detail any possible restriction on plans for expanding or upgrading the hazardous waste facility due to its proximity to the NFSS site.
4. While there are no standards or guidance formally adopted or in place from which to assess the adequacy of the possible alternatives (EPA's standard setting program for residual radioactivity currently has a 1987-8 target date for standard/guidance issuance) the Uranium Mill Tailings Radiation Control Act standards do address similar issues for similar materials. Therefore, 40 CFR 192 Sub-part A - "Standards for the Control of Residual Radioactive Materials from Inactive uranium Processing Sites" was used for guidance in reviewing the proposed alternatives.
- USEPA-8 { a. Alternative 1
- The cap utilized in this alternative could experience a failure as early as 650 years. This falls short of the reasonably achievable 1000 year time span for control listed in the regulations. All of the other caps proposed would be expected to last for at least 1300 years.

USEPA-4 (cont.) a stabilized matrix for the K-65 residues. This engineering-enhanced technique would require additional analysis by DOE. In particular, the "French-system", which utilizes a concrete matrix to stabilize radioactive materials, could provide improved containment of the radioactive residues in a more permanent form. We strongly recommend that the DOE evaluate this option, both from a technical feasibility standpoint and with respect to cost-risk assessment, prior to selection of the preferred alternative and issuance of the final EIS.

As an ongoing effort during the long-term management of radioactive wastes and residues at NFSS, the DOE should reevaluate off-site disposal options at periodic intervals (e.g., every 5 to 10 years). Because DOE is stressing the management of this material for a period of 200 years, the reevaluation of viable off-site disposal options may present more cost-effective and environmentally sound methods of dealing with this material in the future. This approach implies that the technology for transporting and disposing of radioactive wastes and residues may be significantly improved at some point in the future."

Several variations of the basic alternatives are discussed in Appendix C. DOE's selection of basic alternatives for detailed analysis in this EIS was based on public and technical scoping input. The range of alternatives chosen is consistent with the tentative listing included in the Notice of Intent (U.S. Dep. Energy 1983c), except that Alternative 4 involving separate handling of the residues has been added. The alternatives are consistent with EPA regulations for uranium mill tailings (40 CFR 192) that DOE is using for guidance.

Management concepts involving greater isolation, particularly for the residues, were also considered in less detail in Appendix C. As a result of further discussions with EPA, DOE has given further consideration to two options that EPA suggested for greater isolation of the residues: (1) an additional intruder barrier (additional to the 1-m layer of rock riprap in the cap), and (2) the "French system". These are discussed in Topical Response 1.

The detailed information in the main body of the EIS regarding potential environmental impacts associated with the various alternatives involving near-surface management of the NFSS wastes and residues, as well as the less detailed information on other designs, will be considered in reaching the major decision. Further detailed engineering and supporting analyses will be considered at the time of implementation of the selected alternative. If a decision is made to implement the preferred Alternative 2, later implementation decisions will include details of the final cap, the additional intruder barrier, and the residue form (see Figure 1.3).

- USEPA-5 Historical background of NFSS is given in Sections 1.1 and 1.2. As required by the CEQ regulations (40 CFR 1502.21), several documents giving more detailed historical information are incorporated by reference. These documents are available in the public reading rooms and libraries that have the EIS. The projected results of the interim actions (e.g., all wastes and residues consolidated within the containment area) are important as the baseline for analysis of the long-term management alternatives in the EIS and are, therefore, summarized in Section 1. The no-action alternative (1) is based on the assumption that all interim remedial actions are completed.
- USEPA-6 The interim cap is being constructed as part of maintenance operations to protect the wastes from erosion. DOE believes that it would not be responsible to delay the interim cap construction until a decision regarding long-term management of the wastes and residues could be reached and implemented. Therefore, partial or total removal of the interim cap will be necessary for the preferred Alternative 2 (about 0.9 m [3 ft] of clay would be left intact) and total removal would be necessary for any of the alternatives involving complete removal of the wastes and residues from NFSS.
- USEPA-7 One effect that operations at SCA or other nearby developments may have on the integrity of the NFSS site is the possible change of drainage patterns upstream or downstream of NFSS, resulting in flooding of the NFSS containment area. This potential impact is discussed in Section 4.2.1.2. It is noted in this section and in the summary of impacts in Section 2.1.2 that the drainage system (ditches) above and below NFSS will need to be controlled so that the containment system is not jeopardized. Implementation of the various alternatives relative to surrounding land uses at NFSS are discussed in Section 4.6.2.1. An emergency at one of the surrounding sites could adversely affect one of the action alternatives at NFSS by causing NFSS operations to be suspended because of potential danger to NFSS workers from the other sites. However, it is anticipated that an emergency at NFSS (e.g., a spill of residues--Section 4.1.2) would not affect activities at surrounding sites. DOE has no plans that would restrict expansion of the SCA hazardous waste site. (See also Responses BROSS-7, and USEPA-31.)
- USEPA-8 In the analysis in Section 4.2.1, two extreme land uses were assumed in order to bound the probable erosion rates. The cap in Alternative 1 would fail in 650 years only in the

- USEPA-9 { b. Alternatives 3a, 4a, 4b
- Due to the drier condition and sandy soil at Hanford, these alternatives fail to meet the Radon-222 release rate criteria of less than 20 pico-curies per square meter per second specified in 192.02(b).
- USEPA-10 { c. The other alternatives appear to conform to the standards. The least expensive alternative which meets the guidelines is alternative 2a which is storage at NFSS with a long-term cap. The matter of going directly to a long-term cap should be reviewed, especially in light of the cost-effectiveness of alternative 2a.
- USEPA-11 { 5. In Table 4.2 of the DEIS, a statement is made that "Cumulative doses to the general public below 0.001 person - or organ - rem are not given because doses this small are immeasurable and meaningless with regard to predicting detrimental health effects". While it is a small dose to an individual, it may not be meaningless when a large population may be exposed. Additionally, the measurability of the dose also has no bearing on the meaningfulness of a committed population dose. The information should be presented for comparison without this value judgment.
- USEPA-12 { 6. It is our understanding that the population dose was based on the integration of individual doses for an 80 km radius around the site. This methodology should be discussed further and be subject to review. It is EPA's experience that a substantial portion of the committed dose from a uranium tailings pile can occur to a population at some distance from the pile.
- USEPA-13 { 7. The potential for air quality impacts were not addressed in the DEIS. Justification as to why this analysis is not provided should be clarified.
- USEPA-14 { 8. Regarding the disposal of radioactive materials (high or low level), the EIS (Section 4.7.2 - Ocean Disposal Regulation) should specifically reference the Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) and the Ocean Dumping Regulations (40 CFR Part 227).
- USEPA-15 { The MPRSA was revised in 1974 to incorporate provisions of the London Dumping Convention (LDC) of 1972. However, the MPRSA does not reflect all parts of the LDC. Additionally, the EIS references definitions of the International Atomic Energy Agency (e.g. "deminimis" levels on page 4-105) which have not been adopted by the LDC or incorporated into the MPRSA.
- USEPA-16 { 9. Currently, ocean disposal of radioactive waste, both high-level and low-level, is prohibited. The MPRSA and EPA's Regulations specifically prohibit disposal of high-level radioactive material (Section 102 (a) and 40 CFR 227.5). Disposal of low-level wastes is prohibited by Congressional moratorium, which is in effect until January 1985. If this moratorium is not reissued, any ocean disposal of low-level radioactive material must be in accordance with the MPRSA. The following inaccuracies are noted in the EIS:
- The MPRSA requires a special permit be issued for disposal of such material. The DEIS references a General Permit which allows bulk dispersal of wastes of less than "deminimis" levels of radioactivity (currently an

- USEPA-8 unlikely event that all controls were lost and the containment area was used for row-crop agriculture. As noted in Section 4.3.2, crop production on the cap would be poor. If land-use controls are not lost, the erosion rates are expected to be very small. (See also Responses NYDEC-19, -20, -22; USDO1-2; WDSHS-2.)
- USEPA-9 The failure of the Hanford alternatives to meet the 20 pCi/m²/s radon-222 release rate and measures to mitigate this impact are discussed in Section 4.1.2.2 of the EIS. To meet the criteria, the trenches would have to be deeper (about 7.5-m [25-ft] deep). This is technically feasible, and if one of the Hanford alternatives were selected, the radon release rate of 20 pCi/m²/s would be met. The Hanford alternatives are not preferred.
- The text in Section 4.1.2.2 has been changed to indicate that if DOE decides to implement any of the Hanford alternatives, the containment system would be designed to meet the 20 pCi/m²/s radon emission criterion. For Alternative 3a (wastes and residues removed to Hanford), a release rate of 20 pCi/m²/s would result in approximately the same dose as is calculated for the 29 pCi/m²/s release estimated for the conceptual design given in this EIS. For Alternatives 4a and 4b (residues only to Hanford), the dose would be approximately 10 times less than that calculated for the 300 pCi/m²/s release; however, the total dose would still be several orders of magnitude higher than any of the alternatives involving long-term management at either of the humid eastern sites (NFSS or Oak Ridge).
- USEPA-10 See Response USEPA-6.
- USEPA-11 The doses given in Table 4.2 are cumulative population doses. A cumulative population dose of 0.001 rem is meaningless considering the approximately 100,000 rem/yr the same population of one million people will receive from natural background sources of radiation.
- USEPA-12 Although it is true that the theoretical world-wide committed dose will be higher if the population beyond 80 km is considered, it is also true that the incremental commitment as a fraction of natural background will decrease. Based on the very small commitment to the population at 80 km, further analysis is unwarranted. The relative comparison between the alternatives would remain the same and the doses would become even more insignificant.
- USEPA-13 Radiological impacts associated with airborne releases are analyzed in Section 4.1. The potential for nonradiological air quality impacts associated with transportation is given in Section 4.6.3.3. It is noted that NFSS traffic could be a significant contribution to air quality degradation during peak traffic periods in the valleys at Oak Ridge on days when there were severe weather inversions. (See also Response TDHE-11).
- USEPA-14 The Marine Protection Research and Sanctuaries Act of 1972 and the ocean dumping regulations are specifically referenced in Section 4.7.2. Reference to 40 CFR 227 has been added to this section. (See also Responses USEPA-15, -16, -17, -18.)
- USEPA-15 It is noted in Section 4.7.2 that if the International Atomic Energy Agency (IAEA) defines de minimis levels and if the EPA adopts the IAEA definition, it is expected that the NFSS wastes will be able to be disposed by bulk disposal under a general permit according to Annex III of the London Dumping Convention. It is also noted that it is anticipated that the IAEA will submit a proposed de minimis definition to the London Dumping Convention within the next year. (See also Responses USEPA-14, -16, -17, -18.)
- USEPA-16 A discussion of high-level radioactive waste disposal and the Congressional moratorium is given in Section 4.7.2. It is also noted that if Annex II of the London Dumping Convention (governing dumping of radioactive wastes other than high-level wastes) applies, the NFSS wastes would have to be disposed in containers. This option is not addressed in the EIS because DOE would not, at this time, consider applying for a permit for containerized disposal of the NFSS wastes. Bulk dispersal is currently authorized by the London Dumping Convention under a general permit, as noted in Section 4.7.2. The EPA issues general and special permits for ocean disposal of wastes under the provisions of its ocean dumping regulations (40 CFR Part 227). Known or suspected carcinogens, mutagens, or teratogens are prohibited from ocean dumping, unless they are present only as trace contaminants. Radioactive materials must be containerized before disposal, and the life expectancy required for the container is the time it takes the wastes to become environmentally innocuous. The moratorium on ocean disposal of low-level radioactive wastes does not include an operational definition of low-level radioactive wastes. The NFSS wastes are classified as nonradioactive for purposes of transportation. The NFSS wastes are natural geologic materials, contaminated with elevated levels of naturally occurring radionuclides that are normally present in soils and ocean sediments. A request for a permit to dispose of NFSS wastes in the ocean would require EPA to determine if this material is low-level radioactive waste. Until the EPA has made a specific determination with regard to classification of the NFSS wastes, it is not possible to determine the regulatory status of the NFSS wastes with respect to ocean disposal. (See also Responses USEPA-14, -15, -17, -18.)

- USEPA-16 { International Atomic Energy Agency rule). However, neither this concept nor definition is currently in the LDC or MPRSA. Presently, disposal of low-level radioactive material, if not prohibited by Congressional moratorium, must meet Special permit requirements (Subparts B-E), must be containerized (40 CFR 227.6), and must be dumped at a site designated specifically for this type of waste. The DEIS does not address disposal of containerized wastes, which is the only option currently authorized by the Ocean Dumping Regulations.
- USEPA-17 { 10. Appendix E provides an in depth technical analysis of permanent disposal of radioactive wastes (non-containerized) at the 106-Mile Site. The major problem with this approach is that, at this time, the 106-Mile Site is specifically designated only for disposal of aqueous industrial wastes. Also, the analysis is based on the historically used 106-Mile Site, which has actually been re-designated to a much smaller area (May 1984). Use of this site for another type of wastes requires site designation in accordance with section 228 of the Ocean Dumping Regulations. The DOE should address site designation procedures prior to stating they will "seek a permit from the EPA to dispose of NFSS wastes at the 106-Mile Site" (p.E-6).
- USEPA-18 { The DEIS should also address possible alternate sites to the 106-Mile Site.
- USEPA-19 { 11. Another major concern left unresolved is that groundwater will inevitably become contaminated, regardless of the alternative disposal process implemented at the NFSS. This contamination will occur sooner and reach higher levels if the caps are not maintained and infiltration of water through the cap and into the wastes and residues increases.
- USEPA-20 { 12. One alternative that must be explored in detail is the disposal of the radioactive wastes/residues via deep-well injection. It is quite possible that the disposal of these wastes by means of injection wells may prove to be more environmentally sound and effective.
- USEPA-21 { 13. Groundwater flow directions and hydraulic head relationships between the aquifers in the overburden zone are not completely addressed in the DEIS
- USEPA-22 { 14. Specific locations of aquifer recharge zones (both areally and vertically) have not been clearly delineated. Additional water quality data, especially pertaining to total dissolved solids (TDS) levels in the aquifers, is needed to evaluate potential impacts and movement of radioactive material.
- USEPA-23 { 15. Radium-226 is the radionuclide of most concern at the NFSS. A worst case assumption that was made in the report using a centrally located well may not be a true representation of the possible contamination scenarios. Additional analyses should be performed using several other well sites.
- USEPA-24 { 16. For all alternatives in which the residues will remain at NFSS, the concentrations of radium-226 in the onsite wells are predicted to be greater

- USEPA-17 Section 4.7.2 has been modified to indicate that EPA will (rather than may) need to designate a particular part of an existing ocean disposal site or a new site for disposal of the NFSS wastes and that the site designation process will entail extensive environmental review and participation. The 106-mile site (Site 106) is used as an example of a nearby deepwater ocean disposal site because site designation and monitoring studies for aqueous industrial waste disposal have provided baseline environmental data on which an assessment of disposal of the NFSS wastes can be based. (See also Responses USEPA-14, -15, -16, -18.)
- USEPA-18 A discussion of possible alternative ocean disposal sites would be included in a disposal permit application. Given the predicted lack of any significant impact associated with dispersal of the NFSS wastes at Site 106, analysis of other possible alternative sites is not warranted at this time. (See also Responses USEPA-14, -15, -16, -17.)
- USEPA-19 In subsequent correspondence, EPA indicated that:
- "In addition, DOE should provide more information on the groundwater monitoring/mitigation plans that would be required if an on-site containment option were selected. ... We continue to believe that the proposed on-site containment alternatives (i.e., alternative 1-no action, and alternatives 2a and 2b) are environmentally unacceptable from the standpoint of potential groundwater impacts. The discussion regarding existing and future conditions if an on-site alternative is selected, leads EPA to conclude that significant adverse environmental impacts to groundwater resources and human health in and around NFSS may result. If wastes and residues remain at NFSS, the DOE suggests the likelihood of significant future impacts if drinking water wells are drilled and utilized in the NFSS vicinity. The suggested prohibition of water usage adjacent to NFSS may be impractical to implement or enforce. ... DOE has stated that additional groundwater modeling, in conjunction with the development of detailed engineering designs, will be incorporated in the Waste Containment Design Report. This information is essential for EPA to complete its review of potential groundwater impacts. Information on aquifer recharge zones should also be presented in this design report, and it should be demonstrated that the selected alternative would not result in the contamination of recharge water in and around NFSS. We are concerned that the on-site alternatives, as proposed, will result in contamination to the lower aquifer which flows north toward Lake Ontario. We believe that mitigation measures should be provided in the final EIS that would effectively eliminate all potential impacts to aquifer recharge zones, including the Queenston aquifer. ... A leachate collection system should be required for on-site containment alternatives because of the potential for migration of radioactive contaminants. ... We are aware that the "Waste Containment Design Report" being prepared by DOE may resolve some of EPA's informational requirements about groundwater impacts and offsite migration/contamination. Accordingly, we request that a copy of this report be presented to EPA for review prior to issuance of the final EIS. As indicated in the attached comments, EPA is unable to complete its review of the DOE's disposal options without the level of technical detail anticipated to be available in this report. (Please note that the "Engineering Evaluation of Alternatives" report did not provide sufficient technical detail for EPA)."
- The rates of groundwater migration and contamination levels, assuming loss of maintenance, are discussed in Sections 4.2.2 and 4.4. Offsite contamination is not expected at any of the alternative sites within the 1000-year design goal set in the EPA mill tailings regulations. Only at a theoretical onsite well in the near-surface unconsolidated aquifer (with limited potential yield or use) would the groundwater become contaminated. This prediction is based on some very conservative assumptions about the nature of the wastes and residues, the groundwater condition (see Topical Response 2), and cap erosion. As noted in Section 2.1.2, this potential impact can be eliminated by instituting controls against the use of water from the near-surface aquifer on the NFSS site. Land records will note the presence of the radioactive waste containment area and the need to control use of the site. A groundwater monitoring program will be implemented and further actions will be taken, if necessary, to ensure that offsite concentrations of radionuclides and other chemicals are not elevated above applicable standards. As noted on Figure 1.3, DOE will have detailed monitoring plans by the time a Record of Decision is published. EPA will be provided with copies of all the major documents, including the Waste Containment Design Report, that will be used in reaching a decision. Our calculations indicate that there will be no offsite contamination of groundwater within the 1000-year time frame that is recommended by EPA and is being used by DOE as a reasonable basis for this decision. Thus, a leachate collection system is not needed.
- USEPA-20 See Response USEPA-4. Conventional deep-well injection (as opposed to hydrofracture/grout injection), is not feasible for disposal of the solid NFSS wastes and residues. (See detailed discussion in Topical Response 1.)
- USEPA-21 Existing information on groundwater flow directions and hydraulic head relationships is summarized and referenced in Section 3.1. The analysis in Section 4.2.2 of groundwater impacts at all sites is adequate to allow reasonable comparison between alternatives. (See detailed discussion in Topical Response 2.)

- USEPA-24 { than the current federal drinking water standard of 5pCi/L (picocuries per liter). If only the wastes and not the residues remain, then the concentrations of radium-226 are predicted to meet the federal standard, but exceed the New York State standard of 3pCi/L. Shallow wells should not be permitted in the NFSS area, especially in the near-surface aquifers.
- USEPA-25 { 17. With regard to the NFSS's hydrologic characteristics (e.g. small hydraulic conductivities and gradients, depth to the deeper aquifers, direction of flow, and slow groundwater velocities), it is unlikely that radiological contamination of the deeper aquifers will occur in the long-term period (up to 32,000 years). The information presented in the DEIS appears to substantiate this fact; however, there is not enough data provided to fully support this conclusion.
- USEPA-26 { 18. There are at least three studies dealing with geology and groundwater at the site, yet no detailed geologic sections or site plan is shown; there are no water table maps nor any other information relating to moisture in the ground. While reference is made to the reports, information of this level of importance should be included.
- USEPA-27 { 19. There is no information provided relating to the chemical character of the wastes, especially with respect to water content, solubility, reactions, etc. This information should be included to permit a comprehensive review of options. The validity of the transport model presented cannot be evaluated without this data. The DEIS should include the entire flow field around the site and its residence time. Residence time may be relatively brief or it may be on the order of 1000 years. This variation can make a significant difference in considering and evaluating alternatives.
- USEPA-28 { 20. Consideration should be given to the use of a cement cap, rather than a soil cap, on the residues. Use of the soil cap has been shown, in areas within fifty miles of the site (which have similar climate), to be ineffective even for relatively short periods (e.g., 10 years or less). Even without climatological factors, the presence of small burrowing animals at the site may affect the integrity of the soil cap over a relatively brief period, without an appropriate operations and maintenance plan. In addition, the applicability of CERCLA to all Federal facilities would also require that appropriate coordination with the procedures of the Resource Conservation and Recovery Act (RCRA), which calls for use of a synthetic liner and a soil/clay cap designed to last a minimum of 35 years.
- USEPA-29 {
- USEPA-30 { 21. Figure 2.1 of the DEIS depicts a true scale for the conceptual design of the no-action alternative at NFSS. The 40% side slopes would be unacceptable for establishing and maintaining adequate vegetative cover (i.e. grass). Similarly, Figure 2.3 presents the conceptual design for alternatives 2a and 2b. The end slopes of the soil cap are shown to be at a 20% slope. Again, this grade may be too severe to properly maintain vegetative cover for a long duration. Therefore, it is recommended that other feasible alternatives be considered for this design of the cap. This analysis of more permanent cover should include evaluating rip rap, gabions, or, as mentioned above, concrete.

USEPA-22 The entire area on and around NFSS is a recharge zone. Existing information on all aquifers is summarized and referenced in Section 3.1. It is expected that infiltration of water through the final cap (preferred Alternative 2) will be less than through surrounding soils; therefore, recharge through the NFSS containment area will be less than through surrounding areas. (See detailed discussion in Topical Response 2.)

USEPA-23 The three-dimensional solute transport model was used for projecting contaminant concentrations at specific locations in the aquifer (i.e., onsite well, nearest major surface water body, and half way between the two--Section 4.2.2). The results indicate that for the assumed modeling conditions, maximum contaminant concentrations would occur in a well located next to the waste/residue containment area.

After further discussions with EPA, another theoretical well point was located at the edge of the NFSS property. Within the time period specified in the mill tailings regulations as being the desired minimum duration of containment (at least 200 years and, to the extent practicable, for 1000 years), it is predicted that there would be no offsite groundwater contamination at NFSS (see further discussion in Topical Response 2 and Section 4.2.2.3).

USEPA-24 DOE agrees that use of water from shallow wells on the NFSS site should not be permitted. The hypothetical impact analyzed in the EIS will not occur if no such sand lens exists, no one drills such a well, or no one uses the groundwater. Land records for the site will note the presence of the waste containment area and the need to control use of the site. (See more detailed discussion in Topical Response 2.)

USEPA-25 No other data are available. The contaminant concentrations at theoretical onsite wells are presented for comparison of the conceptual designs for the various waste-management alternatives. Detailed analyses of potential contaminant migration patterns for specific containment designs for whichever alternative is selected will be conducted and will be available to support decisions on final design. (See more detailed discussion in Topical Response 2.)

USEPA-26 Figure 3.1 is the only figure available showing the geologic formations at NFSS. Because of the noted high degree of variability, no cross section would be representative of the site. As noted in Section 3.1.1, no yearly seasonal data on the near-surface aquifer in the unconsolidated glacial deposits are available. Existing hydrogeologic studies at NFSS indicate that the groundwater in the upper "aquifer" has a small hydraulic gradient and conductivity. Based on information gained during excavations for the dike around the containment area during 1982-1984, it is known that the groundwater elevations in the upper aquifer at a given point in time can vary greatly from one spot to the next--indicating that the various sand lenses may not be interconnected. For the contaminant migration study, it is conservatively assumed that the soils are completely saturated year-round (see Table 4.39) and that the overlying NFSS wastes and residues are also saturated. (See more detailed discussion in Topical Response 2.)

USEPA-27 In subsequent correspondence, EPA indicated that:
 "The results of the three-dimensional transport model used by DOE for predicting contamination concentrations at specific locations in the nearest aquifer are provided in the [previous] response[s]. Contamination to an off-site well, a major surface water body, or at a half-way point between the two are not expected to peak for radium-226 concentrations for at least 3,600 years. While radium-226 concentrations are of the most concern to the DOE with respect to groundwater contamination, predicted values for the other radioactive contaminants should be addressed in the final EIS."

The chemical content of the wastes is given in Section 3.1.8. In the EIS analysis, the initial water content of the wastes and residues is assumed to be approximately 30% because they will be damp. Depending on the success of residue dewatering during interim remedial actions, the water content may be as low as 20%. However, over time, infiltrating water is expected to raise the moisture content to near saturation of about 30%. The amount of water contributed by biological degradation of the trace amounts of organic constituents is expected to be insignificant.

The hydrological model is discussed in Section 4.2.2.1. As noted, the two most sensitive parameters are distribution coefficient and hydraulic conductivity. Many variable parameters that may affect the mobility of a given contaminant (such as solubility) are subsumed into one variable parameter, the distribution coefficient. For the analyses, conservatively low distribution coefficients and conservatively high hydraulic conductivities were input to the model (Sections 4.2.2 and 4.4)--resulting in conservatively high predictions of groundwater impacts. All available data for each alternative site were used to determine reasonable values for the various input parameters for the hydrological modeling. Discussion of why the use of more sophisticated groundwater models is unwarranted and would not result in more accurate prediction of impacts for the purpose of comparing the conceptual alternatives is given in Section 4.2.2.1.

- USEPA-31 { 22. The NFSS is in a location where other environmental impacts from chemical and other types of adverse environmental conditions exist. There is a hazardous materials storage site immediately adjacent to the NFSS property. This situation should be given more consideration when evaluating the overall goals of the project. The presence of a disposal site adjacent to the NFSS would bring into question the justification for expending relatively large sums of money to reduce the effect of one type of material while leaving in place on the adjacent property another, possibly greater, hazard.
- USEPA-32 { 23. In connection with other projects, EPA has investigated the possibility of long-term storage of radioactive materials of similar character at the Oak Ridge Reservation. Our inquiries have received the response that no further long-term storage of any radioactive materials was planned for that site due to a number of containment problems. Is there some mechanism or approach envisioned which would permit the use of the Oak Ridge site for storage of this type? What further modifications of the site or of its institutional requirements would be necessary? Are these all factored into the cost of the presentation?
- USEPA-33 { 24. EPA is in the process of ranking all Federal facility sites for inclusion on the National Priorities List. EPA will be contacting you to assemble data and other pertinent information which will be required in the evaluation process for the NFSS.

USEPA-27 (cont.) Chemical contamination of groundwater within the 1000-year design goal specified in the EPA mill tailings regulations is expected only at a theoretical onsite well at NFSS. As noted in Section 4.4.3.1, background well water concentrations for the various chemicals are expected to be larger than those contributed by leachate from the NFSS contaminated materials. (See more detailed discussion in Topical Response 2.)

USEPA-28 As noted in Section 4.3.2.2, the riprap layer at NFSS for the long-term management alternatives at NFSS (2a and 2b) is expected to initially deter burrowing animals from intruding into the buried wastes and residues. As long as the cap is monitored and maintained, it is expected that animals will not be able to burrow through the total of about 6 m (20 ft) of cap and underlying wastes down to the residues. If it is assumed that controls cease, an additional barrier of a concrete cap on top of the residues could serve to further delay human or animal intruders. DOE is considering this additional option (see Topical Response 1). EPA does not consider such an additional barrier to be necessary for the mill tailings that are similar to the NFSS wastes and residues.

The failure of nonengineered soil-only caps over buried wastes at other nearby sites was taken into consideration in developing the conceptual design for the long-term containment system at NFSS. The wastes and residues are compacted to minimize future slumping. It is expected that most settlement will take place within a few years of construction of the interim cap. Repairs will be made, as necessary, before construction of the final cap (preferred Alternative 2). The various layers, slopes, and thicknesses of the final cap are designed to balance considerations of (1) minimization of erosion, frost heave, infiltration of water, and exhalation of radon, and (2) maximization of runoff and cap drainage. As noted throughout the EIS, maintenance and monitoring plans specific to the selected alternative will be developed and will be summarized in the Record of Decision, as required by the CEQ regulations. (See more detailed discussion in Topical Response 1.)

USEPA-29 Based on site-specific considerations guided by the requirements of 40 CFR 192, and consistent with the guidance in DOE Order 5480.2 (Hazardous and Radioactive Mixed Waste Management), DOE will ensure a degree of protection of the environment and the safety of the public equivalent to that afforded under 40 CFR 260-265, even though NFSS is not subject to the permitting requirements of RCRA. The cap in preferred Alternative 2 is predicted to last at least 200 years. A synthetic liner with a life of 20 years would offer no significant long-term barrier to the migration of contaminants. In EPA guidance documents, it is noted that synthetic liners are intended to provide protection only during burial operations and a 30-year post-closure period, not the 1000 years for which containment systems for mill tailings and the NFSS wastes and residues are to be designed.

USEPA-30 The 40% side slope is for the interim (Alternative 1--no-action). Potential gully erosion of the slopes and potential slope and cover failure are discussed in Sections 4.2.1.3 and 4.2.1.4. Further reduction of the side slopes (to less than 20%) in preferred Alternative 2 would result in decreased erosion and, therefore, decreased maintenance costs. Based on the analysis in this EIS, it appears that a 20% slope would provide reasonable assurance that the integrity of the confinement system could be maintained for 1000 years. Riprap is included in the long-term conceptual designs at these sites (Section 2). The exact percentage of side slope, as well as any additional land requirement associated with slopes less than 20%, will be considered as part of detailed engineering that will be available after the Record of Decision. (See also Response USEPA-28 regarding a cement cap on the residues.)

USEPA-31 DOE is considering the presence of the adjacent hazardous materials storage site in making its decision on long-term management of the NFSS wastes and residues. Comment is noted. (See also Responses BROSS-7, USEPA-7.)

USEPA-32 DOE has informed EPA that there are no "open" low-level waste disposal facilities in operation at DOE's Oak Ridge Reservation--i.e., there are no facilities intended to receive wastes other than those from current DOE production and research activities at Oak Ridge. For the DOE-owned NFSS wastes and residues, a DOE programmatic decision was made to consider the Oak Ridge and Hanford reservations as alternative long-term management sites. Subsequent to this decision, the Pine Ridge Knolls site was designated by DOE Oak Ridge Operations as the specific location to be considered for the NFSS alternative. Conceptual design features for long-term management of the NFSS wastes and residues at Oak Ridge were then developed and comparative environmental analyses were performed. Use of the Pine Ridge Knolls site has been considered only for the NFSS wastes and residues. No wastes are currently stored at this location, and no future DOE waste management activities are currently envisioned for this particular site. (See also Responses RYMAN-4; TDHE-5, WALK-1, -3; YAGER-2.)

USEPA-33 In response to EPA's request, DOE has provided EPA with the relevant information on NFSS.

Attachment No. 2

EPA Region IV Comments

EPA Region IV Associate Review of the Niagara Falls Storage Sites Draft Environmental Impact Statement (DEIS)

- USEPA-34 { 1. The waste source and characteristics should be described adequately in order that pathway analysis and radiation dose estimates can be made for the basic alternatives and the additional action alternatives of a partial decontamination approach. The most commonly occurring long-lived radionuclides of the NFSS wastes and residues should be specified (e.g. uranium 238 and 234, thorium 230, radium 226, etc.).
- USEPA-35 { 2. Soil concentration limits should be derived that are applicable to the actual sites listed for the alternatives. Site specific application of the pathway analysis and radiation estimates should provide the required concentration limits at the individual option sites, and hopefully, the basis for public acceptance of the alternative chosen. The relative importance of the different pathways based on models and assumptions should be developed for each of the alternatives, including hydrological and drinking water aspects of the proposed sites.
- USEPA-36 { 3. The derived soil concentration limits for the NFSS waste and residues at the various alternative sites should provide that individual radiation dose limits do not exceed the accepted radiation protection standards. Other important areas of consideration for each site alternative are state and local government issues, transportation, actual emplacement methodology (particularly in regard to assurance of no water table involvement), drainage of the excavation, and monitoring of the sump and the areas water supply wells for compliance.
- USEPA-37 { 4. Long-term measures for the NFSS radioactive wastes and residues should provide information on the design, monitoring, and interpretation assumptions underlying the models; such as those which relate to the derived soil nuclide concentrations or air gamma readings to human dose commitment. The information should be realistic relative to the individual site containment options, so that cost effectiveness, potential hazard to the public, monitoring and inspection requirements, real versus perceived risk, and application of the ALARA technology (as low as reasonably achievable) is demonstrated with a reasonable margin of safety.
- USEPA-38 { 5. The discussion of the hydrology, water use, and water quality for the alternatives regarding the Oak Ridge site should include: (1) The inter-relationship between groundwater and surface water in the vicinity of the proposed disposal site with respect to the rate and volume of discharge to the surface stream. (2) downstream water supplies of the Clinch River, including location, distance downstream, population served, and potential impact from the radioactive residue disposal site. (3) An evaluation of soil permeability and the rate of groundwater movement. This evaluation should take into account the fracture flow system including the limited effect of dispersion and dilution in this type of flow system.
- USEPA-39 {
- USEPA-40 {

- USEPA-34 This information is provided in Sections 3.1.7 and 4.1.
- USEPA-35 Residual soil concentration limits at NFSS for those alternatives involving removal of the NFSS wastes and residues to other sites would have to be determined at the time such an action was taken. The guidelines given in Appendix H are identical to those given in the EPA mill tailings regulations. The soil concentration guidelines are applicable to areas that are cleaned up, not to areas where wastes are contained. The relative importance of pathways, models, and assumptions for these guidelines are given in the documents referenced in Appendix H. As noted in Appendix G, development of DOE orders is not part of the currently proposed site-specific action and is therefore beyond the scope of this EIS. (See also Responses NYDEC-10, -26; USEPA-36.)
- USEPA-36 See Responses NYDEC-10, NYDEC-26, and USEPA-35 concerning residual soil contamination guidelines. The other important areas of consideration are thoroughly discussed in Sections 3 and 4, and are summarized in Section 2.
- USEPA-37 These issues are discussed throughout the EIS, particularly in Section 4. DOE is considering all of them in making its decision.
- USEPA-38 At the Oak Ridge alternative site, discharge of site groundwater occurs commonly in the form of springs and seeps (Section 3.3.2.2). Most of the springs are in small valleys along the southeast flank of Pine Ridge. At one time, weirs were installed at selected locations within the site to measure the flow rate of groundwater discharge (Exxon Nucl. Co. 1977); except for one measurement, results are not available. (See also Responses TDHE-8, USEPA-40.)
- USEPA-39 Two pumping stations for the Oak Ridge Gaseous Diffusion Plant are located on the Clinch River downstream of the Pine Ridge Knolls site. One of these stations withdraws makeup water for the recirculating cooling system; the other, located immediately downstream of the confluence of Grassy Creek and the Clinch River, withdraws water for potable and process purposes. Of the nine public water systems (serving about 91,500 people) that withdraw surface water within a 32-km (20-mi) radius of the site (Boyle et al. 1982), only one--at Kingston--is located downstream of the Grassy Creek discharge. However, the Kingston intake is actually on the Tennessee River upstream from the confluence with the Clinch River. The average withdrawal rate at Kingston is about 0.014 m³/s (0.31 Mgd). Within the 1000-year time frame considered in the EIS analysis, no significant adverse impact on surface water supplies is predicted.
- USEPA-40 The discussion of soil permeability and groundwater movement is presented in Section 3.3.2.2. The effect of the fractured flow system on contaminant transport at the Oak Ridge site was considered in the selection of hydrogeologic parameters for the contaminant migration analysis (Section 4.2.2). For example, the average hydraulic conductivity at Oak Ridge was set at 0.03 cm/s, whereas at NFSS it was set at 0.000011 cm/s (see p. 4-58). (See also Responses TDHE-8, USEPA-38.)

- USEPA-41 { 6. The discussion of the environmental consequences should include an evaluation of the cumulative effect of radioactive disposal actions at the Hanford and Oak Ridge sites from all other contributing waste sites should monitoring, maintenance, and corrective actions be terminated. The additional effect from the residue and/or soil disposal area could represent an unacceptable impact on the environment in combination with environmental releases from the other disposal areas on-site.
- USEPA-42 { 7. The DEIS indicates that the radiological health impacts will be smaller than the risks of occupational and transportation-related injuries and deaths. Noting that the long-term radiological risks to the general public are also expected to be small for all alternatives, it appears that further consideration of storage or stabilization in place at NFSS should be considered the primary technique for managing the residues and wastes.

- USEPA-41 The cumulative radiological effects (with existing operations) at Hanford and Oak Ridge, as well as existing background radiation sources, are discussed in Section 4.1.2.1. The incremental impact associated with management of the NFSS wastes and residues is insignificant at all sites for all alternatives. Long-term impacts associated with the NFSS wastes and residues, including impacts if controls cease are given in Section 4.1.2.3. No existing predictions of future impacts if controls cease at other sites are available.
- USEPA-42 EPA's comment regarding the preferability of stabilization in place at NFSS is noted. DOE will take this into consideration in reaching a decision. (See also Response USEPA-3.)

Attachment No. 3

EPA Region X Comments

EPA Region X Associate Review of the Niagara Falls Storage Site Draft
Environmental Impact Statement (DEIS)

- USEPA-43 { 1. The DEIS should discuss the relative capacity for radioactive wastes for each of the sites considered.
- USEPA-44 { 2. Truck movement rates along transportation routes proposed for each of the alternatives should be compared to the truck movement rates of radioactive materials that would occur with no-action taken along the same routes.
- USEPA-45 { 3. The DEIS commonly uses pCi/g Radium 226 as the measurement of radionuclide concentration. How does this relate to dosages (mrem) used in Table 4.12?
- USEPA-46 { 4. How is this project related to the effort each state is required to initiate for low-level radioactive wastes under the Low-Level Radioactive Waste Policy Act (PL 96-573)? This act is not mentioned in Table 1.2.

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- USEPA-43 At NFSS and Hanford, the NFSS wastes and residues can be managed within the existing sites. At Oak Ridge, there is adequate space at the Pine Ridge Knolls site to handle the NFSS residues. However, as noted in Section 2.5.1, a major technical uncertainty in implementing Alternative 3b (both residues and wastes at Oak Ridge) is whether or not there will be enough space on top of the knolls. This uncertainty will be taken into consideration in making the decision on where and how to manage the NFSS wastes and residues for the long term.
- USEPA-44 No compilations of existing or projected truck movements of radioactive materials along the transportation routes (in addition to the NFSS shipments) are available.
- USEPA-45 The relationship between radionuclide concentrations, release rates, exposures, and resulting doses to the public and workers are given in Section 4.1.
- USEPA-46 The Low-Level Radioactive Waste Policy Act (PL 96-573) is not applicable to the NFSS project because it does not apply to DOE wastes. (See also Response NYDEC-3.)
- USEPA-47 In subsequent correspondence, EPA indicated that:
"In addition, the central drainage ditch located near the waste containment area at NFSS is within the 100-year floodplain. Measures should be proposed which ensure that increased off-site migration does not occur in the event the waste containment area is inundated during 100-year flood conditions. Adequately designed flood prevention structures should be described in the waste containment report and final EIS. Also, because the long-term management plan provides for a 200 year planning period, the flood prevention structures should be designed to the conditions of, at least, a 200-year level."

See Response NYDEC-1.

BON FUDUA (a) Chairman

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October 5, 1984

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 MANUEL LUJAN JR. N. MEX
 ROBERT S. WALKER PA
 WILLIAM CARNEY NY
 J. JAMES SENSENBRENNER JR. WIS
 JUDG GREGG NM
 RAYMOND J. MC GRATH NY
 JOE SKEEN N. MEX
 CLAUDINE SCHNEIDER RI
 BILL LOWERY CALIF
 BOO CHANDLER WASH
 HERBERT H. BATEMAN VA
 SHERWOOD L. BOHNER NY
 ALFRED A. MCCANDLESS CALIF
 TOM LEWIS FLA

HAROLD P. HANSON
 Executive Director
 ROBERT C. KETCHAM
 General Counsel
 DAVID S. JEFFERY
 Minority Staff Director

James Vaughan
 Acting Assistant Secretary
 for Nuclear Energy
 U.S. Department of Energy
 Washington, D.C. 20585

Dear Mr. Vaughan:

The Department recently requested our comments on the draft environmental Impact statement entitled, "Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site." We continue to believe that the Department should carry out its mandate to clean up this site in the most cost-effective manner.

USHR-1 { We have reviewed the eight cleanup alternatives suggested in the report and have concluded that alternative 2(a) (stabilization in-place) would accomplish the cleanup effort at the least cost to the government. We, therefore, recommend it to the Department.

We appreciate all of your efforts in keeping the Subcommittee fully and currently informed on the activities of the Department. Our staff contacts on the Subcommittee are Mr. Louis Ventre, Jr. (225-2981) for Mrs. Lloyd and Mr. David Clement (225-8152) for Mr. Walker.

Sincerely,


 MARILYN LLOYD, Chairman
 Subcommittee on Energy
 Research & Production


 ROBERT S. WALKER
 Ranking Republican Member
 Subcommittee on Energy
 Research & Production

LW:Vdm

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USHR-1 Recommendation for Alternative 2a is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.



COMMONWEALTH of VIRGINIA

Council on the Environment

KEITH J. BUTTLEMAN
ADMINISTRATOR

803 NINTH STREET OFFICE BUILDING
RICHMOND 23218
804-786-4500

October 12, 1984

Mr. L.F. Campbell
Deputy Director, Technical
Services Division
Oak Ridge Operations Office
U.S. Department of Energy
P.O. Box E
Oak Ridge, Tennessee 37830

Dear Mr. Campbell:

The Commonwealth of Virginia has reviewed the Draft Environmental Impact Statement for Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site. The Council on the Environment is responsible for coordinating Virginia's review of federal environmental documents and responding to appropriate federal officials on behalf of the Commonwealth. The following agencies took part in this review:

Department of Health
Department of Highways and Transportation
State Air Pollution Control Board
State Water Control Board
Office of Emergency and Energy Services
Solid Waste Commission
Mount Rogers Planning District Commission.

Our interest in the subject of this document stems from the possibility that radioactive waste will be transported by truck through Virginia on its way to Oak Ridge, Tennessee (Alternatives 3b, 4c, 4d). If such transportation is contemplated, it would be advisable for you to coordinate truck movements with the Department of Highways and Transportation, particularly in regard to highway tunnels, of which there is at least one on the proposed route (Interstate Routes 77 and 81).

VCE-1

We recommend that the Department of Energy consider carefully the implementation of transportation alternatives to Oak Ridge, since the passage of many heavy trucks through the mountainous terrain in southwestern Virginia would create potential hazards to the environment of the area and the health and safety of its

2207,

VCE-1 The Oak Ridge alternatives are not preferred at this time. If DOE decides to implement one of the Oak Ridge alternatives, transportation through the mountainous terrain of southwestern Virginia would be carefully considered. As noted in the EIS, it is assumed that transport would take place only during the 6-month summer construction season, not during the winter when road conditions are more hazardous. DOE would clean up any spilled material. (See also Responses NCEMC-3, USDOI-7, VCE-2, WDES-1, WEFS-5.)

Mr. L. F. Campbell
Page Two

VCE-1 | citizens. Specifically, we would like the Final EIS to indicate an affirmative commitment on the part of DOE to assume financial and technical responsibility for the recovery after any accidents or clean-up of spilled material. In the absence of such a commitment, we urge that the wastes and residues be shipped so as not to traverse Virginia.

Thank you for the opportunity to review this document. We look forward to reviewing the Final EIS.

Sincerely,

A handwritten signature in dark ink, appearing to read 'Keith J. Buttleman', with a long horizontal flourish extending to the right.

Keith J. Buttleman

Enclosures

cc: The Honorable Betty J. Diener
Mr. K.E. Wilkinson, DHT
Mr. Thomas Taylor, Mount Rogers PDC
Ms. Barbara M. Wrenn, SWC



COMMONWEALTH of VIRGINIA

Council on the Environment

KEITH J. BUTTLEMAN
ADMINISTRATOR900 NINTH STREET OFFICE BUILDING
RICHMOND 23219
804-754-4500

MEMORANDUM

TO: Keith J. Buttleman

FROM: Charles H. Ellis III *Charles H. Ellis III*

SUBJECT: U.S. Department of Energy Draft EIS on Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site

I have reviewed portions of this document and discussed it with people from other Virginia agencies, and my comments follow.

The document presents a range of nine alternatives in four groups. The groups are:

- #1- no action (continued storage at Niagara Falls, New York);
- #2- modified containment alternatives at Niagara Falls;
- #3- long-term management of wastes and residues at Hanford, Washington or Oak Ridge, Tennessee;
- #4- long-term management of residues at Hanford or Oak Ridge, with wastes staying at Niagara Falls or going to an ocean disposal site about 120 miles east of Cape May, New Jersey.

Alternatives 3b (long-term management of wastes and residues at a humid site) and 4c (off-site storage of residues at Oak Ridge and long-term management of wastes at Niagara Falls) implicate Virginia since both assume shipment of the wastes and residues by truck (page D-2) through Virginia by way of Interstate Routes 77 and 81 (page 3-42). (Appendix D reviews and rail transportation possibilities and alternative truck routes, some of which would skirt the State, pp. D-8, D-18, D-21.) With this implication in mind, we took the document under review.

MEMORANDUM
Page Two

The Department of Energy indicated that it has not chosen a preferred alternative yet in this process. The preferred alternative is to be announced in the Final EIS (page i). Thus we may have some opportunity to influence the course of action that DOE will take in this matter.

I have talked with Mr. Thomas Taylor of the Mount Rogers Planning District Commission. Mr. Taylor, whose Planning District covers the portion of the preferred truck route that is within the Commonwealth, indicated that there is no commitment by the Department of Energy to take responsibility for any accidents or leakage of radioactive material that might occur in transit. Some mention of the likelihood of deaths or injuries is made on pages 4-93 and 4-95, together with an indication that state emergency preparedness capabilities would bear the brunt of any clean-up action since DOE is exempt from state laws including those with financial responsibility requirements. Mr. Taylor's concern that localities would be burdened with clean-up costs appears well-founded since the discussion of mitigation measures (pages 4-99 and 4-100) is limited and non-committal.

With all this in mind, I recommend that we indicate concern over the focus of responsibility for mishaps and suggest that a more affirmative stance toward that responsibility be taken. Under the circumstances, we are under no moral obligation to accept the transportation of wastes through Virginia unless the responsibility issue is resolved in a manner more to our liking, e.g., unless DOE accepts responsibility for clean-up of any spills or recovery for any other mishaps. Thus we should recommend implementation of any alternative other than those involving truck transit to Oak Ridge.

VCE-2 Transport to other sites is not preferred at this time. As noted in Section 4.6.7, if DOE decides to transport the NFSS materials to another site, the mitigative measures discussed will be coordinated with the affected states. (See also Responses NCEMC-3, USDOT-7, VCE-1, WDES-1, WEFS-5.)

HANDLER KING CHESAPEAKE DISTRICT
 EDGAR BACON, JONESVILLE ARTIST DISTRICT
 T. GEORGE VAUGHAN, JR., FALLS STATION DISTRICT
 JAMES L. DAVIDSON, JR., LYNCHBURG LYNCHBURG DISTRICT
 W. M. T. FOWLER, RICHMOND RICHMOND DISTRICT
 RICHARD G. BRYDGE, VIRGINIA BEACH SEAFORD DISTRICT
 W. R. HUMPHREYS, JR., VIRGINIA BEACH SEAFORD DISTRICT
 CONSTANCE R. KINCH, CLYDE CLYDE DISTRICT
 ROBERT W. SMITH, RICHMOND RICHMOND DISTRICT
 JOSEPH W. GUTIERREZ, ALEXANDRIA NORTHERN VIRGINIA DISTRICT
 T. EUGENE SMITH, MOUNTAIN VIEW MOUNTAIN VIEW DISTRICT
 ROBERT A. QUINN, BLACKSTONE AT LEBANON DISTRICT

R. L. HUNDLEY
 ENVIRONMENTAL ENGINEER



COMMONWEALTH of VIRGINIA

DEPARTMENT OF HIGHWAYS & TRANSPORTATION

1221 EAST BROAD STREET
 RICHMOND, 23219

September 18, 1984

OSCAR F. HARRY
 DEPUTY COMMISSIONER
 J. M. HARRY, JR.
 CHIEF ENGINEER
 A. T. WARREN
 DIRECTOR OF ADMINISTRATION
 R. W. ROHRALL
 DIRECTOR OF FINANCE
 JACK HODGE
 ASSISTANT CHIEF ENGINEER
 BALLY M. COOPER
 DIRECTOR OF RAIL AND PUBLIC TRANSPORTATION
 A. G. RIPLEY
 DIRECTOR OF PLANNING AND PROGRAMMING

Long-Term Management of Existing
 Radioactive Wastes at Niagara Falls
 Storage Site
 U.S. Department of Energy

Mr. Charles H. Ellis III
 Environmental Impact Coordinator
 Council on the Environment
 9th Street Office Building
 Richmond, Virginia 23219

Dear Mr. Ellis:

We have reviewed the above noted document and would like the Department of Energy to coordinate with the Department of Highways and Transportation if any hazardous wastes are to be transported through highway tunnels.

Thank you for the opportunity to review this material.

Sincerely,

R. L. Hundley
 Environmental Engineer

KEW:smm

K.4 ORAL COMMENTS AND RESPONSES

Public meetings regarding the DEIS were held in the following locations: (1) Lewiston, New York, September 19, 1984; (2) Oak Ridge, Tennessee, September 20, 1984; and (3) Richland, Washington, September 24, 1984. Transcripts of the public meetings (U.S. Dep. Energy 1984c, 1984d, 1984e) can be found in public libraries near Lewiston, New York; Richland, Washington; and Oak Ridge, Tennessee; as well as in the Department's public readings rooms in Richland, Oak Ridge, and Washington, DC. Following are summaries of the oral comments and responses to those comments. Some oral comments were read from written copy; in these cases, the written copy is reproduced in Section K.3 (Written Comments and Responses) and responses also appear in that section. The IDs for the oral comments are listed below in the order that they appear in the document.

Letter ID		Page
<u>Lewiston, New York, September 19, 1984</u>		
BROSS	Irwin D. Bross, Biometatechnology, Inc., Eggertsville	K-200
KADR	Kathy Kadrid	K-200
KLAB	Walter Klabunde, Lewiston	K-200
LAFAL	John LaFalce, Congressman, 32nd District	K-200
LOMB	James Lombardi, Supervisor, Town of Lewiston	K-200
NCEMC	Niagara County Environmental Management Council	K-200
OGG	Alvin Ogg, Town of Lewiston	K-200
PILLI	Joseph Pillittere, New York Assemblyman	K-200
RAUCH	James Rauch, Williamsville	K-200
SIMON	Lee Simonson, Niagara County Legislator	K-200
WILLD	Duke Williams, Town of Lewiston	K-200
<u>Oak Ridge, Tennessee, September 20, 1984</u>		
BEND	F. Delmar Bender, Oak Ridge	K-200
FORD	Walter Ford, Kingston City Council	K-200
LUCKE	Rubey G. Luckey, Mayor, Kingston	K-200
MCNAL	Rand McNalley, Tennessee State Representative	K-200
PEELE	Robert Peele, Roane County Legislator	K-202
WALK	Mike Walker, Research and Budget Director, City of Oak Ridge	K-202
WILLS	Suzanne Williams, Anderson County Resident	K-204
YAGER	Ken Yager, Roane County Executive	K-204
YOUNG	James Young, Roane County Resident	K-204
<u>Richland, Washington, September 24, 1984</u>		
CALD	Larry Caldwell, Hanford Oversight Committee	K-204
FERG	Robert Ferguson, Tri-Cities Nuclear Industrial Council	K-204

Dr. Irwin D. Bross, Biometatechnology, Inc., Eggertsville, New York

BROSS See Section K.3.

Ms. Kathy Kadrid

KADR-1 Suggests investigating a process, possibly being developed by a Canadian firm, to treat wastes by electrical methods, which in some way or other changes the molecular structure (no specifics given).

Mr. Walter Klabunde, Resident, Town of Lewiston, New York

KLAB-1 Suggests adding another alternative--disposal of the NFSS wastes and residues in the caves that were created by atomic bomb tests at the Nevada Test Site.

Mr. John LaFalce, Congressman, 32nd District (by Mr. Richard Lee), New York

LAFAL See Section K.3.

Mr. James Lombardi, Supervisor, Town of Lewiston, New York

LOMB See Section K.3.

Niagara County Environmental Management Council (by Ms. Bonnie W. Soley)

NCEMC See Section K.3.

Mr. Alvin Ogg, Town of Lewiston, New York

OGG-1 Personal preference is for Alternatives 3a or 3b. Believes that Alternative 4c is the correct solution for the problem.

Mr. Joseph Pillittere, New York Assemblyman (by Mr. David McQuade)

PILLI See Section K.3.

Mr. James Rauch, Williamsville, New York

RAUCH See Section K.3.

Mr. Lee Simonson, Niagara County Legislator

SIMON See Section K.3.

Mr. Duke Williams, Resident, Town of Lewiston, New York

WILLD-1 Has been involved with two bomb tests and is concerned about his health.

WILLD-2 Notes that NFSS has not been maintained in the past and thinks that it will not be properly maintained in the future. Would therefore like to see the wastes and residues, or at least the most hazardous stuff (residues), removed from the site.

Mr. F. Delmar Bender, Resident, Oak Ridge, Tennessee

BEND See Section K.3.

Mr. Walter Ford, Member, Kingston City Council, Tennessee

FORD-1 There is enough nuclear waste already stored in Oak Ridge. The mercury pollution is with us. Opposed to the idea of bringing any nuclear waste from the Niagara area or any other area of the United States and storing it in Roane County.

Ms. Ruby G. Luckey, Mayor, Kingston, Tennessee

LUCKE See Section K.3.

Mr. Randy McNalley, State Representative, State of Tennessee

MCNAL-1 Opposes the transfer of the radioactive wastes from their present storage site in Niagara Falls, New York, to a site on Oak Ridge's DOE Reservation. Astronomical cost, no real benefit, runs contrary to the intent of Public Law 96-573 which recognizes that the management of low-level radioactive wastes is handled most efficiently on a regional basis. Should not be forced to take the radioactive wastes of other states or other regions.

BROSS See Section K.3.

KADR-1 The only processes for treating the wastes by electric methods of which the staff is aware are: processing of the residues to recover valuable metals, electric furnace fusion of the residues, and in-situ vitrification of the residues and wastes. These methods change the structure of the radioactive materials in that they are changed from a loose sand/soil/clay material into a vitreous (glass) slag. These methods are discussed further in Appendix C. (See also Responses NCMEC-2, RAUCH-7.)

KLAB-1 At the Nevada Test Site, wastes are buried in trenches in a manner similar to that analyzed for the Hanford site. (See also Response BEND-3.)

LAFAL See Section K.3.

LOMB See Section K.3.

NCMEC See Section K.3.

OGG-1 Recommendation for Alternative 4c is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

PILLI See Section K.3.

RAUCH See Section K.3.

SIMON See Section K.3.

WILLD-1 Concern is noted. DOE will take this into consideration in reaching a decision.

WILLD-2 Recommendation for Alternative 3a, 3b--or at least 4a, 4b, 4c, or 4d--is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

BEND See Section K.3.

FORD-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

LUCKE See Section K.3.

MCNAL-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

Mr. Robert Peele, Roane County Legislator

- PEELE-1 Thinks the DEIS is a good report and will help the decision-makers come to a reasonable conclusion. Questions further consideration of long-distance transport of the wastes and residues when it would cost several million dollars, cause death for some transport workers, and the only gain would be to remove ore treatment tailings from an area adjacent to a hazardous materials site in Niagara Falls and put them on a clean, rural hillside drained by one of the few remaining pristine streams on the Oak Ridge Reservation.
- PEELE-2 The report should add the cost of the transportation deaths. Usually it is some millions of dollars per life. It should also estimate the value of retaining unpolluted land on the Reservation.
- PEELE-3 The conceptual designs for waste storage areas at Oak Ridge show long, unbroken slopes; this is usually not done to help control erosion. Perhaps that's a detail that should be revised in the final design.
- PEELE-4 No details are given of what monitoring would be required other than visual inspection of erosion of the waste site during the 200 years. This should be elaborated a little in order to see what institutions will be required.
- PEELE-5 It is necessary to identify the cost for perpetual care for the assumed 200-year maintenance and monitoring period.
- PEELE-6 The statement is made twice that health and emergency services in the surrounding county areas are more than adequate. Roane County does not have police and fire protection that is adequate by any written standards ever seen by this commenter.

Mr. Mike Walker, Research and Budget Director, City of Oak Ridge, and Staff Representative to the City's Environmental Quality Review Advisory Board (EQAB)

- WALK-1 EQAB found the statement to be a useful evaluation of the relative merits of the alternative sites. The scale of the inquiry seems adequate. However, concerned about the appropriateness of selecting specific sites within the Oak Ridge Reservation, particularly in relation to soils, drainage, other DOE facilities, and private sector industrial development. If Oak Ridge were selected as the preferred alternative, the city would expect a more thorough treatment of these topics.
- WALK-2 The DEIS does not include the cumulative impacts of the proposed facility and existing Oak Ridge waste storage facilities.
- WALK-3 Beyond a mere statement of preemption, the environmental statement does not explore the consequences to the Oak Ridge area of removing the Pine Ridge Knolls site from other potential uses. Subdividing the original Exxon tract may reduce its attractiveness for other job-producing facilities. The statement does not explore the compatibility of storing offsite waste with long-range plans for Oak Ridge self-sufficiency.
- WALK-4 The Oak Ridge National Environmental Research Park is a designated use for 13,000 acres of the Oak Ridge Reservation. This fact is not acknowledged in the report.

- PEELE-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- PEELE-2 There is no acceptable method for assigning a dollar value to human life or for retaining land in a given condition.
- PEELE-3 It is noted in Section 4.2.1.3 that drainage control measures such as drainage swales to collect runoff from the pile and riprapped channels down the side slopes can be used to minimize gully development (severe erosion). However, it is also noted that without maintenance, the effectiveness of drainage control measures will decrease during the long-term period. A modification such as having less steep side slopes, thus decreasing the average slope, could decrease erosion rates (see Appendix C). This will be considered in developing the detailed design for whichever alternative is chosen.
- PEELE-4 Mitigative measures and monitoring for other parameters are discussed in general terms under each type of potential impact. Discussion of the environmental regulations concerning monitoring requirements is provided in Section 4.7.1. More detailed discussion of mitigative measures and monitoring to which DOE will be committed for the specific alternative chosen for implementation will be given in the Record of Decision, as required by the CEQ regulations for implementation of the National Environmental Policy Act. (See also Responses LAFAL-3; NYDEC-5, -24; USDOT-8; USEPA-28.)
- PEELE-5 These costs are detailed in Appendix F and are presented in terms of annual cost, total payout (for 200 years), and a sinking fund (see Table F.1).
- PEELE-6 A statement about the concern regarding the adequacy of health and emergency services has been added to Section 3.6.6.3, p. 3-38 (see Section K.5).
- WALK-1 Oak Ridge was not selected as the preferred alternative. The concern about site selection within the Oak Ridge Reservation is noted. (See also RYMAN-4, TDHE-5, USEPA-32, WALK-3, YAGER-2.)
- WALK-2 Cumulative radiological impacts are discussed in Section 4.1.2.1 (p. 4-18). During the action period when the greatest radioactive releases are expected to occur, the predicted 16-rem whole-body dose to the general public near Oak Ridge compares to the 200-rem dose that is predicted to occur over the same 10-year period because of other existing nuclear activities on the Reservation. Comparison is also made to the several million rem to the same population from natural background radiation over the same period of time. Other cumulative impacts are also covered, particularly transportation impacts (Section 4.6.3).
- WALK-3 More discussion of the potentially significant impact of preemption of land at Oak Ridge is given in Section 4.6.1 wherein it is noted that the Pine Ridge Knolls site is considered to be a prime potential industrial site in a hilly region where such sites are scarce. It is also noted that there is a scarcity of waste-management and landfill sites in the area and that dedication of the Pine Ridge Knolls site to management of the NFSS contaminated materials will lessen the amount of land available for disposal of other wastes. The Planning Director for the City of Oak Ridge (Lucien Faust) has indicated that although land is available within the city for industrial development for the next few years, land that could be developed for industrial purposes will become scarce; more land outside the city boundaries (e.g., along the Pellissippi Parkway) might be developable (personal communication to G. Williams, Argonne National Laboratory, June 5, 1984).
- Use of the Pine Ridge Knolls site would remove about 24 ha (60 acres) from potential development if all the NFSS wastes and residues were brought to Oak Ridge (Table 4.58). The land in the valley along Bear Creek Road would still be available for potential industrial development. One measure of the potential impact of the preemption of the knolls for management of the DOE-owned NFSS wastes and residues is the potential income that might accrue to local governments if the site were someday developed for commercial waste management. Based on a recent proposal to the city of Oak Ridge by Westinghouse/Hittman (January 5, 1984), the city would collect \$27 million if the same amount of commercial waste were disposed at the Pine Ridge Knolls site (\$4/ft³). (See also Responses RYMAN-4, TDHE-5, USEPA-32, WALK-1, YAGER-2.)
- WALK-4 The information in Section 3.3.5 has been corrected to include this fact (see Section K.5). Designation of other portions of the Reservation as a National Environmental Research Park is compatible with use of the Pine Ridge Knolls site for waste disposal.

Mr. Mike Walker (Continued)

- WALK-5 The text promises a discussion in Appendix D of offsite sources for fill to cover the wastes, yet the appendix does not include it.
- WALK-6 Chemical modification of the wastes and residues was considered for the Niagara Falls site, but not the Oak Ridge site.
- WALK-7 Geological faulting on the Oak Ridge Reservation is mentioned, but faults are not located nor is their capacity indicated.
- WALK-8 The population area of Oak Ridge is underestimated in figures such as Figure 3.13. The southwest quadrant contains residences and these may be closest to the proposed disposal site.
- WALK-9 Oak Ridge is located in both Anderson and Roane counties, not just Anderson.
- WALK-10 Believes that the Norfolk-Southern Railway has access to the Oak Ridge Gaseous Diffusion Plant as well as to the city of Knoxville.

Ms. Suzanne Williams, Resident, Anderson County

- WILLS-1 Opposed to the option of bringing the Niagara Falls Storage Site low-level radioactive waste to Oak Ridge. People do not want more waste brought here.
- WILLS-2 Suggests that the taxpayer's money would be much better spent in cleaning up the sites on the Oak Ridge Reservation, that it will be difficult to attract other industries if the area becomes known as a nuclear waste dump, and that the Oak Ridge area is a very poor area for waste disposal because of its geology and hydrology.

Mr. Ken Yager, Roane County Executive

YAGER See Section K.3.

Mr. James Young, Resident, Roane County

- YOUNG-1 Opposes this proposal [to possibly bring NFSS wastes and/or residues to Oak Ridge] vehemently because there are enough problems in this area without importing any more. The past history of DOE [Oak Ridge] operations should be taken into consideration. This state is in trouble.

Mr. Larry Caldwell, Hanford Oversight Committee, Washington

- CALD-1 The Manhattan Engineer District was not formed to win the war for Washington State alone. The fruits of victory over the Axis powers were enjoyed by all of the states and regions. Therefore, sincerely believes that the burdens should be shared in an equitable manner. The people of the Northwest are tired of acting as the nation's garbage dump. They do not want the Niagara Falls wastes or residues. They want Hanford cleaned up.

Mr. Robert Ferguson, Tri-Cities Nuclear Industrial Council, Washington

- FERG-1 Suggests presenting the radon information so that it can be related to common doses that people experience in their everyday living.
- FERG-2 Believes that the state of Washington should not be the disposal site for all radioactive wastes and strongly opposes the transfer of the wastes from NFSS. Believes that other regions, too, should bear a similar obligation to assume their fair share of responsibility.
- FERG-3 Hanford clearly stands out as the most expensive and impractical alternative. Expenditure of over a quarter of a billion dollars when compared to the much smaller costs of other workable alternatives would be a gross insult to the American taxpayers.

- WALK-5 It is noted in Section 4.2.3 that limited supplies of sand and gravel may be available in Roane and Anderson counties and that the requirements for the cover system at the Oak Ridge site may strain existing supplies or may compete with existing or future demands for these materials. Fill requirements are given in Table D.10. Specific sites for sources of fill materials would be identified at a much later stage in the decision-making process as part of procurement efforts after a Record of Decision is reached and after detailed design engineering is completed.
- WALK-6 Only modification of the residues at NFSS was considered. Analysis showed that modification of the residue form provided little benefit with respect to either radon emanation or contaminant migration in groundwater (Section 4.1.2.2 and 4.2.2.3), so it was not considered further.
- WALK-7 This information is summarized in Section 3.3. More detailed information can be found in the referenced reports.
- WALK-8 Figure 3.13 is not meant to show population distribution; rather it is meant to show relative locations of various developments. The locations of nearby individuals for which specific radiological doses were calculated are shown in Table 4.8 and include a residence located south-southwest of the Pine Ridge Knolls site.
- WALK-9 The first paragraph of Section 3.3.5 has been corrected to include Roane County.
- WALK-10 Section D.5.4.1 has been corrected to include the Norfolk Southern connection.
- WILLS-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- WILLS-2 Opinion is noted. DOE prefers to manage the NFSS wastes and residues at NFSS and not remove them to Oak Ridge. DOE is also conducting extensive studies to define the extent of contamination at Oak Ridge, and plans are being prepared to take appropriate remedial actions at Oak Ridge.
- YAGER See Section K.3.
- YOUNG-1 Opposition to Alternatives 3b, 4c, and 4d is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- CALD-1 Recommendation against Alternatives 3a, 4a, and 4b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- FERG-1 Comparisons to everyday living are given in several parts of the EIS. In Section 4.1.2.1, doses during the action period are compared to doses from natural background radiation. The doses at Niagara Falls are compared to having each member of the exposed population spend the 10-year action period at a 3.5-cm (1.4-in.) higher elevation. Comparisons are also given in Section 4.1.2.2 and 4.1.2.3.
- FERG-2 Recommendation against Alternatives 3a, 4a, and 4b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.
- FERG-3 Recommendation against Alternatives 3a, 4a, and 4b is noted. This comment, along with those from other commenters, was taken into consideration in determining the preferred alternative.

REFERENCES (Appendix K)

- Alacević, M. 1980. Progress in Environmental Mutagenesis. Proceedings of the EEMF, 9th Annual Meeting held in Tucepi, Yugoslavia, 30th September - 5th October, 1979. Developments in Toxicology and Environmental Science, Volume 7. Amsterdam, Elsevier/North-Holland Biomedical Press.
- Anderson, T.L., J.F. Dettorre, D.R. Jackson, and B.S. Ausmus. 1981. A Comprehensive Characterization and Hazard Assessment of the DOE-Niagara Falls Storage Site. BMI-2074 (Revised). Prepared for the U.S. Department of Energy, Remedial Action Program, by Battelle Columbus Laboratories, Columbus, OH. June 1981. 3 v.
- Bechtel National, Inc. 1984. Engineering Evaluation of Alternatives for the Disposition of Niagara Falls Storage Site, Its Residues and Wastes. DOE/OR/20722-1. Prepared for U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN. January 1984.
- Bechtel National, Inc. 1985. Building 411 Top. Estimates prepared for the U.S. Department of Energy, Oak Ridge Operations. June 1985. Attachment to letter from J. Nemec (Bechtel) to E.L. Keller (DOE), June 10, 1985.
- Boyle, J.W., R. Blumberg, S.J. Cotter, G.S. Hill, C.R. Kerley, R.H. Ketelle, R.L. Kroodsmas, D.W. Lee, R.C. Martin, R.D. Roop, D.N. Secora, W.P. Staub, and R.E. Thoma. 1981. Environmental Analysis of the Operation of Oak Ridge National Laboratory (X-10 Site). ORNL-5870. Prepared for U.S. Department of Energy by Oak Ridge National Laboratory, Oak Ridge, TN. November 1982.
- Council on Environmental Quality. 1978. National Environmental Policy Act - Regulations; proposed implementation of procedural revisions (40 CFR Parts 1500, 1501, 1502, 1503, 1504, 1505, 1506, 1507, 1508). Fed. Regist. 43(112):25230-25247 (June 9, 1978).
- DeSerres, F.J., and M.D. Shelby. 1981. Comparative Chemical Mutagenesis. Plenum Press, New York.
- EAL Corporation. 1984. Analysis Report to Eberline Instrument Corporation. November 19, 1984.
- Exxon Nuclear Company, Inc. 1977. Nuclear Fuel Recovery and Recycling Center. XN-FR-33. Environmental Report, Docket No. 50-564. Vols. 1 and 3.
- Foster, C. 1984. Low-level radioactive waste in monitoring wells at ORNL. Oak Ridger, October 23, 1984, p. 1.
- Hodel, D.P. 1983. Letter (Secretary, U.S. Department of Energy, Washington, DC) to Honorable J.V. Evans, Chairman of the Subcommittee on Nuclear Power, National Governors Association, Washington, DC), December 13, 1983.
- International Atomic Energy Agency. 1980. Radiological Equivalents of Chemical Pollutants. Proceedings of an Advisory Group Meeting, Vienna, 12-16 December 1977. Vienna, Austria.
- Luckey, T.D. 1980. Hormesis with Ionizing Radiation. CRC Press, Inc., Boca Raton, FL.
- Luckey, T.D. 1982. Physiological benefits from low levels of ionizing radiation. Health Phys. 43(6): 771-789.
- Momeni, M.H., Y. Yuan, and A.J. Zielen. 1979. The Uranium Dispersion and Dosimetry (UDAD) Code. NUREG/CR-0553; ANL/ES-72. Prepared for U.S. Nuclear Regulatory Commission by Argonne National Laboratory, Argonne, IL. May 1979.
- National Research Council. 1985. The Management of Radioactive Waste at the Oak Ridge National Laboratory, A Technical Review. National Academy Press.
- Pradel, J. 1982. La Gestion des Dechets Solides de l'Extraction et du Traitement des Minerais d'Uranium en France. Management of Wastes from Uranium and Milling. Proceedings of a Symposium, International Atomic Energy Agency, Vienna, Austria.
- Streng, D.L., and T.J. Bander. 1981. MILDOS - A Computer Program for Calculating Environmental Radiation Doses from Uranium Recovery Operations. NUREG/CR-2011; PNL-3767. Prepared for U.S. Nuclear Regulatory Commission, Washington, DC, by Pacific Northwest Laboratory, Richland, WA. April 1981.
- U.S. Department of Energy. 1982a. Action Description Memorandum, Niagara Falls Storage Site, Proposed 1982 Interim Remedial Action (R-10 Pile Stabilization). Final, April 14, 1982.
- U.S. Department of Energy. 1982b. Action Description Memorandum, Niagara Falls Storage Site, Proposed Interim Remedial Action for Buildings 413 and 414. Final, April 14, 1982.

- U.S. Department of Energy. 1982c. Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley, New York. Final Environmental Impact Statement. DOE/EIS-0081. June 1982.
- U.S. Department of Energy. 1983a. Action Description Memorandum, Niagara Falls Storage Site, Proposed Interim Remedial Actions for FY 1983. Final, February 14, 1983.
- U.S. Department of Energy. 1983b. Action Description Memorandum, Niagara Falls Storage Site, Proposed Interim Remedial Actions for FY 1983-85 Accelerated Program. Final, June 20, 1983.
- U.S. Department of Energy. 1983c. Long-Term Management of Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site: Notice of Intent to Prepare an Environmental Impact Statement and Conduct a Public Scoping Meeting. Fed. Regist. 48(22):4522 (February 1, 1983).
- U.S. Department of Energy. 1984a. Draft Environmental Impact Statement, Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site. DOE/EIS-01090. Washington, DC. August 1984.
- U.S. Department of Energy. 1984b. Announcement of availability of Draft Environmental Impact Statement, Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site; and intent to conduct public hearings. Fed. Regist. 49(161): 33706 (August 24, 1984).
- U.S. Department of Energy. 1984c. Transcript of the Public Hearing on the Draft Environmental Impact Statement for the Niagara Falls Storage Site. Conducted by the U.S. Department of Energy, September 19, 1984, Lewiston-Porter Senior High School, Lewiston, New York.
- U.S. Department of Energy. 1984d. Transcript of the Public Hearing Re: The Niagara Falls Storage Site, Draft Environmental Impact Statement. Meeting Held at the Main Auditorium, Federal Building, Richland, Washington, on Monday, September 24, 1984 at 7:30 p.m.
- U.S. Department of Energy. 1984e. Transcript of the United States Department of Energy Public Hearing, American Museum of Science and Industry, Oak Ridge, Tennessee, September 20, 1984.
- U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR 192. Fed. Regist. 48(3):590-609 (January 5, 1983).
- U.S. Supreme Court. 1983. Metropolitan Edison Co. et al. v. People Against Nuclear Energy et al. (103S.C.T.1556). Argued March 1, 1983--Decided April 19, 1983.
- Van Kote, F. 1982. 12 years of experience of shallow land disposal of low and intermediate level radioactive waste in France. In Proceedings of the Symposium on Low-Level Waste Disposal, September 29-30, 1982. NUREG/CP-0028; CONF-820911. U.S. Nuclear Regulatory Commission.

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