Appendix B

Assumed Disposal Cell Cover Conceptual Design and Construction

B1.0 Introduction

This appendix describes the technical basis for the disposal cell cover conceptual design assumed for the purposes of this environmental impact statement (EIS) at the Moab, Klondike Flats, and Crescent Junction, Utah, sites. The design is strictly pre-conceptual and is intended to develop a basis for comparing impacts between the alternatives. This assumed design is not intended to commit the U.S. Department of Energy (DOE) to any specific cover design but rather to establish a reasonable basis for evaluating environmental impacts associated with this component of site remediation and reclamation.

The design for the White Mesa Mill site disposal cell cover is different from the design described here because it is based on an unsolicited proposal submitted to DOE. The White Mesa Mill cover approach reflects an alternative design more typical of Title II (Uranium Mill Tailings Radiation Control Act [UMTRCA]) uranium mill tailings reclamation similar to that proposed in the U.S Nuclear Regulatory Commission's (NRC's) *Final Environmental Impact Statement Related to Reclamation of the Uranium Mill Tailings at the Atlas Site, Moab, Utah* (NRC 1999). A brief description of the White Mesa Mill cover design is included in Section B4.0.

By including both design approaches, DOE has attempted to support decision-making by presenting a range of potential cover design approaches and a sense of the associated impacts related to the cover component selected for the final remedy.

B2.0 Current Design Concept

Engineered covers are the accepted remedial action to achieve containment (DOE 1989). In the case of uranium mill tailings, the engineering process must address the regulatory requirement that the cover remain effective for 1,000 years where reasonably achievable, and in no case for less than 200 years (EPA 1983).

In the semiarid Moab environment, ground water recharge is naturally limited where thick, fine-grained soils store precipitation until soil evaporation and plant transpiration seasonally return it to the atmosphere. The current assumed design mimics and enhances this natural water conservation. The design includes a water storage soil layer consisting of thick, fine-grained soil. This water storage soil layer overlies a coarse-grained capillary break layer that limits downward water movement and increases the water storage capacity of the water storage soil layer. High tensions in the small pores of the water storage soil layer impede movement of water into the larger pores of the underlying coarse-grained layer. Drainage into the capillary break layer occurs only if water accumulation at the sponge/capillary break layer interface approaches saturation and tensions decrease sufficiently for water to enter the larger pores (Ho and Webb 1998; Stormont and Morris 1998; Hillel 1980).

Evapotranspiration prevents excessive water accumulation above the textural break (Waugh et al. 1991; Anderson et al. 1993; Link et al. 1994; Sackschewsky et al. 1995; Waugh et al. 2004; Anderson and Forman 2002). In short, the water storage soil layer stores water while plants are dormant, then plants extract stored water during the growing season and return it to the atmosphere. Performance monitoring data for similar water balance designs have shown that flux rates are considerably less than 1×10^{-7} centimeters per second (cm/s) (Waugh 2004).

The assumed design relies on management of the water balance as the primary means for limiting water infiltration. Figure 2–6 of DOE's current draft EIS is a conceptual cross section of the final condition of the proposed disposal cell. The figure also illustrates the types and cover dimensions of the materials that would be placed on the sides and top of the cell to contain radon emissions and stabilize the cell. Variations of this design would be used for both the on-site and off-site alternatives analyzed in the draft EIS.

The assumed cover system's top slope**,** described from the base upward, would consist of

- A 1.5-foot-thick radon/infiltration barrier consisting of basal clay.
- A 0.5-foot-thick capillary break layer consisting of coarse sand/fine gravel.
- A 3.5-foot-thick water storage soil layer consisting of fine-grained soil.
- A 0.5-foot-thick surface erosion protection layer (called the soil/rock admixture) consisting of 80 percent soil and 20 percent limestone riprap.
- A vegetated surface for water balance control.

The assumed cover system's side slope would be identical to the top slope system with the exception of the soil/rock admixture. Because the side slope would be steep, a much greater erosion potential would exist compared to the top slope. A 1-foot-thick riprap rock surface would be designed and constructed in accordance with NUREG-1623, *Design of Erosion Protection for Long-Term Stabilization* (NRC 2002). To facilitate water-balance control, voids in the riprap would be filled with soil and planted.

Table B–1 lists the basis for each component of the assumed design.

Table B–1. Technical Basis and Assumptions for Components of the Assumed Cover Design

Compacted Soil Layer
• Layer thickness would be based on calculations of radon flux at the surface of the compacted soil layer. • Soil type (e.g., clay loam) would be selected from available borrow sources that can satisfy performance requirements for permeability and radon attenuation. • Compaction requirements would be determined with tests and calculations of saturated hydraulic conductivity and radon attenuation. • Soil conditioning requirements would consider the morphology and structure of borrow soils.
Capillary Break Layer
• Grain size and gradation requirements would be based on tests and calculations of (1) unsaturated flow (e.g., Richard's equation) between the water storage soil layer and capillary break layer, and (2) saturated hydraulic conductivity. • The layer thickness would be based on the design (monolayer or graded filter) and constructability.

Table B–1 (continued). Technical Basis and Assumptions for Components of the Assumed Cover Design

Water Storage Soil Layer ***Materials:*** • The soil type would be selected from available borrow sources that can satisfy water balance and revegetation performance standards. • Soil selection criteria would include soil hydraulic properties and water storage capacity. • Soil materials would have adequate fertility and nominal phytotoxicity (e.g., low salinity and sodicity) for establishing and sustaining a diverse plant community. ***Thickness*:** The thickness would be based on evaluations of • Current and possible future climates. • Water storage capacity. • Plant evapotranspiration rates and seasonality. • Plant root ecology, depths, and distribution. • Burrowing animal ecology, habitat conditions, and burrow characteristics. • Frost protection requirements for the underlying compacted soil layer.
Soil/Rock Admixture • Rock mixed into the soil/rock admixture on the top slope and side slope would satisfy NRC criteria for size and durability. • The hydraulic properties of interstitial soil would match the underlying water storage soil layer. • The interstitial soil would be live topsoil with favorable fertility, microbiology, propagules, and nominal phytotoxicity. • The admixture layer would be placed to act as a mulch, to reduce evaporation, and to hold plant-available water near the surface. • No credit would be taken for erosion protection provided by plants.
Vegetation • Revegetation goals would include rapid establishment; ability to adapt to soil/rock admixture habitat; ample and spatially uniform evapotranspiration rates; sustainability; resilience to disturbance (e.g., fire, drought, disease); and consistency with future land use. • The revegetation design would be based on current and future climate, potential natural vegetation, and borrow soil hydrology, chemistry, fertility, and biology.

B3.0 Construction

After all the contaminated materials from the site and vicinity properties were relocated to the top of the tailings pile and the consolidation process was under way, the final side slope would be graded and recontoured to a 3:1 horizontal:vertical slope. The top would be contoured to slope (less than 0.5 percent) outward toward the side slopes.

B3.1 Side Slope Construction

Side slope cover construction would start with placement of the compacted soil layer that would form the radon barrier. Clayey soil borrow material would be transported to the site by truck or tandem trailers, dumped at the base of the pile, and pushed up the recontoured slopes with a dozer. A similar procedure would be used to place the capillary break layer’s sand/gravels and the water storage soil layer’s fine-grained soils. The soil/rock admixture would be the final layer placed on the side slopes. For this layer, erosion control limestone riprap would be placed to the required thickness, and interstitial voids would be loosely filled with soils.

B3.2 Top Slope Construction

Top slope cover construction would begin when pore pressure readings indicated that the slimes were 90 percent consolidated. Construction would follow the same order as side slope construction described above. A surface layer consisting of a soil/rock admixture 0.5 foot thick would protect the underlying layers from the effects of erosion. This layer would be constructed by creating a 20 percent–80 percent mixture of rock-soil by volume. Rock would be sized to resist wind and water erosion. Soil would promote plant growth, which is crucial for a successful water-balance cover. The soil/rock admixture would be planted with vegetation for water extraction and infiltration control.

B3.3 Construction-Related Features and Objectives

B3.3.1 Vegetation

A diverse mixture of native plants on the cover would maximize water removal by evapotranspiration (Link et al. 1994) and remain more resilient to major disturbances and fluctuations in the environment. Revegetation efforts would attempt to emulate the structure, diversity, dynamics, and function of native plant communities occurring on deep, fine-grained soils in the area. The native vegetation at Moab is a mosaic of species that structurally and functionally change in response to disturbances and climatic fluctuations (Tausch et al. 1993). Similarly, biological diversity in the cover vegetation would be important to plant community stability and resilience, given variable and unpredictable changes in the environment resulting from pest outbreaks, disturbances (overgrazing, fire, etc.), and climatic fluctuations.

B3.3.2 Erosion Control

A primary erosion control issue for vegetated cover designs is whether vegetation alone adequately limits soil loss or if gravel and rock admixtures are necessary to armor the soil when vegetation is sparse or less dependable. Vegetation and organic litter disperse raindrop energy, slow flow velocity, bind soil particles, filter sediment from runoff, increase infiltration, and reduce surface wind velocity (Wischmeier and Smith 1978). However, vegetation alone may be inadequate, particularly in the first years after construction. To achieve the benefits of a combination of rock for erosion protection and plants for evapotranspiration, DOE’s assumed cover design includes mixing rock into the upper soil layer. Erosion studies (Finely et al. 1985; Ligotke 1994) and soil-water balance studies (Waugh et al. 1994; Sackschewsky et al. 1995) suggest that rock mixed into the cover topsoil would control both water and wind erosion and act as a mulch to enhance plant establishment and growth. As wind and water passed over the surface, some winnowing of fines from the admixture would be expected, leaving a vegetated erosion-resistant pavement.

B3.3.3 Frost Protection

The 3.5-foot-thick water storage soil layer would provide more than adequate depth to isolate the capillary break layer and compacted soil layer from frost damage. The estimated maximum frost depth in the topsoil layer would be less than 3 feet given historical climatic conditions. A modified Berggren approach (DOE 1989; Smith and Rager 2002) would be used to calculate the maximum frost depth for a range of possible future climate changes.

B3.3.4 Biointrusion Control

The current assumed design includes measures to limit biological intrusion by plant roots and burrowing vertebrates. By retaining soil water close to the surface, the water storage soil layer and capillary break layer would create a habitat for relatively shallow-rooted plant species; root growth would generally be limited to regions within the soil where extractable water was available. The thickness of the water storage soil layer is expected to exceed the burrow depths of most vertebrates in the Moab area. If deeper burrowing were likely for either current conditions or for a future climate scenario, a layer of rock would be mixed into the water storage soil layer as an added deterrent. Loosely aggregated gravel and rock have been shown to deter burrowing mammals (Cline et al. 1980; Hakonson 1986; Bowerman and Redente 1998). A rock biointrusion layer would be placed immediately above the capillary break layer.

B4.0 White Mesa Mill Site Disposal Cell Cover

The White Mesa Mill site cover design consists of an erosion-protection layer consisting of 3-inch-diameter riprap, a 2-foot frost barrier, a 12-inch compacted clay radon barrier, and 3 feet of platform fill. Side slopes would consist of random fill covered by riprap. The cover design is consistent with other Title II cell designs approved by NRC. DOE has determined that at the conceptual stage, the design appears to be reasonable.

B5.0 References

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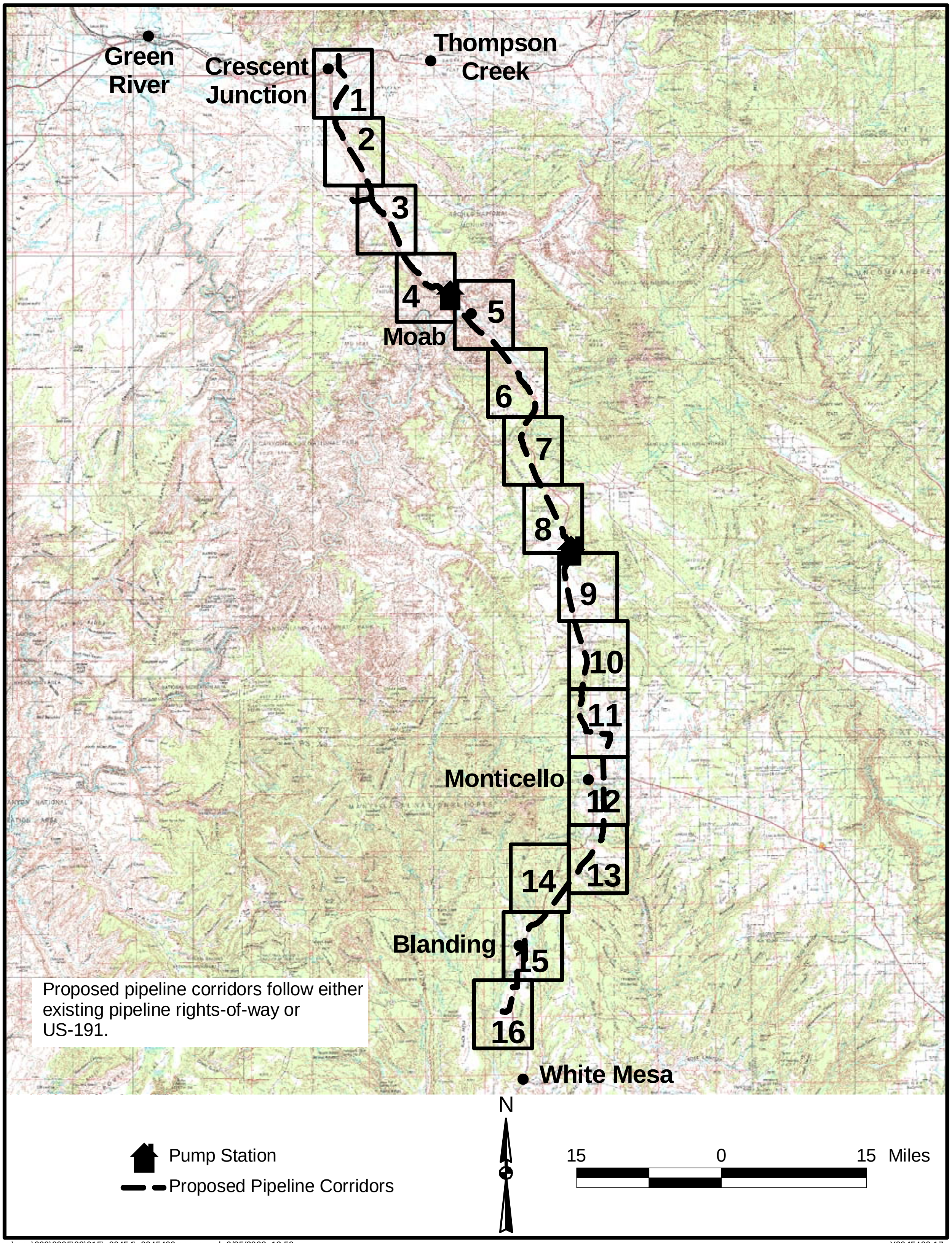
Appendix C

Slurry Pipeline Route Maps


Green River
Crescent Junction
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White Mesa
Proposed pipeline corridors follow either existing pipeline rights-of-way or US-191.
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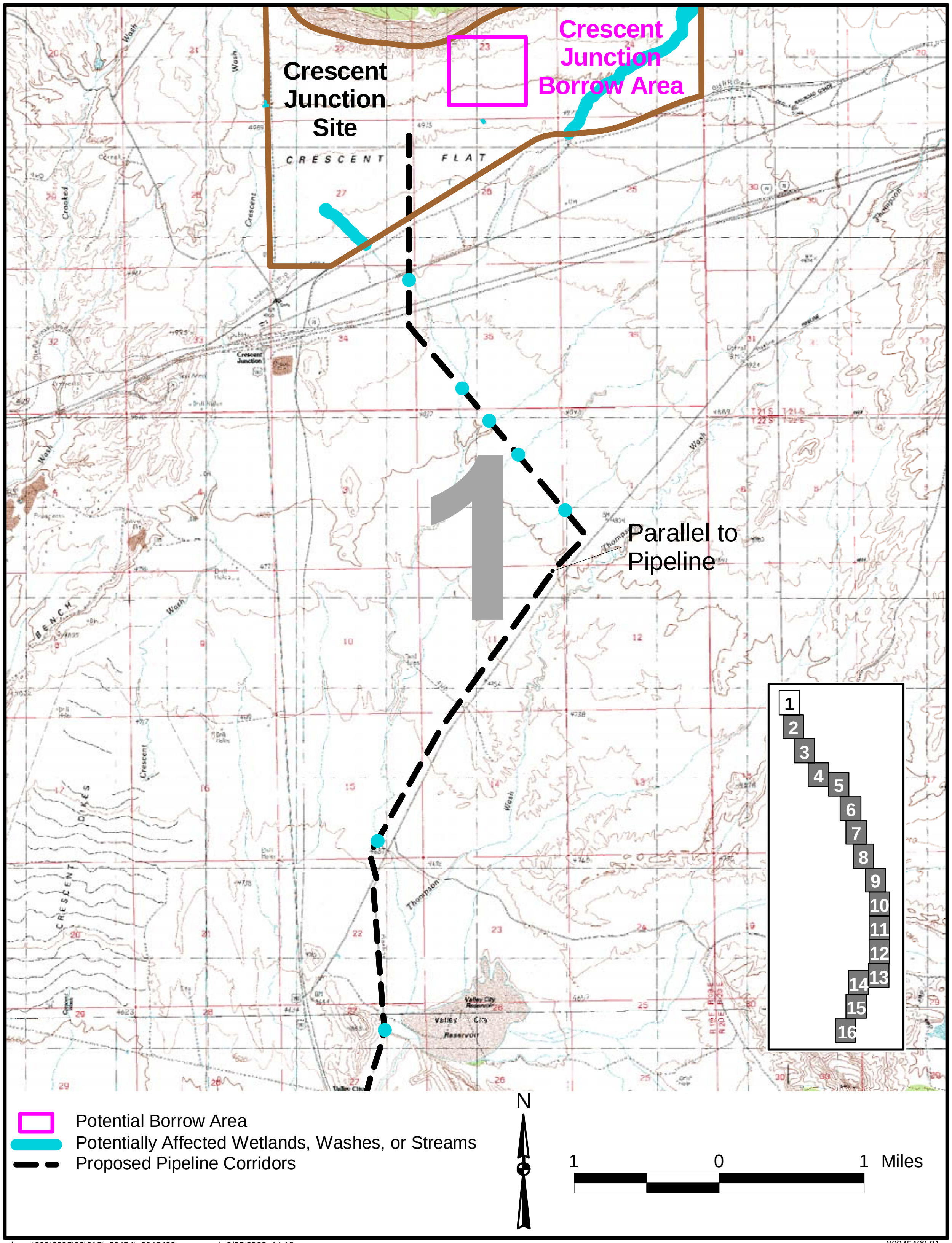
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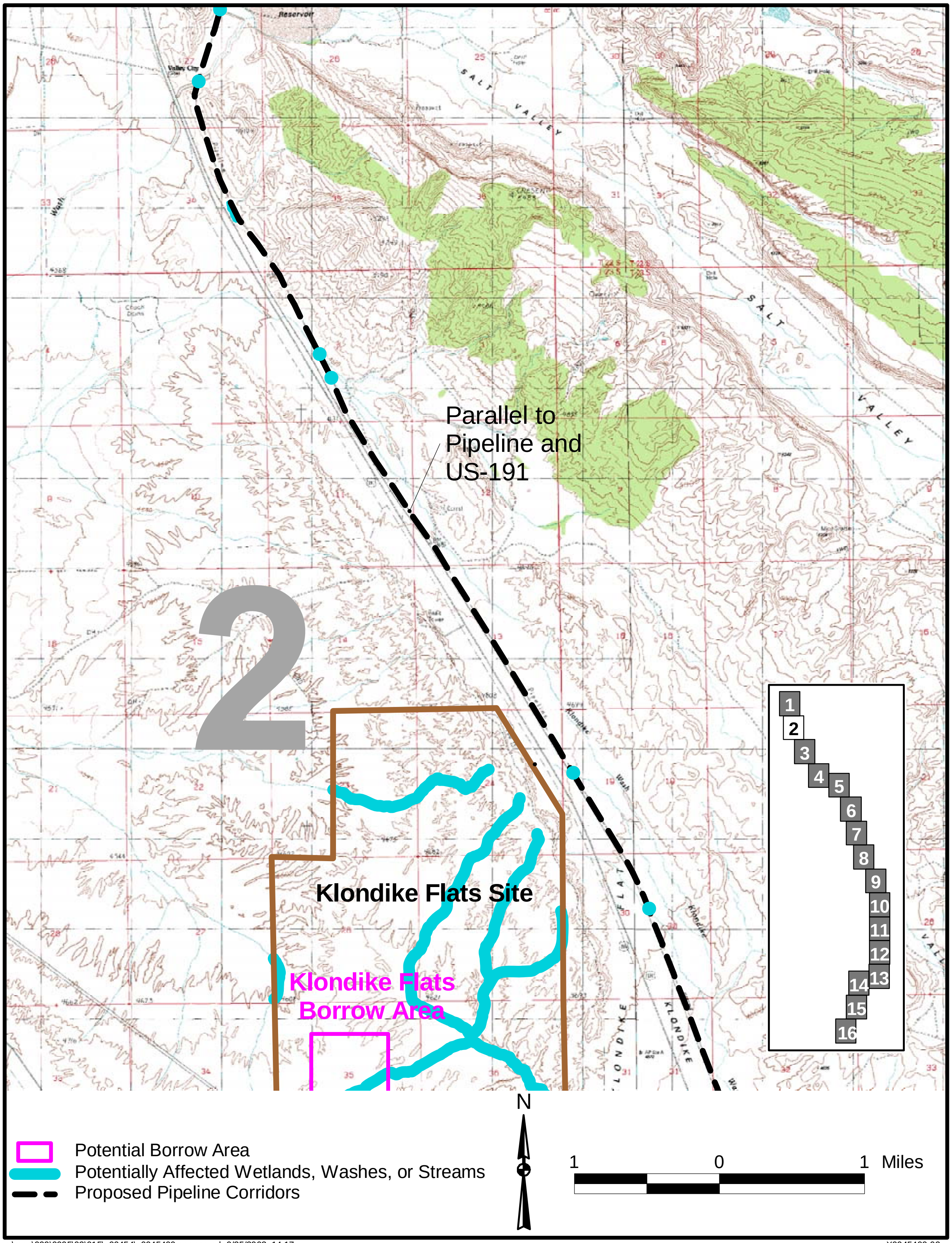
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Klondike Flats Site
Klondike Flats Borrow Area
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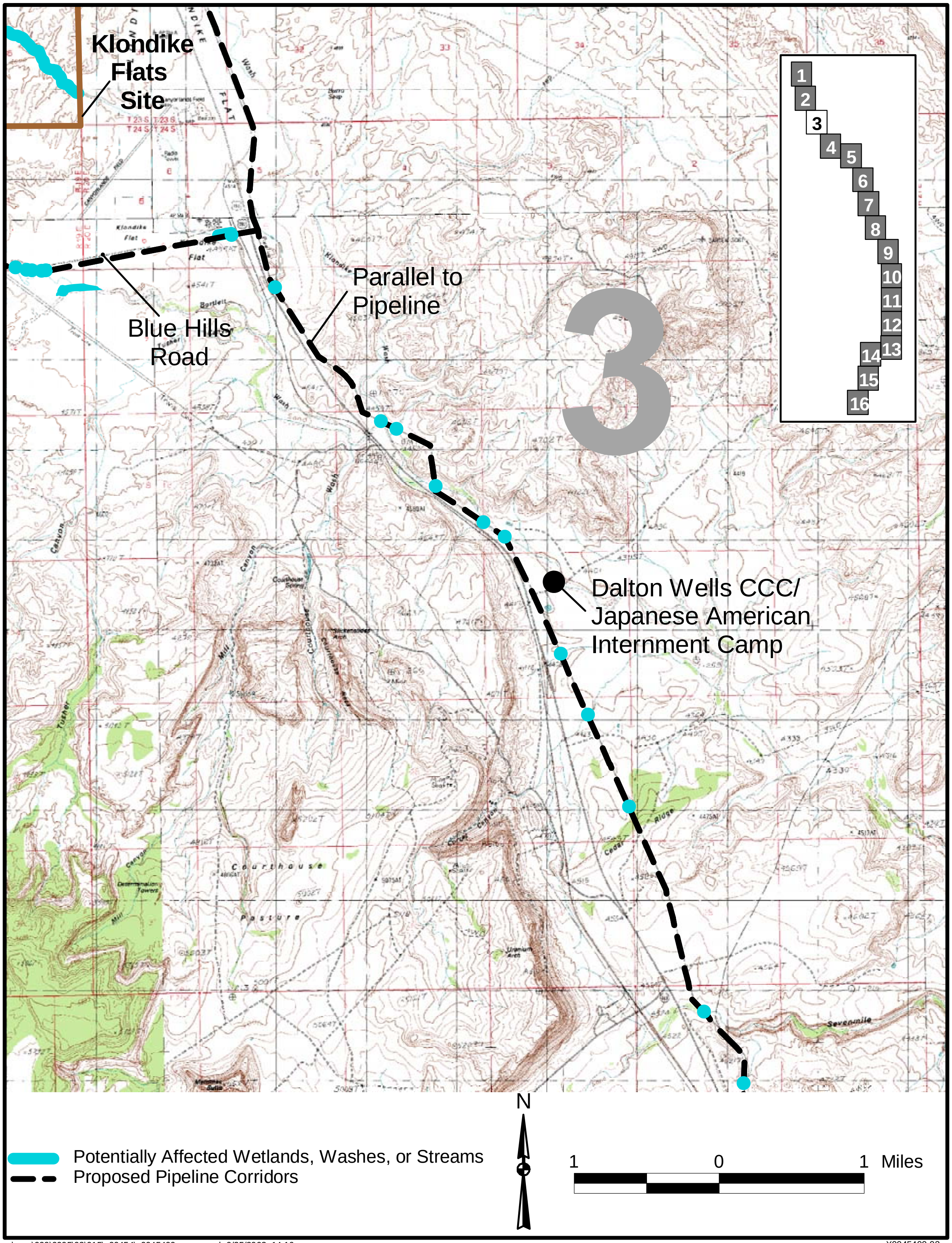

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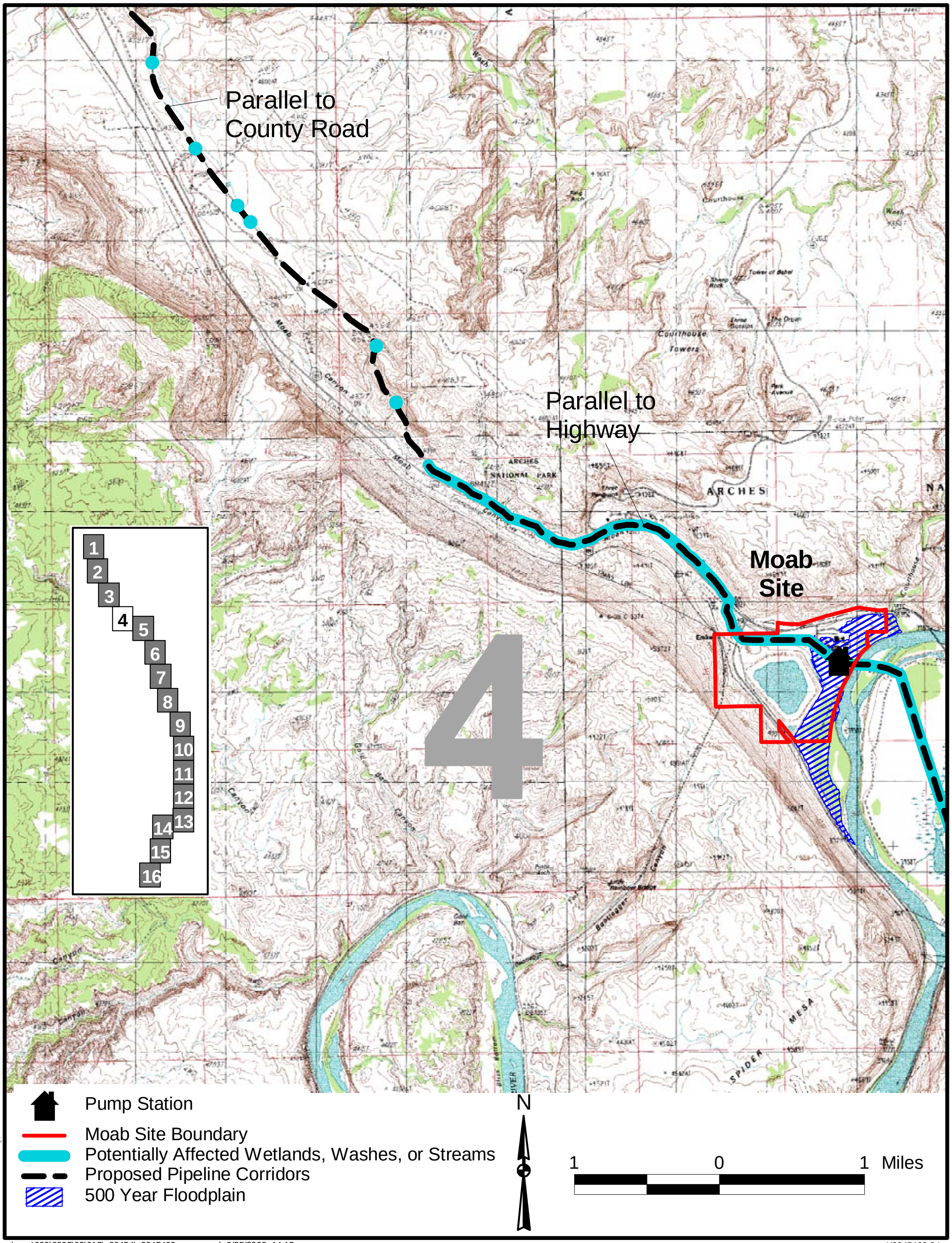
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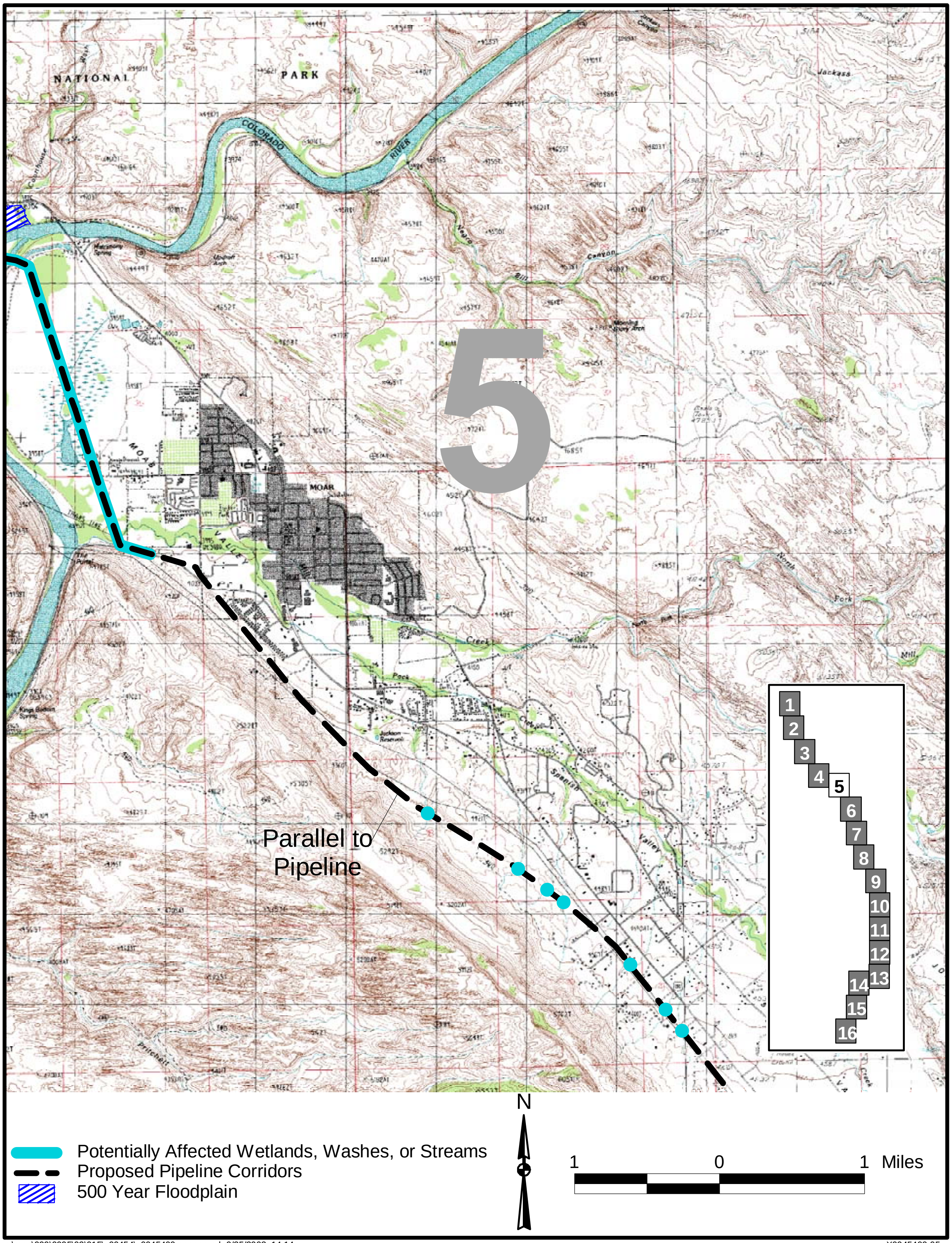

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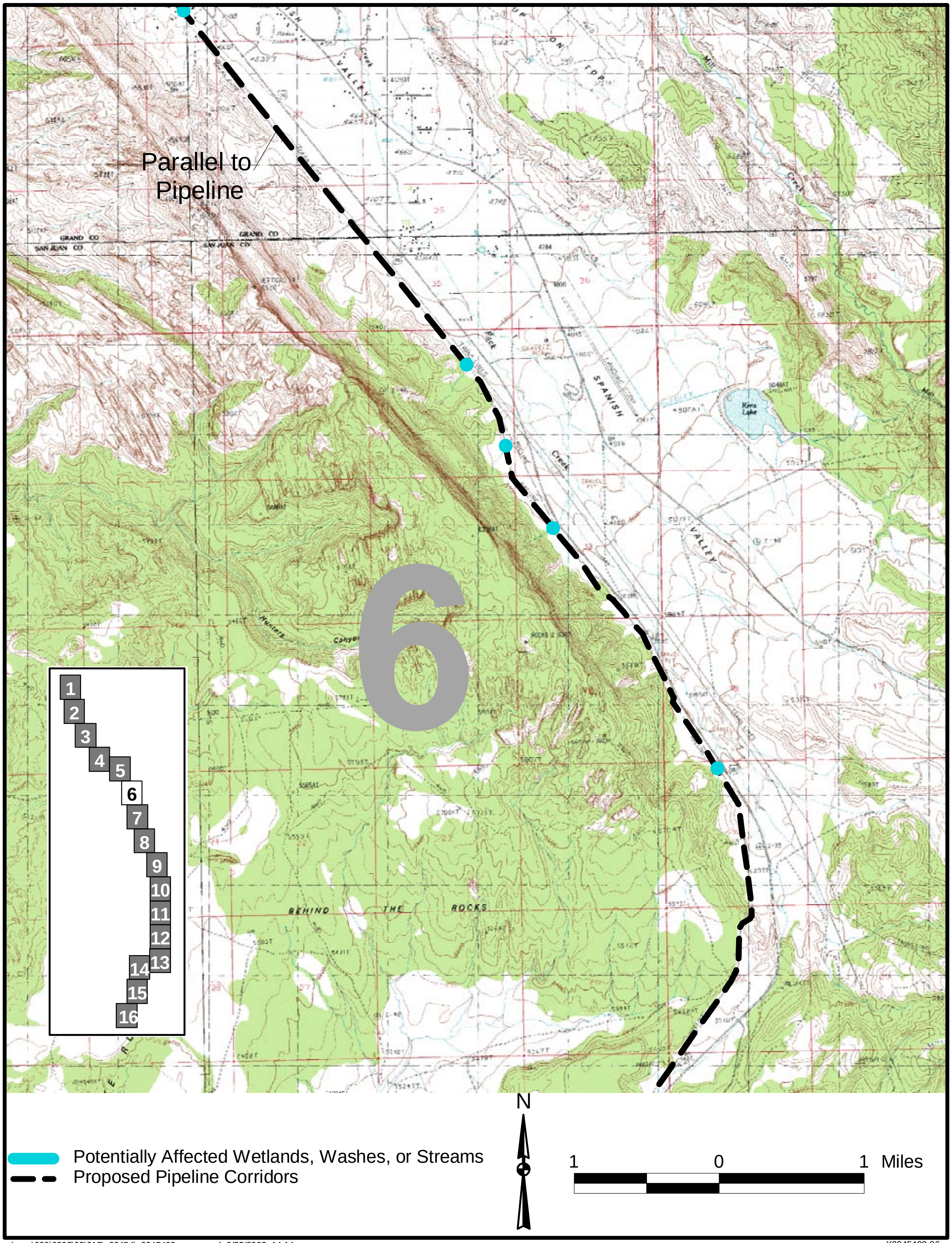

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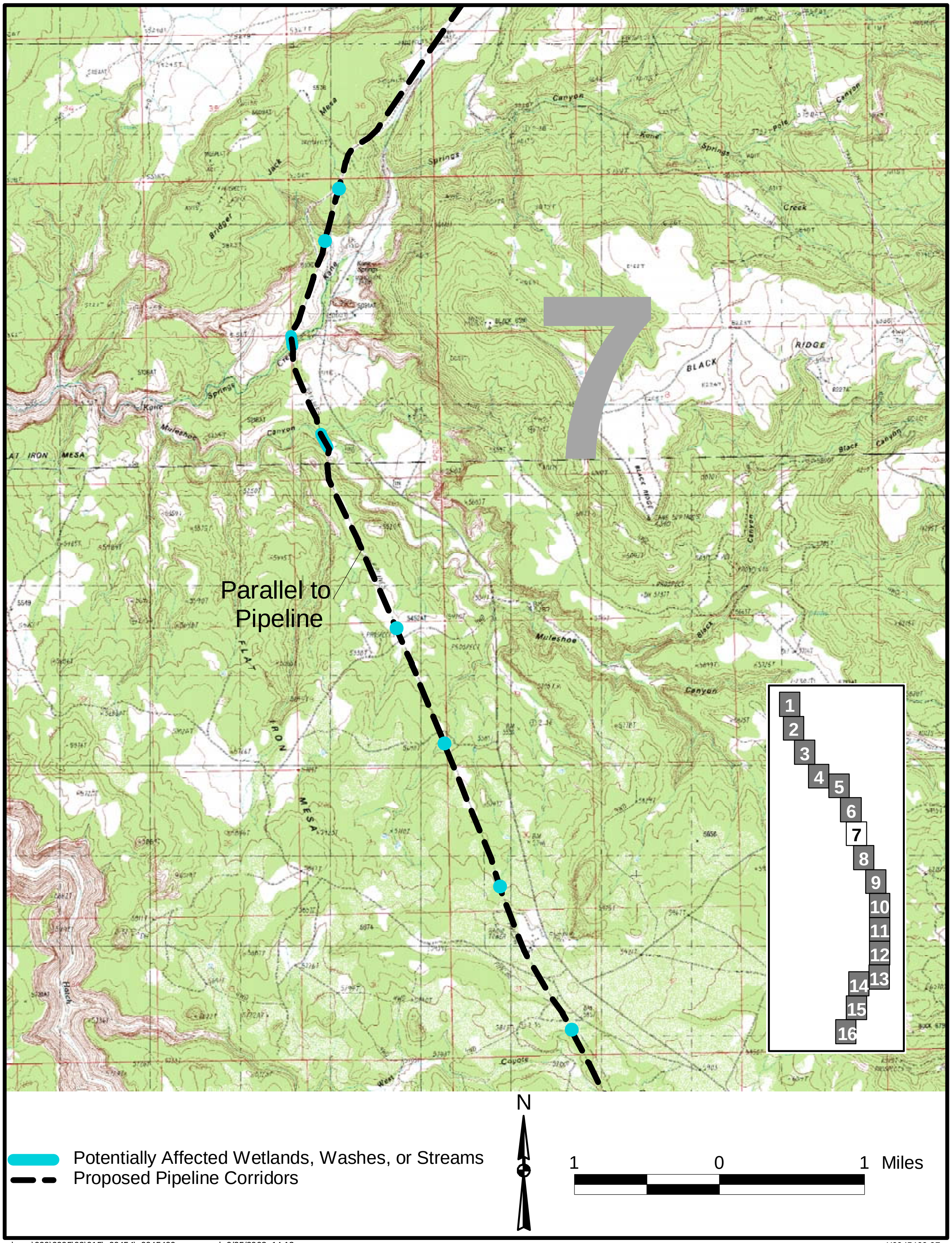
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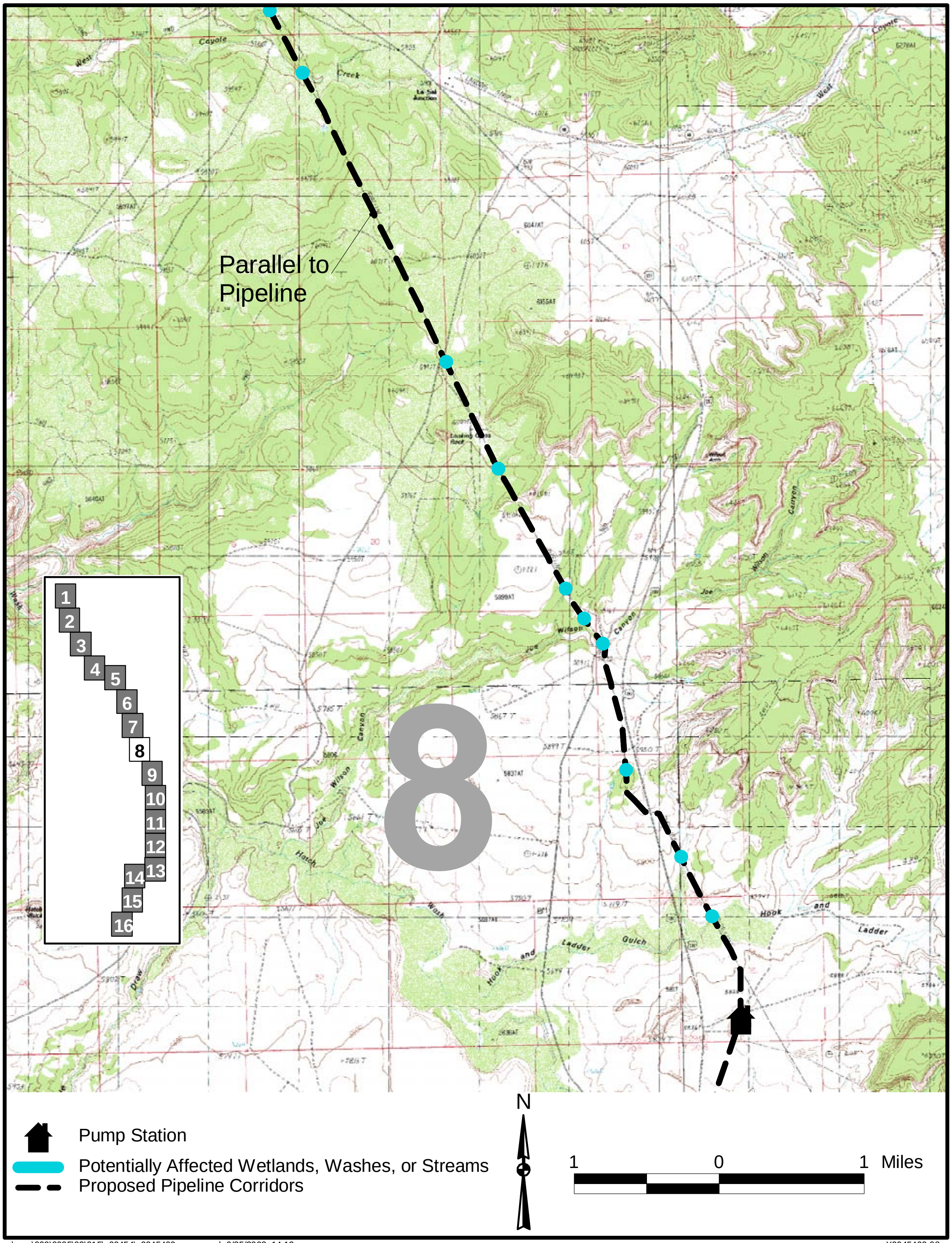
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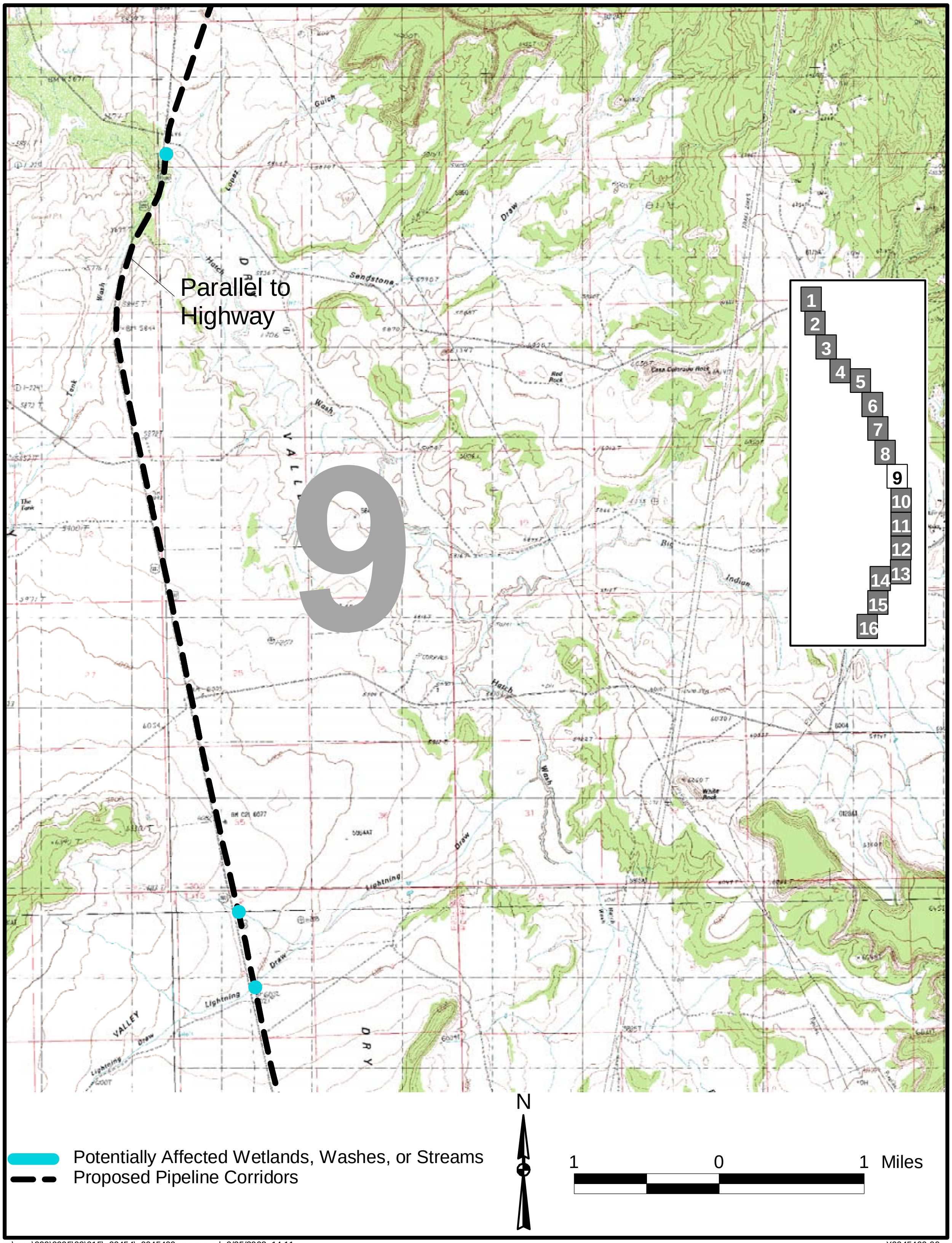

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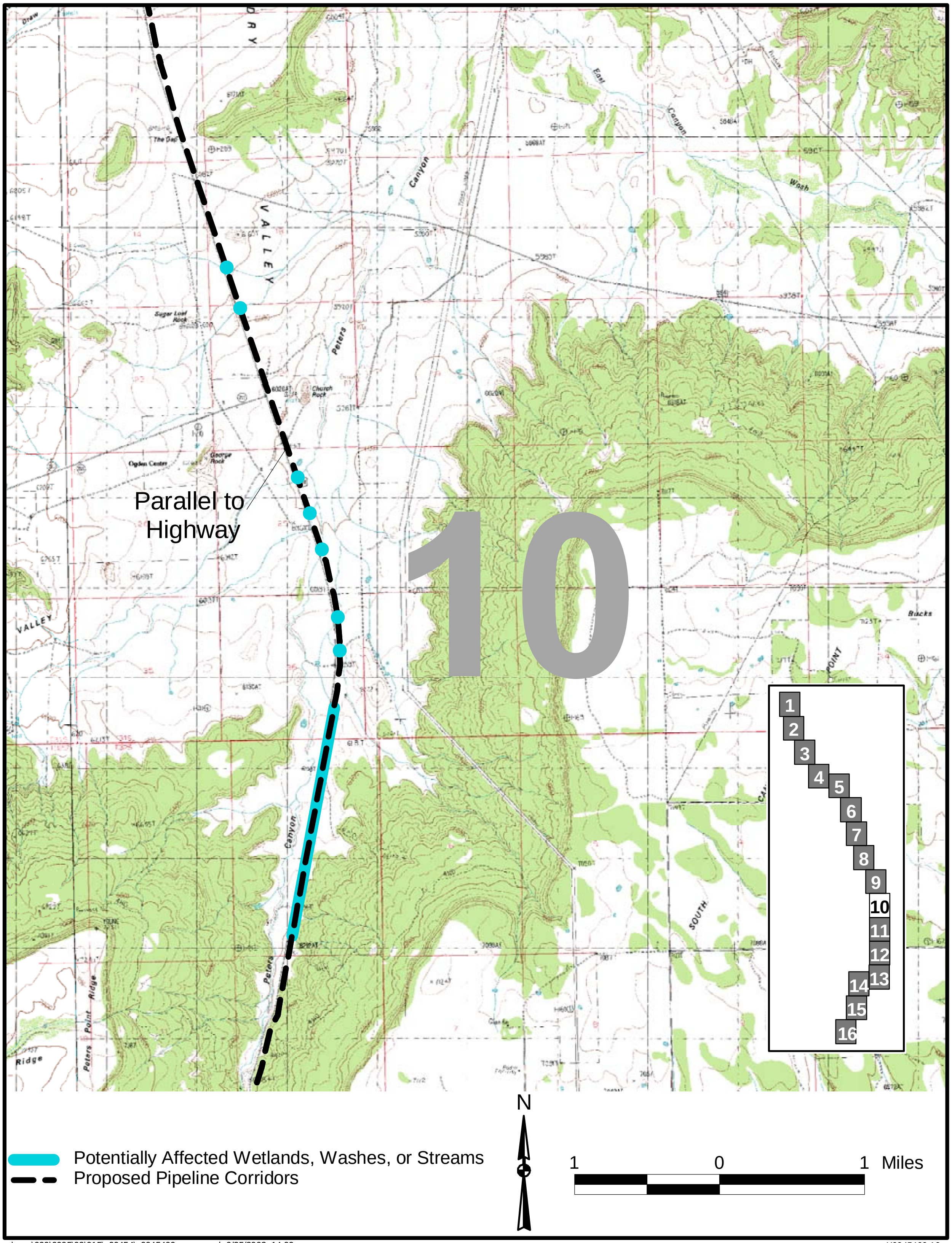

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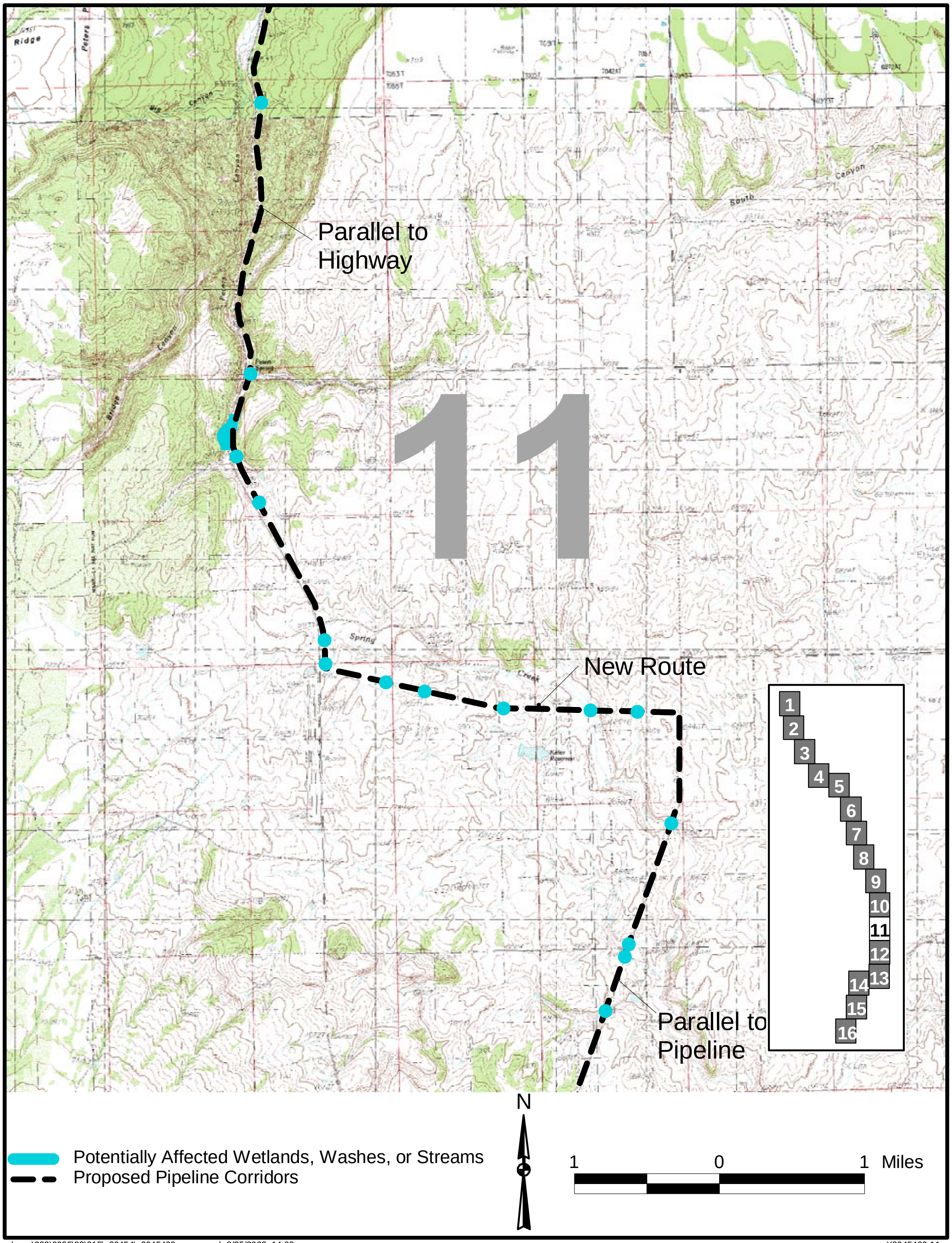

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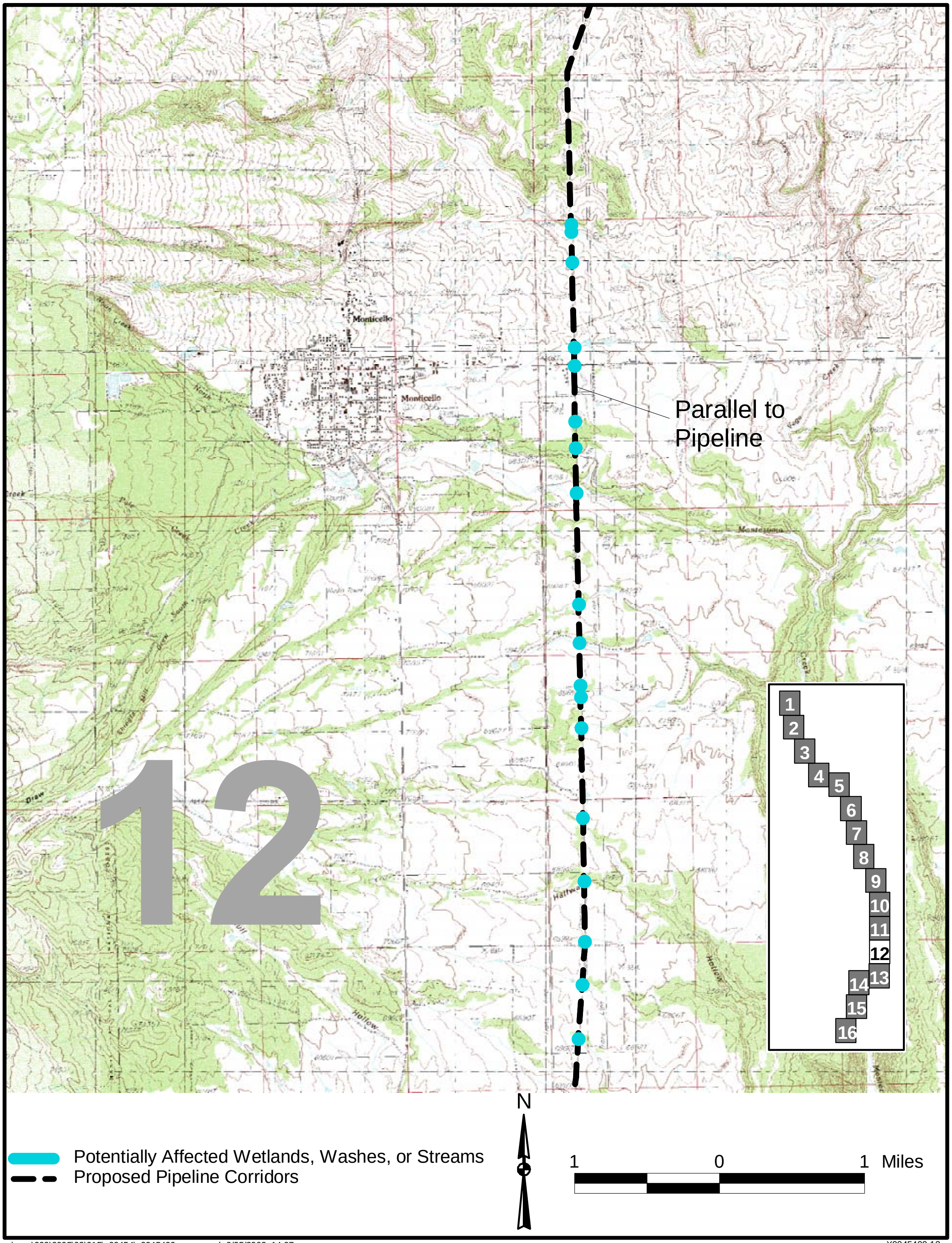

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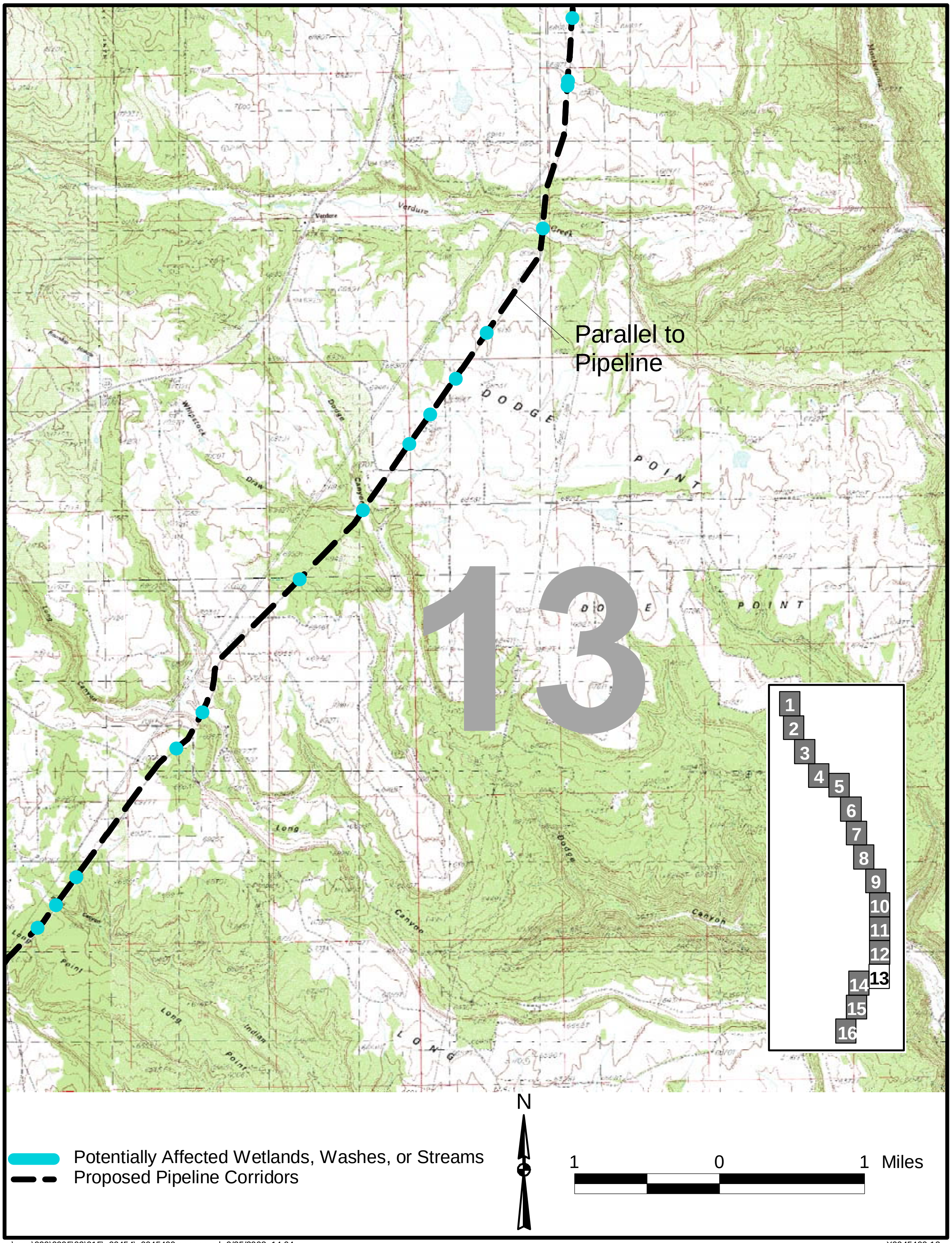

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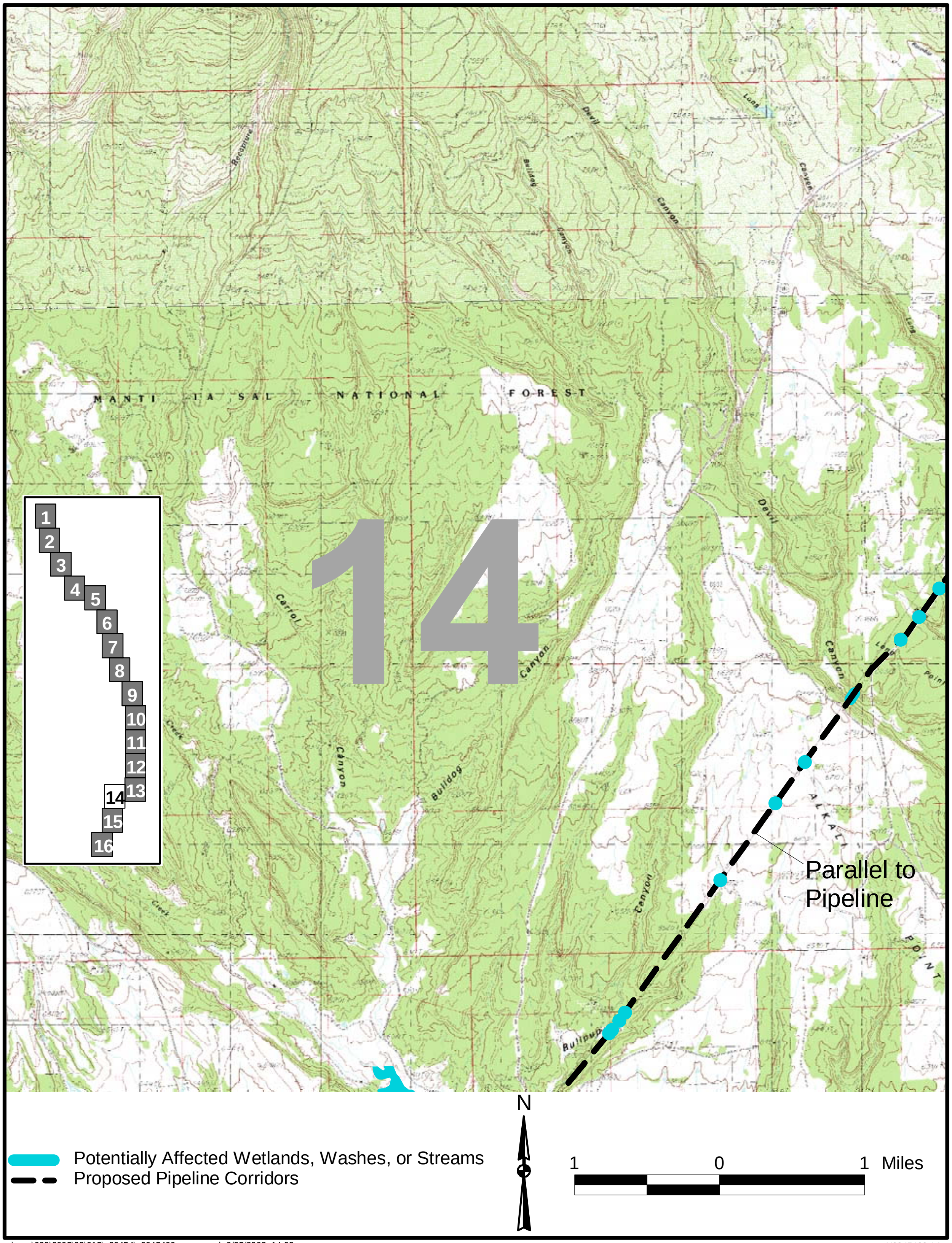

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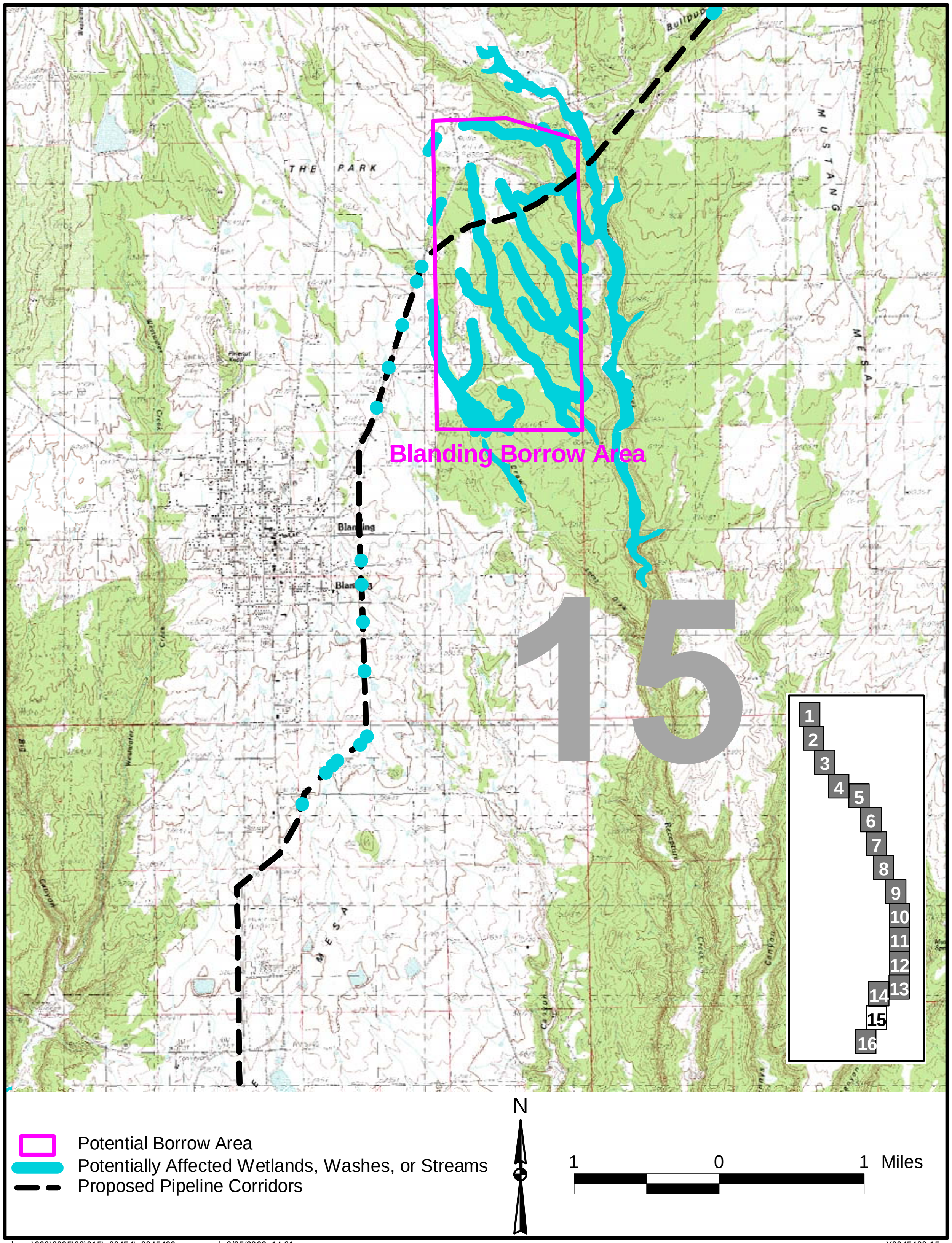

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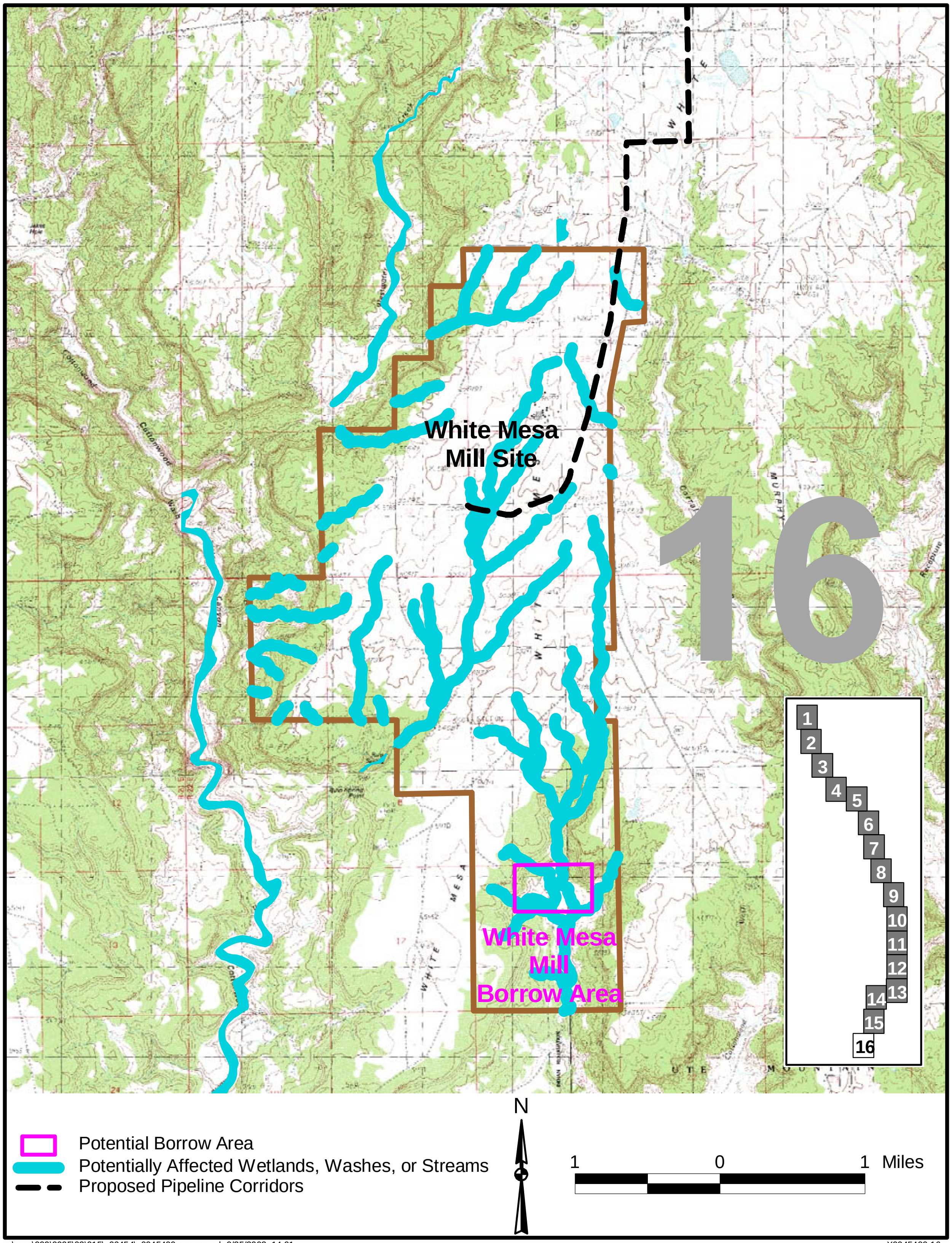
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Appendix D

Human Health

D1.0 Introduction

This appendix is organized into the following sections:

D2.0 Radiation and Human Health—This section provides a general overview of how radiation affects the human body.

D3.0 Future Potential Risks—This section presents the assumptions and calculation methods used to estimate risks from possible future uses of the Moab site. Most of this information is presented in the form of calculation spreadsheets that include the assumptions. A complete set of calculation spreadsheets is presented for the No Action alternative; only the different exposure point concentrations and results are presented for the off-site alternatives and the on-site alternative.

D4.0 Construction Risks—This section provides information on potential risks from construction accidents and the approach used to estimate radiological risks to workers and members of the public during construction activities.

D2.0 Radiation and Human Health

Radiation is the emission and propagation of energy through space or through a material in the form of waves or bundles of energy called photons or in the form of high-energy subatomic particles. Radiation generally results from atomic or subatomic processes that occur naturally. The most common kind of radiation is electromagnetic radiation, which is transmitted as photons. Electromagnetic radiation is emitted over a range of wavelengths and energies. We are most commonly aware of visible light, which is part of the spectrum of electromagnetic radiation. Radiation of longer wavelengths and lower energy includes infrared radiation, which heats material when the material and the radiation interact, and radio waves. Electromagnetic radiation of shorter wavelengths and higher energy (which are more penetrating) includes ultraviolet radiation (which causes sunburn), X-rays, and gamma radiation.

Ionizing radiation is radiation that has sufficient energy to displace electrons from atoms or molecules to create ions. It can be electromagnetic (for example, X-rays or gamma radiation) or subatomic particles (for example, alpha and beta radiation). The ions have the ability to interact with other atoms or molecules; in biological systems, this interaction can cause damage in the tissue or organism.

Radioactivity is the property or characteristic of an unstable atom to undergo spontaneous transformation (to disintegrate or decay) with the emission of energy as radiation. Usually the emitted radiation is ionizing radiation. The result of the process, called radioactive decay, is the transformation of an unstable atom (a radionuclide) into a different atom, accompanied by the release of energy (as radiation) as the atom reaches a more stable, lower-energy configuration. Radioactive decay produces three main types of ionizing radiation—alpha particles, beta particles, and gamma or X-rays—but our senses cannot detect them. These types of ionizing radiation can have different characteristics and levels of energy and, thus, varying abilities to penetrate and interact with atoms in the human body. Because each type has different characteristics, each requires different amounts of material to stop (shield) the radiation. Alpha particles are the least penetrating and can be stopped by a thin layer of material such as a single sheet of paper. However, if radioactive atoms (called radionuclides) emit alpha particles in the body when they decay, there is a concentrated deposition of energy near the point where the radioactive decay occurs. Shielding for beta particles, depending on their energies, may require thicker layers of material such as several reams of paper or several inches of wood or water. Shielding from gamma rays, which are highly penetrating, requires very thick material such as several inches to several feet of heavy material (for example, concrete or lead). Deposition of the energy by gamma rays is dispersed across the body in contrast to the local energy deposition by an alpha or a beta particle. In fact, some gamma radiation will pass through the body without interacting with it.

Radiation that originates outside of an individual's body is called external or direct radiation. Such radiation can come from an X-ray machine or from radioactive materials (materials or substances that contain radionuclides), such as radioactive waste or radionuclides in soil. Internal radiation originates inside a person's body following intake of radioactive material or radionuclides through ingestion or inhalation. Once in the body, the fate of a radioactive material is determined by its chemical behavior and how it is metabolized. If the material is soluble, it might be dissolved in bodily fluids and transported to and deposited in various body organs; if it is insoluble, it might move rapidly through the gastrointestinal tract or be deposited in the lungs.

Exposure to ionizing radiation is expressed in terms of absorbed dose, which is the amount of energy imparted to matter per unit mass. Often simply called dose, it is a fundamental concept in measuring and quantifying the effects of exposure to radiation. The unit of absorbed dose is the rad. The different types of radiation mentioned above have different effects in damaging the cells of biological systems. Dose equivalent is a concept that considers the absorbed dose and the relative effectiveness of the type of ionizing radiation in damaging biological systems, using a radiation-specific quality factor. The unit of dose equivalent is the rem. In quantifying the effects of radiation on humans, other concepts are also used. The concept of effective dose equivalent is used to relate absorbed dose in a single part or limited volume of the body to an equivalent risk of effect on the whole body. It involves estimating the susceptibility of the different tissue in the body to radiation to produce a tissue-specific weighting factor. The weighting factor is based on the susceptibility of that tissue to cancer. The sum of the products of each affected tissue's estimated dose equivalent multiplied by its specific weighting factor is the effective dose equivalent. The potential effects from a one-time ingestion or inhalation of radioactive material are calculated over a period of 50 years to account for radionuclides that have long half-lives and long residence time in the body. The result is called the committed effective dose equivalent. The unit of effective dose equivalent is also the rem. Total effective dose equivalent is the sum of the committed effective dose equivalent from radionuclides in the body plus the dose equivalent from radiation sources external to the body (also in rem). All estimates of dose presented in this environmental impact statement (EIS), unless specifically noted as something else, are total effective dose equivalents, which are quantified in terms of rems or millirems (mrem), which is one one-thousandth of a rem.

More detailed information on the concepts of radiation dose and dose equivalent are presented in publications of the National Council on Radiation Protection and Measurements (NCRP) (1993) and the International Commission on Radiological Protection (ICRP) (1991).

The factors used to convert estimates of radionuclide intake (by inhalation or ingestion) to dose are called dose conversion factors (DCFs). The ICRP and federal agencies such as the U.S. Environmental Protection Agency (EPA) publish these factors (Eckerman and Ryman 1993; Eckerman et al. 1988). They are based on original recommendations of the ICRP (1977).

The radiation dose to an individual or to a group of people can be expressed as the total dose received or as a dose rate, which is dose per unit time (usually an hour or a year). Collective dose is the total dose to an exposed population. Person-rem is the unit of collective dose. Collective dose is calculated by summing the individual dose to each member of a population. For example, if 100 workers each received 0.1 rem, the collective dose would be 10 person-rem (100×0.1 rem).

Exposures to radiation or radionuclides are often characterized as being acute or chronic. Acute exposures occur over a short period of time, typically 24 hours or less. Chronic exposures occur over longer periods of time (months to years); they are usually assumed to be continuous over a period, even though the dose rate might vary. For a given dose of radiation, chronic radiation exposure is usually less harmful than acute exposure because the dose rate (dose per unit time, such as rem per hour) is lower, providing more opportunity for the body to repair damaged cells.

On average, members of the public nationwide are exposed to approximately 300 mrem per year from natural sources (NCRP 1987). Natural sources that contribute the most to the public collective effective dose equivalent are radon-222 and its radioactive decay products in outside air and in air in homes, buildings, and other enclosed spaces, which contribute about 200 mrem per year. Additional natural sources include radioactive material in the earth (primarily the uranium and thorium decay series and potassium-40), radioactive material in our bodies (primarily potassium-40), and cosmic rays from space filtered through the atmosphere. With respect to exposures resulting from human activities, the combined doses from weapons testing fallout, consumer and industrial products, and air travel (cosmic radiation) account for the remainder (approximately 3 percent) of the total annual dose. Nuclear fuel cycle facilities contribute less than 0.1 percent (0.05 mrem per year) of the total dose.

Cancer is the principal potential risk to human health from exposure to low or chronic levels of radiation. This EIS expresses radiological health impacts as the incremental changes in the number of expected fatal cancers (latent cancer fatalities) for populations and as the incremental increases in lifetime probabilities of contracting a fatal cancer for an individual. The estimates are based on the dose received and on dose-to-health effect conversion factors recommended by the Interagency Steering Committee on Radiation Standards (DOE 2002). The committee estimated that, for the general population, a collective dose of 1 person-rem would yield 6×10^{-4} excess latent cancer fatality. For radiation workers, a collective dose of 1 person-rem would yield an estimated 5×10^{-4} excess latent cancer fatality. The higher risk factor for the general population is primarily due to the inclusion of children in the population group, while the radiation worker population includes only people older than 18 (see Table D–1).

For radon-222 and its short-lived radioactive progeny polonium-218, lead-214, bismuth-214, and polonium-214, the Working Level (WL) is the common unit for expressing exposure rates.

Table D−1. Risk of Latent Cancer Fatalities and Other Health Effects from Exposure to Radiation[a]

Population	Latent Cancer Fatality (per rem)	Nonfatal Cancer (per rem)	Genetic Effects (per rem)	Total Detriment (per rem)
Workers	4.0×10^{-4}	8.0×10^{-5}	8.0×10^{-5}	5.6×10^{-4}
General Population	5.0×10^{-4}	1.0×10^{-4}	1.3×10^{-4}	7.3×10^{-4}

Source: ICRP 1991. The latent cancer fatality, nonfatal cancer, and genetic risks for workers and the public from ICRP (1991) have not been revised to include the latent cancer fatality risks from DOE (2002).
[a]Epidemiological studies of human radiation exposure are not sufficiently sensitive to determine the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region, and the dose-incidence curve at low doses still remains highly uncertain. The data do not suffice to rule out the possible existence of a threshold (ICRP 1991).

Numerically, the WL is any combination of the short-lived radioactive progeny of radon-222 in 1 liter of air that will result in the emission of 1.3×10^5 million electron volts of potential alpha energy. When radon-222 is in complete equilibrium with its short-lived radioactive progeny polonium-218, lead-214, bismuth-214, and polonium-214, one WL equals 100 picocuries per liter (pCi/L) of radon-222. Differences in the activity concentrations between radon-222 and its short-lived radioactive progeny are considered using an equilibrium factor; the WL considers this factor. The advantage of the WL concept is that different equilibrium levels and different concentrations of radon progeny can be expressed and compared using a common unit.

The exposure of workers and the public to radon-222 and its short-lived radioactive progeny polonium-218, lead-214, bismuth-214, and polonium-214 are expressed in units of Working Level Months (WLMs), which is an exposure rate of 1 WL for 170 hours. WLMs are converted to units of effective dose equivalent using a conversion factor of 400 mrem per WLM for the public or 500 mrem per WLM for workers (ICRP 1994). WLMs are converted to the risk of a latent cancer fatality using a conversion factor of 5.38×10^{-4} latent cancer fatalities per WLM (EPA 2003).

Other health effects such as nonfatal cancers and genetic effects can occur as a result of chronic exposure to radiation. Inclusion of the incidence of nonfatal cancers and severe genetic effects from radiation exposure increases the total detriment by 40 to 50 percent, compared to the change for latent cancer fatalities (ICRP 1991). As is the general practice for any U.S. Department of Energy (DOE) EIS, estimates of the total change have not been included in this EIS.

Exposures to high levels of radiation at high dose rates over a short period (less than 24 hours) can result in acute radiation effects. Minor changes in blood characteristics might be noted at doses in the range of 25 to 50 rad. The external symptoms of radiation sickness begin to appear following acute exposures of about 50 to 100 rad and can include anorexia, nausea, and vomiting. More severe symptoms occur at higher doses and can include death at doses higher than 200 to 300 rad of total body irradiation, depending on the level of medical treatment received. Information on the effects of acute exposures on humans was obtained from studies of the survivors of the Hiroshima and Nagasaki bombings and from studies following a multitude of acute accidental exposures. Factors to relate the level of acute exposure to health effects exist but are not applied in this EIS because effective dose equivalents during normal operations and accidents would be well below 50 rem.

The standards for inactive uranium mill tailings sites are in 40 CFR 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, and were issued in 1983. The environmental impact statement issued for these standards was the *Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium and Thorium Processing Sites (40 CFR 192)* (EPA 1982).

For radon releases from a remediated mill tailings site, these standards specify that the radon release rate may not exceed 20 pCi/m^2-s. Also, the annual average atmospheric radon concentration from radon releases from the site may not exceed 0.5 pCi/L at any location outside the site. These standards must be met for a time period of 200 to 1,000 years. These standards are estimated to reduce the residual risk of cancer to 1 in 1,000 (EPA 1982).

For vicinity properties, these standards specify a radon decay product concentration objective of 0.02 WL (including background), with an upper bound of 0.03 WL (including background), and an external gamma exposure rate of 20 microroentgens per hour above background. The estimated residual risk of cancer for this level of radon and external gamma exposure is 1.3 in 100 (EPA 1982).

These standards also specify radium-226 concentration limits of 5 picocuries per gram (pCi/g) above background in surface soil (0–15 cm) and 15 pCi/g above background for subsurface soil (more than 15 cm below the surface). The residual risk of cancer for this level of radium-226 contamination is 2 in 100 (EPA 1982). This residual risk does not include background concentrations of radium-226 in soil, which typically range from 1 to 2 pCi/g in the Moab area.

D3.0 Future Potential Risks

This assessment of future potential risks generally follows the format recommended by EPA (1989); additional narrative is provided on the assessment of exposure and toxicity and the characterization of risks.

D3.1 Exposure Assessment

The objectives of the exposure assessment are to identify potential human populations that may be exposed to millsite-related contaminants, to determine the potential pathways through which exposure may occur, and to identify the exposure assumptions that will be used to estimate risks. Exposure is defined as the contact of an organism (i.e., humans for this assessment) with a chemical or physical agent. Information presented in the exposure assessment will be used to estimate pathway-specific chronic daily intakes (CDIs) for the potentially exposed populations. CDIs are then combined with chemical-specific toxicity information to characterize potential risks.

A complete exposure pathway comprises the following four elements:

- A contamination source and mechanism for release;
- Environmental retention of the contamination or transport mechanism to disperse contaminants;
- A point of potential human contact with the contaminated media; and

- A route of exposure (i.e., inhalation, ingestion, dermal absorption) at the point of contact.

An exposure pathway is incomplete when one or more of these elements are missing. No exposure is possible for incomplete pathways as long as the pathways remain incomplete into the future.

D3.1.1 Current Site Conditions

The perimeter of the Moab site is fenced (except adjacent to the Colorado River and "no trespassing" signs have been posted; the main access points have locked gates or chains when representatives from DOE are not present. Nevertheless, the perimeter of the site is not actively patrolled, and unauthorized access by the public has occurred. DOE contract personnel are on the site Mondays through Thursdays, except on holidays.

On-site personnel are conducting maintenance activities and environmental characterization activities. Maintenance activities include dust control using calcium chloride or water spraying, repairing the tailing pile after major precipitation events, constructing and operating interim ground water corrective action measures, and removing legacy chemicals and other process-related material from the site.

The property south of the site boundary, which is bounded by the Colorado River and SR-279, is privately owned. This property is mostly vegetated with tamarisk and has numerous dirt roads; it is frequently used for camping. This property occupies approximately 44 acres.

The other section of private property adjacent to the site is located to the northwest; it is bounded by the Colorado River and US-191. This property covers 10 to 13 acres and has two habitable structures. One structure, which is occupied by the property owners, is located next to the Colorado River approximately 350 feet from the DOE property boundary. The owners are retired; however, the structure is occupied only 6 to 8 months of the year because the owners typically spend the winter months in Arizona. The house is built on a concrete slab. Two other residents currently occupy the second habitable structure. This structure is a trailer set on concrete blocks with skirting. Because of a misunderstanding on property easements, part of this trailer is located on DOE property. No children live on the property. The full-time residents have jobs in Moab and are, therefore, not usually on the property during normal working hours. Both residents bring in potable water from off-site for drinking and cooking. The owners use Colorado River water (piped from a location upstream of the Moab site) for bathing and irrigation water. The water used for bathing is stored in a cistern to settle out particulates, and chorine is added before it is used.

The next closest residents are west of the private property described above, and within one-half mile of the site boundary. A trailer park (Moab Valley RV Park) is located on the east side of the Colorado River near US-191. Water from the Moab municipal water system is used at this location. On the basis of radon and gamma monitoring data, this area does not appear to be significantly affected by site contamination. Less than 1 mile northwest of the site, employees of the National Park Service (NPS) and their families live in NPS-supplied housing near the entrance to Arches National Park. From February to October, approximately 13 people live in this housing; only 4 to 6 people live in this area during the winter season (November to January) (NPS 2003). The drinking water is supplied by the well Arches 1978, which is upgradient of the Moab site and is considered a background well with respect to the Moab site. Other areas near the site are not inhabited and will not likely be inhabited in the near future, either because the

U.S. Government owns most of the nearby land or because the lands are located in a floodplain or wetlands.

The closest population center is the city of Moab, which is approximately 3 miles southeast of the site. According to the U.S. Census Bureau, the population of Moab was 4,779 in 2000 (Governor's Office of Planning and Budget 2001). During the spring and summer months, a large number of tourists visit the area because of the nearby national parks and other recreation and tourist attractions. No other communities are within 25 miles of the site; the nearest large city is Grand Junction, Colorado, about 120 miles to the northeast.

The primary individuals exposed to the contaminants at the Moab site are the nearby residents and recreational users of land adjacent to the site. Recreational users include Moab residents and tourists. The major recreational activities occurring near the site are rafting on the Colorado River and camping on adjacent lands.

D3.1.2 Future Site Conditions

In the future, it is plausible that some future development of the site may occur. A comparison of the census data from 1990 and 2000 showed an increase of more than 20 percent (808 people) (Governor's Office of Planning and Budget, 2001). Because of limited private land in the Moab area, some future residential or commercial development of the Moab site is possible. The site offers nearby access to Moab, river frontage, easy access to US-191, and excellent views. On the basis of these assumptions, the following future scenarios are assumed:

- Residential use—Although this has a low probability of occurrence in the short term, future residential use was assumed as the worst-case scenario. This scenario assumes that a future residence that includes children in the household would be established in the relatively level area northeast of the tailings pile and west of the adjacent private property. Because the water quality is poor and supplemental standards are being applied to the site, it is assumed that contaminated ground water would not be used for domestic purposes. The residents are assumed to have a vegetable garden. The assumption of future residential use is consistent with previous risk assessments done under the Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project.
- Outside worker—It is becoming more common to use former industrial sites for some type of recreational purpose. Accordingly, it was assumed that this location could be used for a park or a golf course and that an adult maintenance worker, who is typically outdoors, is the primary receptor.

D3.1.3 Summary

In identifying the potentially exposed populations, DOE had considered previous land uses, land ownership, local zoning, and precedents used at other Uranium Mill Tailings Radiation Control Act (UMTRCA) sites. On the basis of this information, the following populations are the most likely to be exposed to the contaminants at the Moab site:

- Future recreational users that may camp adjacent to the site or stop next to the site during rafting trips
- Future residents who may be exposed to contaminated soil

- Future outdoor workers exposed to contaminated ground water used for irrigation (adults only)

Other populations could be exposed to on-site contamination in the future; however, because of limited exposure duration and/or frequency, their exposures would be lower than the populations listed above. Examples include recreational users that trespass on DOE property and other recreational users of land adjacent to the site such as bikers.

D3.1.4 Exposure Assumptions

Pathway-specific exposures (CDIs) are estimated using exposure-point concentrations and exposure assumptions specific to the activities being conducted by the receptor population. Two types of exposure assumptions are used to provide risk managers with a range of potential exposures: reasonable maximum exposure (RME) and central tendency (CT). RME is defined as an exposure well above the average but still within the range of possible values. EPA guidance (EPA 1992) suggests that RME is analogous to "high end" exposure estimates corresponding to an approximate 90th percentile of the population distribution. CT uses exposure assumptions that result in an average or best-estimate exposure to an individual (approximately 50th percentile of possible exposures). While generally considered to be average estimates, CT still tends to provide somewhat conservative exposure estimates. CT provides additional information for risk management decisions by showing a plausible range of risks and by highlighting the sensitivity of the risk estimates to the exposure factors.

As suggested in EPA risk assessment guidance (EPA 1989) and as was commonly done in UMTRA Ground Water Project risk assessments, exposure assumptions based on site-specific data and conditions are used whenever possible to more accurately reflect actual exposures. Because most of the exposure scenarios are associated with the conditions at or adjacent to the Moab site, numerous site-specific exposure assumptions are used. These have been based on professional judgment, and they will be adjusted if more accurate information is obtained from members of the public or other interested individuals. When standard scenarios are evaluated and site-specific data are not appropriate, standard EPA default assumptions for both RME and CT exposures were used. Please note that because no site-specific data were available for the camping and the rafting scenarios, exposure frequency and durations were assumed to be 1. If additional information is available, this should be adjusted, as risks will be proportional.

D3.2 Toxicity Assessment

A toxicity assessment involves assessing the potential for the identified contaminants of concern to cause adverse effects in exposed individuals. The toxicity assessment also seeks to develop a reasonable assessment of the associations between the degree of exposure to a contaminant and the possibility of adverse health effects. A chemical or radionuclide may not cause adverse effects in biological systems unless the agent, or its metabolic by-products, reach critical receptor sites in the body at specific levels and for a period of time sufficient to elicit an effect. Whether or not an adverse response occurs depends on the chemical and physical properties of the chemical or radionuclide, the degree of exposure, and the susceptibility of an individual to the particular effect.

Toxicants are divided into two categories on the basis of their health effects. This division is based on the different mechanisms of action associated with each category. Chemicals posing cancer risks may also produce noncancer effects. These chemicals are assessed in both categories. In the discussion of carcinogenic effects, the assessment will be further divided into nonradionuclides and radionuclides (because of distinct differences in mechanisms).

D3.2.1 Noncancer Effects

Noncancer or systemic effects are assumed to be associated with a level of exposure exceeding some threshold value that can be tolerated by the organism (e.g., a human) without causing an adverse health effect. Noncancer health effects include a variety of toxicological endpoints and may include effects on specific organs or systems, such as the kidney (nephrotoxicants), the liver (hepatotoxicants), the nervous system (neurotoxicants), the lungs (pulmonary toxicants), and the reproductive system. The systemic toxicity of a chemical is assessed through a review of toxic effects noted in long-term animal studies and epidemiological investigations describing observed effects on humans.

A “toxic response” depends on the degree of exposure to a substance. Toxicity endpoints (severity and incidence) are quantitative expressions of the dose-response relationship for a chemical. For noncarcinogens, reference doses (RfDs) are used to quantitatively express toxicological impacts. RfDs are derived from the lowest end of a dose-response relationship for noncancer health effects (also referred to as the no observed adverse effect level [NOAEL]); RfDs are the chemical-specific NOAEL divided by uncertainty factors. EPA (1989) defines the RfD as “. . .an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.” The RfD is generally expressed in units of milligrams per kilogram of body weight per day (mg/kg-day).

D3.2.2 Carcinogenic Effects

D3.2.2.1 Nonradionuclides

Some chemical exposures result in, or are suspected of resulting in, the development of cancer. On the basis of available data, EPA assumes a nonthreshold mechanism for carcinogens (for example, a small number of molecular events can cause changes in a single cell that can eventually lead to cancer). Therefore, EPA conservatively assumes there is essentially no level of exposure to a carcinogenic chemical that does not pose a finite probability, however small, of generating a corresponding carcinogenic response in the exposed organism (i.e., dose-response holds true because the lower or higher the dose, the lower or higher the response).

The dose-response relationship for cancer effects for nonradionuclides is usually expressed as a cancer slope factor (CSF). Generally, the slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The response predicted is cancer incidence (the number of cases in a defined population at a point in time). The slope factor is usually, but not always, the 95 percent upper confidence limit of the slope of the dose-response curve and is expressed as the inverse of milligrams of chemical per kilogram of body weight per day $(mg/kg\text{-}day)^{-1}$(EPA 1989). EPA also notes that the slope factor could be zero, thus indicating no carcinogenic response from exposure (EPA 1989).

D3.2.2.2 Radionuclides

EPA categorically classifies all radionuclides as human carcinogens, based on their property of emitting ionizing radiation and on the weight of evidence provided by epidemiological studies of radiogenic cancers in humans (EPA 1989, 1995a). Radiation produces damage in biological systems through ionization of molecules. Damage may occur directly, as when a chromosome breaks into smaller pieces after absorption of energy from radiation. Damage may also occur indirectly through ionization of water molecules to produce highly reactive oxygen-free radicals. The free radicals may react with other cellular compounds and cause damage through abnormal oxidation reactions. Chronic exposure to ionizing radiation falls into three categories: (1) carcinogenic effects, (2) mutagenic (genetic damage) effects, and (3) teratogenic effects (embryonic or fetal damage).

In accordance with EPA guidelines, the risk associated with radiation exposure is evaluated using maximum likelihood estimates (MLEs) of CSFs that represent lifetime excess cancer incidence per picocurie of intake for each radionuclide.

The slope factors are the average risk per unit intake or exposure for an individual in a stationary population with vital statistics (mortality rates) typical of the United States. Radionuclide ingestion and inhalation slope factors are not expressed as a function of body weight and time and do not require corrections for gastrointestinal absorption or lung-transfer efficiencies (EPA 1995a)[1].

D3.3 Risk Characterization

D3.3.1 Risk Characterization Methods

Risk characterization methods used in this section are based on the approach used for UMTRA risk assessments, *Human Health Risk Assessment Methodology for the UMTRA Ground Water Project* (DOE 1994), which is based on conventional EPA guidance (EPA 1989). Two overall approaches were used to estimate risk. First, the traditional estimation approach presented in EPA (1989) was used to estimate risks from chemical exposures (see exposure assumptions for the simplified approach used to estimate risks for camper and rafter scenarios) and exposures to radionuclides in ground water. Second, the computer code RESRAD was used to estimate risks from exposure to radon gas, gamma radiation, and inhalation of radioactive particulates. RESRAD was developed at Argonne National Laboratory for DOE to estimate radiation dose and excess cancer risk for chronically exposed individuals (ANL 2001, 2003). It is an established method to estimate risks from these pathways. Included in this appendix are the detailed spreadsheets of the risk characterization calculations.

[1]Although similar to the nonradionuclide approach, this approach differs in three significant ways: (1) the CSF is an MLE estimate, which is analogous to an average (e.g., "the expected value"); in the nonradionuclide evaluation, an upper-bound estimate of the slope factor is used; (2) radionuclide risk is estimated from total intake; nonradionuclide cancer risk is estimated from the average daily intake—normalized to body weight; and (3) radionuclide cancer-risk estimates are for mortality; nonradionuclide cancer-risk estimates are for incidence. Thus, radionuclide and nonradionuclide risk estimates are fundamentally different and should not be added together.

D3.3.1.1 Exposure Estimation

Intakes for Noncarcinogenic Contaminants of Concern

The CDI is the appropriate intake estimator for exposure to noncarcinogenic contaminants of concern at the Moab site because exposures are assumed to be recurrent and long-term (e.g., 30 years in the RME case). According to EPA (1989), the CDI for assessing noncarcinogenic effects is computed as:

$$CDI\ (mg/kg-day) = \frac{(C \times IR \times EF \times ED \times f)}{(BW \times AT)}$$

where

C	=	media concentration,
IR	=	daily intake rate (grams or liters per day),
EF	=	exposure frequency (days per year),
ED	=	exposure duration (years),
f	=	fraction of intake from the contaminated source,
BW	=	body weight (kilograms), and
AT	=	averaging time (365 days per year × ED).

Chronic Intakes for Carcinogenic Contaminants of Concern

Arsenic and cadmium are the only carcinogens identified as contaminants of concern. According to EPA (1989), the CDI for assessing carcinogenic effects is computed as:

$$CDI\ (mg/kg - day) = \frac{(C \times IR \times EF \times ED \times f)}{(BW \times AT)}$$

where

C	=	media concentration,
IR	=	daily intake rate (liters or grams per day),
EF	=	exposure frequency (days per year),
ED	=	exposure duration (years),
f	=	fraction of intake from the contaminated source,
BW	=	body weight (kilograms), and
AT	=	averaging time (days).

This is the same equation used to calculate intakes for noncarcinogenic compounds (presented above) with the exception that intake is averaged over a 70-year lifetime (*AT* = 25,550 days [EPA 1989]) as opposed to a 1-year (365 days) averaging period used to estimate CDIs for assessing noncarcinogenic effects.

<u>Intakes for Radionuclides (soils)</u>

The CDI is not the appropriate intake estimator for exposure to radionuclides at the Moab site. Instead, EPA recommends use of a total radionuclide intake over the exposure period (EPA 1989, Chapter 10). According to EPA (1989), the total intake for assessing the carcinogenic effects of radionuclides is computed as

$$\text{Total intake (pCi)} = C \times IR \times EF \times ED \times f,$$

where

C	=	media concentration,
IR	=	daily intake rate (liters or grams per day),
EF	=	exposure frequency (days per year),
ED	=	exposure duration (years), and
f	=	fraction of intake from the contaminated source.

Unlike the previous intake estimates, exposure to radionuclides is neither normalized to body weight nor averaged over time. Exposure is considered chronic and routine for the consumption of ground water. However, the time-dependent modifications in the discussion of intakes for noncarcinogenic compounds are made to reflect an intermittent exposure that would occur for the recreational exposures.

D3.3.1.2 Risk Characterization

<u>Noncarcinogenic Risks</u>

Hazard quotient (HQ) is the ratio of a single-substance exposure level over a specified time period to an RfD for a substance derived from a similar exposure (EPA 1989).

HQ is computed using the following formula:

$$HQ = CDI/RfD$$

where

CDI = chronic daily intake for noncarcinogens in milligrams per kilograms-day and
RfD = reference dose in milligrams per kilograms-day.

This approach assumes the individual HQs can be summed into a hazard index (HI), as specified by EPA (1989). The HI is computed using the following formula:

$$HI = HQ1 + HQ2 + \ldots + HQn,$$

where

HQ1 through *HQn* are individual *HQs*.

When the HI exceeds 1.0, it is a numerical indicator of the transition between acceptable and unacceptable exposure levels, and there may be concern for potential health effects (EPA 1989).

The assumption that HQs are additive is applied most appropriately to chemicals that induce the same effect by the same mechanism or act on the same target organ at similar levels of exposure. If no individual HQ exceeds 1.0, but the HI exceeds 1.0, the chemicals in the mixture may be segregated by critical organ effect or target organ, and separate indices may be derived for each effect or organ.

Carcinogenic Nonradionuclide Risks

The method of using CSFs to estimate potential cancer risks from nonradionuclides also comes from EPA guidance (EPA 1989). The cancer slope factor equation is

$$\text{Added cancer risk} = CDI_C \times SF$$

where

Added cancer risk is the probability of cancer incidence attributable to exposure,
CDI_C = chronic daily intake for nonradionuclide carcinogens in units of milligrams per kilograms-day, and
SF = cancer dose-response slope factor in units of kg-day/mg

Added cancer risk, computed in this manner, is a dimensionless probability of cancer incidence. It can also be used to estimate population risk metrics such as cancer incidence per 100,000 exposed persons or to gauge the magnitude of attributable risk relative to other sources of cancer risk, such as the background incidence rate. For example, an added cancer risk of 0.0001 is an added chance of cancer incidence of 1 in 10,000 attributable to exposure. On a population basis, 0.0001 implies one additional case of cancer in 10,000 persons exposed under the conditions of the exposure scenario. An added cancer risk of 0.0001, when appended to the background cancer incidence rate in the United States of about 0.25, produces an overall individual cancer risk of 0.2501, which represents a 0.04 percent increase in the overall total (i.e., absolute) cancer risk.

Carcinogenic Radionuclide Risks from Soils

The method used to estimate potential cancer risks from exposure to radionuclides also uses a CSF approach detailed in EPA guidance (EPA 1989). The CSF equation for radionuclides is

$$\text{Added cancer risk} = TI \times SF,$$

where

Added cancer risk is the probability of cancer incidence attributable to exposure,
TI = total exposure period radionuclide intake in units of picocuries (exposure periods are 30 years for the RME case and 9 years in the CT case), and
SF = cancer intake slope factor in units of liters per picocurie.

As with the nonradionuclides, added cancer risk computed in this manner is a dimensionless probability of cancer mortality that can be compared to EPA's benchmark range and can be used to estimate population-risk metrics or to gauge the attributable risk from exposure relative to other sources. Radionuclide-added cancer risks can also be added to give a summed risk for all compounds in a mixture. Because there are multiple radionuclide contaminants of concern, cancer risks will be summed to give an aggregate cancer risk for this mixture, as appropriate.

Radionuclide and nonradionuclide cancer risk will not be added together because (1) nonradionuclide cancer risks express incidence, and radionuclide risks express risk of mortality, and (2) the slope factors for nonradionuclide cancer risks are "upper-bound estimates" of the dose response function (i.e., potency), and radionuclide slope factors are MLEs of radionuclide cancer potency (MLE estimates are similar to CT estimates).

Carcinogenic Radionuclide Risks from Radon and Particulates in Air and Gamma Exposures

RESRAD (Version 6.0) was used to estimate risks from airborne contamination and from gamma exposures (ANL 2001, 2003). Among the advantages that RESRAD brings to a radiological dose or risk assessment is its ability to derive values for exposure parameters based on built-in fate and transport computations using well-defined site-specific data. It is widely accepted as an industry standard tool for performing radiological dose assessments and specifically for deriving concentration guideline values. A few of the key points that should be recognized about the RESRAD modeling code and the algorithms it uses are

- Default DCFs used in RESRAD 6.0 were taken from FGR #13 (the data library for FGR #13 was added to this version of RESRAD) and EPA's 1997 Health Effects Assessment Summary Tables (HEAST) (EPA 1997a) and are derived using the ICRP 30 dosimetry model. The bio-kinetic dosimetry model accounts for particle fractioning that might occur following exposure. For example, the DCFs for particle inhalation account for the dose to the gastrointestinal tract from the fraction of respired particles that are ingested. As a result, there is no need to independently account for biological fractioning in the dose calculations.
- RESRAD integrates and normalizes exposure factors based on the fraction of time a receptor is exposed during the exposure period. For example, a soil ingestion rate of 100 mg/day for a receptor who is exposed on the site for only 50 percent of 1 day would result in an ingestion intake of 50 mg.
- RESRAD requires that the risk assessor input single-point estimates for values of every parameter required to evaluate complete pathways in the deterministic module of the code. RESRAD uses the single-point deterministic value for a specific parameter to calculate dose or risk unless the risk assessor specifies that the value be evaluated with a range of possible values selected from a specified distribution. It is not necessary to evaluate the uncertainty in every parameter, as variability (perhaps stemming from uncertainty) in many parameters does not contribute to variability or uncertainty in the resulting dose.

The RESRAD modeling code is recognized as an industry standard and is accepted for use by the U.S. Nuclear Regulatory Commission (NRC), DOE, and EPA for modeling dose and risk to individuals exposed to radioactivity originating in soils.

Conservatism has been built into the modeling by conscientiously selecting exposure factor values that err on the side of safety when confronted with uncertainty in the selection of input parameters.

D3.4 Risk Evaluations for the On-Site and Off-Site Disposal Alternatives

This section examines risks to human health after remediation of the tailings pile is completed. This assumes that the site has been remediated and the surface soils are clean (i.e., no risks from soils, air [including radon] or gamma exposure). It was assumed that contaminated ground water would not be used as the primary source of drinking water for the on-site residential scenario because the site is close to Moab, which has municipal water. However, it was assumed that contaminated water could be used for irrigation. The off-site locations do not have and are not expected to have contaminated ground water, so the use of ground water at those locations does not add to the risks.

D3.5 Backup Calculations

This section presents the detailed calculation spreadsheets used to develop the estimated risks for scenarios and pathways that did not use RESRAD. The detailed RESRAD calculation backup will be furnished on request via paper copy or compact disc.

The following tables present calculation spreadsheets:

Table D−2. Scenarios, Exposure Facts, Abbreviations, References (Overview Sheet)
Table D−3. No Action—Future Incidental Ingestion of Contaminated Soil by a Resident
Table D−4. No Action—Future Exposure to Contaminated Produce Grown Adjacent to a Residence
Table D−5. No Action—Future Dermal Exposure to Contaminated Ground Water for an Outside Worker
Table D−6. No Action—Future Incidental Ingestion of Contaminated Soil During Camping
Table D−7. No Action—Future Dermal Exposure to Contaminated Ground Water During Camping
Table D−8. No Action—Future Ingestion of Contaminated Ground Water by a Camper
Table D−9. No Action—Current Dermal Exposure to Contaminated Ground Water During Rafting
Table D−10. No Action—Current Incidental Ingestion of Contaminated Ground Water by a Rafter
Table D−11. On-Site—Exposure Point Concentrations
Table D−12. On-Site—Risk Summary for the Residential Scenario (Adult)
Table D−13. On-Site—Risk Summary for the Residential Scenario (Children)
Table D−14. On-Site—Risk Summary for the Rafting Scenario (Children)
Table D−15. On-Site—Risk Summary for the Camping Scenario (Adult)
Table D−16. On-Site—Risk Summary for the Camping Scenario (Children)
Table D−17. On-Site—Risk Summary for the Outside Worker Scenario (Adult)
Table D−18. On-Site—Overall Summary for All Receptors and Pathways
Table D−19. Off-Site—Exposure Point Concentrations
Table D−20. Off-Site—Risk Summary for the Residential Scenario (Adult)
Table D−21. Off-Site—Risk Summary for the Residential Scenario (Children)
Table D−22. Off-Site—Risk Summary for the Rafting Scenario (Children)
Table D−23. Off-Site—Risk Summary for the Camping Scenario (Adult)
Table D−24. Off-Site—Risk Summary for the Camping Scenario (Children)
Table D−25. Off-Site—Risk Summary for the Outside Worker Scenario (Adult)
Table D−26. Off-Site—Overall Summary for All Receptors and Pathways

Table D−2. Scenarios, Exposure Facts, Abbreviations, References (Overview Sheet)

Scenarios

Current	Adults	Children	Notes
-Off Site Resident	x	x	Air and dust only; evaluated with RESRAD
-Rafter		x	Worst-case scenarios with children; current/future
-Camper	x	x	Current and future could occur
Future			
-Residential	x	x	Low probability
-Office Worker	x		
-Outdoor Worker	x		

Exposure Factors (See Exposure Factor Worksheet for Values)

Factor	Abbreviation	Units
Exposure Frequency	EF	days/year
Exposure Duration	ED	years
Averaging Time-Cancer	AT-c	days
Averaging Time-Non Cancer	AT-NC	days
Soil-Sediment Ingestion Rate	IR-S	mg/day
Fraction Intake From Source	FI	fraction
Inhalation Rate	IR-A	m^3/day
Surface Water Ingestion Rate	IR-SW	L/day
Ground Water Ingestion Rate	IR-GW	L/day
Body Weight	BW	kg
Hours per Day	HpD	hours/day
Conversion Factor-Solids	CF	mg/kg
Conversion Factor-Water	CF	µg/mg
Conversion Factor- Solids rad	CF	mg/gr
Conversion Factor-Dermal	CF	L/cm^3
gamma exposure fraction	gef	fyear exposed
gamma shield & roughness factor	Se	ftransmitted

-

Equations

Nonradionuclides

1) $CDI_{\text{soil ingestion carcinogenic}}$ (mg/kg-day) = (Cs [mg/kg] * 1 kg/1E 6 mg * EF * IR-S * ED * FI) / (BW * AT-c)
2) $CDI_{\text{soil ingestion non cancer}}$ (mg/kg-day) = (Cs [mg/kg] * 1kg/1E 6 * mg * EF* IR* ED *) /(BW * AT-NC)
3) $CDI_{\text{sw ingestion carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * IR-SW * EF * ED * FI)/(BW * AT-c)
4) $CDI_{\text{sw ingestion non cancer}}$ (mg/kg-day) = (Cw [mg/L] * IR-SW * EF * ED * FI)/(BW * AT-NC)
5) $CDI_{\text{Dermal contact with water carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * SA * EF * PC * ED * EF * ET * CF) / (BW * AT-c)
6) $CDI_{\text{Dermal contact with water non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * SA * PC* EF * ED * ET *CF) / (BW * AT-NC)
7) $CDI_{\text{ground water ingestion carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * IR-GW * EF * ED * FI)/(BW * AT-c)
8) $CDI_{\text{ground water ingestion non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * IR-GW * EF * ED * FI)/(BW * AT-NC)

9) HQ (unitless) = CDI/RfD
10) HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$
11) Risk (unitless probability) = CDI * SF (Chemical)
12) Risk (fatal and nonfatal cancer) = TI * SF (Radionuclide)

Radionuclides

13) $TI_{\text{ground water ingestion}}$ (pCi) = Cw * IR-GW * EF * FI * ED

Table D−2. Scenarios, Exposure Facts, Abbreviations, References (overview sheet) (continued)

Abbreviations

Abbreviation	Description
EF	Exposure Frequency (days per year)
DEP	Daily Exposure Period
ED	Exposure Duration (years)
AT-c	Averaging Time-Cancer (days)
AT-NC	Averaging Time-Non-Cancer (days)
IR-S	Soil-Sediment Ingestion Rate
FI	Fraction Intake From Source
IR-A	Inhalation Rate
IR-SW	Surface Water Ingestion Rate (liters per day)
IR-GW	Ground Water Ingestion Rate (liters per day)
IR -Play	Water ingestion rate during play at the edge of the river (liters per day)
BW	Body Weight (kilograms)
HpD	Hours per Day
CF	Conversion factor (media dependant)
CDI	Chronic Daily Intake (milligrams per kilograms-day)
mg	milligrams
L	liters
Cw	Chemical concentration in water (milligrams per liter or picocuries per liter)
Cs	Chemical concentration in soil (milligrams per kilograms or picocuries per kilograms)
SA	Skin surface area available for contact (square centimeter)
cm	centimeters
PC	Chemical-specific dermal permeability constant (centimeters per hour)
HQ	Hazard Quotient (unitless)
HI	Hazard Index (unitless)
SF	Slope Factor (kilograms-day per milligram or risk/pCi)
ET	Exposure Time (dermal) (hours per day)
RME	Reasonable Maximum Exposure
CT	Central Tendency
Cf	Chemical concentration in food (milligrams per kilogram)
IR-F	Ingestion rate for food (grams per day)
TI	Total Intake (picocurie)

Table D−3. No Action—Future Incidental Ingestion of Contaminated Soil by a Resident

Description - A future residence is established on the Moab site and incidental ingestion of contaminated soil occurs. Exposure occurs to children only, mostly while playing outside, although estimates include some indoor dust ingestion.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**CT**	**RME**	**Notes**
Exposure Frequency	EF	days/year	350	365	RME from EPA 1989; CT assumes 2 weeks away from residence
Exposure Duration—Child	ED	years	7	9	RME over entire period, CT based on typical 50% from Table 15-168 in EPA 1997b
Averaging Time—Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time—Non Cancer Child	AT-NC	days	2,450	3,285	Default with child EDs
Body Weight—Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Soil Ingestion Rate—Child	IR-S	mg/day	100	400	EPA 1997b, Table 4-23, defaults
Fraction Intake From Source	FI	fraction	0.8	1	CT based on professional judgment
Conversion Factor (1)	CF1	kg/mg	1.00E-06	1.00E-06	1 kg/1,000,000 mg
Conversion Factor (2)	CF2	g/mg	1.00E-03	1.00E-03	1 kg/1,000 g

Note: Ingestion rates centered around a 6-year-old child but include other age children. The same range of ages was assumed in the calculations for this pathway as other pathways for the residential scenario.

Equations

Exposure - Nonradionuclides
CDI soil $_{\text{ingestion non carcinogenic}}$ (mg/kg-day) = (Cs [mg/kg] * IR-S * CF1 * EF * ED * FI)/(BW * AT-Nc)
CDI soil $_{\text{ingestion carcinogenic}}$ (mg/kg-day) = (Cs [mg/kg] * IR-S * CF1 * EF * ED * FI)/(BW * AT-c)

Risk - Nonradionuclides
HQ (unitless) = CDI/RfD
HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$
Risk (unitless probability) = CDI * SF

Exposure - Radionuclides
TI $_{\text{soil ingestion}}$ (pCi) = Cs (pCi/g) * IR-S * EF * FI * ED *CF2

Risk - Radionuclides
Risk (unitless probability) = TI*SF

Estimated CDI and Risks-Child				
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonium	0.00	NA	0.00	NA
Arsenic	0.00	0.09	0.00	0.45
Uranium (mg/kg)	0.00	0.19	0.00	0.93
Vanadium	0.00	0.32	0.01	1.61
Sulfate	0.02	NA	0.12	NA
Total		0.60		3.00
	Central Tendency		**RME**	
	CDI	**Risk**	**CDI**	**Risk**
Chemicals as Carcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Arsenic	2.58E-06	3.87E-06	1.73E-05	2.59E-05
Total		3.87E-06		2.59E-05
Radionuclides				
Radium-226	4.47E+03	3.26E-06	3.00E+04	2.19E-05
Thorium-230	2.61E+04	5.27E-06	1.75E+05	3.53E-05
Uranium-234	9.43E+03	1.49E-06	6.32E+04	9.99E-06
Uranium-238	1.18E+04	2.47E-06	7.90E+04	1.66E-05
Total	5.18E+04	1.25E-05	3.47E+05	8.38E-05

Table D−4. No Action—Future Exposure to Contaminated Produce Grown Adjacent to a Residence

Description - A future residence is established on the Moab site and a vegetable garden is located adjacent to the residence. Vegetables from the garden are used as a source of food, and ground water is used as an irrigation source.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**CT**	**RME**	**Notes**
Exposure Frequency	EF	days/year	350	365	RME from EPA 1989; CT assumes 2 weeks away from residence
Exposure Duration - Adult	ED	years	9	30	EPA 1997b, Chapter 15.4.3; 50th and 95th %
Exposure Duration - Child	ED	years	7	9	RME over entire period, CT based on typical 50% from Table 15-168 in EPA 1997b
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Adult	AT-NC	days	3,150	10,950	Default from EPA 1989
Averaging Time-Non Cancer Child	AT-NC	days	2,450	3,285	Default with child EDs
Body Weight -Adult	BW	kg	70	70	EPA 1989, average of US population
Body Weight - Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Ingestion Rate - Food Adult	IR-F	g/day	74.9	434.7	Table 13-17 in EPA 1997b adjusted by body weight, homegrown vegetables only; households that garden in the western U.S.
Ingestion Rate - Food Child	IR-F	g/day	23.54	136.62	Table 13-17 in EPA 1997b adjusted by body weight, homegrown vegetables only; households that garden in the western U.S.
Fraction Intake for Source	F	Unitless	1	1	RME and CT values were adjusted in the ingestion rate, home produce is assumed to be contaminated.
Conversion Factor (Food)	CF	kg/g	1.00E-03	1.00E-03	1 kg/1,000 g

Equations

Exposure – Nonradionuclides

$CDI_{\text{vegetable ingestion non carcinogenic}}$ (mg/kg-day) = (Cf [mg/kg] * IR-F * EF * ED * FI* CF)/(BW * AT-Nc)

$CDI_{\text{vegetable ingestion carcinogenic}}$ (mg/kg-day)= (Cf [mg/kg] * IR-F * EF * ED * FI * CF)/(BW * AT-c)

Risk – Nonradionuclides

HQ (unitless) = CDI/RfD

HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$

Risk (unitless probability) = CDI * SF

Exposure – Radionuclides

$TI_{\text{vegetable ingestion}}$ (pCi) = Cf (pCi/kg) *IR-F * EF * FI * ED *CF

Risk – Radionuclides

Risk (unitless probability) = TI*SF

Table D−4. No Action—Future Exposure to Contaminated Produce Grown Adjacent to a Residence (continued)

Estimated CDI and Risks-Adult				
	Central Tendency		**RME**	
	CDI	**Risk**	**CDI**	**Risk**
Chemicals as Carcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Arsenic	6.33E-04	9.50E-04	3.68E-03	2.45E-03
Total		9.50E-04		2.45E-03
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Arsenic	0.001	2.11	0.004	12.25
Uranium	0.000	0.14	0.002	0.80
Vanadium	0.005	0.66	0.027	3.86
Total		2.91		16.91
Estimated CDI and Risks-Children				
	Central Tendency		**RME**	
	CDI	**Risk**	**CDI**	**Risk**
Chemicals as Carcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Arsenic	1.99E-04	2.99E-04	1.16E-03	7.70E-04
Total		2.99E-04		7.70E-04
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Arsenic	0.001	2.11	0.004	12.25
Uranium	0.000	0.14	0.002	0.80
Vanadium	0.005	0.66	0.027	3.86
Total		2.91		16.91

Note: Risks to children and adults are the same for noncarcinogens because the intake rate was proportioned based on body weight.
Uptake factors are unknown for radionuclides; this exposure pathway also results in much lower risks compared to other pathways.

Table D−5. No Action—Future Dermal Exposure to Contaminated Ground Water for an Outside Worker

Description - A future golf course is established on the Moab site and contaminated ground water is used as the primary source of irrigation water. Exposure occurs during watering and maintenance activities at the golf course.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**CT**	**RME**	**Notes**
Exposure Frequency	EF	days/year	230	250	RME assumes 50 weeks, 5 days/week; CT assumes 46 weeks, 5 days /week
Exposure Duration - Adult	ED	years	7	20	EPA 1997b, Table 15-158, Tenure of employment, CT is average, RME range for older workers
Exposure Time	ET	hours/day	4	8	RME assumes exposure for the full work day; CT assumes water contact for 1/2 day
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Adult	AT-NC	days	2,555	7,300	Default from EPA 1989
Body Weight -Adult	BW	kg	70	70	EPA 1989, average of US population
Dermal Permeability Constant	PC	cm/hour	Chemical Specific	Chemical Specific	See below
Skin Surface Available for Contact-Adult	SA	cm^2	361	432	EPA 1997b, Table 6-2, assumes hands, forearms, and feet exposure only.
Conversion Factor	CF	L/cm^3	0.001	0.001	$1L/1{,}000\ cm^3$

Equations

Exposure – Nonradionuclides

$CDI_{\text{ground water ingestion non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * SA * PC - EF * ED * ET * CF)/(BW * AT-Nc)
$CDI_{\text{ground water ingestion carcinogenic}}$ (mg/kg-day)= (Cw [mg/L] * SA * PC * EF * ED * ET * CF)/(BW * AT-c)

Risk – Nonradionuclides

HQ (unitless) = CDI/RfD
HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$
Risk (unitless probability) = CDI * SF

Exposure – Radionuclides

TI_{dermal} (pCi) = Cw (pCi/L) * SA* PC* EF * FI * ED * CF

Risk – Radionuclides

Risk (unitless probability) = TI*SF

Dermal Permeability Constants (PC)

Chemical Name	**PC (K_p) cm/h**	**Notes**
Ammonia	NA	Inhalation route
Arsenic	1.0E-03	Not listed; default assumed, Exhibit 3-1
Boron	1.0E-03	Not listed; default assumed, Exhibit 3-1
Cadmium	1.0E-03	Experimental
Fluoride	1.0E-03	Not listed; default assumed, Exhibit 3-1
Iron	1.0E-03	Not listed; default assumed, Exhibit 3-1
Lithium	1.0E-03	Not listed; default assumed, Exhibit 3-1
Manganese	1.0E-03	Not listed; default assumed, Exhibit 3-1
Molybdenum	1.0E-03	Not listed; default assumed, Exhibit 3-1
Nitrate	NA	
Selenium	1.0E-03	Not listed; default assumed, Exhibit 3-1
Strontium	1.0E-03	Not listed; default assumed, Exhibit 3-1
Uranium	1.0E-03	Not listed; default assumed, Exhibit 3-1
Vanadium	1.0E-03	Not listed; default assumed, Exhibit 3-1

Source: EPA (2001)

Table D–5. No Action—Future Dermal Exposure to Contaminated Ground Water for an Outside Worker (continued)

Estimated CDI and Risks-Adult	**Central Tendency**		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonia	NA	NA	NA	NA
Arsenic	0.000	0.00	0.000	0.01
Boron	0.000	0.00	0.000	0.00
Cadmium (water)	0.000	0.00	0.000	0.00
Fluoride	0.000	0.00	0.000	0.00
Iron	0.000	0.00	0.000	0.00
Lithium	0.000	0.00	0.000	0.00
Manganese (nonfood)	0.000	0.00	0.000	0.00
Molybdenum	0.000	0.00	0.000	0.00
Nitrate	NA	NA	NA	NA
Selenium	0.000	0.00	0.000	0.00
Strontium	0.000	0.00	0.000	0.00
Uranium	0.000	0.02	0.000	0.06
Vanadium	0.000	0.00	0.000	0.01
Total		0.03		0.09
		Added		**Added**
Chemicals as Carcinogens		**Cancer**		**Cancer**
Arsenic	9.03E-08	1.36E-07	6.71E-07	1.01E-06
Total		1.36E-07		1.01E-06

Note: Estimations of dermal exposure require a contaminant mass and the contribution to risk from dermal exposure to radionuclides is expected to be much less than other pathways (ingestion, direct exposure). Therefore, dermal exposure to radionuclides was not estimated.

Table D−6. No Action—Future Incidental Ingestion of Contaminated Soil During Camping

Description – The Moab site is used for camping in the future and incidental ingestion of contaminated soil occurs. Exposure occurs to children only mostly while playing around the camping site. Exposures are based on a one night camping event. The camping trip is assumed to occur over one 24-hour period.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**Central Tendency**	**RME**	**Notes**
Exposure Frequency	EF	days/year	1	1	Unit estimate based on one event per year (see note)
Exposure Duration - Child	ED	years	1	1	Unit estimate based on one event per year (see note)
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Child	AT-NC	days	365	365	Default with child EDs
Body Weight - Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Soil Ingestion Rate - Child	IR-S	mg/day	100	400	EPA 1997b, Table 4-23, defaults
Fraction Intake From Source	FI	fraction	1	1	CT based on professional judgment
Conversion Factor	CF1	kg/mg	1.00E-06	1.00E-06	1 kg/1,000 mg
Conversion Factor	CF2	kg/mg	1.00E-03	1.00E-03	1 g/1,000 mg

Note: Ingestion rates centered on a 6-year-old child but include other age children. The same range of ages was assumed in the calculations for this pathway as other pathways for the residential scenario.
Actual exposures may be greater. Site-specific data should be used if available. Results will be linear. For example, camping for 5 days will increase risks by a factor of 5.

Equations

Exposure – Nonradionuclides

$CDI\ soil_{ingestion\ non\ carcinogenic}$ (mg/kg-day) = (Cs [mg/kg] * IR-S * CF * EF * ED * FI)/(BW * AT-Nc)

$CDI\ soil_{ingestion\ carcinogenic}$ (mg/kg-day) = (Cs [mg/kg] * IR-S * CF * EF * ED * FI)/(BW * AT-c)

Risk – Nonradionuclides

HQ (unitless) = CDI/RfD

HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$

Risk (unitless probability) = CDI * SF

Exposure – Radionuclides

$TI_{soil\ ingestion}$ (pCi) = Cs (pCi/g) * IR-S * EF * FI * ED

Risk – Radionuclides

Risk (unitless probability) = TI*SF

Table D–6. No Action—Future Incidental Ingestion of Contaminated Soil During Camping (continued)

Exposure - Radionuclides				
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Arsenic	9.22E-08	0.000307	3.69E-07	0.001229
Uranium	1.92E-06	6.39E-04	7.67E-06	2.56E-03
Vanadium	7.74E-06	1.11E-03	3.10E-05	4.42E-03
Total	9.75E-06	2.05E-03	3.90E-05	8.21E-03
	Central Tendency		**RME**	
Chemicals as Carcinogens	**CDI**	**Risk**	**CDI**	**Risk**
	(mg/kg-day)	(Unitless)	(mg/kg-day)	(Unitless)
Arsenic	1.32E-09	1.97E-09	5.27E-09	7.90E-09
Total	1.32E-09	1.97E-09	5.27E-09	7.90E-09
Radionuclides				
Radium-226	2.28E+00	1.66E-09	9.12E+00	6.66E-09
Thorium-230	1.33E+01	2.69E-09	5.32E+01	1.08E-08
Uranium-234	4.81E+00	7.60E-10	1.92E+01	3.04E-09
Uranium-238	6.01E+00	1.26E-09	2.40E+01	5.05E-09
	2.64E+01	6.38E-09	1.06E+02	2.55E-08

Table D−7. No Action—Future Dermal Exposure to Contaminated Ground Water During Camping

Description – The Moab site is used for camping and dermal exposure to contaminated surface water occurs. Ground water entering the Colorado River is assumed to be where exposure occurs. Exposure is assumed to children while playing by the edge of the Colorado River. The camping trip is assumed to occur over one 24-hour period.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**Central Tendency**	**RME**	**Notes**
Exposure Frequency	EF	days/year	1	1	Unit estimate based on one event per year (see note)
Exposure Duration - Child	ED	years	1	1	Unit estimate based on one event per year (see note)
Exposure Time	ET	hours/day	2	4	Based on professional judgment for play time in river
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Child	AT-NC	days	365	365	Default with child EDs
Body Weight - Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Dermal Permeability Constant	PC	cm/hour	Chemical Specific	Chemical Specific	See Below
Skin Surface Available for Contact-Child	SA	cm^2	486	591	Total for 6-9 old male, % for arms, legs, hands, feet for 6-7 year old (52%), Table 6-8, EPA 1997b
Conversion Factor	CF	L/cm^3	0.001	0.001	$1L/1{,}000\ cm^3$

Note: Actual exposures may be greater. Site-specific data should be used if available. Results will be linear. For example, camping for 5 days will increase risks by a factor of 5.

Equations

Exposure - Nonradionuclides

$CDI_{\text{ground water ingestion non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * SA * * PC - EF * ED * ET * CF)/(BW * AT-Nc)

$CDI_{\text{ground water ingestion carcinogenic}}$ (mg/kg-day)= (Cw [mg/L] * SA * PC * EF * ED * ET * CF)/(BW * AT-c)

Risk - Nonradionuclides

HQ (unitless) = CDI/RfD

HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$

Risk (unitless probability) = CDI * SF

Exposure - Radionuclides

TI_{dermal} (pCi) = Cw (pCi/L) * SA* PC* EF * FI * ED * CF

Risk - Radionuclides

Risk (unitless probability) = TI*SF

Dermal Permeability Constants (PC)

Chemical Name	**PC (K_p) cm/hr**	**Notes**
Ammonia	NA	Inhalation route
Arsenic	1.0E-03	Not listed; default assumed from Exhibit 3-1
Boron	1.0E-03	Not listed; default assumed from Exhibit 3-1
Cadmium	1.0E-03	Listed in Exhibit 3-1
Fluoride	1.0E-03	Not listed; default assumed from Exhibit 3-1
Iron	1.0E-03	Not listed; default assumed from Exhibit 3-1
Lithium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Manganese	1.0E-03	Not listed; default assumed from Exhibit 3-1
Molybdenum	1.0E-03	Not listed; default assumed from Exhibit 3-1
Nitrate	NA	
Selenium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Strontium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Uranium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Vanadium	1.0E-03	Not listed; default assumed from Exhibit 3-1

Source: EPA 2001

Table D–7. No Action—Future Dermal Exposure to Contaminated Ground Water During Camping (continued)

Estimated CDI and Risks-Children				
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonia	NA	NA	NA	NA
Arsenic	0.000	0.00	0.000	0.00
Boron	0.000	0.00	0.000	0.00
Cadmium (water)	0.000	0.00	0.000	0.00
Fluoride	0.000	0.00	0.000	0.00
Iron	0.000	0.00	0.000	0.00
Lithium	0.000	0.00	0.000	0.00
Manganese (nonfood)	0.000	0.00	0.000	0.00
Molybdenum	0.000	0.00	0.000	0.00
Nitrate	NA	NA	NA	NA
Selenium	0.000	0.00	0.000	0.00
Strontium	0.000	0.00	0.000	0.00
Uranium	0.000	0.00	0.000	0.00
Vanadium	0.000	0.00	0.000	0.00
Total		0.00		0.00
Chemicals as Carcinogens				
Arsenic	1.20E-10	1.80E-10	5.34E-09	8.01E-09
Total		1.80E-10		8.01E-09

Note: Estimations of dermal exposure require a contaminant mass and the contribution to risk from dermal exposure to radionuclides is expected to be much less than other pathways (ingestion, direct exposure). Therefore, dermal exposure to radionuclides was not estimated.

Table D−8. No Action—Future Ingestion of Contaminated Ground Water by a Camper

Description – The Moab site is used for camping and ingestion of contaminated surface water occurs. Ground water entering the Colorado River is assumed to used as the drinking water source. The camping trip is assumed to occur over one 24-hour period.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**Central Tendency**	**RME**	**Notes**
Exposure Frequency	EF	days/year	1	1	Unit estimate based on one event per year (see note)
Exposure Duration - Adult	ED	years	1	1	Unit estimate based on one event per year (see note)
Exposure Duration - Child	ED	years	1	1	Unit estimate based on one event per year
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Adult	AT-NC	days	365	365	Default from EPA 1989
Averaging Time-Non Cancer Child	AT-NC	days	365	365	Default with child EDs
Body Weight -Adult	BW	kg	70	70	EPA 1989, average of US population
Body Weight - Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Ground water Ingestion Rate - Adult	IR-GW	L/day	1.4	2	EPA 1997b, Section 3.6
Ground water Ingestion Rate - Child	IR-GW	L/day	0.74	1.29	Age 1-10 mean and 90 %, Table 3-33 EPA 1997b
Fraction Intake From Source	FI	fraction	0.8	1	CT based on professional judgment

Note: Actual exposures may be greater. Site-specific data should be used if available. Results will be linear. For example, camping for 5 days will increase risks by a factor of 5.

Equations

Exposure - Nonradionuclides
$CDI_{\text{ground water ingestion non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * IR-GW * EF * ED * FI)/(BW * AT-Nc)
$CDI_{\text{ground water ingestion carcinogenic}}$ (mg/kg-day)= (Cw [mg/L] * IR-GW * EF * ED * FI)/(BW * AT-c)
Risk - Nonradionuclides
HQ (unitless) = CDI/RfD
HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$
Risk (unitless probability) = CDI * SF
Exposure - Radionuclides
$TI_{\text{ground water ingestion}}$ (pCi) =Cw (pCi/L) * IR-GW * EF * FI * ED
Risk - Radionuclides
Risk (unitless probability) = TI*SF

Estimated CDI and Risks-Adults	**Central Tendency**		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonia	NA	NA	NA	NA
Arsenic	0.000	0.00	0.000	0.00
Boron	0.000	0.06	0.000	0.10
Cadmium (water)	0.000	0.00	0.000	0.00
Fluoride	0.000	0.00	0.000	0.00
Iron	0.000	0.00	0.000	0.00
Lithium	0.000	0.00	0.000	0.00
Manganese (nonfood)	0.000	0.00	0.000	0.00
Molybdenum	0.000	0.00	0.000	0.01
Nitrate	0.006	0.00	0.012	0.01
Selenium	0.000	0.00	0.000	0.00
Strontium	0.001	0.00	0.001	0.00
Uranium	0.000	0.08	0.000	0.15
Vanadium	0.000	0.01	0.000	0.01
Total		0.16		0.28
Chemicals as Carcinogens		**Added Cancer**		**Added Cancer**
Arsenic	4.35E-08	6.53E-08	5.44E-06	8.16E-06
Total		6.53E-08		8.16E-06
Radionuclides				
Radon-222	247.632	0.00E+00	442.2	0.00E+00
Radium-226+D	1.71472	6.62E-10	3.062	1.18E-09
Radium-228+D	3.36	3.49E-09	6	6.24E-09
Uranium-234	2,021.6	1.43E-07	3610	2.55E-07
Uranium-238+D	2,129.12	1.85E-07	3802	3.31E-07
Total		3.33E-07		5.94E-07

Table D–8. No Action—Future Ingestion of Contaminated Ground Water by a Camper (continued)

Estimated CDI and Risks-Children				
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonia	NA	NA	NA	NA
Arsenic	0.000	0.02	0.000	0.04
Boron	0.000	0.00	0.000	0.00
Cadmium (water)	0.000	0.00	0.000	0.00
Fluoride	0.000	0.00	0.000	0.00
Iron	0.000	0.00	0.000	0.00
Lithium				
Manganese (nonfood)	0.000	0.00	0.000	0.00
Molybdenum	0.000	0.01	0.000	0.01
Nitrate	0.011	0.01	0.024	0.01
Selenium	0.000	0.00	0.000	0.00
Strontium	0.001	0.00	0.002	0.00
Uranium	0.000	0.14	0.001	0.31
Vanadium	0.000	0.01	0.000	0.03
Total		0.19		0.42
Chemicals as Carcinogens				
Arsenic	7.32E-08	1.10E-07	1.60E-07	2.39E-07
Total		1.10E-07		2.39E-07
Radionuclides				
Radon-222	130.8912	0.00E+00	285.219	0.00E+00
Radium-226+D	0.906352	3.50E-10	1.97499	7.62E-10
Radium-228+D	1.776	1.85E-09	3.87	4.02E-09
Uranium-234	1,068.56	7.55E-08	2,328.45	1.65E-07
Uranium-238+D	1,125.392	9.80E-08	2,452.29	2.14E-07
Total		1.76E-07		3.83E-07

Table D−9. No Action—Current Dermal Exposure to Contaminated Ground Water During Rafting

Description – The sandbars adjacent to the Moab site could be used as a stopping (lunch) area for rafters. Children playing at the edge of the river could be dermally exposed to contaminated water. Ground water entering the Colorado River is assumed to be the source of the water. Rafters are assumed to stop at this location for 1 hour.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**Central Tendency**	**RME**	**Notes**
Exposure Frequency	EF	days/year	1	1	Unit estimate based on one event per year (see note)
Exposure Duration - Child	ED	years	1	1	Unit estimate based on one event per year (see note)
Exposure Time	ET	hours/day	1	1	Exposure occurs for only 1 hour/day
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Child	AT-NC	days	365	365	Default with child EDs
Body Weight - Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Dermal Permeability Constant	PC	cm/hour	Chemical Specific	Chemical Specific	See Below
Skin Surface Available for Contact-Child	SA	cm^2	486	591	Total for 6-9 old male, % for arms, legs, hands, feet for 6-7 year old (52%), Table 6-8, EPA 1997b
Conversion Factor	CF	L/cm^3	0.001	0.001	1L/1,000 cm^3

Note: Actual exposures may be greater. Site-specific data should be used if available. Results will be linear. For example, camping for 5 days will increase risks by a factor of 5.

Equations

Exposure - Nonradionuclides

$CDI_{\text{ground water ingestion non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * SA * PC - EF * ED * ET * CF)/(BW * AT-Nc)
$CDI_{\text{ground water ingestion carcinogenic}}$ (mg/kg-day)= (Cw [mg/L] * SA * PC * EF * ED * ET * CF)/(BW * AT-c)

Risk - Nonradionuclides

HQ (unitless) = CDI/RfD
HI (unitless) = HQ_1+ HQ_2 +….+ HQ_i
Risk (unitless probability) = CDI * SF

Exposure - Radionuclides

TI_{dermal} (pCi) = Cw (pCi/L) * SA* PC* EF * FI * ED * CF

Dermal Permeability Constants (PC)

Chemical Name	**PC (K_p) cm/hr**	**Notes**
Ammonia	NA	Inhalation route
Arsenic	1.0E-03	Not listed; default assumed from Exhibit 3-1
Boron	1.0E-03	Not listed; default assumed from Exhibit 3-1
Cadmium	1.0E-03	Listed in Exhibit 3-1
Fluoride	1.0E-03	Not listed; default assumed from Exhibit 3-1
Iron	1.0E-03	Not listed; default assumed
Lithium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Manganese	1.0E-03	Not listed; default assumed from Exhibit 3-1
Molybdenum	1.0E-03	Not listed; default assumed
Nitrate	NA	
Selenium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Strontium	1.0E-03	Not listed; default assumed from Exhibit 3-1
Uranium	1.0E-03	Not listed; default assumed
Vanadium	1.0E-03	Not listed; default assumed from Exhibit 3-1

Source: EPA (2001)

Table D–9. No Action—Current Dermal Exposure to Contaminated Ground Water During Rafting (continued)

Estimated CDI and Risks-Children				
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonia	NA	NA	NA	NA
Arsenic	0.000	0.00	0.000	0.00
Boron	0.000	0.00	0.000	0.00
Cadmium (water)	0.000	0.00	0.000	0.00
Fluoride	0.000	0.00	0.000	0.00
Iron	0.000	0.00	0.000	0.00
Lithium	0.000	0.00	0.000	0.00
Manganese (nonfood)	0.000	0.00	0.000	0.00
Molybdenum	0.000	0.00	0.000	0.00
Nitrate	NA	NA	NA	NA
Selenium	0.000	0.00	0.000	0.00
Strontium	0.000	0.00	0.000	0.00
Uranium	0.000	0.00	0.000	0.00
Vanadium	0.000	0.00	0.000	0.00
Total		0.00		0.00
Chemicals as Carcinogens				
Arsenic	6.01E-11	9.01E-11	7.31E-11	1.10E-10
Total		9.01E-11		1.10E-10

Note: Estimations of dermal exposure require a contaminant mass, and the contribution to risk from dermal exposure to radionuclides is expected to be much less than other pathways (ingestion, direct exposure). Therefore, dermal exposure to radionuclides was not estimated.

Table D−10. No Action—Current Incidental Ingestion of Contaminated Ground Water by a Rafter

Description – The sandbars adjacent to the Moab site could be used as a stopping (lunch) area for rafters. Children playing at the edge of the river could inadvertently ingest contaminated water. Ground water entering the Colorado River is assumed to be the source of the water. Rafters are assumed to stop at this location for one hour.

Exposure Factors					
			Parameters		
Factor	**Abbreviation**	**Units**	**Central Tendency**	**RME**	**Notes**
Exposure Frequency	EF	days/year	1	1	Unit estimate based on one event per year (see note)
Exposure Duration - Child	ED	years	1	1	Unit estimate based on one event per year (see note)
Averaging Time-Cancer	AT-c	days	25,550	25,550	Default from EPA 1989
Averaging Time-Non Cancer Child	AT-NC	days	365	365	Default with child EDs
Body Weight - Child	BW	kg	22	22	Mean for 1-10 year olds, Table 7-3 EPA 1997b
Ground water Ingestion Rate - Child	IR-Play	L/day	0.05	0.05	Based on Incidental Ingestion while swimming, EPA 1989, Page 6-34.
Fraction Intake From Source	FI	fraction	0.8	1	CT assumes some play occurs in the main channel of the river (minimal site influence)

Note: Actual exposures may be greater. Site-specific data should be used if available. Results will be linear. For example, camping for 5 days will increase risks by a factor of 5.

Equations

Exposure - Nonradionuclides

$CDI_{\text{ground water ingestion non carcinogenic}}$ (mg/kg-day) = (Cw [mg/L] * IR-Play * EF * ED * FI)/(BW * AT-Nc)
$CDI_{\text{ground water ingestion carcinogenic}}$ (mg/kg-day)= (Cw [mg/L] * IR-Play * EF * ED * FI)/(BW * AT-c)

Risk - Nonradionuclides
HQ (unitless) = CDI/RfD
HI (unitless) = $HQ_1 + HQ_2 + \ldots + HQ_i$
Risk (unitless probability) = CDI * SF

Exposure - Radionuclides
$TI_{\text{ground water ingestion}}$ (pCi) = Cw (pCi/L) * IR-Play * EF * FI * ED

Risk - Radionuclides
Risk (unitless probability) = Ti*SF

Estimated CDI and Risks-Children				
	Central Tendency		**RME**	
	CDI	**HQ**	**CDI**	**HQ**
Chemicals as Noncarcinogens	**(mg/kg-day)**	**(Unitless)**	**(mg/kg-day)**	**(Unitless)**
Ammonia	NA	NA	NA	NA
Arsenic	0.000	0.00	0.000	0.00
Boron	0.000	0.00	0.000	0.00
Cadmium (water)	0.000	0.00	0.000	0.00
Fluoride	0.000	0.00	0.000	0.00
Iron	0.000	0.00	0.000	0.00
Lithium	0.000	0.00	0.000	0.00
Manganese (nonfood)	0.000	0.00	0.000	0.00
Molybdenum	0.000	0.00	0.000	0.00
Nitrate	0.001	0.00	0.001	0.00
Selenium	0.000	0.00	0.000	0.00
Strontium	0.000	0.00	0.000	0.00
Uranium	0.000	0.01	0.000	0.01
Vanadium	0.000	0.00	0.000	0.00
Total		0.01		0.02
Chemicals as Carcinogens				
Arsenic	4.95E-09	7.42E-09	6.18E-09	9.27E-09
Total		7.42E-09		9.27E-09
Radionuclides				
Radon-222	8.844	0.00E+00	11.055	0.00E+00
Radium-226+D	0.061	2.36E-11	0.077	2.95E-11
Radium-228+D	0.120	1.25E-10	0.150	1.56E-10
Uranium-234	72.200	5.10E-09	90.250	6.38E-09
Uranium-238+D	76.040	6.62E-09	95.050	8.28E-09
Total		1.19E-08		1.48E-08

Table D−11. On-Site—Exposure Point Concentrations

Presents contaminant concentrations by medium for each exposure scenario.		
Residential Scenario		
	Ground Water Concentrations (Northeast area)	
Chemicals (mg/L)	**95 % UCL**	**Notes**
Ammonia	11.41	Ammonia, total reported as N; Reduced by an order of magnitude based on general modeling results
Arsenic	0.00695	Reduced by an order of magnitude based on general modeling results
Boron	0.127	Reduced by an order of magnitude based on general modeling results
Cadmium	0.00011	Reduced by an order of magnitude based on general modeling results
Fluoride	0.1768	Reduced by an order of magnitude based on general modeling results
Iron	0.2397	Reduced by an order of magnitude based on general modeling results
Lithium	0.02485	Reduced by an order of magnitude based on general modeling results
Manganese (nonfood)	0.1662	Reduced by an order of magnitude based on general modeling results
Molybdenum	0.03589	Reduced by an order of magnitude based on general modeling results
Nitrate	14.77	Reduced by an order of magnitude based on general modeling results
Selenium	0.00733	Reduced by an order of magnitude based on general modeling results
Strontium	1.44	Reduced by an order of magnitude based on general modeling results
Uranium	0.5738	Reduced by an order of magnitude based on general modeling results
Vanadium	0.1324	Reduced by an order of magnitude based on general modeling results
Radionuclides		
Radon-222	23.01	Unfiltered; Reduced by an order of magnitude based on general modeling results
Radium-226	0.04618	Reduced by an order of magnitude based on general modeling results
Radium-228	0.3237	Reduced by an order of magnitude based on general modeling results
Uranium-234	209.5	Reduced by an order of magnitude based on general modeling results
Uranium-238	221.1	Reduced by an order of magnitude based on general modeling results
	Soil concentrations	
Chemicals (mg/kg)	**95 % UCLs**	
Ammonium	0	Clean fill; assumed to be 0
Arsenic	0	Clean fill; assumed to be 0
Uranium (mg/kg)	0	Clean fill; assumed to be 0
Vanadium	0	Clean fill; assumed to be 0
Sulfate	0	Clean fill; assumed to be 0
Radionuclides (pCi/g)	**95 % UCLs**	
Radium-226	0	Clean fill; assumed to be 0
Thorium-230	0	Clean fill; assumed to be 0
Uranium-234	0	Clean fill; assumed to be 0
Uranium-238+D	0	Clean fill; assumed to be 0
	NH_3 in Air	
		Notes
NH_3 (mg/m^3)	0.01	Based on NH_3 conc. In water; default from EPA 1991a of 0.0005; conversion factor of 1,000 L/m^3, conversion from NH_4 to NH_3
		NH_3 conc. in air = water conc. x water-to-air volatilization factor x conversion factor
		NH_3 available in water based on a temperature of 20 °C and a pH of 7.5 from Emerson 1975. 1.24 % is unionized NH_3.
		Reduced by an order of magnitude for the on-site alternative compared to the no action
Food Concentrations (Vegetables)		
Chemicals (mg/kg)		Notes
Arsenic	0.00	Uptake value of 0.08; default from Resrad (ANL 1993), Table C.3
Uranium	0.00	Uptake value of 0.0025; default from Resrad (ANL 1993), Table C.3
Vanadium	0.00	Uptake value of 0.007; 90 % UCL from the Weinberg Group, Inc. 2000, Table C-1

Table D–11. On Site—Exposure Point Concentrations (continued)

Camper and Rafter Scenarios		
	Ground Water (assumed surface water) Concentrations	
Chemicals (mg/L)	**95 % UCL**	**Notes**
Ammonia	11.41	Ammonia, total reported as N; Reduced by an order of magnitude based on general modeling results
Arsenic	0.00695	Reduced by an order of magnitude based on general modeling results
Boron	0.127	Reduced by an order of magnitude based on general modeling results
Cadmium (water)	0.00011	Reduced by an order of magnitude based on general modeling results
Fluoride	0.1768	Reduced by an order of magnitude based on general modeling results
Iron	0.2397	Reduced by an order of magnitude based on general modeling results
Lithium	0.02485	Reduced by an order of magnitude based on general modeling results
Manganese (nonfood)	0.1662	Reduced by an order of magnitude based on general modeling results
Molybdenum	0.03589	Reduced by an order of magnitude based on general modeling results
Nitrate	14.77	Reduced by an order of magnitude based on general modeling results
Selenium	0.00733	Reduced by an order of magnitude based on general modeling results
Strontium	1.44	Reduced by an order of magnitude based on general modeling results
Uranium	0.5738	Reduced by an order of magnitude based on general modeling results
Vanadium	0.1324	Reduced by an order of magnitude based on general modeling results
Radionuclides		
Radon-222	23.01	Unfiltered; Reduced by an order of magnitude based on general modeling results
Radium-226	0.04618	Reduced by an order of magnitude based on general modeling results
Radium-228	0.3237	Reduced by an order of magnitude based on general modeling results
Uranium-234	209.5	Reduced by an order of magnitude based on general modeling results
Uranium-238	221.1	Reduced by an order of magnitude based on general modeling results
	Soil concentrations	
Chemicals (mg/kg)	**95 % UCLs**	**Notes**
Ammonium	0	Clean fill; assumed to be 0
Arsenic	0	Clean fill; assumed to be 0
Uranium (mg/kg)	0	Clean fill; assumed to be 0
Vanadium	0	Clean fill; assumed to be 0
Sulfate	0	Clean fill; assumed to be 0
Radionuclides (pCi/g)	**95 % UCLs**	**Notes**
Radium-226	0	Clean fill; assumed to be 0
Thorium-230	0	Clean fill; assumed to be 0
Uranium-234	0	Clean fill; assumed to be 0
Uranium-238+D	0	Clean fill; assumed to be 0
Worker Scenarios		
	Ground Water Concentrations	
Chemicals (mg/L)	**95 % UCL**	**Notes**
Ammonia	11.41	Ammonia, total reported as N; Reduced by an order of magnitude based on general modeling results
Arsenic	0.00695	
Boron	0.127	
Cadmium (water)	0.00011	
Fluoride	0.1768	
Iron	0.2397	
Lithium	0.02485	
Manganese (nonfood)	0.1662	
Molybdenum	0.03589	
Nitrate	14.77	Reduced by an order of magnitude based on general modeling results
Selenium	0.00733	
Strontium	1.44	

Table D–11. On Site–Exposure Point Concentrations (continued)

Uranium	0.5738	
Vanadium	0.1324	
Radionuclides (pCi/L)		
Radon-222	221.1	
Radium-226	1.531	
Radium-228	3	
Uranium-234	1805	
Uranium-238	1901	
	Soil concentrations	
Exposure is assumed not to occur to adults under a worker scenario.		
	NH_3 in Air	
		Notes
NH_3 (mg/m^3)	0.01	Based on NH_3 conc. In water; default from EPA 1991a of 0.0005; conversion factor of 1,000 L/m^3, conversion from NH_4 to NH_3.
		NH_3 conc. in air = water conc. × water-to-air volatilization factor × conversion factor
		NH_3 available in water based on a temperature of 20 C and a pH of 7.5 from Emerson 1975. 1.24 % is un-ionized NH_3
		Reduced by an order of magnitude for the on-site alternative compared to the no action

Table D−12. On-Site—Risk Summary for the Residential Scenario (Adult)

	Added Cancer Risk							
					Residential Scenario Combined Pathways			
	Soil Ingestion		Vegetable Ingestion		Compound Contribution		Compound Contribution	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	NA	NA	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	NA
Total	NA	NA	0.00E+00	0.00E+00	0.00E+00		0.00E+00	
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	NA	NA	NA	NA	NA	NA	NA	NA
Radium-226+D	NA	NA	NA	NA	NA	NA	NA	NA
Radium-228+D	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-234	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-238+D	NA	NA	NA	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA	NA	NA	NA
Pathway Contribution %								
	Noncarcinogenic Risks							
					Residential Scenario Combined Pathways			
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	0.00	0.00	0.00	NA	0.00	NA
Boron	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lithium	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	NA	NA	0.00	0.00	0.00	NA	0.00	NA
Vanadium	NA	NA	0.00	0.00	0.00	NA	0.00	NA
Total	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA

Table D−13. On-Site—Risk Summary for the Residential Scenario (Children)[a]

	Added Cancer Risk							
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	NA
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	
					Residential Scenario Combined Pathways			
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0	0	NA	NA	NA	NA	NA	NA
Radium-226+D	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Radium-228+D	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Uranium-234	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Uranium-238+D	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Total	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Pathway Contribution %								
	Noncarcinogenic Risks							
					Residential Scenario Combined Pathways			
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA
Boron	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lithium	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA
Vanadium	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA
Total	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA

[a]Assumes a clean source of domestic water and that all contaminated soil is isolated in the repository.

Table D−14. On-Site—Risk Summary for the Rafting Scenario (Children)[a]

	Added Cancer Risk							
					Rafter Scenario Combined Pathways			
	SW Ingestion		**Dermal**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	7.42E-10	9.27E-10	9.01E-12	1.10E-11	7.51E-10	100%	9.38E-10	100%
Total	7.42E-10	9.27E-10	9.01E-12	1.10E-11	7.51E-10		9.38E-10	
Pathway Contribution %	98.8%	98.8%	1.2%	1.2%				
	SW Ingestion		**Dermal**		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0.00	0.00	NA	NA	0.00E+00	0.0%	0.00E+00	0.0%
Radium-226+D	0.00	0.00	NA	NA	7.13E-13	0.1%	8.91E-13	0.1%
Radium-228+D	0.00	0.00	NA	NA	1.35E-11	1.0%	1.68E-11	1.0%
Uranium-234	0.00	0.00	NA	NA	5.92E-10	43.0%	7.41E-10	43.0%
Uranium-238+D	0.00	0.00	NA	NA	7.70E-10	55.9%	9.63E-10	55.9%
Total	0.00	0.00	NA	NA	1.38E-09	100.0%	1.72E-09	100.0%
Pathway Contribution %								
	Noncarcinogenic Risks							
					Rafter Scenario Combined Pathways			
	SW Ingestion		**Dermal**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.00	0.00	8.9%	0.00	8.9%
Boron	0.00	0.00	0.00	0.00	0.00	0.5%	0.00	0.5%
Cadmium	0.00	0.00	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	0.00	0.00	1.1%	0.00	1.1%
Iron	0.00	0.00	0.00	0.00	0.00	0.3%	0.00	0.3%
Lithium	0.00	0.00	0.00	0.00	0.00	0.5%	0.00	0.5%
Manganese	0.00	0.00	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	0.00	0.00	2.8%	0.00	2.8%
Nitrate	0.00	0.00	NA	NA	0.00	3.5%	0.00	3.5%
Selenium	0.00	0.00	0.00	0.00	0.00	0.6%	0.00	0.6%
Strontium	0.00	0.00	0.00	0.00	0.00	0.9%	0.00	0.9%
Uranium	0.00	0.00	0.00	0.00	0.00	73.4%	0.00	73.4%
Vanadium	0.00	0.00	0.00	0.00	0.00	7.3%	0.00	7.3%
Total	0.00	0.00	0.00	0.00	0.00	100.0%	0.00	100.0%
Pathway Contribution %								

[a]Assumes no contaminated soil is available for exposure.

Table D–15. On-Site—Risk Summary for the Camping Scenario (Adult)

		Added Cancer Risk				
			Camping Scenario Combined Pathways			
	SW Ingestion		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	6.53E-09	8.16E-07	6.53E-09	100%	8.16E-07	100%
Total	6.53E-09	8.16E-07	6.53E-09		8.16E-07	
	SW Ingestion		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0.00E+00	0.00E+00	0.00E+00	0.0%	0.00E+00	0.0%
Radium-226+D	2.00E-11	3.57E-11	2.00E-11	0.1%	3.57E-11	0.1%
Radium-228+D	3.77E-10	6.73E-10	3.77E-10	1.0%	6.73E-10	1.0%
Uranium-234	1.66E-08	2.96E-08	1.66E-08	43.0%	2.96E-08	43.0%
Uranium-238+D	2.16E-08	3.85E-08	2.16E-08	55.9%	3.85E-08	55.9%
Total	3.86E-08	6.88E-08	3.86E-08		6.88E-08	100.0%
		Noncarcinogenic Risks				
			Camping Scenario Combined Pathways			
	SW Ingestion		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.0%	0.00	0.0%
Boron	0.01	0.01	0.01	35.0%	0.01	35.0%
Cadmium	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	0.8%	0.00	0.8%
Iron	0.00	0.00	0.00	0.2%	0.00	0.2%
Lithium	0.00	0.00	0.00	0.3%	0.00	0.3%
Manganese	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	2.0%	0.00	2.0%
Nitrate	0.00	0.00	0.00	2.5%	0.00	2.5%
Selenium	0.00	0.00	0.00	0.4%	0.00	0.4%
Strontium	0.00	0.00	0.00	0.7%	0.00	0.7%
Uranium	0.01	0.01	0.01	52.7%	0.01	52.7%
Vanadium	0.00	0.00	0.00	5.2%	0.00	5.2%
Total	0.02	0.03	0.02	100%	0.03	100.0%

Table D−16. On-Site—Risk Summary for the Camping Scenario (Children)

	Added Cancer Risk							
					Camping Scenario Combined Pathways			
	SW Ingestion		Dermal		Compound Contribution		Compound Contribution	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	1.10E-08	2.39E-08	1.80E-11	8.01E-10	1.10E-08	100%	2.47E-08	100%
Total	1.10E-08	2.39E-08	1.80E-11	8.01E-10	1.10E-08		2.47E-08	
Pathway Contribution %	99.8%	96.8%	0.2%	3.2%				
					Camping Scenario Combined Pathways			
	SW Ingestion		Dermal		Compound Contribution		Compound Contribution	
Radionuclide	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.0%	0.00E+00	0.0%
Radium-226+D	1.06E-11	2.30E-11	NA	NA	1.06E-11	0.1%	2.30E-11	0.1%
Radium-228+D	1.99E-10	4.34E-10	NA	NA	1.99E-10	1.0%	4.34E-10	1.0%
Uranium-234	8.77E-09	1.91E-08	NA	NA	8.77E-09	43.0%	1.91E-08	43.0%
Uranium-238+D	1.14E-08	2.48E-08	NA	NA	1.14E-08	55.9%	2.48E-08	55.9%
Total	2.04E-08	4.44E-08	NA	NA	2.04E-08	100.0%	4.44E-08	100.0%
Pathway Contribution %								
	Noncarcinogenic Risks							
					Camping Scenario Combined Pathways			
	SW Ingestion		Dermal		Compound Contribution		Compound Contribution	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.00	0.00	8.9%	0.00	8.9%
Boron	0.00	0.00	0.00	0.00	0.00	0.5%	0.00	0.5%
Cadmium	0.00	0.00	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	0.00	0.00	1.1%	0.00	1.1%
Iron	0.00	0.00	0.00	0.00	0.00	0.3%	0.00	0.3%
Lithium	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.0%
Manganese	0.00	0.00	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	0.00	0.00	2.8%	0.00	2.8%
Nitrate	0.00	0.00	NA	NA	0.00	3.6%	0.00	3.6%
Selenium	0.00	0.00	0.00	0.00	0.00	0.6%	0.00	0.6%
Strontium	0.00	0.00	0.00	0.00	0.00	0.9%	0.00	0.9%
Uranium	0.01	0.03	0.00	0.00	0.01	73.8%	0.03	73.8%
Vanadium	0.00	0.00	0.00	0.00	0.00	7.3%	0.00	7.3%
Total	0.02	0.04	0.00	0.00	0.02	100.0%	0.04	100.0%
Pathway Contribution %	99.8%	99.8%	0.2%	0.2%				

Table D−17. On-Site—Risk Summary for the Outside Worker Scenario (Adult)[a]

	Added Cancer Risk					
			Outside Worker Scenario Combined Pathways			
	Dermal		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	1.36E-08	1.01E-07	1.36E-08	100.0%	1.01E-07	100.0%
Total	1.36E-08	1.01E-07	1.36E-08		1.01E-07	
			Outside Worker Scenario Combined Pathway			
	Dermal		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	NA	NA	NA	NA	NA	NA
Radium-226+D	NA	NA	NA	NA	NA	NA
Radium-228+D	NA	NA	NA	NA	NA	NA
Uranium-234	NA	NA	NA	NA	NA	NA
Uranium-238+D	NA	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA	NA
	Noncarcinogenic Risks					
			Outside Worker Scenario Combined Pathway			
	Dermal		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	9.2%	0.00	9.2%
Boron	0.00	0.00	0.00	0.6%	0.00	0.6%
Cadmium	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	1.2%	0.00	1.2%
Iron	0.00	0.00	0.00	0.3%	0.00	0.3%
Lithium	0.00	0.00	0.00	0.5%	0.00	0.5%
Manganese	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	2.9%	0.00	2.9%
Nitrate	NA	NA	NA	NA	NA	0.00
Selenium	0.00	0.00	0.00	0.6%	0.00	0.6%
Strontium	0.00	0.00	0.00	1.0%	0.00	1.0%
Uranium	0.00	0.01	0.00	76.1%	0.01	76.1%
Vanadium	0.00	0.00	0.00	7.5%	0.00	7.5%
Total	0.00	0.01	0.00	100.0%	0.01	100.0%

[a]Assumed clean fill material and an alternate clean water source.

Table D−18. On-Site—Overall Summary for All Receptors and Pathways

	Added Cancer (Unitless Probability)				Noncarcinogenic Risks (HI)		Notes
	Chemical		Radionuclides				
Receptor	**CT**	**RME**	**CT**	**RME**	**CT**	**RME**	
Resident							Assumes clean, municipal source of domestic water
Adult	0.00E+00	0.00E+00	NA	NA	0.00	0.00	Assumes clean fill at the site from borrow areas
Child	0.00E+00	0.00E+00			0.00	0.00	
Rafter							Assumes one day of exposure per year
Child	7.51E-10	9.38E-10	1.38E-09	1.72E-09	0.00	0.00	Exposure is from child playing in water
Camper							Assumes one day of exposure per year
Adult	6.53E-09	8.16E-07	3.86E-08	6.88E-08	0.02	0.03	Clean soil in areas of exposure
Child	1.10E-08	2.47E-08	2.04E-08	4.44E-08	0.02	0.04	
Outside Worker							Assumes clean, municipal source of domestic water
Adult	1.36E-08	1.01E-07	NA	NA	0.00	0.01	

Table D−19. Off-Site—Exposure Point Concentrations

Presents contaminant concentrations by medium for each exposure scenario.		
Residential Scenario		
	Ground Water Concentrations (Northeast area)	
Chemicals (mg/L)	**95 % UCL**	**Notes**
Ammonia	1.141	Ammonia, total reported as N; Reduced by two orders of magnitude based on general modeling results
Arsenic	0.000695	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Boron	0.0127	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Cadmium	0.000011	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Fluoride	0.01768	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Iron	0.02397	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Lithium	0.002485	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Manganese (nonfood)	0.01662	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Molybdenum	0.003589	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Nitrate	1.477	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Selenium	0.000733	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Strontium	0.144	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium	0.05738	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Vanadium	0.01324	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Radionuclides		
Radon-222	2.301	Unfiltered; Reduced by an order of magnitudes based on general modeling results
Radium-226	0.004618	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Radium-228	0.03237	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium-234	20.95	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium-238	22.11	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
	Soil concentrations	
Chemicals (mg/kg)	**95 % UCLs**	
Ammonium	0	Clean fill; assumed to be 0
Arsenic	0	Clean fill; assumed to be 0
Uranium (mg/kg)	0	Clean fill; assumed to be 0
Vanadium	0	Clean fill; assumed to be 0
Sulfate	0	Clean fill; assumed to be 0
Radionuclides (pCi/g)	**95 % UCLs**	
Radium-226	0	Clean fill; assumed to be 0
Thorium-230	0	Clean fill; assumed to be 0
Uranium-234	0	Clean fill; assumed to be 0
Uranium-238+D	0	Clean fill; assumed to be 0

Table D–19. Off Site—Exposure Point Concentrations (continued)

	NH_3 in Air	
		Notes
NH_3 (mg/m^3)	0.00	Based on NH_3 conc. In water; default form EPA 1991a of 0.0005; conversion factor of 1,000 L/ m^3, conversion from NH_4 to NH_3.
		NH_3 conc. in air = water conc. x water-to-air volatilization factor x conversion factor
		NH_3 available in water based on a temperature of 20 C and a pH of 7.5 from Emerson 1975. 1.24 % is un-ionized NH_3
		Reduced by an order of magnitude over the no action for the cap in place
	Food Concentrations (Vegetables)	
Chemicals (mg/kg)		Notes
Arsenic	0.00	Uptake value of 0.08; default from RESRAD (ANL 1993), Table C.3
Uranium	0.00	Uptake value of 0.0025; default from RESRAD (ANL 1993), Table C.3
Vanadium	0.00	Uptake value of 0.007; 90 % UCL from the Weinberg Group, Inc. 2000, Table C-1
Camper and Rafter Scenarios		
	Ground Water (assumed surface water) Concentrations	
Chemicals (mg/L)	**95 % UCL**	**Notes**
Ammonia	1.141	Ammonia, total reported as N; Reduced by two orders of magnitude based on general modeling results
Arsenic	0.000695	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Boron	0.0127	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Cadmium (water)	0.000011	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Fluoride	0.01768	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Iron	0.02397	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Lithium	0.002485	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Manganese (nonfood)	0.01662	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Molybdenum	0.003589	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Nitrate	1.477	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Selenium	0.000733	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Strontium	0.144	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium	0.05738	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Vanadium	0.01324	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Radionuclides		
Radon-222	2.301	Unfiltered; Reduced by an order of magnitudes based on general modeling results
Radium-226	0.004618	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Radium-228	0.03237	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium-234	20.95	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium-238	22.11	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
	Soil concentrations	
Chemicals (mg/kg)	**95 % UCLs**	**Notes**
Arsenic	0	Clean fill; assumed to be 0
Uranium (mg/kg)	0	Clean fill; assumed to be 0
Vanadium	0	Clean fill; assumed to be 0

Table D–19. Off Site—Exposure Point Concentrations (continued)

Radionuclides (pCi/g)	**95 % UCLs**	**Notes**
Radium-226	0	Clean fill; assumed to be 0
Thorium-230	0	Clean fill; assumed to be 0
Uranium-234	0	Clean fill; assumed to be 0
Uranium-238+D	0	Clean fill; assumed to be 0
Worker Scenarios		
	Ground Water Concentrations	
Chemicals (mg/L)	**95 % UCL**	**Notes**
Ammonia	1.141	Ammonia, total reported as N; Reduced by two orders of magnitude based on general modeling results
Arsenic	0.000695	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Boron	0.0127	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Cadmium (water)	0.000011	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Fluoride	0.01768	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Iron	0.02397	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Lithium	0.002485	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Manganese (nonfood)	0.01662	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Molybdenum	0.003589	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Nitrate	1.477	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Selenium	0.000733	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Strontium	0.144	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Uranium	0.05738	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Vanadium	0.01324	Reduced by two orders of magnitude compared to the no action alternative based on general modeling results
Radionuclides (pCi/L)		
Radon-222	221.1	
Radium-226	1.531	
Radium-228	3	
Uranium-234	1805	
Uranium-238	1901	
	Soil concentrations	
Exposure is assumed not to occur to adults under a worker scenario.		
	NH_3 in Air	
		Notes
NH_3 (mg/m^3)	0.00	Based on NH_3 conc. In water; default form EPA 1991a of 0.0005; conversion factor of 1,000 L/ m^3, conversion from NH_4 to NH_3.
		NH_3 conc. in air = water conc. × water-to-air volatilization factor × conversion factor
		NH_3 available in water based on a temperature of 20 C and a pH of 7.5 from Emerson 1975. 1.24 % is un-ionized NH_3
		Reduced by two orders of magnitude compared to the no action alternative based on general modeling results

Table D−20. Off-Site—Risk Summary for the Residential Scenario (Adult)

					Residential Scenario Combined Pathways			
	Added Cancer Risk							
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	NA	NA	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	NA
Total	NA	NA	0.00E+00	0.00E+00	0.00E+00		0.00E+00	
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	NA	NA	NA	NA	NA	NA	NA	NA
Radium-226+D	NA	NA	NA	NA	NA	NA	NA	NA
Radium-228+D	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-234	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-238+D	NA	NA	NA	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA	NA	NA	NA
Pathway Contribution %								
	Noncarcinogenic Risks							
					Residential Scenario Combined Pathways			
	Soil Ingestion		**Vegetable Ingestion**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	0.00	0.00	0.00	NA	0.00	NA
Boron	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lithium	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	NA	NA	0.00	0.00	0.00	NA	0.00	NA
Vanadium	NA	NA	0.00	0.00	0.00	NA	0.00	NA
Total	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA

Table D−21. Off-Site—Risk Summary for the Residential Scenario (Children)[a]

	Added Cancer Risk							
					Residential Scenario Combined Pathways			
	Soil Ingestion		**Vegetable Ingestion**		**Compound**	**Contribution**	**Compound**	**Contribution**
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	NA
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	
	Soil Ingestion		**Vegetable Ingestion**		**Compound**	**Contribution**	**Compound**	**Contribution**
Radionuclide	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0	0	NA	NA	NA	NA	NA	NA
Radium-226+D	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Radium-228+D	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Uranium-234	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Uranium-238+D	0.00E+00	0.00E+00	NA	NA	0.00E+00	NA	0.00E+00	NA
Total	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.0%	0.00E+00	0.00%
Pathway Contribution %								
	Noncarcinogenic Risks							
					Residential Scenario Combined Pathways			
	Soil Ingestion		**Vegetable Ingestion**		**Compound**	**Contribution**	**Compound**	**Contribution**
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA
Boron	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lithium	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA
Vanadium	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA
Total	0.00	0.00	0.00	0.00	0.00	NA	0.00	NA

[a]Assumes a clean source of domestic water and that all contaminated soil is isolated in the repository.

Table D−22. Off-Site—Risk Summary for the Rafting Scenario (Children)[a]

			Added Cancer Risk					
					Rafter Scenario Combined Pathways			
	SW Ingestion		**Dermal**		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	7.42E-11	9.27E-11	9.01E-13	1.10E-12	7.51E-11	100%	9.38E-11	100%
Total	7.42E-11	9.27E-11	9.01E-13	1.10E-12	7.51E-11		9.38E-11	
Pathway Contribution %	98.8%	98.8%	1.2%	1.2%				
Radionuclide	**SW Ingestion**		**Dermal**		**Compound Contribution**		**Compound Contribution**	
	CT	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0.00	0.00	NA	NA	0.00E+00	0.0%	0.00E+00	0.0%
Radium-226+D	0.00	0.00	NA	NA	7.13E-14	0.1%	8.91E-14	0.1%
Radium-228+D	0.00	0.00	NA	NA	1.35E-12	1.0%	1.68E-12	1.0%
Uranium-234	0.00	0.00	NA	NA	5.92E-11	43.0%	7.41E-11	43.0%
Uranium-238+D	0.00	0.00	NA	NA	7.70E-11	55.9%	9.63E-11	55.9%
Total	0.00	0.00	NA	NA	1.38E-10	100.0%	1.72E-10	100.0%
Pathway Contribution %								
			Noncarcinogenic Risks					
					Rafter Scenario Combined Pathways			
Chemical	**SW Ingestion**		**Dermal**		**Compound Contribution**		**Compound Contribution**	
	CT	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.00	0.00	8.9%	0.00	8.9%
Boron	0.00	0.00	0.00	0.00	0.00	0.5%	0.00	0.5%
Cadmium	0.00	0.00	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	0.00	0.00	1.1%	0.00	1.1%
Iron	0.00	0.00	0.00	0.00	0.00	0.3%	0.00	0.3%
Lithium	0.00	0.00	0.00	0.00	0.00	0.5%	0.00	0.5%
Manganese	0.00	0.00	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	0.00	0.00	2.8%	0.00	2.8%
Nitrate	0.00	0.00	NA	NA	0.00	3.5%	0.00	3.5%
Selenium	0.00	0.00	0.00	0.00	0.00	0.6%	0.00	0.6%
Strontium	0.00	0.00	0.00	0.00	0.00	0.9%	0.00	0.9%
Uranium	0.00	0.00	0.00	0.00	0.00	73.4%	0.00	73.4%
Vanadium	0.00	0.00	0.00	0.00	0.00	7.3%	0.00	7.3%
Total	0.00	0.00	0.00	0.00	0.00	100.0%	0.00	100.0%
Pathway Contribution %								

[a]Assumes no contaminated soil is available for exposure.

Table D−23. Off-Site—Risk Summary for the Camping Scenario (Adult)

	Added Cancer Risk					
			Camping Scenario Combined Pathways			
	SW Ingestion		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	6.53E-10	8.16E-08	6.53E-10	100%	8.16E-08	100%
Total	6.53E-10	8.16E-08	6.53E-10		8.16E-08	
	SW Ingestion		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0.00E+00	0.00E+00	0.00E+00	0.0%	0.00E+00	0.0%
Radium-226+D	2.00E-12	3.57E-12	2.00E-12	0.1%	3.57E-12	0.1%
Radium-228+D	3.77E-11	6.73E-11	3.77E-11	1.0%	6.73E-11	1.0%
Uranium-234	1.66E-09	2.96E-09	1.66E-09	43.0%	2.96E-09	43.0%
Uranium-238+D	2.16E-09	3.85E-09	2.16E-09	55.9%	3.85E-09	55.9%
Total	3.86E-09	6.88E-09	3.86E-09		6.88E-09	100.0%
	Noncarcinogenic Risks					
			Camping Scenario Combined Pathways			
	SW Ingestion		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.0%	0.00	0.0%
Boron	0.00	0.00	0.00	35.0%	0.00	35.0%
Cadmium	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	0.8%	0.00	0.8%
Iron	0.00	0.00	0.00	0.2%	0.00	0.2%
Lithium	0.00	0.00	0.00	0.3%	0.00	0.3%
Manganese	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	2.0%	0.00	2.0%
Nitrate	0.00	0.00	0.00	2.5%	0.00	2.5%
Selenium	0.00	0.00	0.00	0.4%	0.00	0.4%
Strontium	0.00	0.00	0.00	0.7%	0.00	0.7%
Uranium	0.00	0.00	0.00	52.7%	0.00	52.7%
Vanadium	0.00	0.00	0.00	5.2%	0.00	5.2%
Total	0.00	0.00	0.00	100%	0.00	100.0%

Table D−24. Off-Site—Risk Summary for the Camping Scenario (Children)[a]

	Added Cancer Risk									
							Camping Scenario Combined Pathways			
	SW Ingestion		Dermal		Soil Ingestion		Compound Contribution		Compound Contribution	
Chemical	**CT**	**RME**	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	1.10E-09	2.39E-09	1.80E-12	8.01E-11	0.00E+00	0.00E+00	1.10E-09	100%	2.47E-09	100%
Total	1.10E-09	2.39E-09	1.80E-12	8.01E-11	0.00E+00	0.00E+00	1.10E-09		2.47E-09	
Pathway Contribution %	99.8%	96.8%	0.2%	3.2%	0.0%	0.0%				
Radionuclide	**SW Ingestion**		**Dermal**		**Soil Ingestion**		**Compound Contribution**		**Compound Contribution**	
	CT	**RME**	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	0.00E+00	0.00E+00	NA	NA	0	0	0.00E+00	0.0%	0.00E+00	0.0%
Radium-226+D	1.06E-12	2.30E-12	NA	NA	0.00E+00	0.00E+00	1.06E-12	0.1%	2.30E-12	0.1%
Radium-228+D	1.99E-11	4.34E-11	NA	NA	0.00E+00	0.00E+00	1.99E-11	1.0%	4.34E-11	1.0%
Uranium-234	8.77E-10	1.91E-09	NA	NA	0.00E+00	0.00E+00	8.77E-10	43.0%	1.91E-09	43.0%
Uranium-238+D	1.14E-09	2.48E-09	NA	NA	0.00E+00	0.00E+00	1.14E-09	55.9%	2.48E-09	55.9%
Total	2.04E-09	4.44E-09	NA	NA	0.00E+00	0.00E+00	2.04E-09	100.0%	4.44E-09	100.0%
Pathway Contribution %										
	Noncarcinogenic Risks									
							Camping Scenario Combined Pathways			
Chemical	**SW Ingestion**		**Dermal**		**Soil Ingestion**		**Compound Contribution**		**Compound Contribution**	
	CT	**RME**	**CT**	**RME**	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.9%	0.00	8.9%
Boron	0.00	0.00	0.00	0.00	NA	NA	0.00	0.5%	0.00	0.5%
Cadmium	0.00	0.00	0.00	0.00	NA	NA	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	0.00	NA	NA	0.00	1.1%	0.00	1.1%
Iron	0.00	0.00	0.00	0.00	NA	NA	0.00	0.3%	0.00	0.3%
Lithium	0.00	0.00	0.00	0.00	NA	NA	0.00	0.0%	0.00	0.0%
Manganese	0.00	0.00	0.00	0.00	NA	NA	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	0.00	NA	NA	0.00	2.8%	0.00	2.8%
Nitrate	0.00	0.00	NA	NA	NA	NA	0.00	3.6%	0.00	3.6%
Selenium	0.00	0.00	0.00	0.00	NA	NA	0.00	0.6%	0.00	0.6%
Strontium	0.00	0.00	0.00	0.00	NA	NA	0.00	0.9%	0.00	0.9%
Uranium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.8%	0.00	73.8%
Vanadium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.3%	0.00	7.3%
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0%	0.00	100.0%
Pathway Contribution %	99.8%	99.8%	0.2%	0.2%	0.0%	0.0%				

[a]Assumes no contaminated soil available for exposure.

Table D−25. Off-Site—Risk Summary for the Outside Worker Scenario (Adult)[a]

	Added Cancer Risk					
			Outside Worker Scenario Combined Pathways			
	Dermal		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Arsenic	1.36E-09	1.01E-08	1.36E-09	100.0%	1.01E-08	100.0%
Total	1.36E-09	1.01E-08	1.36E-09		1.01E-08	
	Dermal		**Compound Contribution**		**Compound Contribution**	
Radionuclide	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Radon-222	NA	NA	NA	NA	NA	NA
Radium-226+D	NA	NA	NA	NA	NA	NA
Radium-228+D	NA	NA	NA	NA	NA	NA
Uranium-234	NA	NA	NA	NA	NA	NA
Uranium-238+D	NA	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA	NA
	Noncarcinogenic Risks					
			Outside Worker Scenario Combined Pathways			
	Dermal		**Compound Contribution**		**Compound Contribution**	
Chemical	**CT**	**RME**	**CT**	**%**	**RME**	**%**
Ammonia	NA	NA	NA	NA	NA	NA
Arsenic	0.00	0.00	0.00	9.2%	0.00	9.2%
Boron	0.00	0.00	0.00	0.6%	0.00	0.6%
Cadmium	0.00	0.00	0.00	0.1%	0.00	0.1%
Fluoride	0.00	0.00	0.00	1.2%	0.00	1.2%
Iron	0.00	0.00	0.00	0.3%	0.00	0.3%
Lithium	0.00	0.00	0.00	0.5%	0.00	0.5%
Manganese	0.00	0.00	0.00	0.1%	0.00	0.1%
Molybdenum	0.00	0.00	0.00	2.9%	0.00	2.9%
Nitrate	NA	NA	NA	NA	NA	0.00
Selenium	0.00	0.00	0.00	0.6%	0.00	0.6%
Strontium	0.00	0.00	0.00	1.0%	0.00	1.0%
Uranium	0.00	0.00	0.00	76.1%	0.00	76.1%
Vanadium	0.00	0.00	0.00	7.5%	0.00	7.5%
Total	0.00	0.00	0.00	100.0%	0.00	100.0%

[a]Assumed clean fill material and an alternate clean water source.

Table D−26. Off-Site—Overall Summary for All Receptors and Pathways

	Added Cancer (Unitless Probability)				**Noncarcinogenic Risks (HI)**		
	Chemical		**Radionuclides**				
Receptor	**CT**	**RME**	**CT**	**RME**	**CT**	**RME**	**Notes**
Resident							Assumes clean, municipal source of domestic water
Adult	0.00E+00	0.00E+00	NA	NA	0.00	0.00	Assumes clean fill at the site from borrow areas
Child	0.00E+00	0.00E+00			0.00	0.00	
Rafter							Assumes one day of exposure per year
Child	7.51E-11	9.38E-11	1.38E-10	1.72E-10	0.00	0.00	Exposure is from child play in water
Camper							Assumes one day of exposure per year
Adult	6.53E-10	8.16E-08	3.86E-09	6.88E-09	0.00	0.00	Clean soil in areas of exposure
Child	1.10E-09	2.47E-09	2.04E-09	4.44E-09	0.00	0.00	
Outside Worker							Assumes clean, municipal source of domestic water
Adult	1.36E-09	1.01E-08	NA	NA	0.00	0.00	Dermal exposure to contaminated ground water used for irrigation

D4.0 Construction Risks

This section provides additional information on the worksheets used to estimate fatalities from construction accidents and risks to workers and members of the public from exposure to radiological contamination that would occur during implementation of the various alternatives.

The following tables present calculation spreadsheets:

Table D−27. Klondike Flats Disposal Alternative–Truck

Moab Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
Mechanics	0	0	4.5	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							1.37E-01	
Vicinity Property								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
Mechanics	0	0	3	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							3.08E-02	

Table D−27. Klondike Flats Disposal Alternative–Truck (continued)

Borrow Areas								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	7	14.7	4	58.80	2.16E-04	Scott et al. 2001	1.27E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	4	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	4	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	4	84.00	3.29E-04	Scott et al. 2001	2.76E-02	
Mechanics	0	0	4	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							4.22E-02	
Disposal Cell Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
Mechanics	0	0	4.8	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							1.64E-01	

Table D−27. Klondike Flats Disposal Alternative–Truck (continued)

Transportation Related Labor								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	9	18.9	3.5	66.15	7.47E-05	Hoskin et al. 1994	4.94E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
Mechanics	3	6.3	3.5	22.05	5.40E-05	Scott et al. 2001	1.19E-03	
Total							6.13E-03	

Table D–28. Klondike Flats Disposal Alternative–Truck Summary

	Moab Operations	Vicinity Properties	Borrow Areas	Disposal Cell	Transportation	Worker Total
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	9	51
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
Mechanics	0	0	0	0	3	3
Total	67	20	20	70	9	186

Table D−29. Klondike Flats Disposal Alternative–Rail

			Moab Operations					
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
Conveyor Operators	0	0	4.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							1.37E-01	
			Vicinity Property					
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
Conveyor Operators	0	0	3	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							3.08E-02	

Table D−29. Klondike Flats Disposal Alternative–Rail (continued)

			Borrow Areas					
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	7	14.7	3.5	51.45	2.16E-04	Scott et al. 2001	1.11E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	3.5	22.05	7.47E-05	Hoskin et al. 1994	1.65E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3.5	73.50	3.29E-04	Scott et al. 2001	2.42E-02	
Conveyor Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							3.69E-02	
			Disposal Cell Operations					
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
Conveyor/Operators	0	0	4.8	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							1.64E-01	

Table D−29. Klondike Flats Disposal Alternative–Rail (continued)

			Transportation Related Labor					
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 3,600-hour year because of the 6 day work schedule for rail transport
Site Support	9	16.2	3.5	56.70	7.47E-05	Hoskin et al. 1994	4.24E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
Conveyor Operators	6	10.8	3.5	37.80	2.16E-04	Hoskin et al. 1994	8.16E-03	Assume fatality rate the same as operating engineer
Track Maintenance	1	1.8	3.5	6.30	7.62E-04	Scott et al. 2001	4.80E-03	Assume railroad worker fatality rates
Total							1.72E-02	

Table D−30. Klondike Flats Disposal Alternative–Rail Summary

	Moab Operations	Vicinity Properties	Borrow Areas	Disposal Cell	Transportation	Worker Total
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	9	51
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
Conveyor operators	0	0	0	0	6	6
Track Maintenance	0	0	0	0	1	1
Total	67	20	20	70	16	193

Table D−31. Klondike Flats Disposal Alternative–Slurry

				Moab Operations				
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
System Operators	0	0	4.5	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							1.37E-01	
				Vicinity Property				
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
System Operators	0	0	3	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							3.08E-02	

Table D−31. Klondike Flats Disposal Alternative–Slurry (continued)

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Borrow Areas								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	7	14.7	4	58.80	2.16E-04	Scott et al. 2001	1.27E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	4	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	4	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	4	84.00	3.29E-04	Scott et al. 2001	2.76E-02	
System Operators	0	0	4	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							4.22E-02	
Disposal Cell Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
								Disposal cell is 4 and 10 months
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
System Operators	0	0	4.8	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							1.64E-01	

Table D−31. Klondike Flats Disposal Alternative–Slurry (continued)

Transportation Related Labor								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 3,600-hour year because of the 6-day work schedule for rail transport
Site Support	4	7.2	3.5	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
System Operators	21	37.8	3.5	132.30	5.40E-05	Hoskin et al. 1994	7.14E-03	Operating engineer risk values
Pipeline Construction	250	450	0.5	225.00	2.32E-04	Scott et al. 2001	5.22E-02	Fatality rate is based on 50% general laborer, 25% mechanic and 25% equipment operator. General laborer has higher fatality rates
Total							6.12E-02	

Table D−32. Klondike Flats Disposal Alternative–Slurry Summary

	Moab Operations	**Vicinity Properties**	**Borrow Areas**	**Disposal Cell**	**Transportation**	**Worker Total**
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	9	51
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
System Operators	0	0	0	0	3	3
Pipeline Construction	67	20	20	70	9	186
Total	134	40	40	140	21	375

Table D−33. Crescent Junction Disposal Alternative–Truck

Moab Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
Mechanics	0	0	4.5	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							1.37E-01	
Vicinity Property								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
Mechanics	0	0	3	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							3.08E-02	

Table D−33. Crescent Junction Disposal Alternative–Truck (continued)

Borrow Areas								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	7	14.7	4	58.80	2.16E-04	Scott et al. 2001	1.27E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	4	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	4	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	4	84.00	3.29E-04	Scott et al. 2001	2.76E-02	
Mechanics	0	0	4	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							4.22E-02	

Disposal Cell Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
Mechanics	0	0	4.8	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							1.64E-01	

Table D−33. Crescent Junction Disposal Alternative–Truck (continued)

Transportation Related Labor								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	9	18.9	3.5	66.15	7.47E-05	Hoskin et al. 1994	4.94E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
Mechanics	4	8.4	3.5	29.40	5.40E-05	Scott et al. 2001	1.59E-03	
Total							6.53E-03	

Table D−34. Crescent Junction Disposal Alternative–Truck Summary

	Moab Operations	Vicinity Properties	Borrow Areas	Disposal Cell	Transportation	Worker Total
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	9	51
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
Mechanics	0	0	0	0	4	4
Total	67	20	20	70	9	186

Table D−35. Crescent Junction Disposal Alternative–Rail

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Moab Operations								
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
Conveyor Operators	0	0	4.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							1.37E-01	
Vicinity Property								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
Conveyor Operators	0	0	3	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							3.08E-02	

Table D−35. Crescent Junction Disposal Alternative–Rail (continued)

Borrow Areas

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Equipment Operators	7	14.7	3.5	51.45	2.16E-04	Scott et al. 2001	1.11E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	3.5	22.05	7.47E-05	Hoskin et al. 1994	1.65E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3.5	73.50	3.29E-04	Scott et al. 2001	2.42E-02	
Conveyor Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							3.69E-02	

Disposal Cell Operations

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
Conveyor Operators	0	0	4.8	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Assume fatality rate the same as operating engineer
Total							1.64E-01	

Table D−35. Crescent Junction Disposal Alternative–Rail (continued)

Transportation Related Labor

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 3,600-hour year because of the 6-day work schedule for rail transport
Site Support	9	16.2	3.5	56.70	7.47E-05	Hoskin et al. 1994	4.24E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
Conveyor Operators	6	10.8	3.5	37.80	2.16E-04	Hoskin et al. 1994	8.16E-03	Assume fatality rate the same as operating engineer
Track Maintenance	1	1.8	3.5	6.30	7.62E-04	Scott et al. 2001	4.80E-03	Assume railroad worker fatality rates
Total							1.72E-02	

Table D−36. Crescent Junction Disposal Alternative–Rail Summary

	Moab Operations	Vicinity Properties	Borrow Areas	Disposal Cell	Transportation	Worker Total
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	9	51
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
Conveyor/operators	0	0	0	0	6	6
Track Maintenance	0	0	0	0	1	1
Total	67	20	20	70	16	193

Table D−37. Crescent Junction Disposal Alternative–Slurry

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Moab Operations								
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
System Operators	0	0	4.5	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							1.37E-01	
Vicinity Property								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
System Operators	0	0	3	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							3.08E-02	

Table D−37. Crescent Junction Disposal Alternative–Slurry (continued)

Borrow Areas								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	7	14.7	4	58.80	2.16E-04	Scott et al. 2001	1.27E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	4	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	4	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	4	84.00	3.29E-04	Scott et al. 2001	2.76E-02	
System Operators	0	0	4	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							4.22E-02	
Disposal Cell Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
								Disposal cell is 4 and 10 months
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
System Operators	0	0	4.8	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							1.64E-01	

Table D−37. Crescent Junction Disposal Alternative–Slurry (continued)

Transportation Related Labor								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 3,600-hour year because of the 6-day work schedule for rail transport
Site Support	4	7.2	3.5	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
System Operators	21	37.8	3.5	132.30	5.40E-05	Hoskin et al. 1994	7.14E-03	Operating engineer risk values
Pipeline Construction	330	594	0.6	356.40	2.32E-04	Scott et al. 2001	8.27E-02	Fatality rate is based on 50% general laborer, 25% mechanic, and 25% equipment operator. General laborer has higher fatality rates
Total							9.17E-02	

Table D−38. Crescent Junction Disposal Alternative–Slurry Summary

	Moab Operations	**Vicinity Properties**	**Borrow Areas**	**Disposal Cell**	**Transportation**	**Worker Total**
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	4	46
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
System Operators	0	0	0	0	21	21
Pipeline Construction	0	0	0	0	330	330
Total	67	20	20	70	355	532

Table D−39. White Mesa Mill Disposal Alternative–Truck

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Moab Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
Mechanics	0	0	4.5	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							1.37E-01	
Vicinity Property								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
Mechanics	0	0	3	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							3.08E-02	

Table D−39. White Mesa Mill Disposal Alternative–Truck (continued)

Work Category	Labor	Labor/2000 h/yr	Years Worked	Person Years	Fatality Rate	Rate Reference	Fatalities	Notes
Borrow Areas								
Equipment Operators	7	14.7	4	58.80	2.16E-04	Scott et al. 2001	1.27E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	4	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	4	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	4	84.00	3.29E-04	Scott et al. 2001	2.76E-02	
Mechanics	0	0	4	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							4.22E-02	
Disposal Cell Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
Mechanics	0	0	4.8	0.00	5.40E-05	Scott et al. 2001	0.00E+00	
Total							1.64E-01	

Table D−39. White Mesa Mill Disposal Alternative–Truck (continued)

Transportation Related Labor								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	10	21	3.5	73.50	7.47E-05	Hoskin et al. 1994	5.49E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
Mechanics	8	16.8	3.5	58.80	5.40E-05	Scott et al. 2001	3.18E-03	
Total							8.67E-03	

Table D−40. White Mesa Mill Disposal Alternative–Truck Summary

	Moab Operations	**Vicinity Properties**	**Borrow Areas**	**Disposal Cell**	**Transportation**	**Worker Total**
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	10	52
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
Mechanics	0	0	0	0	8	8
Total	67	20	20	70	10	187

Table D−41. White Mesa Mill Disposal Alternative–Slurry

Moab Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	25	52.5	4.5	236.25	2.16E-04	Scott et al. 2001	5.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	19	39.9	4.5	179.55	7.47E-05	Hoskin et al. 1994	1.34E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	1	2.1	4.5	9.45	3.88E-04	Scott et al. 2001	3.67E-03	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	22	46.2	4.5	207.90	3.29E-04	Scott et al. 2001	6.84E-02	
System Operators	0	0	4.5	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							1.37E-01	
Vicinity Property								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	6	12.6	3	37.80	2.16E-04	Scott et al. 2001	8.16E-03	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	4	8.4	3	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	3	63.00	3.29E-04	Scott et al. 2001	2.07E-02	
System Operators	0	0	3	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							3.08E-02	

Table D−41. White Mesa Mill Disposal Alternative–Slurry (continued)

Borrow Areas									
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	7	14.7	4	58.80	2.16E-04	Scott et al. 2001	1.27E-02	Labor is from Section 2 and is based on a 4,200-hour year
Site Support	3	6.3	4	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	4	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	10	21	4	84.00	3.29E-04	Scott et al. 2001	2.76E-02	
System Operators	0	0	4	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							4.22E-02	
Disposal Cell Operations								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	28	58.8	4.8	282.24	2.16E-04	Scott et al. 2001	6.10E-02	Labor is from Section 2 and is based on a 4,200-hour year
								Disposal cell is 4 and 10 months
Site Support	16	33.6	4.8	161.28	7.47E-05	Hoskin et al. 1994	1.21E-02	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	8	16.8	4.8	80.64	3.88E-04	Scott et al. 2001	3.13E-02	On-site truck drivers only; off-site truck driver risks are addressed under transportation risks
General Labor	18	37.8	4.8	181.44	3.29E-04	Scott et al. 2001	5.97E-02	
System Operators	0	0	4.8	0.00	5.40E-05	Scott et al. 2001	0.00E+00	Operating engineer risk values
Total							1.64E-01	

Table D−41. White Mesa Mill Disposal Alternative–Slurry (continued)

Transportation Related Labor								
Work Category	**Labor**	**Labor/2000 h/yr**	**Years Worked**	**Person Years**	**Fatality Rate**	**Rate Reference**	**Fatalities**	**Notes**
Equipment Operators	0	0	3.5	0.00	2.16E-04	Scott et al. 2001	0.00E+00	Labor is from Section 2 and is based on a 3,600-hour year because of the 6-day work schedule for rail transport
Site Support	4	7.2	3.5	25.20	7.47E-05	Hoskin et al. 1994	1.88E-03	Fatality rate is based on 50% inspector, 25% surveyor, and 25% civil engineer
Truck Drivers	0	0	3.5	0.00	3.88E-04	Scott et al. 2001	0.00E+00	Truck drivers are on public roads and are addressed under transportation risks
General Labor	0	0	3.5	0.00	3.29E-04	Scott et al. 2001	0.00E+00	
System Operators	25	45	3.5	157.50	5.40E-05	Hoskin et al. 1994	8.51E-03	Operating engineer risk values
Pipeline Construction	502	903.6	0.75	677.70	2.32E-04	Scott et al. 2001	1.57E-01	Fatality rate is based on 50% general laborer, 25% mechanic, and 25% equipment operator. General laborer has higher fatality rates
Total							1.68E-01	

Table D−42. White Mesa Mill Disposal Alternative–Slurry Summary

	Moab Operations	**Vicinity Properties**	**Borrow Areas**	**Disposal Cell**	**Transportation**	**Worker Total**
Equipment Operators	25	6	7	28	0	66
Site Support	19	4	3	16	4	46
Truck Drivers	1	0	0	8	0	9
General Labor	22	10	10	18	0	60
System Operators	0	0	0	0	25	25
Pipeline Construction	0	0	0	0	502	502
Total	67	20	20	70	531	708

Table D−43. Summary of Construction and Transportation Fatality Estimates for the Disposal Alternatives

Alternative	Construction Fatalities	Transportation Fatalities	Total Fatalities	Notes
Cap-in Place	1.57E-01	6.45E-02	2.22E-01	
Klondike Flats-Rail	1.93E+02	1.05E-01	1.93E+02	Higher than Crescent Junction because of cover soil transport
Klondike Flats -Truck	1.86E+02	3.62E-01	1.86E+02	
Klondike Flats -Slurry	4.35E-01	9.92E-02	5.34E-01	Higher than Crescent Junction because of cover soil transport
Crescent Junction-Rail	1.93E+02	7.16E-02	1.93E+02	
Crescent Junction-Truck	1.86E+02	4.90E-01	1.86E+02	
Crescent Junction-Slurry	5.32E+02	6.06E-02	5.32E+02	
White Mesa -Truck	1.87E+02	1.25E+00	1.88E+02	
White Mesa - Slurry	7.08E+02	7.12E-02	7.08E+02	

Table D−44. On-Site Worker Summary

Used in Sections 4.1.15.1, 4.1.15.2

23 = Vicinity Property Workers
47 = Moab Workers
3 = Duration for VPs (yr)
2.5 = Duration for Moab (yr)

					Rounded Totals			
Worker	Site	Radon LCFs	External LCFs	Total LCFs	Radon LCFs	External LCFs	Total LCFs	
Annual:								
Individual	Moab	2.6E-4	3.5E-4	6.1E-4	2.6E-4	3.5E-4	6.1E-4	
Individual	Vicinity Properties	2.9E-4	1.2E-4	4.2E-4	2.9E-4	1.2E-4	4.1E-4	
Population	Moab	1.2E-2	1.6E-2	2.9E-2	1.2E-2	1.6E-2	2.8E-2	
Population	Vicinity Properties	6.7E-3	2.9E-3	9.5E-3	6.7E-3	2.9E-3	9.6E-3	
Total		1.9E-2	1.9E-2	3.8E-2	1.9E-2	1.9E-2	3.8E-2	
Duration:								
Individual	Moab	6.5E-4	8.8E-4	1.5E-3	6.5E-4	8.8E-4	1.5E-3	
Individual	Vicinity Properties	8.7E-4	3.7E-4	1.2E-3	8.7E-4	3.7E-4	1.2E-3	
Population	Moab	3.0E-2	4.1E-2	7.2E-2	3.0E-2	4.1E-2	7.1E-2	
Population	Vicinity Properties	2.0E-2	8.6E-3	2.9E-2	2.0E-2	8.6E-3	2.9E-2	
Total		5.1E-2	5.0E-2	1.0E-1	5.0E-2	5.0E-2	1.0E-1	
Annual:								
Individual	Moab	241	700	941	240	700	940	<== mrem/yr
Individual	Vicinity Properties	271	248	519	270	250	520	<== mrem/yr
Population	Moab	11,335	32,900	44,235	11,000	33,000	44,000	<== person-mrem/yr
Population	Vicinity Properties	6,224	5,704	11,928	6,200	5,700	12,000	<== person-mrem/yr
Total		17,559	38,604	56,163	17,000	39,000	56,000	<== person-mrem/yr
Duration:								
Individual	Moab	603	1,750	2,353	600	1,800	2,400	<== mrem over duration
Individual	Vicinity Properties	812	744	1,556	810	740	1,600	<== mrem over duration
Population	Moab	28,338	82,250	110,588	28,000	82,000	110,000	<== person-mrem over duration
Population	Vicinity Properties	18,671	17,112	35,783	19,000	17,000	36,000	<== person-mrem over duration
Total		47,009	99,362	146,371	47,000	99,000	150,000	<== person-mrem over duration

Table D−45. Cap-In-Place Workers

Used in Section 4.1.15.1

5.00E-7	= Worker LCF/mrem	
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)	
500	= Worker mrem/WLM	
2,000	= Exposure time (hr/yr)	
4.10E-2	= WL	<== Average of MPS-0114, -0115, -0116
4.8E-1	= WLM per year	
241	= Radon dose (mrem/yr)	
2.6E-4	= Radon risk (lifetime probability of lung cancer per year of exposure)	
350.0	= External exposure rate (µR/hr)	<== Average of external gamma for data >= 200 µR/hr
0.350	= External exposure rate (mR/hr)	
700	= External dose (mR/yr)	
3.5E-4	= External risk (LCFs per year)	
941	= Total annual dose (mrem/yr)	
6.1E-4	= Total annual LCFs	
7.0E-1	= Equilibrium factor (unitless)	
5.9	= Radon concentration (pCi/L)	

Table D−46. Klondike Flats, Crescent Junction, White Mesa Mill Worker Summary

Used in Sections 4.2.15.1, 4.3.15.1, 4.4.15.1

23 = Vicinity Property Workers
67 = Moab Workers
70 = Disposal Site Workers
3 = Duration for VPs (yr)
5 = Duration for Moab (yr)
5 = Duration for disposal site (yr)

					Rounded Totals			
Worker	Site	Radon LCFs	External LCFs	Total LCFs	Radon LCFs	External LCFs	Total LCFs	
Annual:								
Individual	Moab	6.1E-4	6.0E-4	1.2E-3	6.1E-4	6.0E-4	1.2E-3	
Individual	Disposal Site	6.1E-4	6.0E-4	1.2E-3	6.1E-4	6.0E-4	1.2E-3	
Individual	Vicinity Properties	2.9E-4	1.2E-4	4.2E-4	2.9E-4	1.2E-4	4.1E-4	
Population	Moab	4.1E-2	4.0E-2	8.1E-2	4.1E-2	4.0E-2	8.1E-2	
Population	Disposal Site	4.3E-2	4.2E-2	8.5E-2	4.3E-2	4.2E-2	8.5E-2	
Population	Vicinity Properties	6.7E-3	2.9E-3	9.5E-3	6.7E-3	2.9E-3	9.6E-3	
Total		9.0E-2	8.5E-2	1.7E-1	9.1E-2	8.5E-2	1.8E-1	
Duration:								
Individual	Moab	3.0E-3	3.0E-3	6.0E-3	3.0E-3	3.0E-3	6.0E-3	
Individual	Disposal Site	3.0E-3	3.0E-3	6.0E-3	3.0E-3	3.0E-3	6.0E-3	
Individual	Vicinity Properties	8.7E-4	3.7E-4	1.2E-3	8.7E-4	3.7E-4	1.2E-3	
Population	Moab	2.0E-1	2.0E-1	4.0E-1	2.0E-1	2.0E-1	4.0E-1	
Population	Disposal Site	2.1E-1	2.1E-1	4.2E-1	2.1E-1	2.1E-1	4.2E-1	
Population	Vicinity Properties	2.0E-2	8.6E-3	2.9E-2	2.0E-2	8.6E-3	2.9E-2	
Total		4.4E-1	4.2E-1	8.6E-1	4.3E-1	4.2E-1	8.5E-1	
Annual:								
Individual	Moab	565	1,200	1,765	560	1,200	1,800	<== mrem/yr
Individual	Disposal Site	565	1,200	1,765	560	1,200	1,800	<== mrem/yr
Individual	Vicinity Properties	271	248	519	270	250	520	<== mrem/yr
Population	Moab	37,835	80,400	118,235	38,000	80,000	120,000	<== person-mrem/yr
Population	Disposal Site	39,529	84,000	123,529	40,000	84,000	120,000	<== person-mrem/yr
Population	Vicinity Properties	6,224	5,704	11,928	6,200	5,700	12,000	<== person-mrem/yr
Total		83,588	170,104	253,692	84,000	170,000	250,000	<== person-mrem/yr
Duration:								
Individual	Moab	2,824	6,000	8,824	2,800	6,000	8,800	<== mrem over duration
Individual	Disposal Site	2,824	6,000	8,824	2,800	6,000	8,800	<== mrem over duration
Individual	Vicinity Properties	812	744	1,556	810	740	1,600	<== mrem over duration
Population	Moab	189,176	402,000	591,176	190,000	400,000	590,000	<== person-mrem over duration
Population	Disposal Site	197,647	420,000	617,647	200,000	420,000	620,000	<== person-mrem over duration
Population	Vicinity Properties	18,671	17,112	35,783	19,000	17,000	36,000	<== person-mrem over duration
Total		405,494	839,112	1,244,606	410,000	840,000	1,200,000	<== person-mrem over duration

Table D−47. Tailings Piles Worker Risks

Used in Sections 4.2.15.1, 4.3.15.1, 4.4.15.1
Used for off-site disposal scenarios

5.00E-7	= Worker LCF/mrem	
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)	
500	= Worker mrem/WLM	
2,000	= Exposure time (hr/yr)	
9.6E-2	= WL	<== Highest measurement when pile opened
1.1E+0	= WLM per year	
565	= Radon dose (mrem/yr)	
6.1E-4	= Radon risk (lifetime probability of lung cancer per year of exposure)	
600	= External exposure rate (µR/hr)	<== Highest measurement when pile opened
0.60	= External exposure (mR/hr)	
1200	= External dose (mR/yr)	
6.0E-4	= External risk (LCFs per year)	
1,765	= Total annual dose (mrem/yr)	
1.2E-3	= Total annual LCFs	
4.5E-1	= Equilibrium factor (unitless)	
21.3	= Radon concentration (pCi/L)	

Table D−48. Vicinity Property Workers

Used in Section 4.1.15.2

5.00E-7	= Worker LCF/mrem
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)
500	= Worker mrem/WLM
2000	= Worker exposure time (hours/yr)
0.046	= WL at VPs
0.54	= WLM per year
271	= Radon dose (mrem/yr)
2.9E-4	= Radon risk (lifetime probability of lung cancer per year of exposure)
124	= External exposure rate at VPs (µR/hr)
0.124	= External exposure rate at VPs (mR/hr)
248	= External dose (mrem/yr)
1.2E-4	= External risk (LCFs per year)
519	= Total annual dose (mrem/yr)
4.2E-4	= Total annual LCFs
0.7	= F for indoors
6.6	= Indoor radon concentration (pCi/L)

Table D−49. Vicinity Property Public Risks—On-Site, Klondike Flats, Crescent Junction, and White Mesa Mill Disposal Alternatives

Used in Section 4.1.15.2

6.00E-7	= Public LCF/mrem				
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)				
400	= Public mrem/WLM				
8760	= Exposure time (hours/yr)				
0.02	= WL at VPs				
1.03	= WLM per year				
412	= Annual radon dose (mrem/yr)				
5.5E-4	= Annual radon LCF				
20	= External radiation rate at VPs (µR/hr)				
0.020	= External radiation rate at VPs (mR/hr)				
175	= Annual external exposure dose (mrem/yr)				
1.1E-4	= Annual external exposure LCF				
0.7	= F for indoors				
2.9	= Indoor radon concentration (pCi/L)				
587	= Total annual dose (mrem/yr)				
6.6E-4	= Total annual LCF				
392	= Number of VP people	4	= p/VP	98	= Number of VPs
30	= Exposure duration (yrs) After Remediation				
5	= Exposure duration (yrs) Before Remediation				

After Remediation:

Annual:

Individual at VP:

1.1E-4	= Annual external exposure LCF	175	= Annual individual external exposure dose (mrem/yr)
5.5E-4	= Annual radon LCF	412	= Annual individual radon dose (mrem/yr)
6.6E-4	= Total annual LCF	587	= Total annual individual dose (mrem/yr)

Collective Public at VP:

4.1E-2	= Annual external exposure LCF	68.7	= Annual collective external exposure dose (person-rem/yr)
2.2E-1	= Annual radon LCF	162	= Annual collective radon dose (person-rem/yr)
2.6E-1	= Total annual LCF	230	= Total annual collective dose (person-rem/yr)

Duration:

Individual at VP:

30	= Exposure Duration (yrs)		
3.2E-3	= External exposure LCF	5,256	= Duration individual external exposure dose (mrem)
1.7E-2	= Radon LCF	12,367	= Duration individual radon dose (mrem)
2.0E-2	= Total LCF	17,623	= Total duration individual dose (mrem)

Collective Public at VP:

30	= Exposure Duration (yrs)		
1.2E+0	= External exposure LCF	2,060	= Duration collective external exposure dose (person-rem)
6.5E+0	= Radon LCF	4,848	= Duration collective radon dose (person-rem)
7.8E+0	= Total LCF	6,908	= Total duration collective dose (person-rem)

Table D–49. Vicinity Property Public Risks—On-Site, Klondike Flats, Crescent Junction, and White Mesa Mill Disposal Alternatives (continued)

Before Remediation:
Annual:
Individual at VP:

6.5E-4	= Annual external exposure LCF
1.3E-3	= Annual radon LCF
1.9E-3	= Total annual LCF

Collective Public at VP:

2.6E-1	= Annual external exposure LCF
5.0E-1	= Annual radon LCF
7.6E-1	= Total annual LCF

Duration:
Individual at VP:

5	= Exposure Duration (yrs)
3.3E-3	= External exposure LCF
6.4E-3	= Radon LCF
9.6E-3	= Total LCF

Collective at VP:

5	= Exposure Duration (yrs)
1.3E+0	= External exposure LCF
2.5E+0	= Radon LCF
3.8E+0	= Total LCF

Total (Before and After Remediation):

2.9E-2	= Total VP (Individual)
12	= Total VP (Collective)

Table D−50. Vicinity Property Public Risks–No Action Alternative

Used in Section 4.6.15

6.00E-7	= Public LCF/mrem
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)
400	= Public mrem/WLM
8760	= Exposure time (hours/yr)
0.046	= WL at VPs
2.37	= WLM per year
948	= Annual radon dose (mrem/yr)
1.3E-3	= Annual radon LCF
124	= External radiation rate at VPs (µR/hr)
0.124	= External radiation rate at VPs (mR/hr)
1,086	= Annual external exposure dose (mrem/yr)
6.5E-4	= Annual external exposure LCF
0.7	= F for indoors
6.6	= Indoor radon concentration (pCi/L)
2,034	= Total annual dose (mrem/yr)
1.9E-3	= Total annual LCF

392	= Number of VP people	4	= p/VP	98	= Number of VPs
35	= Exposure duration (yrs)				

Annual:

Individual at VP:

6.5E-4	= External exposure LCF	1,086	= Annual individual external exposure dose (mrem/yr)
1.3E-3	= Annual radon LCF	948	= Annual individual radon dose (mrem/yr)
1.9E-3	= Total LCF	2,034	= Total annual individual dose (mrem/yr)

Collective Public at VP:

2.6E-1	= External exposure LCF	426	= Annual collective external exposure dose (person-rem/yr)
5.0E-1	= Radon LCF	372	= Annual collective radon dose (person-rem/yr)
7.6E-1	= Total LCF	797	= Total annual collective dose (person-rem/yr)

Duration:

Individual at VP:

2.3E-2	= External exposure LCF	38,018	= Duration individual external exposure dose (mrem)
4.5E-2	= Radon LCF	33,185	= Duration individual radon dose (mrem)
6.7E-2	= Total LCF	71,203	= Total duration individual dose (mrem)

Collective Public at VP:

8.9E+0	= External exposure LCF	14,903	= Duration collective external exposure dose (person-rem)
1.7E+1	= Radon LCF	13,008	= Duration collective radon dose (person-rem)
2.6E+1	= Total LCF	27,912	= Total duration collective dose (person-rem)

Table D−51. Off-Site MEI

Used in Sections 4.2.15.1, 4.3.15.1, 4.4.15.1, 4.2.15.3, 4.3.15.3, 4.4.15.3, 4.6.15

8,760 = Exposure time (hr/yr)
5.38E-4 = Nominal fatality coefficient (lung cancer fatalities/WLM)
400 = Public mrem/WLM

Site	Ra-226 Concentration (pCi/g)	Ra-226 Concentration (Bq/g)	Rn-222 Specific Flux Bq/m2-s per Bq/g	Area (m^2)	Rn-222 Release (Ci/yr)	CAP88-PC WL (WL/Ci released)	WLM	Annual LCFs	Time Duration (yr)	Total LCFs	Annual Dose (mrem/yr)	Duration Dose (mrem)
Pile is Open:												
Klondike	516	19.1	0.948	129,504	1997.8	6.42E-08	6.6E-3	3.6E-6	5	1.8E-5	2.6E+0	1.3E+1
Crescent Junction	516	19.1	0.948	129,504	1997.8	2.72E-07	2.8E-2	1.5E-5	5	7.5E-5	1.1E+1	5.6E+1
White Mesa	516	19.1	0.948	146,704	2263.1	2.49E-08	2.9E-3	1.6E-6	5	7.8E-6	1.2E+0	5.8E+0
Moab (Pile)	516	19.1	0.948	526,110	8116.0	6.14E-06	2.6E+0	1.4E-3	5	6.9E-3	1.0E+3	5.1E+3
Moab (Drying Areas)	516	19.1	0.948	194,256	2996.7	4.48E-06	6.9E-1	3.7E-4	5	1.9E-3	2.8E+2	1.4E+3
Moab Total								1.8E-3		8.8E-3	1.3E+3	6.5E+3
Moab (Pile) (Used For No-Action)	516	19.1	0.948	526,110	8116.0	6.14E-06	2.6E+0	1.4E-3	30	4.1E-2	1.0E+3	3.1E+4
Moab (Pile) (Used For No-Action) (assumes cover erodes)	516	19.1	0.948	526,110	8116.0	6.14E-06	2.6E+0	1.4E-3	35	4.8E-2	1.0E+3	3.6E+4

Site	Rn-222 Flux (pCi/m2-s)	Area (m^2)	Rn-222 Release (Ci/yr)	CAP88-PC WL (WL/Ci released)	WLM	Annual LCFs	Time Duration (yr)	Total LCFs	Annual Dose (mrem/yr)	Duration Dose (mrem)
Pile is Closed:										
Klondike	20	129,504	81.7	6.42E-08	2.7E-4	1.5E-7	30	4.4E-6	1.1E-1	3.2E+0
Crescent Junction	20	129,504	81.7	2.72E-07	1.1E-3	6.2E-7	30	1.8E-5	4.6E-1	1.4E+1
White Mesa	20	146,704	92.5	2.49E-08	1.2E-4	6.4E-8	30	1.9E-6	4.7E-2	1.4E+0

Site	Total LCFs
Totals (Operations + After NRC cover installed)	
Klondike	2.2E-5
Crescent Junction	9.4E-5
White Mesa	9.7E-6

Table D−52. Off-Site Population Public

Used in Sections 4.2.15.1, 4.3.15.1, 4.4.15.1, 4.2.15.3, 4.3.15.3, 4.4.15.3, 4.6.15

8,760 = Exposure time (hr/yr)
5.38E-4 = Nominal fatality coefficient (lung cancer fatalities/WLM)
400 = Public mrem/WLM

Site	Ra-226 Concentration (pCi/g)	Ra-226 Concentration (Bq/g)	Rn-222 Specific Flux Bq/m2-s per Bq/g	Area (m2)	Rn-222 Release (Ci/yr)	CAP88-PC WL (person-WL/ Ci released)	WLM	Annual LCFs	Time Duration (yr)	Total LCFs	Annual Dose (person-rem/yr)	Duration Dose (person-rem)
Pile is Open:												
Klondike	516	19.1	0.948	129,504	1997.8	4.090E-05	4.2E+0	2.3E-3	5	1.1E-2	1.7E+0	8.4E+0
Crescent Junction	516	19.1	0.948	129,504	1997.8	2.980E-05	3.1E+0	1.7E-3	5	8.3E-3	1.2E+0	6.1E+0
White Mesa	516	19.1	0.948	146,704	2263.1	3.870E-05	4.5E+0	2.4E-3	5	1.2E-2	1.8E+0	9.0E+0
Moab (Pile)	516	19.1	0.948	526,110	8116.0	6.570E-04	2.7E+2	1.5E-1	5	7.4E-1	1.1E+2	5.5E+2
Moab (Drying Areas)	516	19.1	0.948	194,256	2996.7	6.570E-04	1.0E+2	5.5E-2	5	2.7E-1	4.1E+1	2.0E+2
Moab Total								2.0E-1		1.0E+0	1.5E+2	7.5E+2
Moab (Pile) (Used for No-Action)	516	19.1	0.948	526,110	8116.0	6.570E-04	2.7E+2	1.5E-1	30	4.4E+0	1.1E+2	3.3E+3
Moab (Pile) (Used for No-Action)	516	19.1	0.948	526,110	8116.0	6.570E-04	2.7E+2	1.5E-1	35	5.2E+0	1.1E+2	3.8E+3
Moab (Pile) (Used for No-Action, Long-Term) (assumes cover erodes)	516	19.1	0.948	526,110	8116.0	6.570E-04	2.7E+2	1.5E-1	1000	1.5E+2	1.1E+2	1.1E+5

Site	Rn-222 Flux (pCi/m2-s)	Area (m2)	Rn-222 Release (Ci/yr)	CAP88-PC WL (WL/Ci released)	WLM	Annual LCFs	Time Duration (yr)	Total LCFs	Annual Dose (person-rem/yr)	Duration Dose (person-rem)
Pile is Closed:										
Klondike	20	129,504	81.7	4.090E-05	1.7E-1	9.3E-5	30	2.8E-3	6.9E-2	2.1E+0
Crescent Junction	20	129,504	81.7	2.980E-05	1.3E-1	6.7E-5	30	2.0E-3	5.0E-2	1.5E+0
White Mesa	20	146,704	92.5	3.870E-05	1.8E-1	9.9E-5	30	3.0E-3	7.4E-2	2.2E+0
Totals (Operations + After NRC cover installed)										
Klondike								1.4E-2		
Crescent Junction								1.0E-2		
White Mesa								1.5E-2		
Pile is Closed (Long-Term):										
Klondike	20	129,504	81.7	4.090E-05	1.7E-1	9.3E-5	1000	9.3E-2	6.9E-2	6.9E+1
Crescent Junction	20	129,504	81.7	2.980E-05	1.3E-1	6.7E-5	1000	6.7E-2	5.0E-2	5.0E+1
White Mesa	20	146,704	92.5	3.870E-05	1.8E-1	9.9E-5	1000	9.9E-2	7.4E-2	7.4E+1

Table D−53. On-Site Disposal MEI

Used in Sections 4.1.15.1, 4.6.15

Before Remediation (Before NRC Cover Installed):

1.9	= Radon concentration (pCi/L)
0.45	= Equilibrium factor (unitless)
8,760	= Exposure time (hr/yr)
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)
400	= Public mrem/WLM
4.41E-1	= WLM
176	= Annual individual radon dose (mrem/yr)
2.4E-4	= Annual individual radon risk (LCFs)
5	= Exposure time (yrs)
881	= Lifetime individual radon dose (mrem)
1.2E-3	= Lifetime individual radon risk (LCFs)

After Remediation (After NRC Cover Installed):

1.66E-1	= WLM
66.5	= Annual individual radon dose (mrem/yr)
8.9E-5	= Annual individual radon risk (LCFs)
30	= Exposure time (yrs)
1,994	= Lifetime individual radon dose (mrem)
2.7E-3	= Lifetime individual radon risk (LCFs)

Total (Before + After Remediation):

2,876	= Total individual radon dose (mrem)
3.9E-3	= Total individual radon risk (LCFs)

No-Action (assumes current conditions):

4.41E-1	= WLM
176	= Annual individual radon dose (mrem/yr)
2.4E-4	= Annual individual radon risk (LCFs)
35	= Exposure time (yrs)
6,168	= Lifetime individual radon dose (mrem)
8.3E-3	= Lifetime individual radon risk (LCFs)

Table D−54. On-Site Disposal Alternative Radon Risks (Off-Site Population)

Used in Sections 4.1.15.1, 4.6.15

Before Remediation (Before NRC Cover Installed):

1.9	= MEI radon concentration (pCi/L)
2.16E-03	= Calculated MEI concentration per Ci released (pCi/L per Ci released)
8.80E+02	= Calculated radon release (Ci)
526,110	= Area of Moab pile (m^2)
53.0	= Radon release rate (pCi/m^2-s)
6.570E-04	= CAP88-PC WL (person-WL/Ci released)
8,760	= Exposure time (hr/yr)
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)
400	= Public mrem/WLM
29.8	= person-WLM
11.9	= Annual population radon dose (person-rem/yr)
1.6E-2	= Annual population radon risk (LCFs)
5	= Time duration (yrs)
59.6	= Lifetime population radon dose (person-rem)
8.0E-2	= Lifetime population radon risk (LCFs)

After Remediation (After NRC Cover Installed):

11.2	= person-WLM
4.49	= Annual population radon dose (person-rem/yr)
6.0E-3	= Annual population radon risk (LCFs)
30	= Time Duration (yrs)
135	= Lifetime population radon dose (person-rem)
1.8E-1	= Lifetime population radon risk (LCFs)

Total (Before + After Remediation):

194	= Total population radon dose (person-rem)
2.6E-01	= Total population radon risk (LCFs)

No-Action (assumes current conditions):

29.8	= person-WLM
11.9	= Annual population radon dose (person-rem/yr)
1.6E-2	= Annual population radon risk (LCFs)
35	= Time Duration (yrs)
417	= Lifetime population radon dose (person-rem)
5.6E-1	= Lifetime population radon risk (LCFs)

Long-Term (After NRC Cover Installed):

11.2	= person-WLM
4.49	= Annual population radon dose (person-rem/yr)
6.0E-3	= Annual population radon risk (LCFs)
1000	= Time Duration (yrs)
4494	= Lifetime population radon dose (person-rem)
6.0E+0	= Lifetime population radon risk (LCFs)

Table D−55. Moab Post NRC Cover

Used in Section 4.1.15.4

1.9	= Measured radon concentration (pCi/L)
2.16E-3	= Calculated MEI concentration per Ci released (pCi/L per Ci released)
879.6	= Calculated radon release (Ci/yr)
526,110	= Area of Moab pile (m^2)
53.0	= Radon release rate (pCi/m^2-s)
20.0	= Maximum allowable radon release rate (pCi/m^2-s)
331.8	= Maximum allowable radon release rate (Ci/yr)
6.570E-04	= CAP88-PC WL (person-WL/Ci released)
8,760	= Exposure time (hr/yr)
5.38E-4	= Nominal fatality coefficient (lung cancer fatalities/WLM)
400	= Public mrem/WLM
0.45	= Equilibrium factor (unitless)
MEI:	
0.72	= MEI radon concentration (pCi/L)
0.166	= WLM
66.5	= Annual individual dose (mrem/yr)
8.9E-05	= Annual individual radon risk (LCFs)
5	= Time duration (yrs)
332	= Lifetime individual radon dose (mrem)
4.5E-04	= Lifetime individual radon risk (LCFs)
30	= Time duration (yrs)
1,994	= Lifetime individual radon dose (mrem)
2.7E-03	= Lifetime individual radon risk (LCFs)
Population:	
11.2	= person-WLM
4.5	= Annual population radon dose (person-rem/yr)
6.0E-03	= Annual population radon risk (LCFs)
5	= Time duration (yrs)
22.5	= Lifetime population radon dose (person-rem)
3.0E-02	= Lifetime population radon risk (LCFs)
30	= Time Duration (yrs)
135	= Lifetime population radon dose (person-rem)
1.8E-1	= Lifetime population radon risk (LCFs)

D5.0 Air Quality

The SCREEN3 computer code (EPA 1995b) was used to estimate the potential impacts to air quality from emissions from the Moab site, borrow areas, and off-site disposal locations. Tailpipe emissions were calculated using the equipment lists in Table D−56 and Table D−57 and the emission factors in Supplement A to the *Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources* (EPA 1991b). These emission factors are presented in Table D−58. For dust emissions from construction activities, an emission factor of 2.69×10^6 grams per hectare-month (1.2 tons per acre-month) was used from Section 13.2.3, "Heavy Construction Operations," in *Compilation of Air Pollutant Emission Factors, Volume I: Stationary and Point Sources* (EPA 1995c). Dust emissions were estimated using a 90-percent efficiency for dust suppression activities. In addition, it was assumed that 25 percent of the area would be actively worked at any one time.

Table D−56. Equipment List for On-Site Disposal Alternative

Equipment	Moab	Floy Wash Borrow Area	Klondike Flats Borrow Area
Tractor	1	0	0
Backhoe	2	0	0
Grader	3	0	0
Trackhoe	0	0	0
Front-end loader	1	1	1
Water truck	2	1	1
Crane	0	0	0
21-yd^3 scrapers	2	0	0
Dozer	2	0	0
Sheepfoot compactor	1	0	0
Smooth drum roller	1	0	0
Pickup truck	2	3	3
Welding rig	0	0	0
End dump truck	1	0	0
Skidsteer	0	0	0
16-yd^3 dragline	0	0	0
Tandem truck	0	0	0
Total	18	5	5

Table D−57. Equipment List for Off-Site Disposal Alternative

Equipment	Moab	Disposal Cell	Floy Wash Borrow Area	Klondike Flats Borrow Area	Crescent Junction Borrow Area
Tractor	2	1	0	0	0
Backhoe	1	2	1	1	1
Grader	1	2	1	1	1
Trackhoe	1	1	0	0	0
Front-end loader	2	2	1	1	1
End dump truck	0	1	0	0	0
Water truck	1	2	1	1	1
Crane	1	0	0	0	0
21-yd^3 scrapers	3	6	1	1	1
Dozer	3	2	1	1	1
Sheepfoot compactor	1	2	0	0	0
Smooth drum roller	0	0	0	0	0
Pickup truck	4	4	1	1	1
Welding rig	1	0	0	0	0
End dump truck	0	0	0	0	0
Skidsteer	0	1	0	0	0
16-yd^3 dragline	2	0	0	0	0
Tandem truck	0	0	0	0	0
Total	23	26	7	7	7

Table D−58. Emission Factors Used for Construction Equipment

Equipment	CO (g/h)	NOX (g/h)	SOX (g/h)	Particulate (g/h)
Tractor	157.01	570.7	62.3	50.7
Backhoe	306.37	767.3	64.7	63.2
Grader	68.46	324.43	39	27.7
Trackhoe	306.37	767.3	64.7	63.2
Front-end loader	91.15	375.22	34.4	26.4
Water truck	306.37	767.3	64.7	63.2
Crane	306.37	767.3	64.7	63.2
21-yd^3 scrapers	568.19	1740.14	210	184
Dozer	157.01	570.7	62.3	50.7
Sheepfoot compactor	306.37	767.3	64.7	63.2
Smooth drum roller	137.97	392.9	30.5	22.7
Pickup truck	306.37	767.3	64.7	63.2
Welding rig	306.37	767.3	64.7	63.2
End dump truck	816.81	1889.16	206	116
Skidsteer	306.37	767.3	64.7	63.2
16-yd^3 dragline	306.37	767.3	64.7	63.2
Tandem truck	306.37	767.3	64.7	63.2

Source: Supplement A to the *Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources* (EPA 1991b).

Table D−59 presents the emissions predicted for the Moab site, the Floy Wash borrow area, and the Klondike Flats borrow area for the on-site disposal alternative. Table D−60 presents the predicted emissions for the Moab site, the Floy Wash borrow area, the Klondike Flats borrow area, and the Crescent Junction borrow area for the off-site disposal alternatives. Table D−61 and Table D−62 contain the emissions from the Klondike Flats, Crescent Junction, and White Mesa Mill disposal areas for the truck, rail, and slurry pipeline transportation options.

Table D−59. Emissions for On-Site Disposal Alternative

Pollutant	Moab[a] (g/h)	Floy Wash[b] Borrow Area (g/h)	Klondike Flats[c] Borrow Area (g/h)
Tailpipe Emissions			
CO	2,400	630	630
NOX	6,800	1,700	1,700
SOX	690	140	140
Particulate	580	130	130
Construction Activities			
Particulate (dust)	2,400	2,000	910

[a]Moab site = 441 acres.
[b]Floy Wash borrow area = 380 acres.
[c]Klondike Flats borrow area = 170 acres.

Table D−60. Emissions for the Moab Site, the Floy Wash Borrow Area, the Klondike Flats Borrow Area, and the Crescent Junction Borrow Area for the Off-Site Disposal Alternatives

Pollutant	Moab[a] (g/h)	Floy Wash[b] Borrow Area (g/h)	Klondike Flats[c] Borrow Area (g/h)	Crescent Junction[d] Borrow Area (g/h)
Tailpipe Emissions				
CO	3,100	860	860	860
NOX	8,800	2,500	2,500	2,500
SOX	880	260	260	260
Particulate	790	230	230	230
Construction Activities				
Particulate (Dust)	2,400	2,000	910	540

[a]Moab site = 442 acres.
[b]Floy Wash borrow area = 380 acres.
[c]Klondike Flats borrow area = 170 acres.
[d]Crescent Junction borrow area = 100 acres.

Table D−61. Tailpipe Emissions at the Klondike Flats, Crescent Junction, and White Mesa Mill Disposal Sites

Tailpipe Pollutants	Klondike Flats Truck/Rail/Slurry (g/h)	Crescent Junction Truck/Rail/Slurry (g/h)	White Mesa Mill Truck/Slurry (g/h)
CO	4,200	4,200	4,200
NOX	12,000	12,000	12,000
SOX	1,200	1,200	1,200
Particulate	1,100	1,100	1,100

Table D−62. Dust Emissions from Construction Activities at the Klondike Flats, Crescent Junction, and White Mesa Mill Disposal Sites

Dust Pollutants	Klondike Flats[a,b,c] (g/h)	Crescent Junction[d,e,f] (g/h)	White Mesa Mill[g,h] (g/h)
Particulate - Truck	2,500	2,400	1,900
Particulate - Rail	2,600	2,600	--
Particulate – Slurry	2,500	2,400	1,900

[a]Klondike Flats Truck Disposal Site = 475 acres.
[b]Klondike Flats Rail Disposal Site = 489 acres.
[c]Klondike Flats Slurry Disposal Site = 459 acres.
[d]Crescent Junction Truck Disposal Site = 448 acres.
[e]Crescent Junction Rail Disposal Site = 477 acres.
[f]Crescent Junction Slurry Disposal Site = 446 acres.
[g]White Mesa Mill Truck Disposal Site = 348 acres.
[h]White Mesa Mill Slurry Disposal Site = 346 acres.

Table D−63 through Table D−70 present the estimated concentrations at 1 mile from each site. In each case, the stability class was assumed to be Class F and the wind speed was assumed to be 1 meter per second. This combination of atmospheric conditions would tend to provide an upper bound on potential impacts.

Table D−63. Criteria Pollutant Concentrations from Emissions at the Moab Site for the On-Site Disposal Alternative

Pollutant	Averaging Period	Standard ($\mu g/m^3$)[a]	Concentration from Emissions ($\mu g/m^3$)
Carbon monoxide	1-hour	40,000	31
	8-hour	10,000	22
Nitrogen dioxide	Annual	100	7.0
Sulfur dioxide	Annual	80	0.71
	24-hour	365	3.6
	3-hour	1,300	8.0
PM_{10}[b]	Annual	50	3.0
	24-hour	150	15

[a]$\mu g/m^3$ = micrograms per cubic meter.
[b]PM_{10} includes fugitive dust emissions from construction activities.

Table D−64. Criteria Pollutant Concentrations from Emissions at the Floy Wash Borrow Area for the On-Site Disposal Alternative

Pollutant	Averaging Period	Standard ($\mu g/m^3$)[a]	Concentration from Emissions ($\mu g/m^3$)
Carbon monoxide	1 hour	40,000	8.6
	8 hours	10,000	6.0
Nitrogen dioxide	Annual	100	1.8
Sulfur dioxide	Annual	80	0.15
	24 hours	365	0.77
	3 hours	1,300	1.7
PM_{10}	Annual	50	0.15
	24 hours	150	0.73

[a]$\mu g/m^3$ = micrograms per cubic meter.

Table D−65. Criteria Pollutant Concentrations from Emissions at the Klondike Flats Borrow Area for the On-Site Disposal Alternative

Pollutant	Averaging Period	Standard (μg/m³)[a]	Concentration from Emissions (μg/m³)
Carbon monoxide	1 hour	40,000	12
	8 hours	10,000	8.5
Nitrogen dioxide	Annual	100	2.5
Sulfur dioxide	Annual	80	0.22
	24 hours	365	1.1
	3 hours	1,300	2.4
PM_{10}	Annual	50	0.20
	24 hours	150	1.0

[a]μg/m³ = micrograms per cubic meter.

Table D−66. Criteria Pollutant Concentrations from Emissions at the Moab Site for the Klondike Flats, Crescent Junction, and White Mesa Mill Disposal Alternatives

Pollutant	Averaging Period	Standard (μg/m³)[a]	Concentration from Emissions (μg/m³)
Carbon monoxide	1 hour	40,000	40
	8 hours	10,000	28
Nitrogen dioxide	Annual	100	9.1
Sulfur dioxide	Annual	80	0.90
	24 hours	365	4.5
	3 hours	1,300	10
PM_{10}[b]	Annual	50	3.2
	24 hours	150	16

[a]μg/m³ = micrograms per cubic meter.
[b]PM_{10} includes fugitive dust emissions from construction activities.

Table D−67. Criteria Pollutant Concentrations from Emissions at the Klondike Flats Site for the Klondike Flats Disposal Alternative

Pollutant	Averaging Period	Standard (μg/m³)[a]	Concentration from Emissions (μg/m³)		
			Truck	Rail	Slurry
Carbon monoxide	1 hour	40,000	52	52	53
	8 hours	10,000	37	36	37
Nitrogen dioxide	Annual	100	12	12	12
Sulfur dioxide	Annual	80	1.2	1.2	1.3
	24 hours	365	6.2	6.1	6.3
	3 hours	1,300	14	14	14
PM_{10}[b]	Annual	50	3.6	3.7	3.6
	24 hours	150	18	18	18

[a]μg/m³ = micrograms per cubic meter.
[b]PM_{10} includes fugitive dust emissions from construction activities.

Table D−68. Criteria Pollutant Concentrations from Emissions at the Crescent Junction Site for the Crescent Junction Disposal Alternative

Pollutant	Averaging Period	Standard (μg/m³)[a]	Concentration from Emissions (μg/m³)		
			Truck	Rail	Slurry
Carbon monoxide	1 hour	40,000	53	52	53
	8 hours	10,000	37	36	37
Nitrogen dioxide	Annual	100	12	12	12
Sulfur dioxide	Annual	80	1.3	1.2	1.3
	24 hours	365	6.3	6.2	6.3
	3 hours	1,300	14	14	14
PM_{10}[b]	Annual	50	3.6	3.6	3.6
	24 hours	150	18	18	18

[a]μg/m³ = micrograms per cubic meter.
[b]PM_{10} includes fugitive dust emissions from construction activities.

Table D−69. Criteria Pollutant Concentrations from Emissions at the White Mesa Mill Site for the White Mesa Mill Disposal Alternative

Pollutant	Averaging Period	Standard (μg/m³)[a]	Concentration from Emissions (μg/m³)	
			Truck	Slurry
Carbon monoxide	1 hour	40,000	59	59
	8 hours	10,000	41	41
Nitrogen dioxide	Annual	100	13	13
Sulfur dioxide	Annual	80	1.4	1.4
	24 hours	365	7.0	7.0
	3 hours	1,300	16	16
PM_{10}[b]	Annual	50	3.3	3.3
	24 hours	150	17	17

[a]μg/m³ = micrograms per cubic meter.
[b]PM_{10} includes fugitive dust emissions from construction activities.

Table D−70. Criteria Pollutant Concentrations from Emissions at the Floy Wash, Klondike Flats, and Crescent Junction Borrow Areas for the Klondike Flats, Crescent Junction, and White Mesa Mill Disposal Alternatives

Pollutant	Averaging Period	Standard (μg/m³)[a]	Concentration from Emissions (μg/m³)		
			Floy Wash	Klondike Flats	Crescent Junction
Carbon monoxide	1 hour	40,000	12	17	21
	8 hours	10,000	8.3	12	15
Nitrogen dioxide	Annual	100	2.8	3.9	4.9
Sulfur dioxide	Annual	80	0.28	0.40	0.50
	24 hours	365	1.4	2.0	2.5
	3 hours	1,300	3.2	4.5	5.6
PM_{10}	Annual	50	0.25	0.35	0.44
	24 hours	150	1.3	1.8	2.2

[a]μg/m³ = micrograms per cubic meter.

Table D−71 presents the estimated concentrations at the Arches National Park entrance, located about 1.25 miles northwest of the Moab site. These concentrations were estimated using the same atmospheric conditions (Class F stability class and 1 meter per second wind speed) as the concentrations at 1 mile and are lower than the concentrations at 1 mile.

Table D−71. Criteria Pollutant Concentrations at the Arches National Park Entrance from Emissions at the Moab Site

Pollutant	Averaging Period	Standard ($\mu g/m^3$)[a]	Concentration from Emissions ($\mu g/m^3$)	
			On-Site Disposal	Off-Site Disposal
Carbon monoxide	1 hour	40,000	26	33
	8 hours	10,000	18	23
Nitrogen dioxide	Annual	100	5.9	7.6
Sulfur dioxide	Annual	80	0.60	0.76
	24 hours	365	3.0	3.8
	3 hours	1,300	6.8	8.5
PM_{10}[b]	Annual	50	2.5	2.7
	24 hours	150	13	14

[a]$\mu g/m^3$ = micrograms per cubic meter.
[b]PM_{10} includes fugitive dust emissions from construction activities.

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End of current text