4

Environmental Impacts of Repository Construction, Operation and Monitoring, and Closure

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4. ENVIRONMENTAL IMPACTS OF REPOSITORY CONSTRUCTION, OPERATIONS, MONITORING, AND CLOSURE

This chapter describes *preclosure* environmental *impacts* that could result from the *Proposed Action*, which is to construct, operate, monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

Preclosure refers to the time from the beginning of *construction* to final *repository-closure* and includes the *construction analytical period*, *operations analytical period*, *monitoring analytical period*, and *closure analytical period* that the U.S. Department of Energy (DOE or the Department) analyzed. Chapter 5 of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) discusses the environmental consequences of *postclosure* repository performance—that period out to 10,000 years and beyond after *repository-closure*. Chapter 6 discusses the environmental consequences of transportation, and Chapter 7 discusses the environmental consequences of the *No-Action Alternative*.

Section 4.1 describes potential environmental impacts from activities at the repository site and from offsite manufacturing of repository components [for example, *transportation, aging, and disposal (TAD) canisters*, *waste packages*, and *drip shields*]. It also describes the impacts from proposed special-use airspace above the repository. The methods DOE used in the analyses to predict the potential impacts in this section were conservative. This means that the predicted results are likely to be higher than the actual values that would be measured or observed. Examples of conservative methods included not considering *best management practices* for dust suppression in the predictive release and concentration analyses for *particulate matter*, not taking credit for demonstrated successful remediation and reclamation efforts in the disturbed land analyses, and not applying DOE *radiation* protection program objectives such as As Low As Reasonably Achievable into worker radiation *exposure* analyses. The occupational and human health and safety and *accident* analyses used multiple methods that were conservative, which increases the likelihood that the predicted results would be higher than the actual measured or observed values. Each of the resource sections in this chapter and any associated appendices provide the specifics of the analyses.

Since DOE completed the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS), it has modified its repository design and operational plans. These modifications have resulted in changes to information for the analyses of potential environmental impacts and, therefore, resulted in new impact analyses for each of the 15 resource and subject areas evaluated in this Repository SEIS. Land disturbance, water and fuel use, number of repository workers, and credible accidents from repository-related activities are examples of information DOE used for analysis of impacts that have changed since the completion of the FEIS. This new information, in turn, resulted in changes to the impact analyses for multiple resource areas. For example, new information for land disturbance required a reevaluation of impacts to land use and ownership, *air quality*, *hydrology*, biological resources and soils, cultural resources, aesthetics, and noise.

DEFINITIONS OF DURATION TERMS

Repository SEIS analytical periods:

Four timeframes are defined for use in this Repository SEIS to best evaluate potential preclosure environmental impacts:

- **Construction analytical period: 5 years**—Begins upon receipt of the construction authorization from the NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and subsurface development.
- **Operations analytical period: 50 years**—Begins upon receipt of a license to receive and possess radiological materials and ends upon emplacement of the final waste package. Activities would include receipt, handling, aging, emplacement, and monitoring of waste, as well as continued construction of surface and subsurface facilities.
- **Monitoring analytical period: 50 years**—Begins upon emplacement of the final waste package. Activities would include maintaining active ventilation of the repository for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to postclosure performance.
- **Closure analytical period: 10 years**—Overlaps the last 10 years of the monitoring period and includes activities that would begin upon receipt of a license amendment to close. Activities would include decommissioning and demolishing surface facilities, emplacing drip shields, backfilling subsurface-to-surface openings, restoring the surface to its approximate condition before repository construction, and constructing monuments to mark the site.

Operational phases:

Four phases used in DOE's application for construction authorization to indicate when specific facilities are expected to be operational under the planned phased construction. Operational phases are Phase 1, Phase 2, Phase 3, and Phase 4.

Preclosure:

The timeframe from construction authorization to repository closure.

Postclosure:

The timeframe after permanent closure of the repository through the 1 million years analyzed in this Repository SEIS.

Repository-closure:

The point in time when activities associated with the closure analytical period, such as decommissioning and demolishing surface facilities and backfilling subsurface-to-surface openings, have been completed. Permanent closure of the repository would be complete; postclosure timeframe would begin.

Where noted in this chapter of the Repository SEIS, DOE summarizes, incorporates by reference, and updates Chapter 4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-1 to 4-128) and presents new information, as applicable, from studies and investigations that continued after the completion of the FEIS. If the Department did not use information from the FEIS, but rather based the impact analysis in a subsection on new information, the introduction to that subsection so states and does not reference the FEIS. To ensure that the source of the information is clear, DOE states it is summarizing, incorporating by reference, and updating the FEIS in the introduction to each applicable section or subsection of Section 4.1.

Section 4.2 describes potential environmental impacts of waste *retrieval* if this option became necessary. The current concept for retrieval has not changed from that which DOE analyzed in the Yucca Mountain FEIS, which is summarized and incorporated by reference.

Section 4.3 presents a new section that evaluates actions that include repair, replacement, or improvement of existing Yucca Mountain Project facilities that would enable DOE to continue ongoing operations, scientific testing, and routine maintenance until the U.S. Nuclear Regulatory Commission (NRC) decides whether to authorize construction of a repository. DOE needs to improve the *Yucca Mountain site infrastructure* not only to ensure safety for workers, regulators, and visitors, but also to comply with applicable environmental, health, and safety standards and DOE Directives. The Department could implement these specific elements before it received construction authorization from the NRC. Before implementation, a Record of Decision on this Repository SEIS will present any decisions DOE might make in relation to the improvements. These actions would be independent of repository construction.

4.1 Preclosure Environmental Impacts of Construction, Operations, Monitoring, and Closure of a Repository

This section describes the preclosure environmental impacts from the Proposed Action. DOE has described these impacts by the *analytical periods* of the Proposed Action—construction, operations, monitoring, and closure—and the activities (some of which overlap) associated with them.

The following paragraphs summarize the periods and associated activities DOE has evaluated in this Repository SEIS. Chapter 2 (Table 2-1) of this Repository SEIS describes these periods and activities in detail.

Construction Analytical Period (5 Years)

The *construction analytical period* would begin when the NRC authorized DOE to build the repository. For analysis purposes, this Repository SEIS assumes construction would begin in about 2012 and would be complete upon receipt of the NRC license to receive and possess radiological materials. Site preparation would include such activities as the demolition or relocation of existing facilities, excavation of fill material down to the original ground contours, and placement and compaction of engineered *backfill* in the areas of facility construction. The Department would construct new surface facilities and balance of plant facilities (which would include infrastructure) necessary for initial receipt and *emplacement* of spent nuclear fuel and high-level *radioactive* waste. In addition, DOE would begin development (excavation and preparation for use) of the *subsurface facility*.

Operations Analytical Period (up to 50 Years)

For this analysis, DOE assumed that repository operations would begin in 2017, after it received a license from the NRC to receive and possess spent nuclear fuel and high-level radioactive waste. The *operations analytical period* would include continued construction of surface facilities and development (excavation and preparation for use) of the *subsurface* repository, receipt and handling of spent nuclear fuel and high-level radioactive waste in surface facilities, and emplacement of these materials in the completed portions of the repository. Surface facility construction activities would continue for approximately 5 years into the operations period. Development activities would last 22 years and would be concurrent with handling and emplacement. Handling and emplacement activities would last up to 50 years.

Monitoring Analytical Period (50 Years)

Monitoring of the emplaced material and maintenance of the repository would start with the first emplacement of a waste package and would continue through the *closure analytical period*. After the completion of the operations analytical period (emplacement), the *monitoring analytical period* that DOE used for analysis in this Repository SEIS would begin. Monitoring would be the primary activity. DOE would maintain the repository in a configuration that enabled continued monitoring and inspection of the waste packages, continued investigations in support of long-term repository performance (the ability to isolate waste from the *accessible environment*), and the retrieval of waste packages, if necessary. This period would last 50 years. DOE has also analyzed the potential for a monitoring period of up to 250 years. This analysis is included in Appendix A, Section A.6.

Closure Analytical Period (10 Years)

Repository closure would occur after DOE applied for and received a license amendment from the NRC. Closure would take 10 years and would occur during the last 10 years of the monitoring analytical period. The closure of the repository facilities would include the following activities:

- Emplacing the drip shields,
- Removing and salvaging reusable equipment and materials,
- Backfilling and sealing subsurface-to-surface openings,
- Constructing monuments to mark the area,
- *Decommissioning* and demolishing surface facilities, and
- Restoring the surface to its approximate condition before repository construction.

4.1.1 IMPACTS TO LAND USE AND OWNERSHIP

This section describes potential land use and ownership impacts from activities under the Proposed Action. The *region of influence* for land use and ownership impacts is the *analyzed land withdrawal area* and an area to the south that DOE proposes to use for offsite facilities and an access road from U.S. Highway 95. Congress would define the actual land withdrawal area. The analysis considered impacts from direct disturbances in relation to proposed repository construction, operations, monitoring, and closure as well as construction and operation of the access road and offsite facilities. It also considered impacts from the transfer of lands to DOE control. Section 4.1.1.1 summarizes, incorporates by reference, and updates Section 4.1.1.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-5 and 4-6). Section 4.1.1.2 provides a new analysis based on the modified design and operational plan. Section 4.1.15 describes the requirement for airspace restrictions and the impacts to airspace use from these restrictions.

4.1.1.1 Impacts to Land Use and Ownership from Land Withdrawal

To develop a repository at Yucca Mountain, DOE would have to obtain permanent control of the geologic repository operations area, currently under the control of DOE (National Nuclear Security Adminsitration), the U.S. Department of Defense (U.S. Air Force), and the U.S. Department of the Interior (Bureau of Land Management). This would require Congressional action. The geologic repository operations area would occupy a small portion of a larger area [600 square kilometers (230 square miles or approximately 150,000 acres)], which would include a buffer zone. Because Congress has not withdrawn this land, this Repository SEIS refers to the 230 square miles as the analyzed land withdrawal area.

At present, the Bureau of Land Management administers approximately 180 square kilometers (44,000 acres) of the analyzed land withdrawal area. Most of this area is associated with the current right-of-way (N-47748) for previous *site characterization* activities. As such, with the exception of about 17.22 square kilometers (4,255.50 acres) near the site of the proposed repository (67 FR 53359) and an existing patented mining claim, these lands are available for public uses such as mineral exploration, recreation, and grazing. Congress granted these rights under various federal laws, such as the *Federal Land Policy and Management Act of 1976*, as amended (43 U.S.C. 1701 et seq.).

The Bureau of Land Management would conduct mineral examinations to assess valid existing rights in all mining claims within the lands subject to the permanent legislative withdrawal. DOE would provide just compensation for the acquisition of such valid property rights. DOE, in consultation with the U.S. Air Force and the Bureau of Land Management, as appropriate, would manage the withdrawn land in accordance with the *Federal Land Policy and Management Act of 1976*, the conditions of the permanent legislative withdrawal set forth by Congress, and other applicable laws.

4.1.1.2 Impacts to Land Use and Ownership from Construction, Operations, Monitoring, and Closure

During the construction, operations, and monitoring analytical periods, DOE would disturb or clear land for subsurface and surface facility construction. The total land disturbance for the proposed repository, access road, and offsite facilities would be approximately 9 square kilometers (2,200 acres).

Land disturbances would include approximately 8.5 square kilometers (2,100 acres) of small noncontiguous areas inside the analyzed land withdrawal area. Most of the surface facilities and disturbed land would be in the *geologic repository operations area* (Chapter 2, Section 2.1.2). Repository activities would not conflict with current land uses on adjacent lands under control of the Bureau of Land Management, U.S. Air Force, and DOE.

The Proposed Action would disturb approximately 0.57 square kilometer (140 acres) of Bureau of Land Management land outside the analyzed land withdrawal area for construction of offsite facilities and an access road from U.S. Highway 95. DOE would relocate the current access road intersection with U.S. Highway 95 approximately 0.39 kilometer (0.24 mile) to the southeast to line up with the intersection of Nevada State Route 373 and U.S. Highway 95. The projected volume of traffic could be handled by acceleration and deceleration lanes and a controlled access at the Gate 510/State Route 373/U.S. Highway 95 intersection. The estimated area for such an intersection would be approximately 0.11 square kilometer (28 acres). Because the existing highway through this area uses approximately 0.065 square kilometer (16 acres), only about 0.049 square kilometer (12 acres) of new land would be necessary. Approximately 0.097 square kilometer (24 acres) would be necessary for 1.6 kilometers (1 mile) of new road about 61 meters (200 feet) wide. Relocation of the road would require cooperation with Nye County plans for the Amargosa Valley area, a right-of-way from the Bureau of Land Management, and coordination with the Nevada Department of Transportation.

The analysis assumed a training facility, the Sample Management Facility, a marshalling yard and warehouse, and temporary housing for construction workers would be near Gate 510 on Bureau of Land Management land outside the analyzed land withdrawal area. As noted in Section 3.1.1.1 of this Repository SEIS, the Bureau of Land Management has designated for disposal a portion of the land south of the analyzed land withdrawal area and Nye County has formally notified the Bureau of its intent to

purchase up to 1.2 square kilometers (296 acres) for development that could host these facilities (DIRS 182804-Maher 2006, all). The training facility would require a 0.02-square-kilometer (5-acre) parcel for the facility, associated parking, landscaping, and access. The Sample Management Facility would require 0.012 square kilometer (3 acres). DOE could build the Sample Management Facility inside the analyzed land withdrawal area; however, to be conservative, the analysis assumed it would be outside the land withdrawal area. The marshalling yard and warehouse would require fencing, offices, warehousing, open laydown, and shops on 0.2 square kilometer (50 acres). Temporary housing accommodations for construction workers would require approximately 0.10 square kilometer (25 acres), but DOE would reclaim the lands when it no longer needed to use them. DOE could use the temporary accommodations for *railroad* construction workers in the Crater Flat area, which is part of the proposal in the Rail Alignment EIS. Depending on the need for housing, the Department could use the rail construction camp either in lieu of temporary accommodations at the southern boundary or in addition to those accommodations.

The Bureau of Land Management controls lands to the south of the analyzed land withdrawal area and manages them in accordance to the *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement* (DIRS 176043-BLM 1998, all). This plan designates corridors in its planning area to avoid Areas of Critical Environmental Concern. The proposed activities outside the analyzed land withdrawal area would not overlap such areas (DIRS 103079-BLM 1998, Map 2-7) and, therefore, they do not conflict with the Bureau's management plan.

Chapter 6 discusses land use and impacts from construction and operation of a *railroad* in Nevada and associated rail facilities.

Before any ground disturbing activities, DOE would identify geodetic control monuments in areas that could be disturbed. If there was a need to relocate a monument, DOE would notify the Office of the Director of the National Oceanic and Atmospheric Administration, National Geodetic Survey no less than 90 days before any planned activities that could disturb or destroy the monument. During closure, DOE would restore disturbed areas it no longer needed to their approximate condition before repository construction.

Surface disturbance inside the analyzed land withdrawal area of approximately 8.5 square kilometers (2,100 acres) would represent a small amount of the 600 square kilometers (150,000 acres) of the withdrawal. Further, 2.43 square kilometers (600 acres) were previously disturbed (Chapter 3, Section 3.1.1.2). DOE also would disturb approximately 0.48 square kilometer (120 acres) of previously undisturbed land outside the analyzed land withdrawal area but would avoid conflicts with surrounding land uses to the extent possible. Therefore, land use impacts from activities under the Proposed Action would be small.

4.1.2 IMPACTS TO AIR QUALITY

This section updates potential impacts to air quality in the Yucca Mountain region from release of nonradiological air pollutants during construction, operations, monitoring, and closure of the proposed repository since completion of the Yucca Mountain FEIS. DOE based its reanalysis of impacts to air quality for this Repository SEIS on the modified design that Chapter 2 describes. The region of influence is an area with a radius of approximately 84 kilometers (52 miles) around the Yucca Mountain site. Appendix B discusses the methods DOE used for air quality analysis for this Repository SEIS, including

the new model for estimation of the annual and short-term (24-hour or less) air quality impacts at the proposed repository, and provides additional data and intermediate results the Department used to estimate air quality impacts. Section 4.1.7.2 discusses health impacts associated with radiological air quality.

PARTICULATE MATTER

$PM_{2.5}$:
Particulate matter with an aerodynamic diameter of 2.5 micrometers or less (about 0.0001 inch).

PM_{10}:
Particulate matter with an aerodynamic diameter of 10 micrometers or less (about 0.0004 inch).

As a frame of reference, the diameter of the average human hair is approximately 70 micrometers.

Sources of nonradiological air pollutants at the repository site would include *fugitive dust* emissions from land disturbances and excavated rock handling; fugitive dust emissions from concrete batch plant operations; and *nitrogen dioxide*, *sulfur dioxide*, *carbon monoxide*, and particulate matter emissions from fossil-fuel use. DOE used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) computer program to estimate the annual and short-term (24-hour or less) air quality impacts. The Department evaluated impacts for five *criteria pollutants*: carbon monoxide, nitrogen dioxide, sulfur dioxide, *ozone*, and particulate matter. The analysis did not *quantitatively* address the criteria pollutant lead because there would be no significant sources of airborne lead at the repository (Appendix B, Section B.1). DOE used the *National Ambient Air Quality Standards*, described in Chapter 3, Section 3.1.2.1, to analyze air quality impacts. These standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. In addition to the criteria pollutants, DOE evaluated potential impacts from cristobalite, a form of silica dust that is the causative agent for silicosis and might be a *carcinogen*. *Erionite* is an uncommon zeolite mineral that underground construction could encounter, but it appears to be absent or rare at the proposed repository depth and location. Erionite would not affect air quality in the area around the repository, and DOE did not consider it in the analysis. Ozone is not emitted directly into the atmosphere, but is created by complex chemical reactions of precursor pollutants in the presence of sunlight. The precursor pollutants are *nitrogen oxides* (including nitrogen dioxide) and volatile organic compounds. The major source for volatile organic compounds and nitrogen dioxide is the burning of fossil fuels. DOE's analysis of ozone evaluated the emissions of these precursors. Section 4.1.2.6 of this Repository SEIS discusses greenhouse gases, primarily carbon dioxide.

The air quality analysis evaluated impacts at the potential locations of *maximally exposed individual* members of the public. (Section 4.1.7.1 presents impacts to workers.) The analysis defined the locations as the nearest points of unrestricted public access outside the analyzed land withdrawal area. For periods of 1 year or longer, the analysis assumed maximally exposed individuals were at the southern boundary of the land withdrawal area, the closest location they could be for long periods during repository activities. The maximum air quality impact (that is, air concentration) that would result from repository activities could occur at different locations along the boundary of the land withdrawal area depending on the release period and the averaging time. The maximally exposed individual would be the person at the location with the highest concentration per release period and averaging time. Appendix B, Section B.3 describes the locations of maximally exposed individuals in greater detail.

CONFORMITY

Section 176(c)(1) of the *Clean Air Act* (42 U.S.C. 7401 et seq.) requires federal agencies to ensure that their actions conform to applicable implementation plans for the achievement and maintenance of National Ambient Air Quality Standards for criteria pollutants. To achieve conformity, a federal action must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern (for example, a state or smaller air quality region). The U.S. Environmental Protections Agency (EPA) general conformity regulations (40 CFR Part 93, Subpart B) contain guidance for determination of whether a proposed federal action would cause emissions to be above certain levels in locations that EPA designated as nonattainment or maintenance areas. If there are not enough air quality data to determine the status of attainment of a remote or sparsely populated area, the area is listed as unclassifiable. The quality of the air in the region of influence is unclassifiable because of limited air quality data (40 CFR 81.329). For regulatory purposes, EPA considers unclassifiable areas to be in attainment.

A portion of Clark County is in nonattainment for carbon monoxide, PM_{10}, and the 8-hour ozone standard (40 CFR Part 81). These nonattainment areas are outside the 84-kilometer (52-mile) region of influence for air quality. A portion of Inyo County, California, is in nonattainment for the PM_{10} standard (40 CFR Part 81). This nonattainment area is also outside the 84-kilometer region of influence for air quality. A portion of Nye County near the town of Pahrump has a maintenance status for PM_{10}. This maintenance area is at the edge of the 84-kilometer region of influence for air quality.

The provisions of the conformity rule apply only where the action is in a federally classified nonattainment or maintenance area. As already specified, there are no nonattainment areas in the region of influence for air quality. The repository would be less than 84 kilometers (52 miles) from a PM_{10} maintenance area, and PM_{10} impacts from repository activities would be very small. Although the conformity regulations would not apply to the Proposed Action, DOE would work with Nye County to ensure that the Proposed Action would not contribute to additional violations of PM_{10} air quality standards in the maintenance area.

This conformity review applies only to those portions of the Proposed Action that are in the 84-kilometer (52-mile) region of influence for air quality. The conformity review for the balance of the rail alignment is in the Rail Alignment EIS.

4.1.2.1 Impacts to Air Quality from Construction

This section describes nonradiological air quality impacts that could occur during the construction analytical period of the proposed repository. For analytical purposes, DOE assumed that the construction period would last 5 years and that construction activities would be evenly distributed over the period. Activities during this period would include infrastructure upgrades, excavation of fill material, subsurface excavation to prepare the repository for initial emplacement operations, construction of surface facilities in the geologic repository operations area and *South Portal development area*, and construction of ventilation *shafts* and associated access roads. Table 2-1 of this Repository SEIS lists activities during the construction period.

Construction activities would result in emissions of air pollutants from subsurface and surface activities. These emissions would include the following:

- Fugitive dust in the form of PM_{10} (particulate matter with an aerodynamic diameter of 10 micrometers or less) during site preparation from the excavation of undocumented fill in the geologic repository operations area;

- Fugitive dust (PM_{10}) from land-disturbing activities during surface construction, which would include the access road, utility corridor, surface facilities, *Aging Facility*, and Rail Equipment Maintenance Yard and other rail facilities;

- Fugitive dust (PM_{10}) from the placement and maintenance of excavated rock at a surface storage pile;

- Particulate matter (PM_{10}) from ventilation exhausts during subsurface excavation;

- Particulate matter (PM_{10}) from three concrete batch plants; and

- Gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide) and particulate matter with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$) from fossil fuel consumption by construction vehicles.

Table 4-1 lists the maximum estimated impacts to air quality at the boundary of the analyzed land withdrawal area for repository activities that would occur in that area. Maximum concentrations of carbon monoxide, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$ at the analyzed land withdrawal area boundary would be small. The maximum concentration of PM_{10} would be within the regulatory limit. Although normal dust suppression measures such as watering the ground surface would reduce the PM_{10} concentration, the analysis did not consider such measures.

The maximum annual concentration of the ozone precursor nitrogen dioxide would be less than 0.05 percent of the regulatory limit, and the annual emissions would be less than 4 percent of the total estimated nitrogen oxide emissions of approximately 1.3 million kilograms (1,400 tons) in Nye County during 2002 (DIRS 177709-EPA 2006, all). The other ozone precursor, volatile organic compounds, would have estimated annual emissions of about 5,300 kilograms (about 12,000 pounds) from repository construction activities. Because Yucca Mountain is in an attainment area for ozone, the analysis compared the estimated annual release of volatile organic compounds to the Prevention of Significant Deterioration of Air Quality emission threshold for volatile organic compounds for stationary sources (40 CFR 52.21). The volatile organic compound emission threshold is 36,000 kilograms (80,000 pounds) per year, so the peak annual release from the repository would be well below the level. The impact of these pollutants on ozone formation should not cause violations of the ozone standard.

Cristobalite is one of several naturally occurring crystalline forms of silica (silicon dioxide) that occur in Yucca Mountain *tuffs*. Cristobalite is principally a concern for workers who could inhale the particles during subsurface excavation operations (Section 4.1.7.1). Prolonged high exposure to crystalline silica might cause silicosis, a disease characterized by scarring of the lung tissue. Research has shown an increased cancer *risk* to humans who already have developed adverse noncancer effects from silicosis, but the cancer risk to otherwise healthy individuals is not clear.

Cristobalite would be emitted from the subsurface by the ventilation system during excavation operations, and there would be releases in the form of fugitive dust from the excavated rock pile. Fugitive dust from the rock pile would be the largest potential source of cristobalite exposure to surface workers and to the

Table 4-1. Maximum construction analytical period concentrations of criteria pollutants and cristobalite at the land withdrawal area boundary (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide[e]	8-hour	10,000	16	0.16
	1-hour	40,000	130	0.32
Nitrogen dioxide[e]	Annual	100	0.043	0.043
Sulfur dioxide[e]	Annual	80	0.00016	0.00020
	24-hour	365	0.023	0.0062
	3-hour	1,300	0.18	0.014
PM_{10}[e]	24-hour	150	59	40
$PM_{2.5}$[e]	Annual	15	0.0024	0.016
	24-hour	35	0.34	1.0
Cristobalite	Annual	10[f]	0.048	0.48[f]

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction (Appendix B contains more information). Does not include background concentrations. Table 3-2 in Chapter 3 lists the highest measured background concentrations at Yucca Mountain. The maximum concentrations would not exceed the regulatory limits after adding the highest background concentrations.
e. DOE assumed that construction vehicles would be between model years 2006 and 2010 and would meet Tier 3 emission standards.
f. There are no regulatory limits for public exposure to cristobalite. DOE used a comparative benchmark of 10 micrograms per cubic meter (Section 4.1.2.1 and Appendix B, Section B.1).

public. DOE would perform evaluations of airborne crystalline silica at Yucca Mountain during routine operations and tunneling. For this analysis, DOE assumed that 28 percent of the fugitive dust from the rock pile and subsurface excavation would be cristobalite. This reflects the maximum cristobalite content of the parent rock, which ranges from 18 to 28 percent (DIRS 104523-CRWMS M&O 1999, p. 4-81). Using the parent rock percentage overestimates the airborne cristobalite concentration because studies of *ambient* and occupational airborne crystalline silica have shown that most of the silica is coarse (not respirable) and that larger particles do not stay airborne but rapidly deposit on the surface. Table 4-1 lists estimated cristobalite concentrations at the analyzed land withdrawal boundary during the construction analytical period.

There are no regulatory limits for public exposure to cristobalite, even though there are regulatory limits for worker exposure (29 CFR 1910.1000). Due to the lack of regulatory limits for public exposure to cristobalite, this analysis used a comparative benchmark of 10 micrograms per cubic meter. A U.S. Environmental Protection Agency (EPA) health assessment stated that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 micrograms per cubic meter multiplied by years (DIRS 103243-EPA 1996, p. 1-5). Over a 70-year lifetime, this benchmark would correspond to an annual average exposure concentration of approximately 14 micrograms per cubic meter. For added conservatism, the analysis used an annual concentration of 10 micrograms per cubic meter as the benchmark. Table 4-1 compares the estimated cristobalite concentrations and this assumed benchmark. The postulated annual average exposure would be less than 0.5 percent of the benchmark. DOE would use common dust suppression techniques (such as water spraying) to reduce releases of fugitive dust, and thus cristobalite, from the excavated rock pile.

Surface construction outside the analyzed land withdrawal area (that is, off the Yucca Mountain site) would occur during the construction analytical period. Offsite construction would include an intersection at U.S. Highway 95, the Sample Management Facility, and other areas such as a training facility and an offsite marshalling yard for construction materials. Because these activities would be outside the analyzed land withdrawal area, the potential location of the maximally exposed individual member of the public would not be at the boundary of that area, as with activities within the area. The maximally exposed member of the public would be adjacent to the offsite construction. Table 4-2 lists the maximum estimated impacts to air quality as a result of offsite construction. The maximum concentrations are for individuals 100 meters (330 feet) from the construction activities (Appendix B, Section B.3). Although DOE would use dust suppression measures to reduce the PM_{10} concentration, the impact analysis did not consider such measures.

Table 4-2. Maximum construction analytical period concentration of criteria pollutants 100 meters (330 feet) from offsite construction activities (micrograms per cubic meter).

Pollutant	Averaging time	Regulatory limit[a]	Maximum concentration	Percent of regulatory limit
Carbon monoxide[b]	8-hour	10,000	21	0.21
	1-hour	40,000	170	0.42
Nitrogen dioxide[b]	Annual	100	1.0	1.0
Sulfur dioxide[b]	Annual	80	0.0040	0.0051
	24-hour	365	0.032	0.0088
	3-hour	1,300	0.24	0.019
PM_{10}	24-hour	150	64	43
$PM_{2.5}$	Annual	15	0.057	0.38
	24-hour	35	0.49	1.4

Note: All numbers except regulatory limits are rounded to two significant figures.

a. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).

b. DOE assumed construction vehicles would be between model years 2006 and 2010 and would meet Tier 3 emission standards.

The maximally exposed individual member of the public who was near offsite construction would also be exposed to concentrations of criteria pollutants from activities in the land withdrawal area. Therefore, the maximum air quality impact for a person near offsite construction must include a contribution from activities in the land withdrawal area. Because PM_{10} is the criteria pollutant that would be closest to reaching its regulatory limit, DOE selected it for air quality impact analysis. Individuals near offsite construction could be affected by a maximum PM_{10} concentration of 53 micrograms per cubic meter from repository construction activities in the land withdrawal area. This is less than 36 percent of the PM_{10} regulatory limit. Therefore, the total maximum PM_{10} air quality impact near the offsite construction could be about 78 percent of the regulatory limit. DOE calculated this value by adding the less than 36 percent of the regulatory limit from activities in the land withdrawal area to the 43 percent of the regulatory limit from offsite construction activities. (The scenario does not consider background concentrations of PM_{10}. Table 3-2 in Chapter 3 lists the highest measured background concentration of PM_{10} at Yucca Mountain.) This most conservative case assumes that peak offsite construction would occur simultaneously with peak construction in the land withdrawal area. It does not consider normal dust suppression methods. The actual air quality impact for PM_{10} should be less than the most conservative case.

4.1.2.2 Impacts to Air Quality from Operations

This section describes potential nonradiological air quality impacts during the operations analytical period of the Yucca Mountain Repository. For analytical purposes, this period would begin on receipt of an NRC license amendment to receive and possess spent nuclear fuel and high-level radioactive waste, and would include receipt, handling, *aging*, emplacement, and monitoring of these materials. DOE plans to continue surface construction during the first 5 years and to continue subsurface development during the first 25 years of this period. The maximum air quality impacts would occur during the first 5 years of the period, when surface construction and operation activities would occur at the same time. The operations analytical period would last up to 50 years and would end on emplacement of the last waste package.

Continued subsurface development would result in the release of fugitive dust (PM_{10}) from the ventilation exhausts. Activities at the surface would result in the following air emissions during this period:

- Fugitive dust (PM_{10}) from continued land-disturbing construction activities on the surface, which would include the *North Construction Portal*, remaining facilities at the *North Portal*, and a remaining aging pad;
- Fugitive dust (PM_{10}) from the excavation, placement, and maintenance of rock at the excavated rock storage pile;
- Cristobalite emissions from subsurface excavations and the excavated rock storage pile;
- Particulate matter (PM_{10}) from the concrete batch plants;
- Gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, and sulfur dioxide) and particulate matter ($PM_{2.5}$) from vehicles during surface construction and the emplacement of waste packages; and
- Gaseous criteria pollutants and particulate matter ($PM_{2.5}$) from diesel boilers and standby and emergency diesel generators.

Table 4-3 lists the maximum estimated impacts to air quality at the boundary of the analyzed land withdrawal area during the operations analytical period.

As listed in Table 4-3, the maximum offsite concentrations of carbon monoxide, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$ would be small. The public maximally exposed individual would be exposed to less than 3 percent of the applicable regulatory limits. The maximum offsite concentration of PM_{10} could be about 7.6 percent of the applicable regulatory limits. The analysis did not take credit for standard construction dust suppression measures, which DOE would implement to further lower projected PM_{10} concentrations by reducing fugitive dust from surface-disturbing activities. These suppression methods would have little effect on $PM_{2.5}$ concentrations because fugitive dust is not a major source of this pollutant.

The maximum annual concentration of the ozone precursor nitrogen dioxide during the operations analytical period would be about 0.12 percent of the regulatory limit and the annual emissions would be about 10 percent of the total estimated nitrogen dioxide emissions of 1.3 million kilograms (1,400 tons) in Nye County during 2002 (DIRS 177709-EPA 2006, all). Nitrogen dioxide forms primarily from

Table 4-3. Maximum operations analytical period concentrations of criteria pollutants and cristobalite at the land withdrawal area boundary (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide[e]	8-hour	10,000	68	0.68
	1-hour	40,000	550	1.4
Nitrogen dioxide[e]	Annual	100	0.12	0.12
Sulfur dioxide[e]	Annual	80	0.00078	0.00098
	24-hour	365	0.11	0.030
	3-hour	1,300	0.89	0.068
PM_{10}[e]	24-hour	150	11	7.6
$PM_{2.5}$[e]	Annual	15	0.0064	0.043
	24-hour	35	0.91	2.6
Cristobalite	Annual	10[f]	0.0021	0.021[f]

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction (Appendix B contains more information). Does not include background concentrations. Table 3-2 in Chapter 3 lists the highest measured background concentrations at Yucca Mountain. The maximum concentrations would not exceed the regulatory limits after adding the highest background concentrations.
e. DOE assumed that all construction vehicles during the first 5 years of the operations analytical period would be between model years 2006 and 2010 and would meet Tier 3 emission standards.
f. There are no regulatory limits for public exposure to cristobalite. DOE used a comparative benchmark of 10 micrograms per cubic meter (Section 4.1.2.1 and Appendix B, Section B.1).

combustion of fossil fuels from sources such as standby diesel generators, emergency diesel generators, and fossil-fuel vehicles. The Proposed Action would consume only about 2.2 percent of diesel fuel use in Clark, Nye, and Lincoln counties in 2004 and only about 0.04 percent of the gasoline (Section 4.1.11.4). The other ozone precursor, volatile organic compounds, would have an estimated maximum annual emission of about 14,000 kilograms (about 30,000 pounds) during the first 5 years of the operations period. As discussed in Section 4.1.2.1, this would be significantly below the Prevention of Significant Deterioration of Air Quality emission threshold for volatile organic compounds. DOE anticipates that the impact of these pollutants on ozone formation would not cause violations of the ozone standard.

Table 4-3 also lists cristobalite concentrations at the land withdrawal area boundary. As Section 4.1.2.1 discusses for the construction analytical period, the analysis of the operations analytical period assumed that 28 percent of the fugitive dust releases from the excavated rock pile would be cristobalite. There are no public limits for exposure to cristobalite, so the analysis used an approximate annual average concentration of 10 micrograms per cubic meter as a benchmark. The estimated exposures to cristobalite from repository operations would be approximately 0.002 microgram per cubic meter, or less than 0.03 percent of the benchmark.

Concentrations of PM_{10} would be less during the operations analytical period than during the construction analytical period due to a decrease in surface disturbance and a reduction in concrete batch plant operations. Concentrations of cristobalite also would decrease during the operations analytical period even though the amount of subsurface excavation and the size of the excavated rock pile would increase. Concentrations of gaseous criteria pollutants would increase during the first 5 years of the operations period over those of the construction period due to vehicle emissions from construction activities and repository operations and to emissions from diesel generators and boilers.

No air quality impacts would result from facilities outside the land withdrawal area during the operations analytical period. The training facility and marshalling yard would not be significant sources of criteria pollutants. The amount of fuel that vehicles would use at the facilities would not be large. Standard dust suppression methods would mitigate potential fugitive dust (PM_{10}) emissions at the marshalling yard.

4.1.2.3 Impacts to Air Quality from Monitoring

This section describes potential nonradiological air quality impacts during the monitoring analytical period of the proposed repository. For analytical purposes, this period would begin with the emplacement of the final waste package and continue for 50 years after the end of the operations analytical period. Activities during this period would include maintenance of active ventilation of the repository for as long as 50 years, remote inspection of waste packages, retrieval of waste packages to correct detected problems (if necessary), and continuing investigations to support predictions of postclosure repository performance. Section 4.2 discusses air quality impacts of the retrieval contingency.

After the completion of emplacement activities, DOE would continue monitoring and maintenance activities. During this period, air pollutant emissions would decrease. Surface construction, subsurface excavation, and subsurface emplacement activities would be complete, resulting in a lower level of emissions in comparison to previous periods. Pollutant concentrations at the analyzed land withdrawal area boundary would be substantially lower than those in Table 4-3.

No air quality impacts would result from facilities outside the land withdrawal area during the monitoring analytical period. There would be significantly less activity at offsite facilities such as the training facility and marshalling yard, so they would not be significant sources of criteria pollutants.

4.1.2.4 Impacts to Air Quality from Closure

This section describes potential nonradiological air quality impacts during the closure analytical period of the proposed repository. This period, which would last 10 years and would overlap the last 10 years of the monitoring analytical period, would begin on receipt of a license amendment to close the repository. Activities would include closure of subsurface repository facilities, backfilling, sealing of subsurface-to-surface openings, decommissioning and demolition of surface facilities, construction of monuments to mark the site, and reclamation of remaining disturbed lands. These activities would result in the following air emissions during this period:

- Fugitive dust (PM_{10}) emissions from the handling, processing, and transfer of backfill material to the subsurface;
- Fugitive dust (PM_{10}) releases from demolition of buildings, removal of debris, and land reclamation;
- Cristobalite releases from the handling and storage of excavated rock; and
- Gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, and sulfur dioxide) and particulate matter ($PM_{2.5}$) from fuel consumption.

Table 4-4 lists the maximum estimated impacts to air quality at the boundary of the analyzed land withdrawal area during the closure analytical period.

Table 4-4. Maximum closure analytical period concentrations of criteria pollutants and cristobalite at the land withdrawal area boundary (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide[e]	8-hour	10,000	2.9	0.029
	1-hour	40,000	24	0.059
Nitrogen dioxide[e]	Annual	100	0.023	0.023
Sulfur dioxide[e]	Annual	80	0.000045	0.000056
	24-hour	365	0.0065	0.0018
	3-hour	1,300	0.052	0.0040
PM_{10}[e]	24-hour	150	29	16
$PM_{2.5}$[e]	Annual	15	0.0013	0.0090
	24-hour	35	0.19	0.55
Cristobalite	Annual	10[f]	0.0026	0.026[f]

a. Appendix B describes the analysis of maximum concentrations and percent of regulatory limits.
b. All numbers except regulatory limits are rounded to two significant figures.
c. Regulatory limits for criteria pollutants are from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.22097 (Table 3-5).
d. Sum of highest estimated concentrations at the accessible land withdrawal boundary regardless of direction (Appendix B contains more information). Does not include background concentrations. Table 3-2 in Chapter 3 lists the highest measured background concentrations at Yucca Mountain. The maximum concentrations would not exceed the regulatory limits after adding the highest background concentrations.
e. DOE assumed that all construction vehicles would be between model years 2006 and 2010 and would meet Tier 3 emission standards.
f. There are no regulatory limits for public exposure to cristobalite. DOE used a comparative benchmark of 10 micrograms per cubic meter (Section 4.1.2.1 and Appendix B, Section B.1).

Gaseous criteria pollutants would result primarily from vehicle exhaust. During the closure analytical period, the maximum concentrations of carbon monoxide, nitrogen dioxide, sulfur dioxide, and $PM_{2.5}$ would be small. Concentrations of carbon monoxide, nitrogen dioxide, and sulfur dioxide would be less than 0.1 percent of the regulatory limits, and concentrations of $PM_{2.5}$ would be less then 1 percent of the regulatory limits. The maximum offsite concentration of PM_{10} would be less than 17 percent of the regulatory limit. The analysis did not take credit for standard construction dust suppression measures, which DOE would implement and would further lower projected PM_{10} concentrations by reduction of fugitive dust from surface-disturbing activities. These suppression methods would not affect the concentrations of $PM_{2.5}$ because fugitive dust is not a major source of that pollutant.

As with the construction analytical period (Section 4.1.2.1), the analysis of the closure analytical period assumed that 28 percent of the fugitive dust releases from the excavated rock pile would be cristobalite. Table 4-4 lists estimated cristobalite concentrations for the maximally exposed offsite individual during closure. As noted in Section 4.1.2.1, there are no public limits for exposure to cristobalite, so the analysis used an approximate annual average concentration of 10 micrograms per cubic meter as a benchmark. The estimated exposures to cristobalite from repository closure would be approximately 0.0026 microgram per cubic meter, or less than 0.03 percent of the benchmark.

4.1.2.5 Total Impacts to Air Quality from All Periods

The nonradiological air quality analysis examined concentrations of criteria pollutants at the boundary of the land withdrawal area in comparison with the *National Ambient Air Quality Standards* for periods ranging from 1 hour to an annual average concentration of pollutant. The analysis calculated the maximum project impact from the highest unit release concentrations of the AERMOD computer model from the years modeled (Appendix B describes the analysis). The highest concentrations of all criteria

pollutants except PM_{10} would be less than 3 percent of applicable standards in all cases. The highest concentrations of PM_{10} from activities in the land withdrawal area could be 40 percent of the 24-hour limit during the construction analytical period.

4.1.2.6 Impacts from Greenhouse Gases

The burning of fossil fuels such as diesel and gasoline emits carbon dioxide, which is a greenhouse gas. DOE's use of fossil fuel at the repository would be greatest during the construction and operations analytical periods for construction equipment, surface vehicles, boilers, and generators. Although human activities can produce other greenhouse gases such as methane and nitrous oxide, construction and operations activities would release only carbon dioxide in meaningful quantities (Appendix B, Section B.9). Therefore, DOE has considered only carbon dioxide in this Repository SEIS. Appendix B, Section B.9 describes the methodology and emission factors DOE used to determine carbon dioxide emissions.

Greenhouse gases can trap heat in the atmosphere and have been associated with global climate change . The Intergovernmental Panel on Climate Change, in its Fourth Assessment Report issued in 2007, stated that warming of the Earth's climate system is unequivocal, and that most of the observed increase in globally averaged temperatures since the mid-20th Century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (DIRS 185132-Parry et al. 2007, Summary). The Panel describes a range of potential environmental impacts associated with climate change at a global and regional level. In North America, for example, the Panel stated that warming in western mountains is projected to cause decreased snowpack, more winter flooding, and reduced summer flows, exacerbating competition for over-allocated water resources. Among other potential impacts for North America cited in the full report were an increased number, intensity and duration of heatwaves, and an extended period of high fire risk.

Greenhouse gases are well mixed throughout the lower atmosphere, such that any anthropogenic emissions would add to cumulative regional carbon dioxide emissions and to global concentrations of carbon dioxide. DOE quantified carbon dioxide emissions from the Proposed Action of this Repository SEIS and presents the results together with estimates of recent State of Nevada and national carbon dioxide emissions. The Energy Information Administration has estimated that 47.9 million metric tons (52.8 million tons) of carbon dioxide emissions would be produced in Nevada in 2004 (DIRS 185316-EIA n.d., all). Overall estimated U.S. emissions of carbon dioxide were 6,089 million metric tons (6,712.5 million tons) in 2005 (DIRS 185248-EPA 2007, all). Neither the State of Nevada nor the Federal Government has carbon dioxide emissions caps, thresholds, or targets. Carbon dioxide emissions from the Proposed Action would add to state and national emissions, making a relatively small incremental contribution to cumulative emissions of carbon dioxide. DOE is not aware of any methodology to correlate the carbon dioxide emissions exclusively from a specific proposed project to any specific impact on global climate change.

4.1.2.6.1 *Greenhouse Gases from Construction Activities*

Carbon dioxide emissions during the construction analytical period would result primarily from the burning of fossil fuels by construction equipment and the manufacture of concrete at concrete batch plants. The maximum annual diesel use during construction would be about 5.5 million liters (1.5 million gallons) and the maximum annual gasoline use would be about 180,000 liters (47,000 gallons). The annual concrete use would be about 65,000 cubic meters (85,000 cubic yards).

Using the methodology and emission factors in Appendix B, Section B.9 of this Repository SEIS, the maximum annual carbon dioxide emissions during the construction period would be about 36,000 metric tons (39,000 tons). This would be 0.075 percent of the carbon dioxide emissions in the State of Nevada in 2004 and 0.00059 percent of the carbon dioxide emissions in the United States in 2005.

4.1.2.6.2 *Greenhouse Gases from Operations Activities*

Carbon dioxide emissions during the operations analytical period would result primarily from the burning of fossil fuels by construction equipment, surface vehicles, boilers, and generators. Concrete batch plants would also be operating early in the operations period while construction continues. The maximum annual diesel use during full operations would be about 20 million liters (5.3 million gallons) and the annual gasoline use would be about 850,000 liters (220,000 gallons). The annual concrete use would be 41,600 cubic meters (54,000 cubic yards) during construction. Using the methodology and emission factors described in Appendix B, Section B.9, the maximum annual carbon dioxide emissions during the operations period would be about 69,000 metric tons (76,000 tons). This would be less than 0.15 percent of the carbon dioxide emissions in the State of Nevada in 2004 and less than 0.0012 percent of the carbon dioxide emissions in the United States in 2005.

4.1.2.6.3 *Greenhouse Gases from All Analytical Periods*

Carbon dioxide emissions during all analytical periods (up to 105 years) would result from the burning of fossil fuels by construction equipment, surface vehicles, boilers, and generators and by the manufacture of concrete. The total diesel use during all analytical periods would be about 740 million liters (195 million gallons) and the total gasoline use would be about 31 million liters (8.2 million gallons). The total concrete use would be about 490,000 cubic meters (640,000 cubic yards). Using the methodology and emission factors described in Appendix B, Section B.9, the total carbon dioxide emissions during all analytical periods would be about 2.2 million metric tons (2.4 million tons).

4.1.3 IMPACTS TO HYDROLOGY

This section summarizes and incorporates by reference applicable portions of Section 4.1.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-19 to 4-31). In addition, it addresses potential impacts that could change as a result of modifications to repository design and operational plans.

This section describes potential environmental impacts to the hydrology of the Yucca Mountain region from construction, operations, monitoring, and eventual closure of a repository at Yucca Mountain. It identifies and evaluates potential surface-water and *groundwater* impacts separately, as DOE did in the Yucca Mountain FEIS. The region of influence and the assessment attributes, or criteria, are the same as those in the FEIS. Chapter 5 discusses postclosure impacts from the long-term performance of the repository.

The attributes DOE used to assess surface-water impacts were the potential for the introduction and movement of *contaminants*, potential for changes to runoff and infiltration rates, alterations in natural drainage, and potential for flooding to worsen any of these conditions. The region of influence for surface-water impacts includes construction and operation sites that would be susceptible to erosion, areas that permanent changes in surface-water flow could affect near these sites, and downstream areas that eroded soil or potential spills of contaminants would affect. The evaluation of surface-water impacts is

very similar to that in the Yucca Mountain FEIS, but DOE modified it to address a slightly larger amount of land disturbance, two additional wastewater *evaporation ponds*, and a tentative facility layout that more specifically incorporates stormwater *detention ponds* into its design.

The attributes DOE used to assess groundwater impacts included the potential to change infiltration rates that could affect groundwater, the potential for the introduction of contaminants, the availability of groundwater for project use, and the potential for such use to affect other groundwater users. The region of influence for the groundwater analysis includes *aquifers* under the areas of construction and operations, aquifers from which DOE could obtain water, and downstream aquifers that repository uses could affect. The evaluation of groundwater impacts is very similar to that in the Yucca Mountain FEIS, but addresses changes to the estimated water demand from the Proposed Action.

4.1.3.1 Impacts to Surface Water from Construction, Operations, Monitoring, and Closure

There are no perennial streams or other permanent, surface-water bodies in the Yucca Mountain region of influence, and instances when precipitation and runoff are sufficient to generate flowing water in drainage channels are infrequent and short lived. Nevertheless, the manner in which the Proposed Action would accommodate or otherwise affect these infrequent conditions determines potential impacts to surface water. The primary impact areas for the Proposed Action are the following:

- Discharges of water to the surface,
- The potential for introduction of contaminants that could spread to surface water,
- The potential for changes to surface-water runoff or infiltration rates, and
- The potential for alteration of natural surface-water drainage, which would include effects to *floodplains* (or flood zones).

4.1.3.1.1 *Discharge of Water to the Surface*

DOE would pump groundwater at the site and store it in tanks to support the following uses: fire protection, deionized water, potable water, cooling tower makeup, and makeup to other water systems. There would be few discharges of water. DOE would pipe sanitary sewage to septic tank and leach field systems, so there would be no production of surface water, and the processes that routinely produced other wastewater would involve discharges to one of four or possibly five lined evaporation ponds as follows:

1. South Portal evaporation pond for dust control water returned from subsurface development,
2. North Construction Portal evaporation pond for dust control water returned from subsurface development,
3. North Portal evaporation pond for process wastewater,
4. *Central operations area* evaporation pond for process wastewater, and

5. Small evaporation pond (possibly) for concrete batch plant wastewater.

DOE would provide water to the subsurface during the development of the underground areas of the proposed repository. The Department would collect excess water from dust suppression applications and water that percolated into the repository *drifts*, if any, and send the water to evaporation ponds at the South Portal development area or the North Construction Portal. The South Portal evaporation pond would have double polyvinyl chloride liners and a leak detection system. The evaporation pond at the North Construction Portal would be of similar construction.

The North Portal evaporation pond, which DOE would locate adjacent to the facilities in the central operations area just outside the geologic repository operations area, would receive wastewater in the form of cooling tower blowdown and water softener regeneration solutions from facility heating and air conditioning systems. DOE would send water from floor and equipment drains of the surface facilities and the emplacement side of the subsurface to the North Portal evaporation pond after verification that it was not contaminated. (The Department would manage contaminated water as *low-level radioactive waste*.) The North Portal evaporation pond, at a minimum, would have a polyvinyl chloride liner. The fourth evaporation pond, also in the central operations area, would receive process water from two oil-water separators and superchlorinated water from maintenance of the drinking water system.

Table 4-5 lists the combined quantities of water discharges to the North Construction Portal and the South Portal ponds, which would be similar to those in the Yucca Mountain FEIS. As listed in the table, the estimates include two phases of underground development (called "heavy" and "light" only in relation to each other) after completion of the primary surface construction analytical period. The estimated quantity of water DOE would discharge to the North Portal evaporation pond would be no different than that in the Yucca Mountain FEIS; that is, about 34,000 cubic meters (9 million gallons) per year for the operations analytical period.

Table 4-5. Combined annual water discharges to the North Construction Portal and the South Portal evaporation ponds.

Analytical period	Duration[a] (years)	Annual discharge[b]	
		(cubic meters)	(million gallons)
Construction	5	4,500	1.2
Operations			
Heavy development	8	6,800	1.8
Light development	up to 17	2,900	0.77

a. Discharge to this pond would occur only during subsurface development activities.
b. Estimated discharge volumes would be 13 percent of the process water sent to the subsurface based on Exploratory Studies Facility construction experience.

With proper maintenance, the lined evaporation ponds should remain intact and produce no adverse impacts at the repository site. DOE would build another, much smaller lined evaporation pond, as appropriate, in the general area of the concrete batch plants to facilitate the collection and management of equipment rinse water. As an option, DOE could divert wastewater from the batch plants to the South Portal evaporation pond.

The water that DOE would use for dust suppression is a type of discharge. DOE studied dust suppression during characterization activities at Yucca Mountain because of the concern that any water added to the

surface or subsurface could have effects on the subsurface area of the proposed repository. The amount of water used for dust suppression would result in neither runoff nor infiltration. DOE would establish controls as necessary to ensure that dust suppression would not involve unnecessary quantities of water.

Repository facility operations would involve other uses of water, but they would have little, if any, potential to generate surface water. DOE would collect wastewater from the Wet Handling Facility pool, decontamination stations, surface facility drain system, and various equipment drains and, if sampling of the collection tanks and sumps indicated the presence of *contamination*, would manage that water as low-level radioactive waste.

Discharges to the surface during the monitoring and closure analytical periods would be similar to but less than those for the construction and operations analytical periods. The evaporation ponds would have little or no use, but other manmade sources of surface water would be similar—water storage tanks would be in use, there would be sanitary sewage, and dust suppression would occur as necessary.

4.1.3.1.2 *Potential for Contaminant Spread to Surface Water*

There would be no permanently piped, routine, liquid effluents from surface or subsurface facilities to surface water or drainage channels. The potential for contaminants to reach surface water or surface drainages would be limited to the simultaneous occurrence of a spill or leak and heavy precipitation or snowmelt. Because there are no natural perennial surface waters in the Yucca Mountain region of influence and no readily available sources of contamination, it would take both events to result in a surface spread of contamination.

Potential contaminants during construction would consist mostly of fuels (diesel, propane, and gasoline) and lubricants (oils and grease) for equipment. Fuel storage tanks would be in place early in the construction analytical period, and DOE would construct or install them with appropriate secondary containment (consistent with 40 CFR Part 112). Other potential contaminants, such as paints, solvents, strippers, and concrete additives, also would be in use during construction, but in smaller quantities and much smaller containers. Such materials would probably be in 210-liter (55-gallon) or smaller drums and containers. DOE would minimize the potential for spills and, if they occurred, would minimize contamination by adherence to its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all), which it would update for repository construction. The plan would describe actions DOE would take to prevent, control, and remediate spills, and the reporting requirements for a spill or release.

DOE management of the spent nuclear fuel and high-level radioactive waste at the proposed repository would start at the beginning of the operations analytical period. After acceptance at the site and before emplacement in the subsurface facility, DOE would keep these materials in the *restricted area* of the geologic repository operations area. Spent nuclear fuel and high-level radioactive waste, mostly in *canisters*, would also be in transportation *casks*, *aging overpacks*, transfer casks, or waste packages. These containers would minimize the potential for releases and would shield people, to a large extent, from radiation exposure during the transfer of spent nuclear fuel and high-level radioactive waste between facilities in the geologic repository operations area. In the waste handling buildings, facility system and component design would reduce the likelihood of inadvertent releases to the environment; for example, drain lines would lead to internal tanks or catchments, air emissions would be filtered, and the pool of the Wet Handling Facility would have a stainless-steel liner and leak detection.

DOE would use fuels and lubricants during the operations analytical period for equipment operation and maintenance, and would manage them in the manner described above for the construction analytical period. The Department would use other chemicals and hazardous materials during the operations period, particularly in the Low-Level Waste Facility, which would use sodium hydroxide and sulfuric acid in treatment processes. In addition, activities during the operations period would require relatively small quantities of cleaning solvent. With the exception of fuels, which would be in outdoor tanks with secondary containment, DOE would use and store these hazardous materials inside buildings, and would manage all the materials in accordance with applicable environmental, health, and safety standards and the Spill Prevention, Control, and Countermeasures Plan. Therefore, the potential for spills and leaks of contaminants would be small and, if they occurred, there would be little potential for contaminants to spread far beyond the point of release.

DOE would manage liquid low-level radioactive waste from the waste handling facilities in, or adjacent to, the Low-Level Waste Facility and would maintain the waste in monitored containers. It would maintain and move hazardous and *mixed wastes* in closed containers before shipping them to a permitted treatment facility. These conditions would minimize the potential for spills and releases.

There would be a decrease in general activities at the site after emplacement was complete and the monitoring analytical period began. There would be a corresponding decrease in the potential for spills and releases from routine activities during the operations analytical period. However, decontamination actions that would follow the operations or monitoring period could present other risks due to the use of decontamination solutions and the start of new work. DOE would continue to implement plans and controls to limit the potential for contaminant spread by surface water. In addition, DOE would perform environmental monitoring during the operations and monitoring periods to identify the presence of contaminants that could indicate a release.

In addition to measures to reduce the potential for spills or releases to reach or be spread by surface water, DOE would take measures to prevent runoff and flood waters from reaching areas where they could contact contaminated surfaces or cause releases of hazardous materials. The Department would protect surface facilities that were important to safety (basically those in the restricted area of the geologic repository operations area) against the probable maximum flood by building the structures above the corresponding flood elevation or by using *engineered barriers* such as dikes or drainage channels. It would build other facilities to withstand a *100-year flood*, which is consistent with common industrial practice and DOE policy. Inundation levels for any flood level, even the probable maximum flood, would present no hazard to the subsurface facilities because the *portals* would be at higher elevations than the flood-prone areas. The construction of stormwater retention and detention ponds in appropriate areas would address potential flooding and stormwater pollution issues. DOE would augment the effectiveness of the stormwater ponds, as necessary, by providing diversion channels to move runoff away from surface facilities and aging pads.

The closure analytical period would include further reductions in the potential for contaminant spread, but DOE would continue to implement engineering controls, monitoring, and release-response requirements to ensure that the potential was minimal, which would include during the demolition of surface facilities when water use for dust control would be likely to increase.

4.1.3.1.3 *Potential for Changes to Surface-Water Runoff or Infiltration Rates*

Areas disturbed due to the construction of surface facilities at Yucca Mountain probably would experience changes in the rates of infiltration. Areas where infiltration rates decreased would experience a corresponding increase in surface-water runoff. The Proposed Action could disturb as much as 9 square kilometers (2,200 acres) of land, which would include about 2.43 square kilometers (600 acres) already disturbed as a result of Yucca Mountain characterization activities. In this area of disturbance, areas where soil was loosened or scraped away from *fractured* rock probably would experience increased infiltration rates, and covered or compacted surface areas probably would experience decreased infiltration rates. Most land disturbed during construction would fit into the latter scenario that involved compaction of natural surfaces or the installation of relatively impermeable surfaces like asphalt pads, concrete surfaces, or buildings.

Overall, there would be less infiltration and more runoff from the site. However, DOE expects the change in the amount of runoff that would reach the drainage channels to be small, with small impacts, for two reasons. First, the Department would build the surface geologic repository operations area and the balance of plant facilities (that is, the area where most of the facilities and built-up areas would be) with integral stormwater detention ponds. DOE would control all the runoff from this surface area in this manner and, as a result, runoff increases would not adversely affect existing drainage channels outside this surface area. The second reason applies to the relative scale of the disturbed area and its location. The stormwater detention ponds would minimize the most serious concern from increased runoff from built-up areas, so other increases or decreases in runoff would involve a relatively small amount of the natural drainage. For example, the natural drainage area of Drill Hole Wash, which includes the Midway Valley drainage, represents the area the Proposed Action would affect the most. About 4.8 square kilometers (1,200 acres) of land would be disturbed in and adjacent to the geologic repository operations area. This disturbed area is about 12 percent of the 40 square kilometers (9,900 acres) that make up the drainage area of Drill Hole Wash by the time it reaches *Fortymile Wash*. On a larger scale, most if not all of the total land disturbance of 9 square kilometers (2,200 acres) would be in the natural drainage area for Fortymile Wash. The disturbed area would be approximately 1 percent of the Fortymile Wash drainage, which is about 820 square kilometers (200,000 acres) where the wash leaves the Nevada Test Site near U.S. Highway 95 (DIRS 169734-BSC 2004, Table 7-3). Further, because of the isolated location of these drainage channels, there are no downstream facilities that the minor changes in runoff could reasonably affect.

The Proposed Action would disturb no additional land during the monitoring analytical period and, therefore, there would be no adverse impacts to runoff rates. Reclamation of previously disturbed land would restore preconstruction runoff rates.

Closure of the repository would involve only previously disturbed land. Removal of structures and impermeable surfaces coupled with reclamation efforts would help restore infiltration and runoff rates to nearly predisturbance conditions. DOE would construct monuments to provide long-term markers for the site such that their locations would be impervious to infiltration, but the affected areas would be small.

4.1.3.1.4 *Potential for Altering Natural Surface-Water Drainage*

Construction could involve the placement of structures, facilities, or roadways in or over drainage channels or their associated floodplains (or flood zones). These actions could affect Fortymile, Midway

Valley (Sever), Drill Hole, and Busted Butte (Dune) washes and their associated floodplains. DOE would control surface-water drainage in these washes with diversion channels, culverts, stormwater detention ponds, or similar drainage control measures.

Pursuant to Executive Order 11988, *Floodplain Management*, and its implementing regulations at 10 CFR Part 1022, DOE must, when conducting activities in a floodplain, take action to reduce the risk of flood damage; minimize the impacts of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Appendix C of this Repository SEIS contains a floodplain/wetlands assessment that describes the actions DOE could take. The analysis indicated that consequences of DOE actions in or near the floodplains of the four washes would be minor and unlikely to increase the impacts of floods on human health and safety or harm the natural and beneficial values of the affected floodplains.

The closure analytical period would involve no actions that would alter natural drainage beyond those affected in prior periods. DOE would grade areas where it demolished or removed facilities to match the natural topography to the extent practicable. The Department would not build monuments where they would alter important drainage channels or patterns.

4.1.3.2 Impacts to Groundwater from Construction, Operations, Monitoring, and Closure

The groundwater-related impacts of primary concern are as follows:

- The potential for changes in infiltration rates that could increase the amount of water in the *unsaturated zone* and adversely affect performance of waste containment in the repository, or decrease the amount of recharge to the aquifer;
- The potential for migration of contaminants from the surface to reach the unsaturated zone or aquifers; and
- The potential for project water demands to deplete groundwater resources to an extent that could affect downgradient groundwater use.

4.1.3.2.1 *Potential Infiltration Rate Changes*

Surface-disturbing activities would alter infiltration rates in and around the geologic repository operations area, as described in Section 4.1.3.1. Because impermeable surfaces and compacted ground would cover much of the disturbed land, DOE anticipates a net decrease in infiltration and a corresponding increase in runoff over the disturbed area. In the semiarid environment of Yucca Mountain, much of the total infiltration occurs in areas of higher elevation, areas with thin or no soil cover, or in the upper reaches of washes. The amount of projected recharge along Fortymile Wash is very small in comparison with the recharge of the aquifers from farther north. The increased runoff from the disturbed surface area from the Proposed Action could cause more water to reach Fortymile Wash, and the stormwater detention ponds would represent new areas of temporary water accumulation. As a result, additional infiltration could occur in these locations in comparison with existing conditions. However, the areas potentially subject to increased infiltration would be localized and small in comparison with infiltration that occurred over the

entire Fortymile Wash drainage area. Any increase in infiltration would be unlikely to affect overall groundwater recharge or flow patterns.

Surface disturbance along the crest of Yucca Mountain and on the steeper slopes above the proposed repository could present different scenarios for infiltration rate changes because the depth of unconsolidated material (that is, soil and gravel) in these areas is generally thin, and there would be a higher *probability* that disturbance could expose fractured bedrock where precipitation and runoff could enter cracks and crevices and more readily reach deep portions of the unsaturated zone. Ventilation shafts to the subsurface area and access roads to those locations are the primary examples of surface disturbances that would occur in the upper areas of Yucca Mountain. The amount of disturbed land in these areas would be small in comparison with the undisturbed area, and any net change in infiltration would be small.

Subsurface activities could change groundwater recharge rates, primarily due to the amount of water that DOE would pump to the subsurface for dust suppression and tunnel boring during development activities. This potential for increased recharge would be offset by measures to collect and remove accumulating water back to the surface (to the North Construction Portal and the South Portal evaporation ponds), by removal of wet excavated rock to the surface, and by keeping the work areas ventilated, which would promote evaporation of the remaining water. During the excavation of the *Exploratory Studies Facility*, DOE tracked water introduced to the subsurface because water that remained in the subsurface could affect DOE's understanding of postclosure performance of the proposed repository. Tracking of the use of water in the subsurface would continue under the Proposed Action, and DOE anticipates that changes in recharge through Yucca Mountain would have small impacts to the groundwater system.

No additional land disturbance would occur during the monitoring and closure analytical periods, so further effects on infiltration rates would be unlikely. Soil reclamation and revegetation would accelerate a return to more natural infiltration conditions. Monuments that DOE constructed to provide long-lasting markers for the site would probably result in impermeable locations, but the surface area covered by the monuments would be small in relation to the surrounding areas.

4.1.3.2.2 *Potential for Contaminant Migration to Groundwater*

Section 4.1.3.1 discusses the types of contaminants that DOE could use at the proposed repository site and the possibility of spills or releases of these materials to the environment. Adherence to regulatory requirements and a Spill Prevention, Control, and Countermeasures Plan (Section 4.1.3.1) would minimize the potential for spills or releases to occur and would require appropriate responses to clean up or otherwise abate any such incident. Natural conditions, which include depth to groundwater, thickness of *alluvium* in most areas, and *arid* environment, would help ensure that significant contaminant migration did not occur before DOE could take action. Section 4.1.8 discusses the potential for onsite accidents that could involve releases of contaminants. Chapter 5 discusses the postclosure release of contaminants from the waste packages in the repository.

4.1.3.2.3 *Potential for Depletion of Groundwater Resources*

The quantity of water necessary to support the Proposed Action would be greatest during the initial construction analytical period and early in the operations analytical period, when DOE would need water for surface soil compaction and dust suppression as well as subsurface development. The evaluation of

impacts for this Repository SEIS addressed potential impacts from this water demand only during these heavy-use periods. Table 4-6 summarizes water demands during these two periods of heavy water use. Water demand during the monitoring and closure analytical periods would be lower and of less concern and would be likely to remain as presented in the Yucca Mountain FEIS.

Table 4-6. Annual water demand for construction and operations.

Analytical period	Duration[a] (years)	Annual water demand (cubic meters)	Annual water demand (acre-feet)[b]
Construction	5	330,000 to 570,000	270 to 460
Operations			
Emplacement plus continued underground development and surface construction[c]	5	220,000 to 410,000	180 to 330
Emplacement and continued underground development	up to 25	270,000 to 300,000	220 to 240
Emplacement	up to 20	240,000	195

a. Several of the project periods are flexible in the number of years they could last. In such cases, values are "up to" with a breakout representative of the maximum length and most conservative high water demand expected. For example, DOE expects the operations analytical period to last up to 50 years; within that period, subsurface development could last up to a total of 30 years. If development took less time, the last phase of emplacement could be longer than 20 years, so the total would still be 50.
b. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.
c. Although the analysis assumed that the formal construction analytical period would be 5 years, some construction activities could extend into the operations analytical period (Chapter 2, Table 2-1).

Figure 4-1 shows annual water demands during construction and the first few years of the operations analytical period. It shows water demand during the construction analytical period because it would be the period of greatest fluctuation and would include the year of peak water demand. Figure 4-1 also shows estimated water demands for the 3 years prior to the start of repository construction. The first year depicts the minor amount of water that would be necessary to operate and maintain existing facilities. The next 2 years show increased water demand under the assumption that the infrastructure improvements described in Section 4.3 would start before repository construction.

Water demand would be highest during the initial construction analytical period and would range from about 330,000 to 570,000 cubic meters (270 to 460 acre-feet) per year (Table 4-6 and Figure 4-1). During the first 5 years of the operations analytical period, construction of surface and subsurface facilities would occur along with emplacement of spent nuclear fuel and high-level radioactive waste; water demand would range from about 220,000 to 410,000 cubic meters (180 to 330 acre-feet) per year. Other than an increase in the second and third years of this 5-year period, annual water demand would start leveling off to a quantity more representative of the rest of the operations period. Subsurface development could continue for up to the next 25 years, but water demand would generally level off at about 270,000 cubic meters (220 acre-feet) per year. After the development of the subsurface area was complete, the primary operations would consist of waste receipt and emplacement. Water demand would drop slightly to about 240,000 cubic meters (195 acre-feet) per year during this period.

DOE would meet water demand by pumping from existing wells, and possibly one new well, in the Jackass Flats *hydrographic area*. The new well, if installed, would support operations at Gate 510. Table 4-6 and Figure 4-1 do not include Nevada Test Site activities in this area, which would require groundwater during the same period. During the 7-year period from 2000 to 2006, the average Nevada

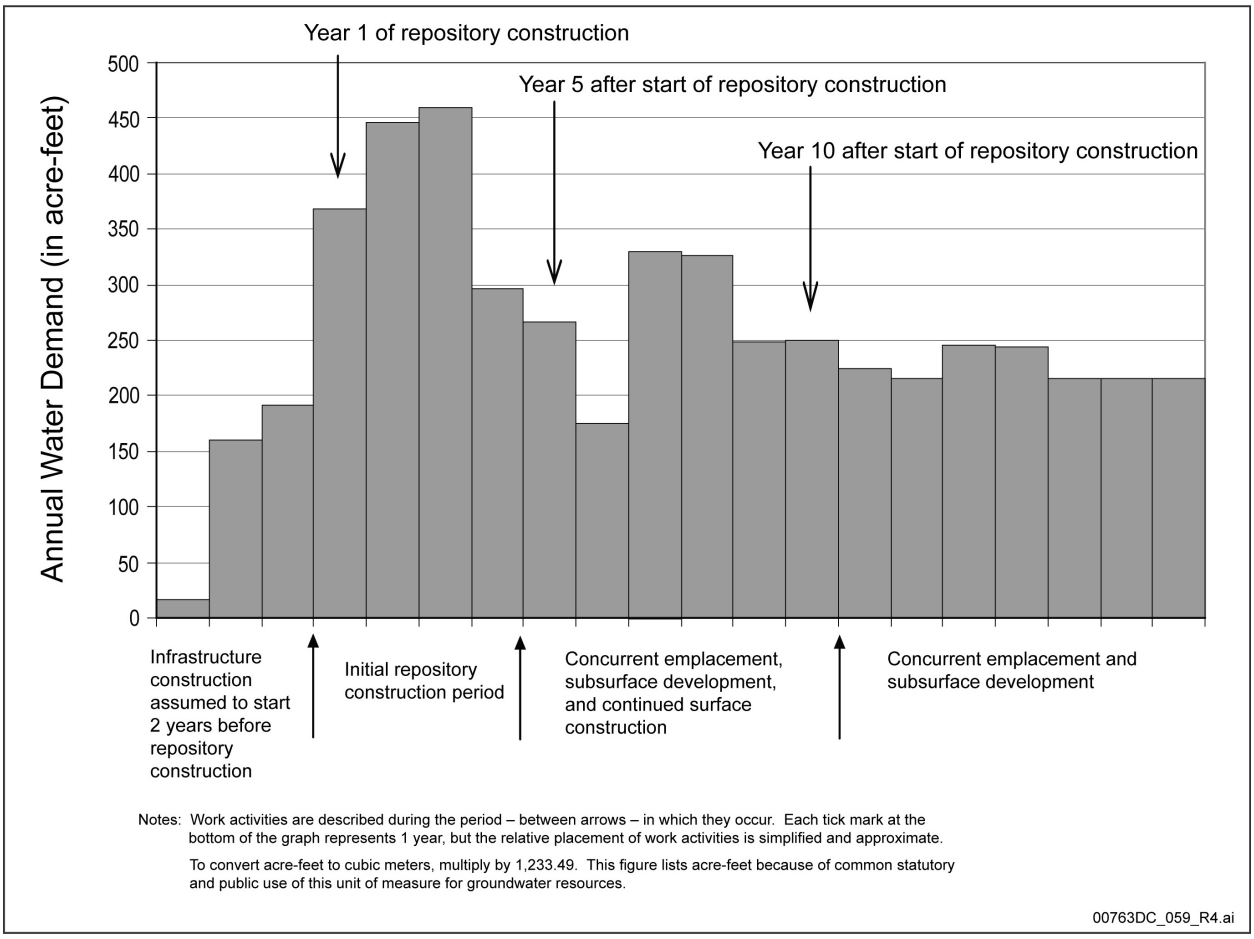

Figure 4-1. Annual water demand during the construction analytical period and the initial phases of operations.

Test Site water withdrawal from this hydrographic area was about 83,000 cubic meters (67 acre-feet) per year (DIRS 181232-Fitzpatrick-Maul 2007, all). In a 2002 analysis, the Test Site indicated there were no planned expansions of existing operations that would affect water use, but potential future programs could involve additional water use (DIRS 162638-DOE 2002, pp. 4-18 and 4-19). The following evaluation assumed that this recent use represents a reasonable estimate of Nevada Test Site water demand from *Jackass Flats*, at least in the near term (5 to 10 years). However, DOE recognizes that Test Site demand could increase in the future. As shown in Table 4-6 and Figure 4-1, water demand for the Proposed Action would generally decrease and level off after completion of surface construction activities. This additional water demand for the Nevada Test Site is part of the *cumulative impacts* analysis in Chapter 8 of this Repository SEIS. At least for the peak water demand years of the Proposed Action, the estimated additional water demand for Nevada Test Site activities would be 83,000 cubic meters (67 acre-feet).

DOE used the three approaches it used in the Yucca Mountain FEIS to evaluate potential impacts of water demand on groundwater resources:

- Comparison with impacts observed or measured during past water withdrawals,
- Comparison of the proposed demand with estimates of perennial yield of the aquifer, and

- Groundwater modeling efforts to assess changes the proposed demand would have on groundwater elevations and flow patterns.

The following paragraphs address potential impacts from the construction and operations analytical periods, when water demand would be highest. Impacts from water demand during the monitoring analytical period would be small in comparison, except during the first 3 years, when they would be comparable to those for operations. Impacts during the closure analytical period would be small in comparison.

4.1.3.2.4 *Comparison with Impacts from Past Water Withdrawals*

The peak water demand would be about 650,000 cubic meters (530 acre-feet) per year [that is, 570,000 cubic meters (460 acre-feet) from the Proposed Action from Table 4-6, plus 83,000 cubic meters (67 acre-feet) for Nevada Test Site needs]. This demand would be 33 percent higher than the peak withdrawal of about 490,000 cubic meters (400 acre-feet) during the past 15 years from the Jackass Flats area (Chapter 3, Section 3.1.4.2.2; DIRS 155970-DOE 2002, Table 3-16, p. 3-66). However, water demand at this level would occur for only 2 years, and the average annual water demand over the 5-year construction analytical period would be about 530,000 cubic meters (430 acre-feet) with the Nevada Test Site needs. This demand would be quite similar to the groundwater withdrawals during the busier period of the Yucca Mountain site characterization activities. During the next 5-year period, when underground development and some surface construction would occur simultaneously with emplacement operations, annual water demand would average about 410,000 cubic meters (330 acre-feet). Based on the past history of groundwater withdrawals from the Jackass Flats hydrographic area and the corresponding minor changes in groundwater elevations (Chapter 3, Table 3-5), the proposed water demand amounts would be unlikely to affect the stability of the *water table* in the area adversely.

4.1.3.2.5 *Comparison with Estimates of Groundwater Perennial Yield*

Perennial yield is the estimated quantity of groundwater that can be withdrawn annually from a basin without depletion of the reservoir. As discussed in Chapter 3, Section 3.1.4.2.1, the estimated perennial yield of the aquifer in the Jackass Flats hydrographic area is between 1.1 million and 4.9 million cubic meters (880 and 4,000 acre-feet). The source of the low end of this range is an estimate of the annual groundwater recharge that occurs in the Jackass Flats hydrographic area, so it includes no underflow that enters the area from upgradient groundwater basins. This low estimate can be further reduced, to be more conservative, by attributing 720,000 cubic meters (580 acre-feet) to the western two-thirds of the Jackass Flats hydrographic area (where the Proposed Action would withdraw water) and 370,000 cubic meters (300 acre-feet) to the eastern one-third. This last reduction accommodates the belief of some investigators that the two portions of Jackass Flats have different general flow characteristics. These yield values (from the low estimates, associated only with local recharge, to the highest estimate, which is more than 4 times greater) occur not only in groundwater studies but also in the Nevada State Engineer's rulings that address water appropriation requests for Jackass Flats groundwater (DIRS 105034-Turnipseed 1992, pp. 9 and 12).

The peak annual demand of 570,000 cubic meters (460 acre-feet) would be below the lowest estimates of the perennial yield of the Jackass Flats area, even if that is the amount attributable to the western two-thirds of the area. With the addition of water demand for the Nevada Test Site, the peak annual demand would still be below the lowest estimate of yield from the western two-thirds of the area; that is, a demand

of 650,000 cubic meters (530 acre-feet) in comparison with the lowest estimate of perennial yield of 720,000 cubic meters (580 acre-feet). A comparison of the peak annual water demand (with the demand from Test Site activities) with the highest estimate of the Jackass Flats perennial yield indicated only 13 percent of the highest value.

Based on these comparisons of the proposed water demand with estimates of the perennial yield of the Jackass Flats area, DOE has concluded that the Proposed Action would not deplete the groundwater reservoir. The Department recognizes that annual recharge can change significantly from year to year, depending on the area weather patterns. For the peak year, water demand could exceed groundwater recharge in the western two-thirds of the Jackass Flats hydrographic area. However, water demand at that high level and similar levels would be relatively short-term. If water demand exceeded local recharge for a few years (longer durations would be unlikely based on the estimates of average annual recharge), there could be some shifting of the general flow patterns in the Jackass Flats area. Shifts in flow patterns would be small because the peak annual water demand would be a small portion of the highest estimate of perennial yield, 4.9 million cubic meters (4,000 acre-feet), which would include underflow from upgradient groundwater basins.

As noted in the Yucca Mountain FEIS, the heaviest water demand in the region of influence for the Proposed Action would be in the Amargosa Desert. The water demand for the Proposed Action would, to some extent, decrease the availability of water in the downgradient area because it would reduce the long-term underflow that reached the Amargosa Desert. However, the peak annual water demand of 650,000 cubic meters (530 acre-feet) for proposed repository and Nevada Test Site activities in Jackass Flats would be small (about 4 percent) in comparison with the average annual withdrawal of 16 million cubic meters (13,000 acre-feet) in the Amargosa Desert between 2000 and 2004 (Chapter 3, Table 3-4) for activities other than the Proposed Action or the Test Site. The demand of repository and Test Site activities in Jackass Flats would be an even smaller fraction of the perennial yield of 30 million to 42 million cubic meters (24,000 to 34,000 acre-feet) in the Amargosa Desert.

Comparisons between water demand and estimates of perennial yield (Chapter 3, Table 3-4) must recognize the wide range of perennial yield estimates for the hydrographic areas of Jackass Flats and Amargosa Desert as well as the adjacent hydrographic areas. One estimate of perennial yield in State of Nevada documentation is 30 million cubic meters (24,000 acre-feet) for the combined area of Jackass Flats, Amargosa Desert, Rock Valley, Buckboard Mesa, and Crater Flat (DIRS 182821-Converse Consultants 2005, p. 100), in comparison with the 30-million-cubic meter estimate just for Amargosa Desert. The state uses estimates of perennial yield as a tool (with other considerations) in the management of groundwater resources and evaluation of requests for groundwater appropriations. The other side of the evaluation of potential impacts on groundwater resources is that, independent of the physical availability of water, the groundwater of the Amargosa Desert is over-appropriated in comparison with many estimates of perennial yield. As noted in Section 3.1.4.2.1, the amount of water actually withdrawn each year from the Amargosa Desert hydrographic area has averaged only about half of the total appropriations in recent years. However, a recent ruling by the Nevada State Engineer (also described in Section 3.1.4.2.1) describes the State's position that the spring discharges in the Ash Meadows area are part of the committed water taken from the hydrographic area along with the amount pumped from wells. Under this scenario, the combined annual water withdrawals and discharges in the Amargosa Desert hydrographic area exceed the perennial yield value of 30 million cubic meters (24,000 acre-feet).

4.1.3.2.6 *Modeled Effects on Groundwater Elevations and Flow Patterns*

This section summarizes the two modeling efforts described in the Yucca Mountain FEIS, one by Thiel Engineering Consultants for DOE (DIRS 145966-CRWMS M&O 2000, all) and the other by the U.S. Geological Survey (DIRS 145962-Tucci and Faunt 1999, all). DOE used the results of these analyses to estimate effects the Proposed Action could have on groundwater elevations and flow patterns. Both modeling efforts generated baseline groundwater conditions from historical water withdrawals from the Jackass Flats area, then generated future groundwater conditions with the assumption of an additional water demand of 530,000 cubic meters (430 acre-feet) per year for the Proposed Action. As indicated in Figure 4-1, the water demand DOE evaluated for the Proposed Action would exceed the model-assumed withdrawal rate for 2 years during repository construction. Because the model conclusions used a long-term withdrawal rate of 530,000 cubic meters per year, those conclusions are very conservative. Over the first 10 years of the Proposed Action, when the peak annual demand would occur, the average annual water demand would be only 390,000 cubic meters (320 acre-feet). Over the life of the Proposed Action, the average annual water demand would be much less. Results from the modeling efforts indicated there would be groundwater elevation differences attributable to the Proposed Action, as follows:

- The Thiel Engineering Consultants study predicted a water elevation decrease of up to 3 meters (10 feet) within about 1 kilometer (0.6 mile) of the Yucca Mountain production wells. The U.S. Geological Survey model predicted a similar water level decrease of less than 2 meters (6.6 feet) at distances a few kilometers from the production wells.

- The models predicted water elevation decreases at the town of Amargosa Valley that ranged from less than 0.4 to 1.1 meters (1.2 to 3.6 feet). [In this case, the predictions were for groundwater roughly at the junction of U.S. Highway 95 and Nevada State Route 373, about 13 kilometers (8 miles) south of well J-12.]

- The Thiel Engineering Consultants study estimated a reduction in the underflow from the Jackass Flats hydrographic area to the Amargosa Desert hydrographic area of about 160,000 cubic meters (130 acre-feet) per year after 100 years of pumping. The U.S. Geological Survey effort estimated an underflow reduction of 180,000 cubic meters (150 acre-feet) per year at steady-state conditions.

The Thiel Engineering Consultants modeling effort looked at numerous locations and pumping scenarios throughout the region and concluded in all areas of the Amargosa Desert that groundwater elevation decreases attributable to the Proposed Action, though possibly moderate by themselves, would be minor in comparison with decreases from the pumping scenarios without the Proposed Action. Both modeling efforts assumed a conservatively high value for the water demand of the Proposed Action, so the predicted impacts, even though moderate in scale, are conservatively high.

4.1.3.3 Summary of Impacts to Hydrology

The following summarize the conclusions of the evaluations in this section:

- Repository construction and operation would result in minor changes to runoff and infiltration rates.

- The potential for flooding at the repository that could cause damage of concern would be extremely small.

- The highest annual water demand for the Proposed Action would be below the Nevada State Engineer's ruling of perennial yield (the amount that can be withdrawn annually without depleting reserves) for the Jackass Flats hydrographic area, including the lowest estimated value of perennial yield [720,000 cubic meters (580 acre-feet)] for the western two-thirds of this hydrographic area. The water demand for the Proposed Action, coupled with that projected for Nevada Test Site activities in Jackass Flats, would still be below the lowest estimated value of perennial yield for the western two-thirds of the hydrographic area.

- The Proposed Action would withdraw groundwater that would otherwise move into aquifers of the Amargosa Desert, but the combined water demand for the repository and Nevada Test Site activities in Jackass Flats would have, at most, small impacts on the availability of groundwater in the Amargosa Desert area in comparison with the quantities of water already being withdrawn there.

4.1.4 IMPACTS TO BIOLOGICAL RESOURCES AND SOILS

The region of influence for biological resources and soils in this Repository SEIS is the area that contains all potential surface disturbances that would result from the Proposed Action plus additional areas to evaluate local animal populations, roughly equivalent in size to the analyzed land withdrawal area that DOE assessed in the Yucca Mountain FEIS, as well as land DOE proposes for an access road from U.S. Highway 95 and land where DOE could construct offsite facilities. The Department has reanalyzed impacts to biological resources and soils for this Repository SEIS based on the modified design that Chapter 2 describes. The evaluation of impacts to biological resources and soils considered the potential for effects to vegetation and wildlife, which included special-status species of plants and animals and their *habitats*; jurisdictional waters of the United States, which included *wetlands*; riparian areas; and soil resources. The evaluation also considered the potential for impacts to migratory patterns and populations of game animals. DOE expects the overall impacts to biological resources would be small because plant and animal species in the Yucca Mountain region are typical of the Mojave and *Great Basin* deserts and generally are common throughout those areas. The removal of vegetation from the area that DOE would require for construction and operation of the repository and the small impacts to some wildlife species from disturbance or loss of individuals or habitat would not affect regional biodiversity and *ecosystem* function.

4.1.4.1 Impacts to Biological Resources from Construction, Operations, Monitoring, and Closure

As discussed in Section 4.1.7 of this Repository SEIS, routine releases of radioactive materials from the repository during its operation would consist mainly of naturally occurring radon-222 and its *decay* products. These releases would result in *doses* to plants and animals around the repository that would be lower than the International Atomic Energy Agency thresholds for detrimental effects to radiosensitive species in terrestrial ecosystems (DIRS 103277-IAEA 1992, p. 53). No detectable impacts to surface biological resources would occur as a result of normal releases of radioactive materials from the repository; therefore, the following sections do not consider these releases.

4.1.4.1.1 *Impacts to Vegetation*

The construction of surface facilities and the disposition of excavated rock from subsurface construction would remove or alter vegetation in the analyzed land withdrawal area and within the 37-square kilometer

(9,100-acre) offsite area directly to the south. Approximately 2.5 square kilometers (620 acres) of the construction would occur in areas (both in the land withdrawal area and in the offsite area to the south) in which site characterization activities had already disturbed the vegetation; however, construction also would occur on as much as 6.5 square kilometers (1,600 acres) of undisturbed areas near the previously disturbed areas. Subsurface construction would continue after emplacement operations began, and the disposal of excavated rock would eliminate vegetation in the area under the excavated rock pile. Table 4-7 lists the amount of land that DOE would clear of vegetation for the majority of repository facilities by land cover type and compares this disturbance to the amounts of each land cover type in the Mojave and Nellis mapping zones in the State of Nevada. Removal of vegetation would result in impacts to small amounts of widely distributed land cover types that are common in the affected mapping zones (Chapter 3, Section 3.1.5.1.1 describes mapping zones), and these impacts would not cause a significant loss to any particular cover type. The largest losses would be to the Sonora-Mojave Creosotebush-White Bursage Desert Scrub land cover type, with disturbance of approximately 0.25 percent of the cover type in the Nellis and Mojave mapping zones in Nevada, and to the Sonora-Mojave Mixed Salt Desert Scrub land cover type, with disturbance of approximately 0.15 percent of the cover type in those mapping zones. Activities during repository construction, operations, monitoring, or closure would not reduce any other land cover type by more than 0.05 percent in the affected mapping zones.

Biological soil crusts likely occur within the region of influence in some areas where there has been no surface disturbance. Because insufficient data exist to assess the amount of biological crusts in the region of influence, and because attempts to locate or map occurrences of biological crusts could result in their disturbance or destruction, it would be extremely difficult for DOE to quantify the predicted impacts of repository construction or operations on biological crusts. However, any biological crusts in areas disturbed by repository construction or operations would be lost.

In cooperation with the U.S. Fish and Wildlife Service, DOE developed a site reclamation plan, in part to satisfy the terms and conditions of the 2001 Biological Opinion. DOE would reclaim lands it no longer needed for repository construction or operations and would monitor those lands to determine if reclamation efforts were successful. As stated in the *Reclamation Implementation Plan*, DOE considers reclamation successful if plant cover, density, and species richness are equal to, or exceed, 60 percent of the value of the same parameters in undisturbed reference areas (DIRS 154386-YMP 2001, pp. 33 and 34). If reclaimed sites meet these criteria, they can be released from further remediation and monitoring. As of April 2007, the Department had successfully reclaimed 119 sites [a total of 0.174 square kilometer (43 acres)] and released them from reclamation monitoring.

Repository construction activities that resulted in land disturbances and removal of vegetation could result in colonization by invasive plant species in additional areas. *Invasive species* that are currently present on the site (Chapter 3, Section 3.1.5.1.1) would be the most likely to colonize disturbed areas. Invasive species could suppress *native species*, although the reclamation actions described above could reduce the likelihood that they would overtake native species on reclaimed lands. To control the spread of undesirable species further, DOE would develop and implement methods to control invasive species and noxious weeds on disturbed sites during construction and operation of the repository.

With an increase in invasive annual plants there could be an increase in fire fuel load from dried annual plants. Because the area that construction activities disturbed would be small in comparison with the total undisturbed vegetated area in the region of influence (Table 4-7), and because DOE would reclaim areas no longer in use as practicable, impacts to native species and the threat of increased fires would be small.

Table 4-7. Land cover types in the region of influence.[a]

Land cover type	Area in Mojave and Nellis mapping zones in the State of Nevada[b]		Disturbed area under the Proposed Action[c]	
	square kilometers	square miles	square kilometers	square miles
Great Basin Pinyon-Juniper Woodland	4,000	1,500	0	0
Great Basin Xeric Mixed Sagebrush Shrubland	6,300	2,400	0.0023	0.00088
Inter-Mountain Basins Big Sagebrush Shrubland	8,000	3,100	0	0
Inter-Mountain Basins Cliff and Canyon	410	160	0	0
Inter-Mountain Basins Greasewood Flat	1,400	540	0.0054	0.0021
Inter-Mountain Basins Mixed Salt Desert Scrub	25,000	9,800	0	0
Inter-Mountain Basins Montane Sagebrush Steppe	20	7.8	0	0
Inter-Mountain Basins Semi-Desert Grassland	78	30	0	0
Inter-Mountain Basins Semi-Desert Shrub Steppe	4,500	1,700	0.15	0.058
Invasive Annual Grassland	55	21	0	0
Mojave Mid-Elevation Mixed Desert Scrub	3,600	1,400	1.7	0.65
North American Warm Desert Active and Stabilized Dune	2.9	1.1	0	0
North American Warm Desert Bedrock Cliff and Outcrop	350	140	0	0
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	24	9.5	0	0
North American Warm Desert Playa	220	85	0.030	0.011
North American Warm Desert Volcanic Rockland	8.2	3.2	0	0
North American Warm Desert Wash	33	13	0	0
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	1,200	480	3.0	1.2
Sonora-Mojave Mixed Salt Desert Scrub	940	360	1.4	0.54
Totals[a]	57,000	22,000	6.3	2.4

Source: Derived from digital land cover map (DIRS 179926-USGS National Gap Analysis Program n.d., all) and land cover descriptions (DIRS 174324-NatureServe 2004, all) with the use of a geographic information system.

a. Numbers are rounded to two significant figures; therefore, totals might differ from sums.

b. Chapter 3, Section 3.1.5.1.1 contains a description of mapping zones.

c. Disturbed land cover area calculated only for disturbances for which a location has been identified. Total disturbance would be approximately 9 square kilometers.

Some invasive species would remain along permanent roads and drainage ditches where reclamation opportunities were limited, and these species could spread and overcome native species under certain conditions. Reclamation or other weed management strategies on long-term topsoil stockpiles and other disturbed areas would help control the abundance of invasive annuals such as red brome (*Bromus rubens*), and would minimize potential fire fuel load and disruption to native plant communities.

The Yucca Mountain FEIS cited studies that indicate that site characterization activities had very small effects on vegetation adjacent to DOE activities at Yucca Mountain. Therefore, impacts to vegetation from construction probably would occur only as a result of direct disturbance, such as during site clearing, and indirect disturbance, such as an increase in invasive annual plants as described above. Little or no disturbance of additional vegetation would occur as a result of monitoring and maintenance activities before closure.

Closure of the repository would involve the removal of structures and reclamation of areas that DOE cleared of vegetation for the construction of surface facilities as practicable and as delineated in the license amendment that DOE would have to obtain before closure. Final reclamation could include backfilling and grading to restore natural drainage patterns and create a stable landform; spreading and contouring topsoil that had been stockpiled during construction; creating erosion-control structures; ripping, seeding, spreading, and anchoring mulch; and fencing to reduce loss of new vegetation to herbivores. Figures 4-2, 4-3, and 4-4 illustrate the reclamation process the Department undertook during site characterization for Yucca Mountain, which has improved the success rate of vegetation reestablishment and helps control encroachment of invasive species. DOE would use such activities in the future to limit impacts of the Proposed Action.

Figure 4-2. Fill material is spread and contoured on the site of a decommissioned borrow area at Yucca Mountain.

Figure 4-3. Decommissioned borrow area at Yucca Mountain that has been recontoured prior to seeding and mulching.

Figure 4-4. Decommissioned borrow area at Yucca Mountain 4 years after reclamation.

4.1.4.1.2 *Impacts to Wildlife*

This section summarizes, incorporates by reference, and updates the Impacts to Wildlife portion of Section 4.1.4.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-34 and 4-35). *Direct impacts* to wildlife would occur through four mechanisms: (1) loss of habitat from construction of facilities and infrastructure; (2) localized deaths of individuals of some species, particularly burrowing species of small mammals and reptiles, and deaths of individual animals from vehicle collisions; (3) fragmentation of undisturbed habitat that created a *barrier* to wildlife movement; and (4) displacement of wildlife because of an aversion to the noise and activity from construction, operations, monitoring, and closure of the repository.

The effect of these impacts on wildlife would be small because: (1) habitats similar to those at Yucca Mountain (identified by land cover type) are widespread locally and regionally; (2) animal species at the proposed repository site are generally widespread throughout the Mojave or Great Basin deserts, and the deaths of some individuals due to repository construction, habitat loss, and vehicle collisions would have small impacts on the regional populations of those species or on the overall biodiversity of the region; (3) large areas of undisturbed and unfragmented habitat would be available away from disturbed areas; and (4) impacts to wildlife from noise and vibration, if any, would be limited to the vicinity of the source of the noise (for example, heavy equipment, diesel generators, and ventilation fans). Overall, no species would be threatened with extinction, either locally, regionally, or globally. Several animals classified as game species by the State of Nevada [such as Gambel's quail (*Callipepla gambelii*), chukar (*Alectoris chukar*), and mule deer (*Odocoileus hemionus*)] are present in low numbers in the region of influence. Adverse impacts to these species would be unlikely and hunting opportunities would not change as DOE would continue to prohibit hunting in the area where most construction activities would occur. There would be no impact to desert bighorn sheep (*Ovis canadensis nelsoni*) in the offsite area to the south of the analyzed land withdrawal area, or their winter habitat in the Striped Hills, because the proposed addition to the access road to the Yucca Mountain site is more than 1.6 kilometers (1 mile) west of the nearest potential habitat for sheep and there is no nearby suitable habitat to the west of the road. Construction and operations of other facilities or structures in the offsite area, such as new electric transmission lines, the Sample Management Facility, and a temporary construction camp, would have no impact on desert bighorn sheep because these actions would be far from important bighorn sheep habitat.

To avoid and minimize adverse impacts to migratory birds during repository construction, DOE would implement best management practices, which would include avoidance of groundbreaking activities to the maximum extent practicable in nesting habitat during the critical nesting period, which the Bureau of Land Management defines as May 1 through July 15. If groundbreaking or land clearing activities were necessary during the nesting season, DOE would conduct surveys for migratory bird nests before any such activities. The Department would prohibit all activities that would harm nesting migratory birds or result in nest abandonment.

Wildlife would be attracted to the water in lined evaporation ponds in the vicinity of the geologic repository operations area. Individuals of some species could benefit from the water, but some animals could become trapped in the ponds depending on the depth and the slope of the sides. Previous experience has shown that a wide variety of animal species use such ponds and that DOE could avoid losses of animals by reduction of the pond slopes or by an earthen ramp at one corner of the pond. Appropriate engineering would minimize potential losses to wildlife.

As Chapter 3, Section 3.1.12.1 discusses, DOE could construct a landfill for construction debris and sanitary *solid waste*, although it has not determined a site for it. The landfill could attract scavengers such as coyotes (*Canis latrans*) and ravens (*Corvus corax*). Frequent covering of the *sanitary waste* in the landfill would minimize use by scavenger species.

After the completion of waste emplacement, human activities and vehicle traffic would decline, as would impacts of those actions on wildlife, with further declines in activities and impacts after repository closure. Animal species could reoccupy the areas DOE reclaimed during the closure period.

4.1.4.1.3 *Impacts to Special-Status Species*

This section summarizes, incorporates by reference, and updates as indicated by new references the Impacts to Special Status Species portion of Section 4.1.4.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-35 and 4-36). The desert tortoise (*Gopherus agassizii*) is the only resident animal species in the analyzed land withdrawal area that is listed as threatened under the *Endangered Species Act* (16 U.S.C. 1531 et seq.). Further, there are no endangered or candidate animal species and no species that are proposed for listing (Chapter 3, Table 3-7). Repository construction would result in the loss of a small portion of desert tortoise habitat at the northern edge of the range of this species in an area where the abundance of tortoises is low.

Based on past experience, DOE anticipates that human activities at the site could directly affect individual desert tortoises. DOE has successfully relocated two tortoise nests and 27 individual tortoises to protect them from potential threats. Since July 1997, three tortoises have been killed on access roads, none by construction activities (DIRS 182586-Spence 2007, all). Therefore, although some tortoises could be killed on roads during repository construction and as a result of increased vehicle traffic during repository operation, DOE anticipates the number of tortoise deaths due to vehicle traffic and construction activities during the repository construction, operations, monitoring, and closure analytical periods would be small. However, the abundance of ravens, which are natural predators of juvenile desert tortoises, could increase as a result of infrastructure construction (the birds could use electric transmission lines and light posts as perches, for example) and could result in increased predation on young tortoises. Frequent covering of the sanitary waste in the potential landfill would limit the attraction of the repository area to ravens.

Although these losses would cause a small decrease in the abundance of desert tortoises in the immediate vicinity of the repository site, they would not affect the long-term survival of the local or regional population of this species. Yucca Mountain is surrounded to the east, south, and west by large tracts of undisturbed tortoise habitat on government property, and desert tortoises are widespread at low densities throughout this region.

The U.S. Fish and Wildlife Service has concluded that tortoise populations are depleted for more than 1 kilometer (0.6 mile) on either side of heavily used roads (DIRS 155970-DOE 2002, p. 4-36). The increase in traffic to Yucca Mountain would contribute to the continued depression of populations along U.S. Highway 95, but would not increase the threat to the long-term survival of tortoise populations in southern Nevada.

As required by Section 7 of the *Endangered Species Act*, DOE has entered into consultations with the U.S. Fish and Wildlife Service on the effects of proposed repository activities on the desert tortoise. The Fish and Wildlife Service issued a Biological Opinion in 2001, which concluded that “construction,

operation and monitoring, and closure of a geologic repository at Yucca Mountain is not likely to jeopardize the continued existence of the threatened Mojave population of the desert tortoise. These actions do not affect any area designated as critical habitat; therefore, no destruction or adverse modification of that habitat is anticipated" (DIRS 155970-DOE 2002, Appendix O, pp. 21 to 22). The Biological Opinion included reasonable and prudent measures, and terms and conditions required to achieve these measures, to ensure that implementation of the Proposed Action would not jeopardize the desert tortoise. Chapter 9, Section 9.2.4.1 of the Yucca Mountain FEIS listed these measures and described how DOE is implementing them (DIRS 155970-DOE 2002, pp. 9-9 to 9-11). DOE would reinitiate consultation with the Fish and Wildlife Service if any of the conditions in 50 CFR 402.16 occurred, for example, if DOE exceeded the limit the Biological Opinion specified on the amount of tortoise habitat that DOE could disturb [6.65 square kilometers (1,643 acres)] (DIRS 155970-DOE 2002, Appendix O, p. 29).

The bald eagle (*Haliaeetus leucocephalus*) was observed once on the Nevada Test Site and might migrate through the Yucca Mountain region. If present at all, eagles would be transient and repository activities would not affect them. The State of Nevada classifies the bald eagle as endangered.

Several animal species considered sensitive by the Bureau of Land Management (Chapter 3, Table 3-7) occur in the region of influence. Impacts to bat species would be small because of their low abundance on the site and broad distribution. Impacts to the common chuckwalla (*Sauromalus ater*) and Western burrowing owl *(Athene cunicularia hypugaea)* from disturbance or loss of individuals would be small because they are widespread regionally and are not abundant in the land withdrawal area. Impacts to the Western red-tailed skink (*Eumeces gilberti rubricaudatus*) would be small because it is widespread regionally and occupies small pockets of isolated habitat that would not be overly affected by any proposed disturbances. Giuliani's dune scarab beetle (*Pseudocotalpa giulianii*) has been reported only in the southern portion of the land withdrawal area away from any proposed disturbances and, therefore, would not be affected.

Monitoring and closure activities at the repository would have little impact on desert tortoises or Bureau of Land Management *sensitive species* because the repository workforce would be smaller than during the operations analytical period. Over time, vegetation would recover on disturbed sites and indigenous species would return. As the habitat recovered over the long term, desert tortoises and other special-status species at the repository site could recolonize areas abandoned by humans.

4.1.4.1.4 *Impacts to Wetlands*

This section summarizes, incorporates by reference, and updates the Impacts to Wetlands portion of Section 4.1.4.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-36 and 4-37). There are no known naturally occurring wetlands subject to permitting requirements under Section 404 of the *Clean Water Act* (42 U.S.C. 1251 et seq.) on the repository site, so no impacts to such wetlands would occur as a result of repository construction, operations, monitoring, or closure. In addition, repository activities would not affect the manmade well pond in the land withdrawal area. Repository-related structures could affect as much as 2.8 kilometers (1.7 miles) of ephemeral washes, depending on the size and location of the facilities. After selecting the location of the facilities, DOE would conduct a formal delineation of waters of the United States near the surface facilities and, if necessary, develop a plan to avoid when practicable and otherwise minimize impacts to those waters. If repository activities would affect waters of the United States, DOE would consult with the U.S. Army Corps of Engineers and obtain permit

coverage for those impacts. If the activities were not covered under a nationwide permit, DOE would apply to the Corps of Engineers for a regional or individual permit. By implementation of the *mitigation* plan and compliance with other permit requirements, DOE would ensure that impacts to waters of the United States would be minimized. Appendix C of this Repository SEIS contains a floodplain and wetlands assessment for the proposed repository.

4.1.4.2 Evaluation of Severity of Impacts to Biological Resources

Table 4-8 lists the results of the DOE evaluation of the impacts to biological resources.

Table 4-8. Impacts to biological resources.

Analytical period	Flora	Fauna	Special-status species	Wetlands	Overall
Construction					
	Small; removal of vegetation from up to 9 square kilometers (2,200 acres) in widespread communities; maximum loss to any one land cover type in the affected mapping zones would be 0.25 percent	Small; loss of small amount of habitat and some individuals of some species	Small; loss of small amount of desert tortoise habitatand few tortoises	None	Small; loss of small amount of widespread but undisturbed habitatand small number of individuals
Operations					
	Small; disturbance of vegetation in areas adjacent to disturbed areas	Small; deaths of small number of individuals due to vehicle traffic and human activities	Small; potential deaths of few individuals due to vehicle traffic	None	Small; disturbance of common land cover types and loss of small number of individual animals
Monitoring					
	Small; no new disturbance of natural vegetation	Small; same as for operations, but smaller due to smaller workforce	Small; same as for operations, but smaller due to smaller workforce	None	Small; very small number of individual animals killed by vehicles
Closure					
	Small; decline in impacts due to reduction in human activity	Small; decline in number of individuals killed by traffic annually	Small; decline in number of individuals killed by traffic annually	None	Small; decline in impacts due to reduction of human activity
Overall rating of impacts	Small	Small	Small	None	Small

4.1.4.3 Impacts to Soils from Construction, Operations, Monitoring, and Closure

This section summarizes and incorporates by reference Section 4.1.4.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-38 and 4-39); there have been no soil surveys that covered the region of influence since completion of the FEIS. The evaluation of impacts to soils considered the potential for soil loss in disturbed areas, recovery of soil viability (that is, the physical, chemical, and biological properties of soil that foster plant growth) after disturbance, and the potential for the spread of contamination due to the relocation of contaminated soils (if present). DOE would use erosion control techniques to minimize erosion. Because soil in disturbed areas would be slow to recover, during the closure analytical period DOE would revegetate the areas it had not reclaimed after the temporary disturbances following construction.

4.1.4.3.1 *Soil Loss*

Activities during the construction, operations, and monitoring analytical periods would disturb varying amounts of land depending on the final design for the repository. DOE would disturb as much as 9 square kilometers (2,200 acres) of land during the construction phase, which could expose bare soil to wind and water erosion.

During earlier activities, DOE established a reclamation program with a goal to return disturbed land to a condition similar to its predisturbance state (DIRS 154386-YMP 2001, all). One of the benefits of such a goal is the minimization of soil erosion. The program includes the implementation and evaluation of topsoil stockpiling and stabilization efforts that would enable the use of topsoil removed during excavation in future reclamation activities. Final reclamation would include spreading and contouring topsoil that was stockpiled during construction; creating erosion control structures; ripping, seeding, spreading, and anchoring mulch; and fencing to reduce loss of new vegetation to herbivores. The reestablishment of vegetation to stabilize stockpiled topsoil would reduce the construction loss of the most critical type of soil.

DOE would use fugitive dust control measures, which would include water spraying, chemical treatment, and wind fences as appropriate, to minimize wind erosion of the stockpiled topsoil and excavated rock. The Department would minimize soil erosion by minimizing areas of surface disturbance and using engineering practices to stabilize disturbed areas. These practices could include such measures as control of stormwater runoff through the use of holding ponds, baffles, and other devices, and the stabilization of disturbed ground, relocated soil, or excavated material. Based on past experience and the continuing topsoil protection and erosion control programs, DOE anticipates little soil loss due to erosion during any period of the project.

4.1.4.3.2 *Recovery*

Studies during the Yucca Mountain site characterization effort and experience at the Nevada Test Site indicate that natural succession on disturbed desert soils would be a very slow *process*. Soil recovery would be unlikely without reclamation. DOE remains fully committed to the reclamation of disturbed areas (DIRS 154386-YMP 2001, Section 1.2).

Land disturbances can compromise or destroy soil viability through salvaging, stockpiling, and compaction. Topsoil handling and stockpiling can have negative impacts on the physical, chemical, and biological properties of the soil, which include decreased soil stability and porosity, increased bulk density, increased ammonium concentrations, decreased nutrients and microbial populations, decreased viable seed populations, and decreased organic matter. While DOE could not avoid most of these impacts, the use of proper techniques for soil handling, stockpiling, and stabilization would minimize them. DOE studied stockpiling and stabilization during site characterization and identified methods that had little effect on chemical and physical proprieties, nutrient content, or microbial content of the soil (DIRS 150174-CRWMS M&O 1999, all). DOE used the study results and information from literature searches to develop a topsoil management plan (DIRS 154386-YMP 2001, Section 4.2). Use of the techniques in this plan would result in minimum impacts on soil viability from salvaging and stockpiling activities.

4.1.4.3.3 *Contamination*

There would be a potential for spills or releases of contaminants under the Proposed Action (Section 4.1.3.1.2), but DOE would implement an updated version of its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all) to prevent, control, and remediate soil contamination. The Department would train workers in the handling, storage, distribution, and use of hazardous materials to provide practical prevention and control of potential contamination sources. Fueling operations and storage of hazardous materials and other chemicals would take place in bermed areas and away from floodplains when possible to decrease the probability of unexpected water flow spreading an inadvertent spill. DOE would provide rapid-response cleanup and response capability, techniques, procedures, and training for potential spills.

4.1.5 IMPACTS TO CULTURAL RESOURCES

This section summarizes, incorporates by reference, and updates the information in Section 4.1.5 of the Yucca Mountain FEIS (DIRS 155790-DOE 2002, pp. 4-39 to 4-41). In this Repository SEIS, the region of influence for cultural resources includes the analyzed land withdrawal area, land that DOE proposes for an access road from U.S. Highway 95, and land where DOE would construct offsite facilities.

Cultural resources are nonrenewable resources with values that physical disturbance could diminish. The Yucca Mountain FEIS evaluation of impacts to cultural resources considered the potential for disruption or modification of the character of cultural resources. The evaluation placed particular emphasis on identification of the potential for impacts to archaeological and historic sites and other cultural resources important to sustaining and preserving American Indian cultures.

For this Repository SEIS, direct comparison of disturbed land as the predominant indicator enables determination of impacts to cultural resources. The primary sources of short-term impacts from construction, operations, monitoring, and closure would be facility construction and operations and human activities.

Overall, estimated impacts to cultural resources identified in this Repository SEIS would be small, as the following sections describe.

4.1.5.1 Impacts to Cultural Resources from Construction, Operations, Monitoring, and Closure

The following sections discuss archaeological and historic resources in the region of influence and the American Indian viewpoint on DOE activities related to the proposed repository and their impacts on these resources.

4.1.5.1.1 *Archaeological and Historic Resources*

The Yucca Mountain FEIS identified direct and *indirect impacts* to archaeological and historic resources. Direct impacts would be those from ground disturbances or activities that destroyed or modified the integrity of archaeological or historic sites, and indirect impacts would result from activities that could increase the potential for intentional or unintentional adverse impacts (for example, increased human activity near resources could result in illicit collection or inadvertent destruction). The FEIS concluded that although there could be some indirect impacts, the overall effect of the proposed repository on the long-term preservation of archaeological and historic sites in the analyzed land withdrawal area would be beneficial. Limited access to and use of the area would protect archaeological and historic resources in most of the area from most *human intrusion*.

The Yucca Mountain FEIS recommended that 51 of the 830 archaeological and historic sites were eligible for inclusion in the *National Register of Historic Places*. In consultation with the Nevada State Historic Preservation Office, DOE has revised its recommendation to include 232 sites (DIRS 182189-Rhode 2007, all). The revised number reflects recent investigations for the U.S. Highway 95 access road and a reevaluation of the importance of obsidian artifacts. Recent studies suggest that obsidian artifacts can provide important information on prehistoric American Indian settlement systems. The large increase in the number of eligible archaeological sites since completion of the FEIS reflects this finding and includes extractive (for example, toolstone quarrying, hunting, and seed gathering) and processing (for example, animal butchering, milling plants, or cooking) localities where obsidian toolstone is present.

Potential impacts to National Register-eligible archaeological sites could occur from land disturbances due to construction. An evaluation by the Desert Research Institute identified 57 archaeological sites and 75 isolated artifacts (DIRS 182189-Rhode 2007, all) in the construction areas. Three of these 57 sites have been recommended for inclusion in the *National Register of Historic Places*. The National Register-eligible sites consist of two prehistoric temporary camps and one resource processing locality. Before construction began, DOE would avoid or mitigate impacts to archaeological and historic resources, so direct adverse impacts from construction and operation of the facilities would be small.

Improved access to the area could lead to indirect impacts from unauthorized excavation or collection of artifacts. DOE would mitigate these impacts through personnel training, archaeological and historic site monitoring, and long-term management. These measures would protect archaeological and historic resources from most human intrusions in the analyzed land withdrawal area. This added protection would result in a beneficial effect.

A draft programmatic agreement among DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Officer has been prepared for cultural resources management related to activities that would be associated with development of a repository at Yucca Mountain. While this

agreement is in ongoing negotiation among the concurring parties, DOE is abiding by the process set forth in Section 106 of the *National Historic Preservation Act of 1966* (16 U.S.C. 470 et seq.).

4.1.5.1.2 *American Indian Viewpoint*

In the Yucca Mountain FEIS, DOE summarized the American Indian view of resource management and preservation, which is holistic in its definition of cultural resources and incorporates all elements of the natural and physical environment in an interrelated context. In the FEIS, DOE committed to continue the Native American Interaction Program throughout implementation of the Proposed Action to enhance the protection of archaeological sites and cultural items important to American Indians. The FEIS reported that construction activities would have no direct impacts on several delineated American Indian sites, areas, and resources in or immediately adjacent to the analyzed land withdrawal area. However, because of the general level of importance that American Indians attribute to these places, which they believe are parts of an equally important integrated cultural landscape, American Indians consider the intrusive nature of the proposed repository to be a significant adverse impact to all elements of the natural and physical environment. Based on Tribal Update Meetings for members of the Consolidated Group of Tribes and Organizations held since the completion of the FEIS, the American Indian viewpoint is unchanged.

4.1.6 SOCIOECONOMIC IMPACTS

This section describes potential socioeconomic impacts from construction and operation of the proposed Yucca Mountain Repository. The analysis for the Yucca Mountain FEIS examined the potential for socioeconomic impacts in Clark, Lincoln, and Nye counties in southern Nevada. For this Repository SEIS, the region of influence consists of Clark and Nye counties (Chapter 3, Section 3.1.7).

Evaluations of the socioeconomic environment—in Nye County where the repository would be and in Clark County where most workers would live—considered changes to employment, population, three economic measures (real personal disposable income, spending by state and local government, and *Gross Regional Product*), housing, and some public services. The evaluation used the Regional Economic Models, Inc. (REMI) model, *Policy Insight*, Version 9, to estimate and project baseline socioeconomic conditions from 2005 to 2067 for employment and population changes that would be due to the Proposed Action. To present a more complete profile of potential impacts, DOE also examined a second residential distribution, where many of the workers would live in Nye County, and analyzed potential impacts to socioeconomic variables from the scenario. The alternative distribution includes an analysis of changes in employment, population, three economic measures, and demand for housing and some public services. Appendix A, Section A.4 contains the results of the analysis.

DOE developed baselines for Gross Regional Product, real disposable personal income, and spending by state and local governments for Clark and Nye counties and for the State of Nevada (DIRS 178610-Bland 2007, all). Chapter 3, Section 3.1.7 presents baseline information that describes the current socioeconomic environment in the region of influence. The potential for changes in the socioeconomic environment would be greatest in the Yucca Mountain region of influence where most of the repository workers would live. Although the analysis focused on regional impacts, DOE acknowledges that Clark County, which has 50 times as many people as Nye County, dominates the region and often obscures impacts in Nye County. DOE has noted when the impact in Nye County would differ meaningfully from regional impacts.

DOE examined the employment that would be necessary for construction and operation of a repository. The Yucca Mountain FEIS analysis projected baseline population and employment in the region of influence to 2035. For this Repository SEIS analysis, DOE included anticipated incremental changes above and below the employment and population projections to 2067 that could result from the Proposed Action. In addition, this section provides estimates and projections through 2067 of baseline values for several economic parameters and estimates of incremental changes attributable to the construction and operation of the proposed repository above and below the baselines for Clark and Nye counties and the State of Nevada.

Socioeconomic impacts described in this Repository SEIS would vary from impacts DOE identified in the Yucca Mountain FEIS because of different underlying assumptions. For the FEIS, the data for analysis of the potential impacts to socioeconomic variables, all of which would be driven by changes in the number of jobs, were based on the employment levels of construction and operations workers assigned to the proposed repository site. That analysis did not include other project jobs, engineering and project safety for example, because those jobs would be off the site, primarily in the Las Vegas area.

The analysis for this Repository SEIS included present and projected offsite workers as well as onsite workers. In addition, estimated worker requirements in this document are specific to the modified repository design and operational plans, while the Yucca Mountain FEIS considered several operating modes and, to bound the evaluation, based potential impacts on the mode that would require the greatest number of workers. The analysis used updated baselines for the evaluated socioeconomic variables. As a result of the refined data, potential impacts to Gross Regional Product, real disposable personal income, spending by state and local governments, housing, and public services from changes in employment and population would be smaller than the impacts the FEIS reported.

4.1.6.1 Socioeconomic Impacts from Construction and Operations

4.1.6.1.1 *Impacts to Employment*

Surface and subsurface construction would begin in 2012. DOE would scale back surface construction in 2016 as emplacement began (in 2017). Subsurface construction would begin in 2012, escalate in 2018, moderate at approximately 170 employees by 2026, and continue until 2042. The number of employees for subsurface construction would be considerably fewer than the number of workers for surface construction. In 2014, the peak year of *direct employment* during the initial construction analytical period, DOE would employ about 2,590 workers (which would represent about 1,090 newly created jobs) for the Proposed Action. About 1,860 of these workers would be employed on the site and 730 workers would work off the site, primarily in the Las Vegas area. Construction workers would include skilled craft workers and professional and technical support personnel (engineering, safety analysis, safety and health, and other field personnel). Onsite employment during construction would peak in 2016 with about

EMPLOYMENT TERMS

Direct Employment:
Jobs that are expressly associated with project activity.

Indirect Employment:
Jobs that are created as a result of expenditures by directly employed project workers (for example, restaurant workers or childcare providers) or jobs that are created by project-related purchases of goods and services (for example, sales manager of a concrete supply store).

Composite Employment:
Sum of direct and indirect employment.

1,920 workers as DOE transferred offsite positions and responsibilities from Clark County sites to the repository in Nye County.

Figure 4-5 shows composite (direct and indirect) employment changes due to construction activities under the Proposed Action by county of residence. Incremental employment increases during the construction analytical period would peak in 2014 with the addition of about 1,000 jobs in the region of influence (about 690 in Clark County and 310 in Nye County). The number of additional jobs in the region of influence would be virtually identical to the number of additional jobs in the State of Nevada because the direct jobs would be confined to Clark and Nye counties, where DOE assumed all workers would reside, and thus new indirect jobs would probably be in the same jurisdictions. The change in the number of new jobs would be less than the number of onsite jobs because some of those would be filled by construction workers who had completed another assignment and some would be filled by individuals who joined the construction industry from another field and were, therefore, part of the baseline employment estimates. Not all project-related jobs would require that individuals move into the region of influence. Employment in the construction industry is constantly in flux and assignments begin and end in a relatively short period, so workers already in the region would fill some repository jobs. The number of onsite jobs would increase as the number of offsite professional and technical positions decreased. The dynamics of the economies in each county and the number of directly employed workers who lived in each county would influence the numbers and locations of indirect jobs. The Proposed Action would increase overall employment in the region of influence from the projected baseline (employment without the repository project) of approximately 1,329,000 jobs to slightly less than 1,330,000 positions—a regional change ofapproximately 0.08 percent, but 1.5 percent in Nye County. These changes would be small. REMI

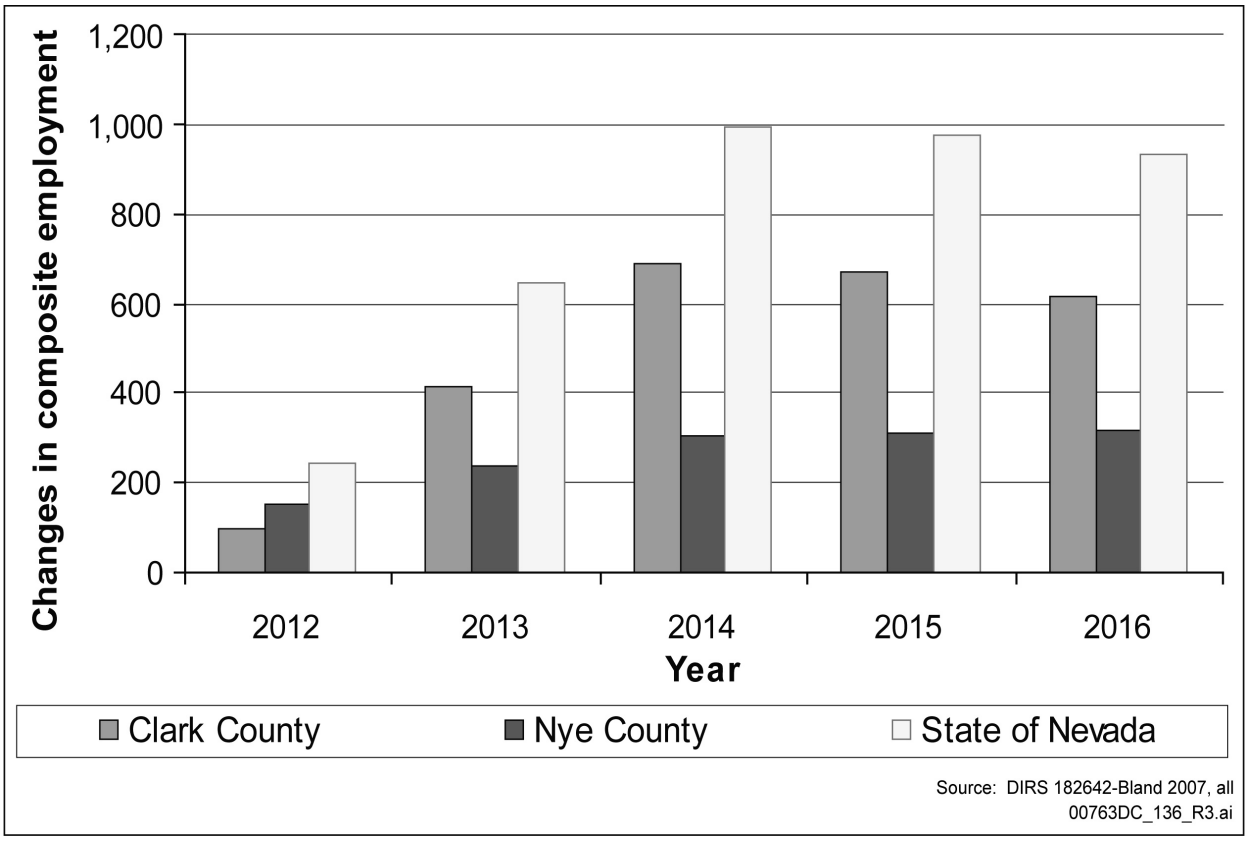

Figure 4-5. Increases in composite regional and State of Nevada employment during construction.

uses historical patterns of spending and in-migration to predict changes. Table 4-9 summarizes peak construction year changes in direct employment by county of worker residence.

Table 4-9. Expected peak construction year (2014) changes in direct employment by county of worker residence.

Area	Employees[a]
Clark County	758
Nye County	328
Region of Influence	1,090

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to three significant figures.
a. Excludes 216 current onsite workers and 1,286 offsite workers.

Table 4-10 lists the expected distribution of project job locations during the initial construction analytical period. Chapter 3, Section 3.1.7 discusses residential distribution patterns of Yucca Mountain Project workers. Emplacement would begin in 2017. Although subsurface construction would continue until about 2042, this Repository SEIS refers to the period from 2017 to 2067 as the operations analytical period. Emplacement activities could continue for up to 50 years from the beginning of emplacement in 2017 until 2067.

Table 4-10. Repository direct employment during the initial construction analytical period by county of job location.[a]

Area	2012	2013	2014	2015	2016
Clark County (offsite)	709	711	730	648	589
Nye County (onsite)	1,010	1,480	1,860	1,900	1,920
Total project employment	1,720	2,200	2,590	2,550	2,510

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to three significant figures; therefore, totals might differ from sums.
a. Includes current positions.

Direct operations peak employment would occur in 2019 when repository operations would require about 2,690 workers. About 2,070 of these workers would be on the site, and the remaining 620 would work in the Las Vegas area. Project-related direct employment would range from 2,600 to 2,300 from 2017 to 2024, then range from 2,300 to 2,000 until 2040. Employment levels from 2041 to 2067 would be essentially stable at about 700 workers (DIRS 182205-Bland 2007, all).

Table 4-11 lists the expected distribution of changes in regional employment in the peak year of employment (2021) during the operations analytical period. The table lists the estimated number of repository-induced jobs in Clark and Nye counties and in Nevada in 2021. Employment in the region of influence would peak with approximately 1,300 workers. The employment baselines in Clark and Nye counties have grown rapidly since completion of the Yucca Mountain FEIS. New indirect jobs result from new direct jobs unless there is some capacity of existing business to meet the increased demand for goods and services. The region, especially Clark County, probably has sufficient excess capacity and impacts would be spread over a number of communities in Clark County, such that the number of indirect jobs would be lower. This would result in a small incremental increase of regional employment from the estimated baseline of about 1,425,000 jobs to about 1,426,000 jobs, a change of less than 0.1 percent from the estimated employment baseline for 2021.

Table 4-11. Expected peak year (2021) increases in the operations analytical period composite employment in the region and in the State of Nevada.

Area	Employees	Percent change
Clark County	861	0.06
Nye County	437	2.0
Total increase in jobs in region of influence	1,300	0.09
State of Nevada	1,300	0.07

Note: Numbers are rounded to three significant figures; therefore, totals might differ from sums.
Source: DIRS 182642-Bland 2007, all.

Table 4-12 summarizes direct repository employment from 2017 to 2067 by expected county of job location. Figure 4-6 shows changes in regional employment for Clark and Nye counties and for the State of Nevada. Beginning in 2042, the rate of employment growth in the region would slow as the need for

Table 4-12. Repository direct employment[a] during the operations analytical period by county of job location, 2017 to 2067.

Area	2017	2020	2025	2030	2045	2067
Clark County (offsite)	572	585	470	470	144	108
Nye County (onsite)	1,940	2,000	1,820	1,800	562	421
State of Nevada	2,510	2,590	2,290	2,270	706	529

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to three significant figures.
a. Includes current positions.

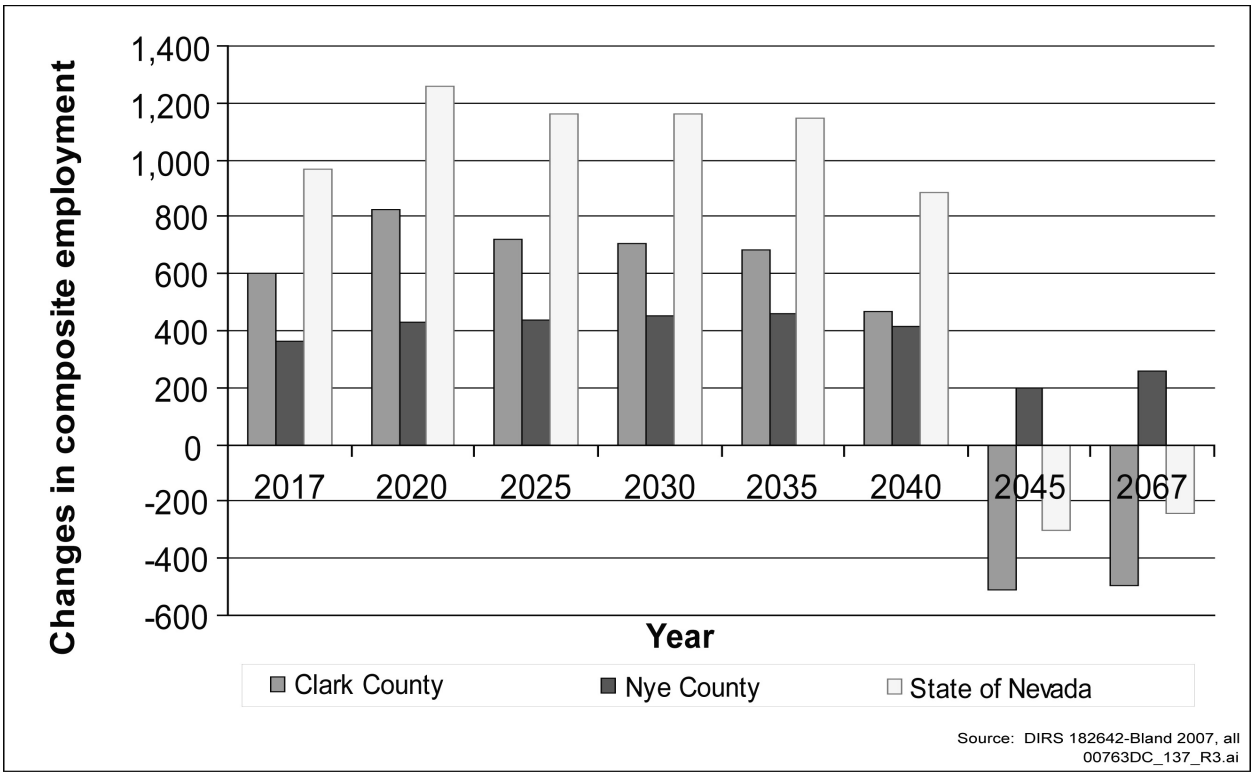

Figure 4-6. Changes in composite regional employment from repository operations activities in the region and in Nevada.

repository workers dropped. The growth would slow by about 148 jobs in 2042, to about 312 jobs in 2045, and would continue slowing by about 230 jobs through 2067. Given the expected economic growth in the region of influence, the region could readily absorb declines in repository employment as subsurface construction and emplacement activities ended. The Yucca Mountain Project would continue to contribute positively to the economy, but losses of offsite jobs would result in the slower growth of jobs in the region. Impacts to regional employment, employment in Clark County and Nevada from repository-related construction and operations would be small, less than 1 percent. Impacts in Nye County would be greater, but not more than 2 percent of the baseline.

4.1.6.1.2 *Impacts to Population*

DOE based assumptions about future residential *distribution* on worker preferences consistent with historical preferences (Chapter 3, Section 3.1.7). Historical patterns of behavior, including choice of preferred county of residence, might not be an accurate barometer of future trends because of the uncertainties in prediction of human behavior. The analysis based estimates of impacts to socioeconomic variables in the region on the assumption that 80 percent of the workers at the site would live in Clark County and 20 percent would live in Nye County. DOE assumed those persons working in Clark County would live in Clark County.

The analysis projected that regional population would grow from about 2,480,000 residents in 2012 to approximately 5,130,000 in 2067 (DIRS 178610-Bland 2007, all). The peak year (2035) population contribution in the region of influence attributable to the repository would be approximately 2,280 people, or about 0.06 percent of the estimated population baseline of 3,630,000 people (DIRS 178610-Bland 2007, all). In general, increases in population occur several years after increases in employment because some workers delay relocation. Clark County would experience the peak increase in population in 2034, and Nye County would experience a peak in 2039. This phenomenon would be largely because Clark County has such a large labor pool, and most project workers and family members would already live there and would not in-migrate to the county. Because the labor force is smaller in Nye County, many project workers or workers who filled the new indirect jobs and who lived in Nye County would represent a new household in the county. The increase in population would represent a small increase, about 1.2 percent of the county's baseline population in 2039. The Proposed Action would have only small effects on population growth in the region of influence. Figure 4-7 shows the projected population increases from the repository project for Clark and Nye counties and the State of Nevada. Prediction of specific residential preferences for one community over another in a county is inexact, so the estimated and projected residential distribution patterns are at the county and state levels rather than the community level.

Table 4-13 lists estimated incremental population increases that would result from repository activities. The incremental peak population increase in Clark County would be about 0.04 percent. Population growth from repository activities would be more evident in Nye County. The county's population increase would be approximately 1.2 percent of the projected population of 84,000 (DIRS 178610-Bland 2007, all) for the county in 2035, which would be the peak period for potential repository population impacts.

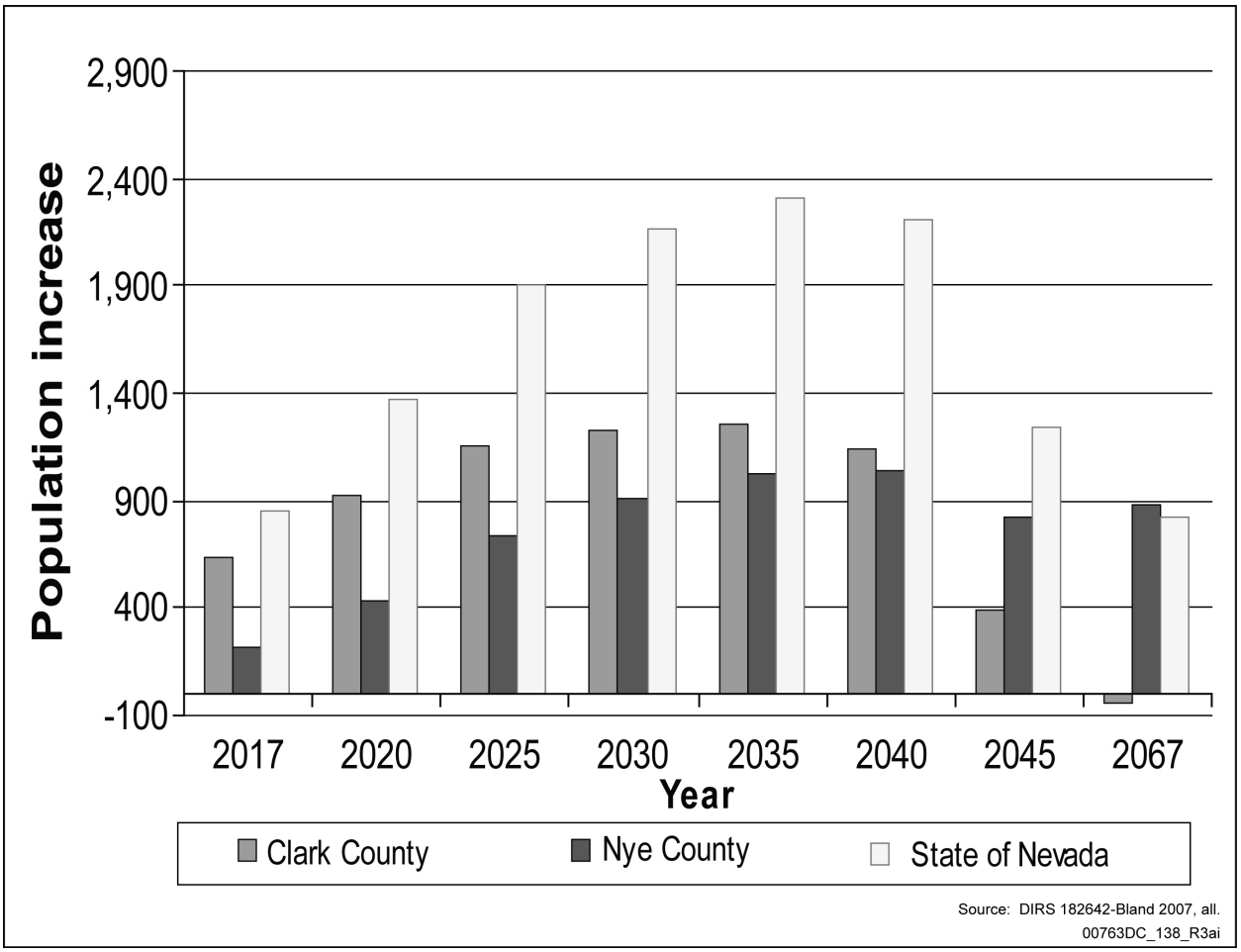

Figure 4-7. Regional population increases from operations, 2017 to 2067.

The estimated changes in population from repository activities would be small in Clark and Nye counties. The workers' choices of place of residence would have a large influence on population increases above the projected baselines. To present a more complete profile of potential impacts, DOE examined a residential distribution where many of the repository workers would live in Nye County. Appendix A, Section A.4 contains the results of that analysis.

Table 4-13. Estimated population increase in Clark County, Nye County, and the State of Nevada from the Proposed Action (2035.

Area	Total population[a]
Clark County	1,260
Nye County	1,020
State of Nevada[b]	2,310

Source: DIRS 182642-Bland 2007, all.
a. Numbers are rounded to three significant figures.
b. Includes population outside of the region of influence.

4.1.6.1.3 *Impacts to Economic Measures*

Table 4-14 lists estimated changes in economic measures that would result from repository activities during the construction analytical period (values are in 2006 dollars). Repository-induced impacts measured by these economic variables would essentially be confined to the region of influence and, therefore, would be the same for the State of Nevada. Increases in real disposable personal income in the

Table 4-14. Increases in economic measures in Clark County, Nye County, and the State of Nevada from repository construction, 2012 to 2016 (millions of 2006 dollars).

Area	2012	2013	2014	2015	2016
Clark County					
State and local government spending	0.2	0.6	1.2	1.8	2.3
Real disposable personal income	4.2	23.9	41.7	40.5	38.4
Gross Regional Product	6.2	33.3	58.9	58.3	54.9
Nye County					
State and local government spending	0.1	0.2	0.4	0.5	0.7
Real disposable personal income	7.6	12.2	16	16.6	17.1
Gross Regional Product	10	16.1	21.6	20.8	22.7
State of Nevada					
State and local government spending	0.3	0.8	1.7	2.4	3
Real disposable personal income	12	36.5	58.3	57.8	56.1
Gross Regional Product	16.2	49.3	80.3	79.1	77.6

Source: DIRS 182642-Bland 2007, all.

region of influence would peak in 2014 with an increase of about $57.8 million or $41.7 million, or 0.05 percent in Clark County and $16.0 million, or 1.1 percent in Nye County. Increases in Gross Regional Product would also peak in 2014 at about $80.5 million. About $58.9 million or 0.05 percent of the change in Gross Regional Project would happen in Clark County. The impact in Nye County would be 1.4 percent above the baseline or $21.6 million. Regional expenditures by the State of Nevada and local governments, which include school districts, would peak at $3 million in 2016. Clark County expenditures would account for $2.3 million of the change in spending. The change in both counties would be less than 0.03 percent. Economic measures for the region of influence would increase by less than 0.1 percent over the projected baseline (estimated economic measures without the repository project).

GROSS REGIONAL PRODUCT

The value of all final goods and services produced in the region of influence.

Table 4-15 lists the changes in economic measures, for representative years that would result from the repository project during the operations analytical period. Increases in Gross Regional Product would peak in 2034 at about $98.7 million, or 0.05 percent in Clark County and $68.9 million, or a small 2.7 percent above the baseline in Nye County for a total of $168 million. Increases in regional real disposable personal income would also peak in 2034 at $85.7 million. Clark County would experience a 0.05-percent increase of $58.3 million and Nye County would experience about $27.4 million, or a 1.3-percent increase.

Increases in regional expenditures by state and local government would peak in 2035 at about $10.7 million. Most of the incremental spending would occur in Clark County, about $5.7 million, which would be a small increase of 0.04 percent. Spending in Nye County would be about $5 million or 1.3 percent of the baseline. The impacts in Nye County would be proportionately greater because the repository would be in Nye County. Economic activity, which would include incidental spending by workers who lived in Clark County but worked in Nye County, would be responsible for this phenomenon. In addition, Nye County would experience many indirect jobs with consequent income and taxes. Economic measures for the region of influence would increase by less than 0.1 percent over the projected baseline. Impacts in the State of Nevada and the region of influence would be essentially the same because changes from economic baselines would be driven largely by changes in employment and population, and those changes would occur almost exclusively in Clark and Nye counties.

Table 4-15. Changes in economic measures in Clark County, Nye County, and the State of Nevada from emplacement activities, 2017 to 2067 (millions of 2006 dollars).

Area	2017	2020	2025	2030	2035	2045	2067
Clark County							
State and local government spending	3.0	4.0	5.0	5.0	5.7	2.0	0.0
Real disposable personal income	40.0	57.0	53.0	55.0	56.2	-34.0	-38.0
Gross Regional Product	58.0	89.0	87.0	92.0	95.0	-92.0	-105.0
Nye County							
State and local government spending	1.0	2.0	3.0	4.0	5.0	4.0	4.0
Real disposable personal income	18.0	21.0	23.0	25.0	27.5	16.0	23.0
Gross Regional Product	34.0	47.0	57.0	63.0	68.8	31.0	42.0
State of Nevada							
State and local government spending	4.0	6.0	8.0	10.0	10.9	6.0	4.0
Real disposable personal income	59.0	79.0	77.0	81.0	84.9	-16.0	-15.0
Gross Regional Product	91.0	136.0	144.0	155.0	164.3	-60.0	-64.0

Source: DIRS 182642-Bland 2007, all.

4.1.6.1.4 *Impacts to Housing*

Given the size of the projected regional employment, the number of workers who would in-migrate to work on the repository would be relatively small. Because the in-migration would be small, the increased demand for housing would be small. Because the maximum change above the population baselines would be so small in Clark County (about 1,260 persons) and in Nye County (about 1,050 persons), demands on the regional housing inventory should be similarly small. In general, housing stock increases at approximately the same ratio as the population. Impacts to housing would be minimal because (1) the expected increase in regional population would be small, (2) the demand would primarily be in metropolitan Clark County, (3) there are no municipal or state growth control measures that limit housing development, and (4) the region of influence has an adequate supply of undeveloped land to meet expected future demands.

Impacts to housing would be more pronounced in Nye County, particularly in Pahrump. Because Nye County and Pahrump have recently experienced rapid and largely unanticipated growth, the county has a limited housing inventory to absorb new workers and worker families. Much of the infrastructure to support housing development is at capacity.

During the late 1990s and early 21st century, the Bureau of Land Management sold approximately 13,500 acres of public land within a specific boundary around Las Vegas. Much of the land was sold to the private sector, and particularly to developers of large master-planned communities. These additional lands have helped to accommodate population growth in the greater Las Vegas area. Nye County has also acquired land to facilitate and accommodate the orderly development of land uses that repository activities could trigger.

DOE analyzed potential impacts to housing at the county level. The Department did not attempt to predict incremental housing demand at the community level because housing preferences (mobile home, modular assembly, stick-built), density or cluster choices (single family, multifamily), and desired lot sizes are difficult to predict. Because the incremental increase in population from repository-related activities would occur over a long period and be more predictable, the private sector housing market could readily adapt. In addition, given the very large housing inventory in the region, the region's baseline growth would mask the changes that were due to the repository.

4.1.6.1.5 *Impacts to Public Services*

Repository-generated impacts to public services such as schools, public safety, and medical services in the region of influence from population changes attributable to construction and operation of the repository would be small. Population changes from repository-related employment would be a small fraction of the anticipated population growth in the region. Even without the addition of repository jobs, the annual regional growth rate would increase by an estimated 1.4 percent through 2050, which would minimize the need to alter plans already in place to accommodate projected growth. As mentioned above, the majority of in-migrating workers would probably live in the many communities of metropolitan Clark County, thereby dispersing the increased demand for public services.

Southern Nye County, particularly Pahrump, would experience an increased demand for public services. However, because the anticipated increases over the baseline population in the county would be small and would occur incrementally over a long period, the county might be able to absorb increased demands in education, law enforcement, and fire protection (public safety) as the local government expanded the levels of these services to accommodate the anticipated non-repository-related growth. The county and communities in the county would continue to provide services as the revenue base grew. Although these public services are currently at capacity, it is uncertain what the infrastructure capacity would be as repository operation began or when the repository-related population increase reached its peak in 2039 with about 1,050 residents or a small increase of 1.2 percent above the baseline. Repository-related population increases in Nye County would be less than 1.3 percent during the entire construction and operations analytical periods. DOE facilities have historically had cooperative agreements with local governments for mutual aid and support of emergency services. If DOE implemented such an agreement in conjunction with the Proposed Action, strains on regional emergency services infrastructure would be reduced. Repository-generated impacts to public services such as education and public safety could require mitigation because the current structure for the generation of local government revenues, primarily from property taxes, would not support the expanded level of services that additional residents would require. The recently opened hospital in Pahrump and the ample services in the metropolitan Las Vegas area could serve to alleviate the scarcity of medical services in Nye County.

4.1.6.2 Summary of Socioeconomic Impacts

For all five socioeconomic parameters that DOE evaluated over the construction and operations analytical periods, the regional impacts would be small, less than 1 percent of the baselines. The operations period would result in higher impacts to employment, population, Gross Regional Product, real disposable personal income, and state and local government spending. Changes in regional employment, which would include direct and indirect workers, would peak in 2021. The increase of about 1,300 workers would represent a 0.09-percent increase above the projected baseline for that year. Gross Regional Product would peak in 2034 because of consumption of goods and services due to construction activities. The estimated increase in Gross Regional Product for 2034 would be about $168 million in 2006 dollars or 0.08 percent of the baseline. Population increases from increased employment opportunities would peak in 2035 at about 2,280 or 0.06 percent of the baseline for that year. Government spending would also peak in 2035 at an increase of $10.7 million or 0.07 percent of the baseline. Real disposable personal income would be highest during the operations period and would peak in 2034 at $85.7 million or 0.07 percent more than the baseline. The regional impacts as measured by all five parameters would be small in all years, as they would be in Clark County. The impacts would be greater, but still small, in Nye County. As a percentage, the greatest population impact would be 1.2 percent in 2034 or 2035, and

employment impacts would reach 2.0 percent in 2021. Spending by local government would peak at 1.3 percent in 2019, and real disposal personal income would increase by 1.4 percent in 2019. The Nye County Gross Regional Product would increase by 2.8 percent in 2023.

4.1.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY IMPACTS

This section describes potential health and safety impacts to workers (occupational impacts) and to members of the public (public impacts) from construction, operations, monitoring, and eventual closure of the proposed repository. Members of the public would be outside the land withdrawal area. The analysis estimated occupational health and safety impacts separately for involved and non*involved workers* for each repository analytical period—construction, operations, monitoring, and closure. Involved workers would be craft and operations personnel who were directly involved in facility construction and operation activities, which would include excavation; receipt, handling, packaging, aging, and emplacement of spent nuclear fuel and high-level radioactive waste; monitoring of the conditions and performance of the waste packages; and closure. Noninvolved workers would be managerial, technical, supervisory, and administrative personnel who would not be directly involved in those activities.

CONCEPT OF INVOLVED AND NONINVOLVED WORKERS

Nonradiological Impacts:

Involved workers would be those doing the physical work of constructing, operating, monitoring, and closing the repository.

Noninvolved workers would be managerial, technical, supervisory, and administrative personnel onsite.

There would be no nonradiological impacts to DOE workers at the Nevada Test Site.

Radiological Impacts:

Involved workers would be those directly engaged in developing subsurface facilities during the construction and operations analytical periods and spent nuclear fuel and high-level radioactive waste processing, emplacement and maintenance during operating, monitoring, and closing the repository.

Noninvolved workers would be managerial, technical, supervisory, and administrative personnel on the site and workers engaged in surface construction during the construction analytical period and the first several years of repository operations, when surface and subsurface construction and operations would proceed in parallel.

DOE workers at the Nevada Test Site were treated separately as a noninvolved worker population.

This section summarizes, incorporates by reference, and updates as necessary Section 4.1.7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-48 to 4-63). Potential health and safety impacts to repository workers would include those from industrial hazards common to the workplace, from exposure to naturally occurring and manmade radiation and radioactive materials in the workplace, and from exposure to naturally occurring nonradioactive airborne hazardous materials. Members of the public could be exposed to airborne releases of naturally occurring and manmade *radionuclides* and naturally occurring hazardous materials. The analysis based estimates of public health impacts from nonradioactive sources on the air quality information in Section 4.1.2.

4.1.7.1 Nonradiological Impacts

4.1.7.1.1 *Impacts to Occupational and Public Health and Safety During Construction*

This section describes estimates of nonradiological health and safety impacts to repository workers and members of the public for the 5-year construction analytical period. Activities would include site preparation, infrastructure construction, construction of surface facilities, and initial construction of subsurface facilities. Potential health and safety impacts to workers could occur from industrial hazards, exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain, and unexploded ordnance. Potential health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials (cristobalite and erionite) and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The Repository SEIS analysis estimated health and safety impacts to workers from industrial hazards using the same method as the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-50). The Computerized Accident/Incident Reporting System (CAIRS) database provided industrial accident statistics from DOE experience with activities similar to those proposed for repository construction (DIRS 182198-DOE 2007, all; DIRS 182199-DOE 2007, all). DOE uses CAIRS to collect and analyze reports of injuries, illnesses, and other accidents that occur during its operations. Information from the database included two impact categories—*total recordable cases*; and Days Away, Restricted, or On Job Transfer cases. The latter category is equivalent to the U.S. Department of Labor Bureau of Labor Statistics *lost workday cases* category.

INDUSTRIAL HAZARDS TERMINOLOGY

Total Recordable Cases:
The total number of work-related deaths, illnesses, or injuries that resulted in the loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid (DIRS 182204-DOE 2004, all).

Lost Workday Case:
A case that involves days away from work or days of restricted work activity, or both. Equivalent to Days Away, Restricted, or On Job Transfer case in CAIRS (DIRS 182204-DOE 2004, all).

Fatality:
Any death that results from workplace activities.

Full-Time Equivalent Worker Years:
The number of employees who would be involved in an activity calculated from work hours. Each full-time equivalent worker year consists of 2,000 work hours (the number of hours DOE assumed for one worker in a normal work year).

CAIRS provides total *recordable cases* and lost workday cases incidence rates per 100 full-time equivalent worker years and provides fatality statistics used to calculate fatality incidence rates per 100,000 worker years. Table 4-16 lists the incident rates for involved construction workers and noninvolved workers at DOE facilities from the past 5 years. To estimate impacts to workers from industrial hazards, DOE multiplied those rates by the number of full-time worker years during the construction analytical period for the proposed repository and divided the results by 100. The statistics for noninvolved workers are from the Government and Service Operation categories. CAIRS contains no

Table 4-16. Health and safety statistics for estimation of occupational safety impacts for involved and noninvolved construction workers.[a]

Worker type	Rate of total recordable cases per 100 FTEs	Rate of lost workday cases per 100 FTEs[b]
Involved worker	2.0	0.86
Noninvolved worker	1.5	0.69

Note: Numbers are rounded to two significant figures.
a. Construction worker statistics from 2002 to 2006 from CAIRS (DIRS 182199-DOE 2007, all).
b. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.
FTE = Full-time equivalent worker year.

involved construction worker and 1 noninvolved worker fatality at DOE facilities during the past 5 years. The fatality rate for noninvolved workers was calculated as 0.55 per 100,000 full-time equivalent worker years. To be conservative, the analysis used the fatality rate of 0.55 per 100,000 full-time equivalent worker years to estimate worker fatalities from industrial hazards for both involved and noninvolved workers. For comparison, there have been no reported fatalities as a result of workplace activities forthe Yucca Mountain Project. Table 4-17 lists the estimated numbers of full-time equivalent worker years during the construction analytical period for involved and noninvolved workers. Table 4-18 lists the estimated impacts to workers for the construction period from industrial hazards.

Table 4-17. Estimated full-time equivalent worker years during the construction analytical period.

Worker group		Number
Involved workers[a]	Surface construction	5,500
	Subsurface construction	340
	Involved workers total	5,800
Noninvolved workers[a]	Noninvolved workers total	2,200

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Workers at site; does not include employees in Las Vegas offices.

Table 4-18. Impacts to workers from industrial hazards during the construction analytical period.

Worker group	Impact category	Number
Involved workers	Total recordable cases	120
	Lost workday cases[a]	50
	Fatalities	0.032
Noninvolved workers	Total recordable cases	34
	Lost workday cases[a]	15
	Fatalities	0.012
All workers (totals)	Total recordable cases	150
	Lost workday cases[a]	66
	Fatalities	0.044

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.

Naturally Occurring Hazardous Materials. Workers at the Yucca Mountain site could encounter two types of naturally occurring hazardous materials—cristobalite, a form of crystalline silica (silica dioxide), and erionite, a naturally occurring zeolite. Both have the potential to become airborne during repository excavation and tunneling operations, or the excavated rock pile could release them as dust. Cristobalite is in the *welded tuff* at the repository level and makes up between 18 and 28 percent of the tuff mineral content (DIRS 104523-CRWMS M&O 1999, p. 4-81). Erionite is an uncommon zeolite mineral that forms wool-like fibrous masses and occurs in rock layers below the proposed repository level. Based on

geologic studies to characterize the repository horizon, most repository operations should not disturb erionite because it appears to be absent or rare at the repository level (Chapter 3, Section 3.1.8.3). Erionite could become a hazard during vertical boring operations if the operations passed through an erionite-bearing rock layer (which would be unlikely). Appendix F, Section F.1.2 of the Yucca Mountain FEIS contains more detail on the potential hazards of these minerals (DIRS 155970-DOE 2002, pp. F-12 to F-14).

DOE would use engineering controls (as part of best management practices) during subsurface work to control exposures of workers to silica dust. These controls would include the use of dust shields and air curtains on tunnel boring machines, water sprays and atomizing nozzles, isolated work areas, air stream scrubbing, and provision of fresh air to work areas through duct lines. In addition, DOE would design and operate the ventilation system to control *ambient air* velocities to minimize dust *resuspension*. The Department would monitor the work environment to ensure that dust concentrations did not exceed the applicable limits for cristobalite. If engineering controls were unable to maintain dust concentrations below the limits, DOE would use administrative controls such as access restrictions or respiratory protection until the engineering controls could establish acceptable conditions. The Department would apply similar controls, if necessary, for surface workers. DOE anticipates that exposure of workers to silica dust would be below the applicable limits and potential impacts to subsurface and surface workers would be small.

The engineering controls for exposure to silica dust would apply to potential exposure to erionite. DOE does not expect to encounter erionite layers at the proposed repository depth and location. If there was an erionite encounter, DOE would seal off the area and evaluate remediation methods to eliminate worker exposure throughout the repository tunnels.

Unexploded Ordnance. There have been U.S. Air Force and other military training activities in the region in the past. Portions of the construction area could have unexploded ordnance in surface locations. Unexploded ordnance could include shell casings, projectiles, or fragments, as well as live small arms ammunition, bombs, and rockets. DOE would coordinate with the Air Force about construction activities and would follow standard and established procedures for unexploded ordnance. An unexploded ordnance specialist would develop a plan, including evaluation of potential types of unexploded ordnance, depths, and other factors. Unexploded ordnance technicians would screen areas where there was a potential for unexploded ordnance before construction crews began work.

Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.1 presents estimated annual maximum concentrations of cristobalite at the boundary of the analyzed land withdrawal area where exposures to members of the public could occur during the construction analytical period. There are no regulatory limits for public exposure to cristobalite. An EPA health assessment (DIRS 103243-EPA 1996, p. 1-5) stated that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 micrograms per cubic meter multiplied by the number of years of exposure. The analysis established a benchmark annual average concentration of 10 micrograms per cubic meter over a 70-year lifetime. The estimated cristobalite concentrations at the boundary of the land withdrawal area would be about 0.048 microgram per cubic meter. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower. Health impacts would be unlikely.

Criteria Pollutants. Section 4.1.2.1 presents estimated maximum concentrations of criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter) at the boundary of the analyzed land withdrawal area where exposures to members of the public could occur during the construction analytical period. (As Section 4.1.2 describes, the maximum air concentration from repository activities could occur at different locations along the boundary of the land withdrawal area dependent on the release period and the averaging time of a particular criteria pollutant. The maximally exposed individual would be the person at the location with the highest concentration per release period and averaging time.) The analysis estimated that concentrations would be less than 1 percent of the regulatory limits for all criteria pollutants except particulate matter. $PM_{2.5}$ could have a maximum concentration of about 1 percent of the 24-hour regulatory limit, and PM_{10} could have a maximum concentration of about 60 percent of the 24-hour regulatory limit. Although DOE would use dust suppression measures to reduce the PM_{10} concentration, the impact analysis did not consider such measures. Health impacts to the public would be small.

4.1.7.1.2 *Impacts to Occupational and Public Health and Safety During Operations*

This section describes potential health and safety impacts to workers and members of the public during the operations analytical period. For analytical purposes, this period would begin with receipt of a license amendment to receive and possess spent nuclear fuel and high-level radioactive waste and would include waste receipt, handling, aging, emplacement, and monitoring. Subsurface development and surface facility construction would continue during the period. The operations analytical period would last up to 50 years and would end with emplacement of the last waste package. Potential health and safety impacts to workers could occur from industrial hazards and exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain. Potential health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The analysis used the method DOE established in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-54 and 4-55) to estimate health and safety impacts to workers from industrial hazards. Table 4-19 lists the estimated number of full-time equivalent worker years during the operations analytical period.

Table 4-19. Estimated onsite full-time equivalent worker years during the operations analytical period.

	Worker group	Number
Involved workers[a]	Surface construction	2,700
	Subsurface construction	4,300
	Emplacement operations	12,000
	Emplacement operations: Maintenance	4,900
	Involved worker total	23,000
Noninvolved workers[a]	Noninvolved workers total	36,000

Source: DIRS 182205-Bland 2007, all.
Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Workers at site; does not include employees in Las Vegas offices.

The incident rates for involved construction workers (which would include subsurface development workers) and noninvolved workers during the operations analytical period would be identical to the incident rates for the construction analytical period (Table 4-16). Table 4-20 lists the incident rates for involved workers who would be engaged in operations activities during the remainder of the operations

Table 4-20. Health and safety statistics for estimation of occupational safety impacts common to the workplace for operations analytical period involved workers.a

Rate of total recordable cases per 100 FTEs	Rate of lost workday cases per 100 FTEs[b]
1.4	0.58

Note: Numbers are rounded to two significant figures.
a. Statistics from 2002 to 2006 for activities at Savannah River Site, Idaho National Laboratory, and Oak Ridge National Laboratory from CAIRS (DIRS 182198-DOE 2007, all).
b. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.
FTE = Full-time equivalent worker year.

period. The rates are statistics from similar activities at DOE facilities (Savannah River Site, Idaho National Laboratory, and Oak Ridge National Laboratory) for 2002 through 2006. No fatalities were recorded at the three DOE facilities during the 5-year reporting period. Therefore, to be conservative, DOE used the fatality rate of 0.55 per 100,000 full-time equivalent worker years that it used for repository construction. Table 4-21 lists the estimated industrial hazards impacts to workers for the operations period.

Table 4-21. Impacts to workers from industrial hazards during the operations analytical period.

Worker group		Impact category	Number
Involved workers	Surface construction	Total recordable cases	53
		Lost workday cases[a]	23
		Fatalities[b]	0.015
	Subsurface construction	Total recordable cases	87
		Lost workday cases[a]	37
		Fatalities[b]	0.024
	Emplacement operations	Total recordable cases	160
		Lost workday cases[a]	67
		Fatalities[b]	0.064
	Emplacement operations: Maintenance	Total recordable cases	68
		Lost workday cases[a]	28
		Fatalities[b]	0.027
Noninvolved workers		Total recordable cases	540
		Lost workday cases[a]	250
		Fatalities[b]	0.20
All workers (totals)		Total recordable cases	910
		Lost workday cases[a]	400
		Fatalities[b]	0.33

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.
b. Fatality impacts based on fatality rate from Section 4.1.7.1.1.

Naturally Occurring Hazardous Materials. As Section 4.1.7.1.1 discusses for the construction analytical period, cristobalite and erionite have the potential to become airborne during continuing repository excavation and as fugitive dust from the excavated rock pile. DOE would use engineering controls and, if necessary, administrative measures to control and minimize impacts to workers from releases of cristobalite and erionite during the operations analytical period. Impacts would be small.

Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.2 presents estimated annual maximum concentrations of cristobalite at the boundary of the analyzed land withdrawal area where exposures to members of the public could occur during the operations analytical period. The analysis estimated concentrations of cristobalite of about 0.002 microgram per cubic meter. This would be about 0.02 percent of the benchmark concentration of 10 micrograms per cubic meter. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower at locations of public exposure.

Criteria Pollutants. Section 4.1.2.2 presents estimated maximum concentrations of criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter) at the boundary of the land withdrawal area where exposures to members of the public could occur during the operations analytical period. The analysis estimated that concentrations would be less than 2 percent of the regulatory limit for all criteria pollutants except particulate matter. $PM_{2.5}$ would have a maximum concentration of less than 3 percent of the 24-hour regulatory limit, and PM_{10} would have a maximum concentration of less than 9 percent of the 24-hour regulatory limit. Health impacts to the public would be unlikely.

4.1.7.1.3 *Impacts to Occupational and Public Health and Safety During Monitoring*

This section describes estimated health and safety impacts to workers and members of the public during the monitoring analytical period. For analytical purposes, this period would begin with the emplacement of the final waste package and would continue for 50 years. Activities during this period would include ventilation maintenance; remote inspection of waste packages; retrieval, if necessary, of waste packages to correct detected problems; and investigations to support predictions of postclosure repository performance. Health and safety impacts to workers could occur from industrial hazards and exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain. Health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The analysis conservatively assumed that health and safety impacts for the monitoring analytical period would be similar to those in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Table 4-27, p. 4-57) even though the duration of the period in the FEIS was 26 years longer. The total recordable cases for all workers could be 380. The estimated lost workday cases for all workers would be 160, and the estimated fatalities for all workers would be 0.36.

Naturally Occurring Hazardous Materials. Monitoring activities would be unlikely to generate large quantities of dust for extended periods. For the monitoring analytical period, DOE would use engineering controls and administrative worker protection measures such as respiratory protection as necessary to control and minimize impacts to workers from releases of cristobalite and erionite during monitoring activities (Section 4.1.7.1.1).

Public Heath Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.3 presents air emissions impacts during the monitoring analytical period. After completion of emplacement, DOE would continue monitoring and maintenance activities. Subsurface excavation would be complete, so there would be less emissions of naturally occurring hazardous materials in comparison to previous periods. Cristobalite concentrations at

the analyzed land withdrawal area boundary would be substantially lower than those during the construction and operations analytical periods. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower than during previous periods.

Criteria Pollutants. During the monitoring analytical period, criteria pollutant emissions would decrease in comparison with previous periods because construction, excavation, and emplacement activities would be complete. Pollutant concentrations at the land withdrawal area boundary would be substantially lower than those for the construction and operations analytical periods. Health impacts to the public would be unlikely.

4.1.7.1.4 *Impacts to Occupational and Public Health and Safety During Closure*

This section describes estimated health and safety impacts to workers and members of the public during the closure analytical period. For analytical purposes, this period would begin with receipt of a license amendment to close the repository, would last 10 years, and would overlap the last 10 years of the monitoring analytical period. Activities during this period would include closure of subsurface repository facilities, backfilling, removal of surface facilities, erection of monuments, and reclamation of disturbed lands. Health and safety impacts to workers could occur from industrial hazards and exposure to naturally occurring cristobalite and erionite in the rock at Yucca Mountain. Health impacts to members of the public could occur from exposure to airborne releases of naturally occurring hazardous materials and from criteria pollutants.

Occupational Health and Safety Impacts

Industrial Hazards. The analysis assumed that health and safety impacts for the closure analytical period would be similar to those in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Table 4-30, p. 4-59). The estimated total recordable cases for all workers would be 370. The estimated lost workday cases for all workers would be 180. The estimated fatalities for all workers would be 0.2.

Naturally Occurring Hazardous Materials. Closure activities could generate dust (for example, during preparation and emplacement of excavated rock for backfill). The potential for dust generation, especially in the underground environment, would be less than that for subsurface excavation during the construction and operations analytical periods. As necessary, DOE would use the engineering controls and worker protection measures (Section 4.1.7.1.1) it developed for the construction analytical period to control and minimize potential impacts to workers. Potential impacts would be small.

Public Health Impacts

Naturally Occurring Hazardous Materials. Section 4.1.2.4 presents estimated annual maximum concentrations of cristobalite at the boundary of the analyzed land withdrawal area where there could be exposures to members of the public during the closure analytical period. The analysis estimated concentrations of about 0.0026 microgram per cubic meter. This would be less than 0.03 percent of the benchmark concentration of 10 micrograms per cubic meter. Health impacts to the public would be unlikely. Quantities and resultant concentrations of erionite, if present, would be much lower at locations of public exposure.

Criteria Pollutants. Section 4.1.2.4 presents estimated maximum concentrations of criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter) at the boundary of the land

withdrawal area where there could be exposures to members of the public during the closure analytical period. The estimated concentrations would be less than 0.06 percent of the regulatory limit for all criteria pollutants except particulate matter. $PM_{2.5}$ could have a maximum concentration of about 0.5 percent of the 24-hour regulatory limit, and PM_{10} could have a maximum concentration of about 19 percent of the 24-hour regulatory limit. Health impacts to the public would be unlikely.

4.1.7.1.5 *Total Impacts to Occupational and Public Health and Safety for All Analytical Periods*

This section presents estimates of the total impacts to workers from industrial hazards from activities at the proposed repository. For this analysis, the entire project duration would be 105 years and would consist of a 5-year construction analytical period, a 50-year operations analytical period, a 50-year monitoring analytical period, and a 10-year closure analytical period that would overlap the last 10 years of the monitoring period. As noted above, health impacts to the public from naturally occurring hazardous material and criteria pollutants would be unlikely. Therefore, DOE did not quantify total health impacts to members of the public.

Table 4-22 lists total impacts to workers from industrial hazards for the entire project.

Table 4-22. Total impacts to workers from industrial hazards for all analytical periods.

Worker group	Impact category	Number
Involved workers	Total recordable cases	1,100
	Lost workday cases[a]	490
	Fatalities	0.62
Noninvolved workers	Total recordable cases	680
	Lost workday cases[a]	310
	Fatalities	0.30
All workers (totals)	Total recordable cases	1,800
	Lost workday cases[a]	800
	Fatalities	0.92

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.

a. Equivalent to Days Away, Restricted, or On Job Transfer in CAIRS.

4.1.7.2 Radiological Impacts

This section describes potential radiological health and safety impacts to workers and members of the public from construction, operations, monitoring, and closure activities. The analysis estimated health and safety impacts separately for involved and noninvolved workers for each analytical period. The types of potential health and safety impacts to workers would include those from exposure to naturally occurring and manmade radiation and radioactive materials in the workplace. The estimated radiological impacts include potential doses and radiological health impacts for the maximally exposed involved workers and the involved worker populations; radiological health impacts for the maximally exposed noninvolved workers and the noninvolved worker populations; and the estimated collective dose and radiological health impacts for the combined worker population. Radiological health impacts for maximally exposed workers would be the estimated increase in the probability of a *latent cancer fatality* that would result from the received radiation dose. Radiological health impacts for affected populations would be the number of estimated latent cancer fatalities that would result from the collective radiation doses. Annual radiological dose impacts from manmade radioactive materials associated with the spent

nuclear fuel and high-level waste to the maximally exposed individual member of the public and worker are included in this section and Appendix D, as part of the application submitted by DOE for construction authorization, to demonstrate that the preclosure performance objectives specified in 10 CFR 63.111(a) and 10 CFR 63.111(b) can be met for the proposed design and operations of repository during normal operations.

There would be exposure of members of the public to airborne releases of naturally occurring and manmade radionuclides from repository activities. The analysis estimated radiation doses and health impacts for the maximally exposed offsite individual and the potentially exposed population. The maximally exposed offsite individual would be a hypothetical member of the public at a point on the analyzed land withdrawal boundary who would receive the highest radiation dose and resultant radiological health impact. This location would be 19 kilometers (12 miles) in the south-southeast direction for releases from the surface geological repository operations area and 18 kilometers (11 miles) in the south-southeast direction for releases from subsurface facilities (DIRS 183160-BSC 2007, Tables 24 and 25).

Appendix D describes the methodology, data, and calculation of estimated radiological health and safety impacts to workers and members of the public and includes detailed results. Chapter 5 discusses the potential human health impacts of postclosure repository performance.

CONSERVATIVE ASSUMPTIONS USED IN RADIOLOGICAL IMPACT ANALYSIS

Radiological Impacts to Workers:

The maximally exposed involved worker would be a worker whose entire working lifetime would span the total operations analytical period up to 50 years for handling of spent nuclear fuel. The involved worker population would be exposed to conservatively estimated dose rates emitted from the casks based on the design-basis commercial spent nuclear fuel characteristics used for shielding design. This conservative approach would result in overestimation of the impacts to workers by a factor of about 3 if dose rates were based on the average spent fuel nuclear fuel characteristics that DOE would process at the proposed repository.

DOE applied no administrative limits to reduce individual exposures for its conservative estimates of involved worker doses.

Impacts to Members of the Public:

The location of the maximally exposed member of the public would be a hypothetical individual who would reside continuously for 70 years at the unrestricted public access area in the prevailing downwind direction from the repository that would receive the highest radiation exposure.

4.1.7.2.1 *Changes Since Completion of the Yucca Mountain FEIS*

The following paragraphs summarize the primary changes from the Yucca Mountain FEIS analysis to that for this Repository SEIS.

Population Distribution Data

The duration of the operations analytical period would be 50 years and would begin in 2017. Because this Repository SEIS assesses radiological impacts to the population within 84 kilometers (52 miles) of the repository, the analysis updated the population projection to 2067 based on projected changes in the

region, including the towns of Beatty, Pahrump, Indian Springs, and the surrounding rural areas (Chapter 3, Section 3.1.8).

Airborne Release Radionuclide Composition

To estimate the magnitude of the airborne radioactive releases under normal operations, this Repository SEIS analysis conservatively assumed that all pressurized-water-reactor spent nuclear fuel would consist of the same radionuclide composition as that estimated for a pressurized-water-reactor fuel assembly with 4.2-percent initial enrichment, 50,000 megawatt-days per metric ton of heavy metal (MTHM) burnup rate, and 10 years cooling time, and all boiling-water-reactor spent nuclear fuel would consist of the same radionuclide composition as that estimated for a boiling-water-reactor fuel assembly with 4-percent initial enrichment, 50,000 megawatt-days per MTHM burnup rate, and 10-year cooling time (DIRS 180185-BSC 2007, Section 7). As described in Appendix D, these fuel compositions bound the expected annual average characteristics of the fuel that has the potential to contribute to airborne releases during normal operations in the Wet Handling Facility during TAD canister loading of uncanistered fuel and fuel from dual-purpose canisters (DIRS 180185-BSC 2007, Section 7).

Dose Assessment Computer Programs

The analysis used the GENII computer program (DIRS 179907-Napier 2007, all) and biosphere model parameters developed for Amargosa Valley (DIRS 177399-SNL 2007, all) to calculate estimated doses to the maximally exposed individual of the public from manmade radionuclide releases. GENII Version 2.05 calculates doses from exposure to radionuclides in the environment based on site-specific biosphere model parameters including food consumption rates and periods and external and inhalation exposure times (DIRS 179907-Napier 2007, all).

The analysis used the CAP88-PC computer program (Version 3) (DIRS 179923-Shroff 2006, all), an atmospheric transport model for assessment of dose and risk from radioactive air emissions, to calculate collective dose to the public and the dose from radon releases to the maximally exposed individual. CAP88-PC is EPA-approved for the demonstration of compliance with the *National Emission Standards for Hazardous Air Pollutants* [40 CFR 61.93(a)]. EPA validated the program through comparison of predictions of annual average concentrations with actual environmental measurements at five DOE sites (DIRS 179923-Shroff 2006, Section 1.4). The program provides capabilities for radon release dispersion and exposure calculations that include *receptor* radon progeny concentrations in working levels. It incorporates updated dose factors that follow the Federal Guidance Report 13 method (DIRS 175452-EPA 1999, all). The Federal Guidance Report 13 factors are based on the methods in Publication 72 of the International Commission on Radiological Protection (DIRS 172935-ICRP 2001, all).

Meteorological Data

Meteorological input data to CAP88-PC used the joint frequency distribution of wind speed, direction, and atmospheric stability class based on onsite meteorological measurements from 2001 to 2005 (DIRS 177510-BSC 2007, all and Attachment III).

Updated Latent Cancer Fatality Conversion Factors

For this Repository SEIS analysis, DOE updated the latent cancer fatality conversion factor to 0.0006 latent cancer fatality per *person-rem* for conversion of worker and public doses to health effects. This conversion factor is from current DOE guidance (DIRS 178579-DOE 2004, pp. 22 to 24; DIRS 174559-Lawrence 2002, p. 2 and Appendix D).

4.1.7.2.2 *Radiological Health Impacts During Construction*

Activities during the 5-year construction analytical period would include site preparation and construction of infrastructure that included the Initial Handling Facility, the balance of plant facilities that would support initial receipt of waste, a *Canister Receipt and Closure Facility*, an Aging Facility, the Wet Handling Facility, and initial construction of subsurface facilities for emplacement. DOE would construct the Initial Handling Facility and the balance of plant facilities first; construction of the Canister Receipt and Closure Facility, Aging Facility, and Wet Handling Facility would proceed in parallel.

Radiological health and safety impacts to workers could occur from exposure to naturally occurring radionuclides in the rock and from exposure to airborne releases of naturally occurring radionuclides (radon-222 and its decay products). Column 2 of Table 4-23 (in Section 4.1.7.2.6) lists estimates of radiological impacts to workers for the construction analytical period.

Health Impacts to Workers

There would be no spent nuclear fuel and high-level radioactive waste at the repository site during the construction analytical period, so they would not contribute to radiological impacts. Radiological health impacts to involved and noninvolved workers in subsurface facilities during the construction period would be from two sources: internal exposure from inhalation of radon-222 and its decay products that emanated from the host rock, and external exposure from naturally occurring radionuclides in the drift walls. Measurements in the Exploratory Studies Facility indicated an underground ambient external dose rate from radionuclides in the drift walls of about 50 *millirem* per worker year of 2,000 hours underground (DIRS 155970-DOE 2002, p. 3-99).

During the construction analytical period the only source of radiation would be from naturally occurring radionuclides in the subsurface, so subsurface facility construction workers would incur most of the radiological health impacts to the workforce. The estimated increase in the number of latent cancer fatalities for workers would be about 0.02 and the estimated increase in probability of a latent cancer fatality for the maximally exposed worker would be about 0.0003.

Public Health Impacts

Potential radiological health impacts to the public during the 5-year construction analytical period would come from exposure to airborne releases of naturally occurring radon-222 and its decay products in the subsurface exhaust ventilation air. Column 2 of Table 4-24 (in Section 4.1.7.2.6) lists estimates of radiological impacts to the public for the construction period. The estimated number of latent cancer fatalities in the public from repository construction would be about 0.05 in a projected population of about 117,000 persons within 84 kilometers (52 miles) of the repository. The estimated increase in probability of a latent cancer fatality for the maximally exposed member of the public would be 0.0000025 over the 5-year period.

The increase in radiological impacts to the public population since DOE completed the Yucca Mountain FEIS is primarily a result of the reduced stack height of the subsurface ventilation exhausts from 60 meters (200 feet) to close to ground level. DOE adopted this design change to improve safety in relation to potential external *events* such as an airplane crash, *earthquake*, and high winds. The primary parameters that contribute to the increase are (1) a factor of about 5 from reduced stack height from 60 meters to about ground level, (2) a factor of about 2 from varied changes of site meteorological parameter height data (for wind speed and frequency toward the population centers) from 60-meter

height to ground level, and (3) a factor of 1.5 from increased population projection within 84 kilometers (52 miles) of the repository.

4.1.7.2.3 *Estimated Radiological Health Impacts During Operations*

The operations analytical period would begin with the receipt of an NRC license to receive and possess radiological materials and would include receipt, handling, aging, and emplacement of waste. During the operations period, surface facility construction would continue and include a *Receipt Facility* and additional Canister Receipt and Closure Facilities. DOE would add aging pads as needed. The operations period would last up to 50 years and would end with emplacement of the last waste package. Subsurface construction (development) would continue into the operations period for approximately 22 years.

Health Impacts to Workers

Occupational radiological health impacts during the operations analytical period would be a combination of impacts to surface workers during spent nuclear fuel and high-level radioactive waste handling operations and impacts to subsurface workers during development and emplacement operations. The principal contributors to radiological health impacts during the operations period would be surface facility operations, which would involve the receipt, handling, and packaging of spent nuclear fuel and high-level radioactive waste for aging and emplacement. Column 3 of Table 4-23 (in Section 4.1.7.2.6) lists the estimated radiological impacts to workers for the operations period.

The estimated number of latent cancer fatalities in the worker population for up to a 50-year operations analytical period would be 2.6 latent cancer fatalities (Table 4-23 in Section 4.1.7.2.6). The estimated increase in probability of a latent cancer fatality for the maximally exposed worker would be 0.018.

Public Health Impacts

Potential radiological health impacts to the public during the operations analytical period would result from (1) exposure to naturally occurring radon-222 and its decay products in subsurface exhaust ventilation air and (2) exposure to potential releases to the air of gases and particulates from resuspension of radioactive contamination from external surfaces of spent nuclear fuel containers and airborne releases from opening spent nuclear fuel containers during handling operations in the Wet Handling Facility and resuspension of surface contamination from TAD canisters and dual-purpose canisters inside aging overpacks during staging at the Aging Facility. The manmade radionuclides from the spent nuclear fuel would contribute small radiological impacts—less than 0.4 percent of the dose—in comparison with that from radon-222 and its decay products. Column 3 of Table 4-24 (in Section 4.1.7.2.6) lists estimates of radiological impacts to the public for repository operations.

For the operations analytical period, the estimated increase in probability of a latent cancer fatality in the maximally exposed member of the public would be about 0.0002. The estimated number of latent cancer fatalities in the affected population would be about 4.

4.1.7.2.4 *Estimated Radiological Health Impacts During Monitoring*

The monitoring analytical period would begin with emplacement of the last waste package and continue for 50 years. The first 3 years of this period would include decontamination of surface handling facilities. The last 10 years would overlap with the closure analytical period. Columns 4 of Tables 4-23 and 4-24 (in Section 4.1.7.2.6) list the estimates of radiological impacts to workers and the public, respectively, for monitoring the repository.

Health Impacts to Workers

Occupational radiological health impacts during monitoring would be a combination of impacts to surface workers during facility decontamination and subsurface workers during monitoring and maintenance activities. The principal contributor to radiological health impacts would be from subsurface facility monitoring and maintenance activities.

The estimated number of latent cancer fatalities in the worker population for the first 40 years of the monitoring analytical period would be about 0.6. The estimated radiological health impacts to the maximally exposed worker would be 13 *rem*, which would represent an increase in probability of latent cancer fatality of 0.008.

Public Health Impacts

Potential radiological health impacts to the public from monitoring activities would result from exposure to releases of naturally occurring radon-222 and its decay products in subsurface exhaust ventilation air. DOE does not anticipate that decontamination activities would generate releases of radioactive material to the environment or radiation doses to the public.

Table 4-24 in Section 4.1.7.2.6 lists the estimates of dose and potential radiological health impacts to the public for the first 40-years of the monitoring analytical period. The increase in probability of a latent cancer fatality in the maximally exposed member of the public would be 0.00018, and the number of latent cancer fatalities that could occur in the affected population would be 3.7.

4.1.7.2.5 *Estimated Radiological Health Impacts During Closure*

The closure analytical period would begin at the completion of the first 40 years of monitoring and last 10 years.

Health Impacts to Workers

During the closure analytical period, subsurface workers would be exposed to radon-222 in the drift atmosphere, to external radiation from naturally occurring radionuclides in the drift walls, and to external radiation from waste packages. Most of the radiation dose and potential radiological health impacts for this period would be to subsurface workers, and the maximally exposed worker would be a subsurface worker. There would be low potential for exposure of surface workers. Column 5 of Table 4-23 (in Section 4.1.7.2.6) lists the estimated radiological impacts to workers for the closure period. The estimated number of latent cancer fatalities in the worker population for the 10-year closure period would be 0.25. The estimated radiological health impacts to the maximally exposed worker would be 1.6 rem with an increase in probability of latent cancer fatality of 0.001.

Public Health Impacts

Potential radiological health impacts to the public from closure activities would result from exposure to releases of radon-222 and its decay products in the subsurface exhaust ventilation air. The estimated dose and radiological health impacts for this period would be small. Table 4-24, column 5 (in Section 4.1.7.2.6) lists estimates of radiological impacts to the public for the closure period. The increase in probability of a latent cancer fatality in the maximally exposed member of the public for the closure period of 10 years would be about 0.00002. The estimated number of latent cancer fatalities in the affected population would be about 0.5.

4.1.7.2.6 *Estimated Radiological Health Impacts for Entire Project Period*

This section summarizes the radiological human health and safety impacts to workers and members of the public from activities at the proposed repository. The project duration would be 105 years and would include 5 years of construction, 50 years of operations, 50 years of monitoring, and 10 years of closure, which would overlap the final 10 years of the monitoring analytical period. In general, the highest potential health and safety impacts would occur during the operations and monitoring periods.

Radiological Health Impacts to Workers for Entire Project

Table 4-23 (last column) lists total radiation dose and radiological health impacts to workers for the entire project (all analytical periods). Doses and impacts for the maximally exposed worker are for the operations analytical period. The collective dose to the worker population and potential radiological health impacts are for the entire project duration of 105 years.

Table 4-23. Estimated radiation doses and radiological health impacts to workers, each analytical period and entire project.[a]

Worker group and impact category	Construction	Operations	Monitoring[b]	Closure	Entire project[c]
Maximally exposed worker					
Maximum annual dose from manmade radionuclides (rem per year)					
Involved	0.0	1.3	0.20	0.039	1.3
Noninvolved	0.0	0.010	0.00001	0.00001	0.010
Total dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Increase in probability of LCF					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	4,200	890	400	5,500
Noninvolved	4.7	190	26	18	240
Nevada Test Site noninvolved	0.12	9.2	8.9	1.2	19
Totals[d]	38	4,400	930	420	5,800
Number of LCFs					
Involved	0.02	2.5	0.54	0.24	3.3
Noninvolved	0.0028	0.12	0.016	0.011	0.14
Nevada Test Site noninvolved	0.000074	0.0055	0.0053	0.00073	0.012
Totals[d]	0.023	2.6	0.56	0.25	3.5

a. Figure D-2 in Appendix D shows the projected worker population for each analytical period.
b. Doses are for the 40-year monitoring analytical period under active ventilation operating mode.
c. Maximally exposed worker doses are for the worker's entire working lifetime spanning the 50-year operations analytical period. Population doses are for the entire 105-year project duration.
d. Numbers are rounded to two significant figures; therefore, totals might differ from sums.
LCF = Latent cancer fatality.

The maximally exposed worker would be a surface facility worker whose entire working lifetime would span the total operations analytical period for handling of spent nuclear fuel. The model assumes this

worker would be a cask operator who handled spent nuclear fuel. The estimated radiation dose would be 30 rem if DOE did not apply administrative limits to reduce individual exposures. The increase in probability of a latent cancer fatality would be about 0.02 for this individual.

The estimated total worker population radiation dose for the entire project duration of 105 years would be 5,800 person-rem. Seventy-six percent of the dose would occur during the operations analytical period for the repository workforce. The principal source of exposure would be external radiation from handling of spent nuclear fuel in surface facilities and monitoring and maintenance activities in the subsurface facility. Exposure to naturally occurring radioactive sources would account for 29 percent of the total worker dose. Inhalation of radon-222 and its decay products by subsurface workers would contribute 17 percent of the total dose, and ambient radiation exposure to subsurface workers would contribute 12 percent.

To put the 5,800-person-rem dose to the worker population in perspective, the same worker population, which represents about 86,000 full-time equivalent worker years, would receive 29,000 person-rem from the natural *background radiation* exposure of 340 millirem per year (Chapter 3, Section 3.1.8.1) over the entire project period of 105 years. Therefore, the addition of 5,800 person-rem would represent an increase of about 20 percent due to the Proposed Action. The estimated increase in number of latent cancer fatalities that could occur in the repository workforce from the received radiation doses over the entire project would be 3.5. This can be compared to the 17 latent cancer fatalities that could result from the 29,000 person-rem the same worker population would normally incur over the entire project period from exposure to natural background radiation.

Radiological Health Impacts to the Public for Entire Project

Table 4-24 (last column) lists the estimated radiation dose and potential radiological health impacts to the public for the entire project (all analytical periods). Doses and radiological impacts would be for the offsite maximally exposed member of the public who resided continuously for 70 years at the site boundary location in the prevailing downwind direction. The increase in probability of a latent cancer fatality to this individual from exposure to radionuclides from the repository during the preclosure period would be about 0.0003. About 99.8 percent of the potential health impact would be from exposure to naturally occurring radon-222 and its decay products in subsurface exhaust ventilation air. The highest annual radiation dose would be 7.6 millirem, which is less than 3 percent of the annual average natural background radiation exposure of 340 millirem per year to members of the public (Chapter 3, Section 3.1.8.1). This background radiation dose includes a 200-millirem dose from ambient background levels of naturally occurring radon-222 and its decay products (Chapter 3, Section 3.1.8.2) but excludes potential radiation dose from repository subsurface radon release.

The estimated collective dose for the population within 84 kilometers (52 miles) for the entire project duration of 105 years would be 13,000 person-rem (Table 4-24). The corresponding number of latent cancer fatalities for this collective dose would be 8 in a projected population in 2067 of about 117,000 persons within 84 kilometers of the repository. For comparison, the analysis examined the number of expected cancer deaths that would occur from other causes in the same population during the same periods. The analysis calculated the expected number of cancer deaths that would not be related to the repository project on the basis of current statistics from the Centers for Disease Control and Prevention, which indicated that 24 percent of all deaths in the State of Nevada were attributable to cancer of some type and cause during 1998 (DIRS 153066-Murphy 2000, p. 8). The comparison indicates that over the

Table 4-24. Estimated radiation doses and radiological health impacts to public, each analytical period and entire project from normal operations.[a,b]

Dose and health impact	Construction	Operations	Monitoring[c]	Closure	Entire project[d]
Maximally exposed offsite individual[e]					
Maximum annual dose from manmade radionuclides (millirem per year)	0.0	0.055	0.0029	0.0029	0.055
Maximum annual dose (millirem per year)	1.4	7.6	7.5	7.5	7.6
Total for period duration (millirem)	4.2	310	300	41	530
Probability of latent cancer fatality	2.5×10^{-6}	1.9×10^{-4}	1.8×10^{-4}	2.5×10^{-5}	3.2×10^{-4}
Exposed 84-kilometer (52-mile) population[f]					
Collective dose (person-rem)	85	6,400	6,100	840	13,000
Number of latent cancer fatalities	0.051	3.8	3.7	0.51	8

a. About 99.8 percent of the total dose and impact would be from naturally occurring radon-222 and decay products.
b. Numbers are rounded to two significant figures; therefore, totals might differ from sums.
c. Doses are for the 40-year monitoring analytical period under active ventilation operating mode.
d. Doses are for the entire 105-year project duration.
e. A hypothetical individual who would reside continuously for 70 years at the site boundary location in the prevailing downwind direction.
f. The projected population includes about 117,000 persons within 84 kilometers of the repository.

105-year project duration the incremental chance of latent cancer fatalities among the projected population of about 117,000 would be about 2 in 10,000.

4.1.8 ACCIDENT AND SABOTAGE SCENARIO IMPACTS

This section describes the impacts from potential accident and sabotage scenarios for the Proposed Action. Section 4.1.8.1 discusses changes in the methods and data DOE used to evaluate impacts from potential accidents since it completed the Yucca Mountain FEIS. Sections 4.1.8.2, 4.1.8.3, and 4.1.8.4 describe the analyses for radiological accident impacts, nonradiological accident impacts, and impacts from hypothetical sabotage events, respectively. DOE calculated impacts for (1) the *maximally exposed offsite individual*, (2) the *noninvolved worker*, and (3) the *offsite population*, which, for purposes of this analysis, includes members of the public who resided within about 84 kilometers (52 miles) of the proposed repository. Because all waste handling operations would be remote, involved workers would be in enclosed facility operating rooms isolated from the waste. Involved workers would be unlikely to receive significant exposures to radioactive materials that an accident could release for the following reasons:

- For releases that occurred in waste handling buildings (11 of the 14 accident scenarios), operators would be in enclosed operating areas that would isolate them.

- For the two fire scenarios that would involve low-level radioactive waste and a truck transportation cask, the fire would cause the release to be lofted into the atmosphere, so workers close to the release would not receive meaningful exposure.

- For the *seismic* scenario, the event would be likely to injure or kill workers in the Low-level Waste Facility, and the dose to the noninvolved worker at 60 meters (200 feet) would be representative of the dose to involved workers outside the facility. Appendix E contains details of the analysis method.

The impacts to offsite individuals from repository accidents under 95th-percentile weather conditions (conditions that resulted in doses that would only be exceeded 5 percent of the time) would be small, with calculated doses of 35 millirem or less to the maximally exposed offsite individual. Doses to a noninvolved worker would be higher than those to offsite individuals, up to 3.5 rem.

The accident analysis for this Repository SEIS is consistent with the preclosure safety analysis included in the application that DOE has filed with the NRC for construction authorization for the Yucca Mountain Repository.

4.1.8.1 Changes Since Completion of the Yucca Mountain FEIS

Since it completed the Yucca Mountain FEIS, DOE has acquired new information and analytical tools that have contributed to the understanding of the potential impacts for accident analyses. The following sections describe the changes in potential accident impact analysis. Appendix E provides a more detailed evaluation of these changes.

4.1.8.1.1 *Commercial Spent Nuclear Fuel Characteristics*

The analysis for this Repository SEIS used a commercial pressurized-water-reactor spent nuclear fuel assembly with the bounding radiological characteristics of 80,000 megawatt-days per metric ton of uranium burnup and a 5-year cooling time for accidents that would involve *commercial spent nuclear fuel*. This fuel bounds other commercial fuel types (*boiling-water-reactor* and mixed-oxide spent fuel) because it would result in the highest accident scenario consequences. Appendix E, Section E.3 provides details.

4.1.8.1.2 *Population Distribution*

For this Repository SEIS, the projected duration of the operations analytical period is 50 years, which would begin in 2017. The projected population for the 84-kilometer (52-mile) region of influence would be about 117,000 persons in 2067 (Chapter 3, Section 3.1.8, Figure 3-16).

4.1.8.1.3 *Accident Analysis and Atmospheric Dispersion Models*

For this Repository SEIS, DOE used the GENII computer program to calculate radiation doses from a release of radioactive material (DIRS 100953-Napier et al. 1988, all). These calculations require site-specific dispersion factors (factors that measure the dilution of the downwind atmospheric plume). DOE used an NRC-developed atmospheric dispersion model to develop the dispersion factors. Appendix E, Section E.4.1 discusses the GENII program and the atmospheric dispersion model in more detail.

4.1.8.1.4 *Commercial Spent Nuclear Fuel Oxidation*

Additional information on fuel oxidation has become available since the completion of the Yucca Mountain FEIS. Fuel oxidation could occur during an accident if commercial spent nuclear fuel pellets at an elevated temperature were exposed to air. The oxidation would involve conversion of the uranium

dioxide fuel pellet material to uranium trioxide. Uranium trioxide is a powder more respirable than the uranium dioxide fuel pellet material and would increase the downwind dose. For this Repository SEIS, if damaged commercial spent nuclear fuel was involved in an accident, the analysis, when appropriate, modeled that oxidation would contribute to the release over a period of 30 days. It also conservatively modeled that these accidents would occur without any measures to mitigate consequences (for example, evacuation or interdiction of food consumption) for this 30-day period to enable a conservative prediction of the radiological consequences. Appendix E, Section E.3.3.1 discusses fuel oxidation further, and Section E.4.3 provides a quantitative evaluation of the effect of mitigation measures.

4.1.8.1.5 *Radiation Dosimetry*

DOE changed the radiation dosimetry it used to evaluate consequences in this Repository SEIS to incorporate International Committee on Radiation Protection Publication 72 (DIRS 172935-ICRP 2001, all), the most recent dosimetry guidance available from the Committee. Appendix D, Section D.1 contains the details of this change.

4.1.8.1.6 *Latent Cancer Fatalities*

Current DOE guidance recommends that estimates of latent cancer fatalities be based on the received radiation dose and on radiation dose-to-health effect conversion factors recommended by the Interagency Steering Committee on Radiation Standards. For this Repository SEIS, DOE used the updated guidance for workers and members of the public, which is 0.0006 fatality per person-rem (DIRS 174559-Lawrence 2002, p. 2).

4.1.8.1.7 *Location of Maximally Exposed Offsite Individual*

In this Repository SEIS, the analysis used locations for the maximally exposed offsite individual of either 7.8 kilometers (4.8 miles), the nearest location in the southeast sector of the repository, or 18.5 kilometers (11 miles), the nearest location in the south-southeast quadrant of the repository, depending on which location would receive the highest calculated dose from the specific accident scenario using the GENII program. Tables 4-25 and 4-26 later in this section specify the location of the maximally exposed offsite individual for each accident. The analysis determined these locations as those that would produce the highest site boundary doses of any of the 16 radial sectors around the site based on sector-specific dispersion factors that the GENII program uses to calculate doses.

4.1.8.2 Radiological Accidents

The first step in the radiological accident analysis was to examine the initiating events that could lead to facility accidents. These events could be external or internal. External initiators originate outside a facility and affect its ability to confine radioactive material; they can include human-caused events such as aircraft crashes, external fires, and explosions and natural phenomena such as seismic disturbances and extreme weather conditions. Internal initiators occur inside a facility and can include human errors, equipment failures, or combinations of the two. DOE analyzed initiating events applicable to repository operations to define subsequent sequences of events that could result in releases of radioactive material or radiation exposure. For each event in these accident sequences, the analysis estimated and combined probabilities to produce an estimate of the overall accident probability for the sequence. Last, it evaluated the consequences of the accident scenarios by estimating the potential radiation dose and radiological impacts.

The materials at risk for various accident scenarios could include several types of radioactive materials—spent nuclear fuel from boiling- and pressurized-water commercial reactors in TAD or dual-purpose canisters, or uncanistered fuel in transportation casks; *DOE spent nuclear fuel* canisters; *naval spent nuclear fuel* canisters; high-level radioactive waste canisters; and weapons-grade plutonium immobilized in a high-level radioactive waste glass matrix or as *mixed-oxide fuel*, both in canisters. Appendix A of the Yucca Mountain FEIS presented many details on the materials DOE would dispose of in the repository (DIRS 155970-DOE 2002, pp. A-1 to A-71).

Under the Proposed Action, up to 90 percent of the commercial spent nuclear fuel would arrive at the repository in TAD canisters. DOE would handle the remaining fuel as uncanistered spent fuel assemblies in the Wet Handling Facility and place it in TAD canisters for disposal. Appendix E, Section E.3 discusses materials at risk and the *source terms* DOE used for the accident analysis. In addition, the analysis examined accident scenarios that would involve the release of low-level waste that DOE generated and handled at the repository.

The analysis considered radiological consequences of the postulated accidents for the following:

- Noninvolved worker (collocated worker). A worker who would not be directly involved with material unloading, transfer, and emplacement activities, who DOE assumed to be 60 meters (200 feet) downwind of the facility where the release occurred. The 60-meter distance corresponds to the location of the exclusion fence around the waste handling buildings. (Some accidents could result in severe consequences for involved workers).

- Maximally exposed offsite individual. A hypothetical member of the public at a point on the site boundary who would be likely to receive the maximum dose. The analysis determined that the location with the highest potential exposure from an accidental release of radioactive material would be either (1) about 18.5 kilometers (11 miles) from the accident location (at the south boundary of the analyzed land withdrawal area), or (2) about 7.8 kilometers (4.8 miles) from the accident location (at the east boundary of the land withdrawal area).

- Offsite population. Members of the public within 84 kilometers (52 miles) of the repository site (Chapter 3, Section 3.1.8).

A review of the possible hazards and initiating events for the most current design concepts and planned operations identified 14 accident scenarios that DOE analyzed in detail. They included accidents in the Initial Handling Facility, the Wet Handling Facility, a Canister Receipt and Closure Facility, the Receipt Facility, and the Low-Level Waste Facility. The accident scenarios considered drops and collisions that involved transportation casks, TAD canisters, dual-purpose canisters, and uncanistered fuel assemblies; a fire that involved low-level radioactive waste and a transportation cask on a truck; and a seismic event. DOE analyzed the scenarios under average (50th-percentile) meteorological conditions (conditions that result in average doses over the spectrum of possible weather conditions) and unfavorable (95th-percentile) meteorological conditions (conditions that result in higher doses that would be exceeded only 5 percent of the time). Appendix E, Section E.2 contains details of the analysis. For this Repository SEIS, DOE did not evaluate the seismic collapse of a waste handling building that it evaluated in the Yucca Mountain FEIS because the Department intends to enhance the capability of the buildings to withstand ground motion associated with seismic events. Further, no bare fuel assemblies would exist in air in any of the waste handling buildings, so a building collapse would be unlikely to produce large

impacts. In addition, DOE did not evaluate the transporter runaway accident it analyzed in the Yucca Mountain FEIS because the event is unlikely and the consequences are expected to be smaller than those of the transporter derailment event analyzed in the FEIS.

Tables 4-25 and 4-26 list the results of the radiological accident scenarios DOE modeled for this Repository SEIS for 95th- and 50th-percentile meteorological conditions, respectively. Impacts to the noninvolved worker would result from the inhalation of airborne radionuclides and external radiation from the passing plume. Impacts to the maximally exposed offsite individual and the offsite population would result from these *exposure pathways* and from long-term external exposure to radionuclides the plume deposited on soil during passage, subsequent ingestion of radionuclides in locally grown food, and inhalation of resuspended particulates. The analysis assumed neither DOE nor other government agencies would implement mitigation measures, such as evacuation, to limit long-term radiation doses. Appendix E, Section E.4.3 evaluates the effect of this assumption.

The accident scenario with the highest consequences in Table 4-25 would involve a seismic event that caused the release of radioactive material from high-efficiency particulate air filters, ducts, and low-level radioactive waste. The estimated health impacts to the offsite population would be 0.19 additional latent cancer fatality in the exposed population of 104,000 in the sector with the largest population (south-southeast) for the 95th-percentile weather condition. The maximum dose to the maximally exposed noninvolved worker could be 3.5 rem, which could result in an increased probability of a latent cancer fatality to the individual of 0.0021.

4.1.8.3 Nonradiological Accidents

A potential release of hazardous or toxic materials would be minimal because the repository would not accept *hazardous waste* under the *Resource Conservation and Recovery Act* (42 U.S.C. 6901 et seq.). However, some potentially hazardous metals, such as arsenic or mercury, could be present in the high-level radioactive waste inventory. Nonradioactive hazardous or toxic substances, such as cleaning solvents, sodium hydroxide, sulfuric acid, and solid chemicals, would be present in limited quantities at the repository as part of operational requirements. Impacts to members of the public would be unlikely due to the limited quantities and because the chemicals would be mostly liquid and solid, so a release would be confined to the site. The generation, storage, and offsite *shipment* of solid and liquid hazardous wastes from operations would represent minimal incremental risk from accidents. Section 4.1.7 describes potential impacts to workers from normal industrial hazards in the workplace (which would include industrial accidents). DOE derived the statistics in the analysis from accident experience at other sites.

4.1.8.4 Sabotage

In response to the terrorist attacks of September 11, 2001, and to intelligence information that has been obtained since then, the United States Government has initiated nationwide measures to reduce the threat of sabotage. These measures include security enhancements to prevent terrorists from gaining control of commercial aircraft, such as (1) more stringent screening of airline passengers and baggage by the Transportation Security Administration, (2) increased presence of Federal Air Marshals on many flights, (3) improved training of flight crews, and (4) hardening of aircraft cockpits. Additional measures have been imposed on foreign passenger carriers and domestic and foreign cargo carriers, as well as charter aircraft.

Table 4-25. Estimated radiological consequences of repository operations accident scenarios for unfavorable (95th-percentile) sector-specific meteorological conditions.

Accident scenario	Expected occurrences over the preclosure period (annual frequency)[a]		Maximally exposed offsite individual[b]		Population		Noninvolved worker	
	Internal events	Seismic events	Dose (rem)	LCF_i[c]	Dose (person-rem)	LCF_p[c]	Dose (rem)	LCF_i[c]
1. Seismic event resulting in LLWF collapse and failure of HEPA filters and ductwork in other facilities	(not applicable)	8×10^{-3} (2×10^{-4})	3.5×10^{-2}	2.1×10^{-5}	3.1×10^{2}	1.9×10^{-1}	3.5×10^{0}	2.1×10^{-3}
2. Breach of sealed HLW canisters in a sealed transportation cask	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	2.6×10^{-5} (2.6×10^{-3})[d]	1.6×10^{-8}	2.1×10^{-1} (2.1×10^{1})[d]	1.3×10^{-4}	3.5×10^{-3} (3.5×10^{-1})[d]	2.1×10^{-6}
3. Breach of sealed HLW canister in an unsealed waste package	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1×10^{-4} (2×10^{-6})	2.6×10^{-4} (2.6×10^{-2})[d]	1.6×10^{-7}	2.1×10^{0} (2.6×10^{-2})[d]	1.3×10^{-3}	3.5×10^{-2} (2.65×10^{-2})[d]	2.1×10^{-5}
4. Breach of sealed HLW canister during transfer (one drops onto another)	1×10^{-2} (2×10^{-4})	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1.0×10^{-4} (1.0×10^{-2})[d]	6.0×10^{-8}	8.5×10^{-1} (8.5×10^{1})[d]	5.1×10^{-4}	1.4×10^{-2} (1.4×10^{0})[d]	8.4×10^{-6}
5. Breach of uncanistered commercial SNF in a sealed truck transportation cask in air	1×10^{-1} (2×10^{-3})	not applicable[e]	1.0×10^{-3}	6.0×10^{-7}	2.7×10^{-5}	1.6×10^{-2}	8.3×10^{-2}	5.0×10^{-5}
6. Breach of uncanistered commercial SNF in an unsealed truck transportation cask in pool	7×10^{-4} (1×10^{-5})	2×10^{-4} (4×10^{-6})	9.4×10^{-4}	5.6×10^{-7}	2.6×10^{1}	1.6×10^{-2}	5.2×10^{-2}	3.1×10^{-5}
7. Breach of a sealed DPC in air	9×10^{-3} (2×10^{-6})	not applicable[e]	9.1×10^{-3}	5.5×10^{-6}	2.5×10^{2}	1.5×10^{-1}	5.5×10^{-2}	3.3×10^{-3}
8. Breach of commercial SNF in unsealed DPC in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	2×10^{-4} (4×10^{-6})	8.4×10^{-3}	5.0×10^{-6}	2.3×10^{2}	1.4×10^{-1}	7.4×10^{-1}	4.4×10^{-4}
9. Breach of a sealed TAD canister in pool	2×10^{-3} (4×10^{-5})	not applicable[e]	5.3×10^{-3}	3.2×10^{-6}	1.4×10^{2}	8.4×10^{-2}	4.3×10^{-1}	2.6×10^{-4}

Table 4-25. Estimated radiological consequences of repository operations accident scenarios for unfavorable (95th-percentile) sector-specific meteorological conditions (continued).

Accident scenario	Expected occurrences over the preclosure period (annual frequency)		Maximally exposed offsite individual[a]		Population		Noninvolved worker	
	Internal events	Seismic events	Dose (rem)	LCF_i[b]	Dose (person-rem)	LCF_p[b]	Dose (rem)	LCF_i[b]
10. Breach of commercial SNF n unsealed TAD canister in pool	5×10^{-4} (1×10^{-5})	not applicable[e]	4.9×10^{-3}	2.8×10^{-6}	1.3×10^{2}	7.8×10^{-2}	2.9×10^{-1}	1.7×10^{-4}
11. Breach of uncanistered commercial SNF assembly in pool (one drops onto another)	3×10^{-1} (6×10^{-3})	not applicable[e]	4.7×10^{-4}	2.8×10^{-7}	1.3×10^{1}	7.8×10^{-3}	2.7×10^{-2}	1.6×10^{-5}
12. Breach of uncanistered commercial SNF in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	not applicable[e]	2.3×10^{-4}	1.4×10^{-7}	6.4×10^{0}	3.8×10^{-3}	1.4×10^{-2}	8.4×10^{-6}
13. Fire involving LLWF inventory	7×10^{-2} (1×10^{-3})	not applicable[e]	9.0×10^{-4}	5.4×10^{-7}	8.4×10^{0}	5.0×10^{-3}	8.1×10^{-2}	4.9×10^{-5}
14. Breach of a sealed truck transportation cask due to a fire	2×10^{-2} (4×10^{-4})	not applicable[e]	4.4×10^{-3}	2.6×10^{-6}	4.2×10^{1}	2.5×10^{-2}	1.3×10^{0}	7.8×10^{-4}

a. For accident scenarios potentially initiated by more than one Category 2 event sequence, the expected occurrence value is the maximum frequency of those Category 2 event sequences. For accident scenarios potentially initiated by only Beyond Category 2 event sequences, the expected occurrence value is less than the maximum frequency of a Beyond Category 2 event over the preclosure period (i.e. $<1 \times 10^{-4}$).

b. Assumed to be at the analyzed land withdrawal boundary either in the east sector [7.8 kilometers (4.8 miles)] or in the southeast sector [18.5 kilometers (11 miles)], whichever produces the highest site boundary dose. For Accident Scenarios 3 through 10, DOE calculated the highest dose for the southeast sector. For all other accident scenarios, DOE calculated the highest dose for the east sector.

c. LCF_i is the estimated likelihood of a latent cancer fatality for an individual who receives the calculated dose (rem). LCF_p is the estimated number of cancers in the exposed population from the collective population dose (person-rem). These values were computed based on a conversion of dose to LCFs as discussed in Section E.4.1.

d. Unfiltered doses presented to illustrate that filtration systems might not be required for these accident scenarios.

e. The seismic event sequence quantification and categorization analysis (DIRS 183261-BSC 2007, Sect. 6.7 and 6.8) did not identify any seismic initiators for these scenarios.

DPC = Dual-purpose canister.
HEPA = High-efficiency particulate air (filter).
HLW = High-level radioactive waste.
LCF = Latent cancer fatality.
LLWF = Low-Level Waste Facility.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

Table 4-26. Estimated radiological consequences of repository operations accident scenarios for annual average (50th-percentile) sector-specific meteorological conditions.

Accident scenario	Expected occurrences over the preclosure period (annual frequency)[a]		Maximally exposed offsite individual[b]		Population		Noninvolved worker	
	Internal events	Seismic events	Dose (rem)	LCF_i[c]	Dose (person-rem)	LCF_p[c]	Dose (rem)	LCF_i[c]
1. Seismic event resulting in LLWF collapse and failure of HEPA filters and ductwork in other facilities	(not applicable)	8×10^{-3} (2×10^{-4})	6.4×10^{-4}	3.8×10^{-7}	2.5×10^{0}	1.5×10^{-3}	5.8×10^{-1}	3.5×10^{-4}
2. Breach of sealed HLW canisters in a sealed transportation cask	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	4.4×10^{-7}	2.6×10^{-10}	1.5×10^{-3}	9.0×10^{-7}	5.8×10^{-4}	3.5×10^{-7}
3. Breach of sealed HLW canister in an unsealed waste package	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1×10^{-4} (2×10^{-6})	4.4×10^{-6}	2.6×10^{-9}	1.5×10^{-2}	9.0×10^{-6}	5.8×10^{-3}	3.5×10^{-6}
4. Breach of sealed HLW canister during transfer (one drops onto another)	1×10^{-2} (2×10^{-4})	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	1.8×10^{-6}	1.1×10^{-9}	5.9×10^{-3}	3.5×10^{-6}	2.3×10^{-3}	1.4×10^{-6}
5. Breach of uncanisterecommercial SNF in a sealed truck transportation cask in air	1×10^{-1} (2×10^{-3})	not applicable[d]	2.6×10^{-5}	1.6×10^{-8}	2.7×10^{-1}	1.6×10^{-4}	2.3×10^{-2}	1.4×10^{-5}
6. Breach of uncanistered commercial SNF in an unsealed truck transportation cask in pool	7×10^{-4} (1×10^{-6})	2×10^{-4} (4×10^{-6})	1.2×10^{-5}	7.2×10^{-9}	1.5×10^{-1}	9.0×10^{-5}	9.0×10^{-3}	5.4×10^{-6}
7. Breach of a sealed DPC in air	9×10^{-3} (2×10^{-6})	not applicable[d]	2.4×10^{-4}	1.4×10^{-7}	2.5×10^{0}	1.5×10^{-3}	2.1×10^{-1}	1.3×10^{-4}
8. Breach of commercial SNF in unsealed DPC in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	2×10^{-4} (4×10^{-6})	1.1×10^{-4}	6.6×10^{-8}	1.4×10^{0}	8.4×10^{-4}	8.1×10^{-2}	4.9×10^{-5}
9. Breach of a sealed TAD canister in pool	2×10^{-3} (4×10^{-5})	not applicable	1.4×10^{-4}	8.4×10^{-8}	1.4×10^{0}	8.4×10^{-4}	1.2×10^{-1}	7.2×10^{-5}

Table 4-26. Estimated radiological consequences of repository operations accident scenarios for annual average (50th-percentile) sector-specific meteorological conditions (continued).

Accident scenario	Expected occurrences over the preclosure period (annual frequency)		Maximally exposed offsite individual[a]		Population		Noninvolved worker	
	Internal events	Seismic events	Dose (rem)	LCF_i[b]	Dose (person-rem)	LCF_p[b]	Dose (rem)	LCF_i[b]
10. Breach of commercial SNF n unsealed TAD canister in pool	5×10^{-4} (1×10^{-5})	2×10^{-4} (4×10^{-6})	6.2×10^{-5}	3.7×10^{-8}	7.9×10^{-1}	4.7×10^{-4}	4.7×10^{-2}	2.8×10^{-5}
11. Breach of uncanistered commercial SNF assembly in pool (one drops onto another)	3×10^{-1} (6×10^{-3})	not applicable[d]	5.9×10^{-6}	3.5×10^{-9}	7.5×10^{-2}	4.5×10^{-5}	4.5×10^{-3}	2.7×10^{-6}
12. Breach of uncanistered commercial SNF in pool	$< 1 \times 10^{-4}$ ($< 2 \times 10^{-6}$)	not applicable[d]	2.9×10^{-6}	1.7×10^{-9}	3.8×10^{-2}	2.3×10^{-5}	2.2×10^{-3}	1.3×10^{-6}
13. Fire involving LLWF inventory	3×10^{-1} (6×10^{-3})	not applicable[d]	1.7×10^{-5}	1.0×10^{-8}	7.3×10^{-2}	4.4×10^{-5}	1.3×10^{-2}	7.8×10^{-6}
14. Breach of a sealed truck transportation cask due to a fire	2×10^{-2} (4×10^{-4})	not applicable[d]	5.4×10^{-4}	3.2×10^{-7}	3.4×10^{0}	2.0×10^{-3}	7.1×10^{-1}	4.3×10^{-4}

a. For accident scenarios potentially initiated by more than one Category 2 event sequence, the expected occurrence value is the maximum probability of those Category 2 sequences. For accident scenarios potentially initiated by only Beyond Category 2 event sequences, the expected occurrence value is less that the maximum frequency of a Beyond Category 2 event over the preclosure period (i.e. $<1 \times 10^{-4}$)

b. Assumed to be at the analyzed land withdrawal boundary in the east sector, which would produce the highest site boundary dose at a distance of 7.8 kilometers (4.8 miles).

c. LCF_i is the estimated likelihood of a latent cancer fatality for an individual who receives the calculated dose (rem). LCF_p is the estimated number of cancers in the exposed population from the collective population dose (person-rem). These values were computed based on a conversion of dose to LCFs as discussed in Section E.4.1.

d. The seismic event sequence quantification and categorization analysis (DIRS 183261-BSC 2007, all) did not identify any seismic initiators for these scenarios.

DPC = Dual-purpose canister.
HEPA = high-efficiency particulate air (filter).
HLW = High-level radioactive waste.
LCF = Latent cancer fatality.
LLW = Low Level Waste Facility.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

Over the long term (after closure), deep geologic disposal of spent nuclear fuel and high-level radioactive waste would provide optimal security by emplacing the material in a geologic formation that would provide protection from human intrusion, including potential terrorist activities. The use of robust metal waste packages to contain the spent nuclear fuel and high-level radioactive waste more than 200 meters (660 feet) below the surface would offer significant impediments to any attempt to retrieve or otherwise disturb the emplaced materials.

In the short term (before closure), the proposed repository at Yucca Mountain would offer certain unique features from a safeguards perspective: a remote location, restricted access afforded by federal land ownership and proximity to the Nevada Test Site, restricted airspace above the site, and access to a highly effective rapid-response security force.

NRC regulations (10 CFR 63.21 and 10 CFR 73.51) specify a repository performance objective that provides "high assurance that activities involving spent nuclear fuel and high-level radioactive waste do not constitute an unreasonable risk to public health and safety." The regulations require the storage of spent nuclear fuel and high-level radioactive waste in a protected area such that:

- Access to the material would require passage through or penetration of two physical barriers. The outer barrier must have *isolation* zones on each side to facilitate observation and threat assessment, to be continually monitored, and to be protected by an active alarm system.
- Adequate illumination must be provided for observation and threat assessment.
- The area must be monitored by random patrol.
- Access must be controlled by a lock system, and personnel identification must be used to limit access to authorized persons.

NRC regulations would require a trained, equipped, and qualified security force to conduct surveillance, assessment, access control, and communications to ensure adequate response to any security threat. NRC requires liaison with response forces to permit timely response to unauthorized entry or activities. In addition, the NRC requires (10 CFR Part 63, by reference to 10 CFR Part 72) comprehensive receipt, periodic inventory, and disposal records for spent nuclear fuel and high-level radioactive waste in storage. A duplicate set of these records must be kept at a separate location sufficiently remote from the original records that a single event would not destroy both sets of records.

Whether acts of sabotage or terrorism would occur, and the exact nature and location of the events, or the magnitude of the consequences of such acts if they were to occur is inherently uncertain—the possibilities are infinite. Nevertheless, in response to public comments and to evaluate a scenario that would approximate the consequences of a major sabotage event, DOE analyzed a hypothetical scenario in which a large commercial jet aircraft crashed into and penetrated the repository facility with the largest inventory of radioactive material vulnerable to damage from such an event.

The analysis conservatively modeled that the aircraft impact would compromise the confining capability of the building and the resulting fire would convert 42 spent nuclear fuel assemblies to an oxide powder. The results of this analysis indicate that the maximally exposed offsite individual could receive a dose of 3.0 rem resulting in an estimated likelihood of a latent cancer fatality of 0.0018, and the offsite public in

the highest population sector (south-southeast), which in 2067 would consist of an estimated 104,000 individuals, could receive a collective dose of 9,900 person-rem for average weather conditions resulting in an estimated 5.9 latent cancer fatalities. Appendix E, Section E.7 contains details of the analysis.

4.1.9 NOISE AND VIBRATION IMPACTS

This section describes potential noise and vibration impacts to workers (occupational noise) and to the public (nuisance noise) from activities under the Proposed Action. The region of influence for noise and vibration impacts includes the Yucca Mountain site and existing and future residences to the south in the town of Amargosa Valley. Section 4.1.9.1 summarizes and incorporates by reference the noise impacts from construction, operations, monitoring, and closure of the repository in Section 4.1.9.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 4-70). Section 4.1.9.2 and Section 4.1.9.3 provide new analyses based on the modified design and operational plan. Section 4.1.9.2 discusses noise impacts from construction of the access road from U.S. Highway 95 and the offsite facilities that DOE would build south of the analyzed land withdrawal area. Section 4.1.9.3 discusses impacts from vibration. Section 4.1.4.1.2 discusses noise impacts on wildlife.

4.1.9.1 Noise Impacts from Construction, Operations, Monitoring, and Closure

Sources of noise impacts in the analyzed land withdrawal area during the construction analytical period would include activities at the site development areas that involved heavy equipment (for example, bulldozers, graders, loaders, cranes, and pavers), ventilation fans, and diesel generators. Sources of noise during the operations and monitoring analytical periods would include diesel generators, cooling towers, ventilation fans, air conditioners, and concrete batch plant activities. Ventilation fans would have noise suppressors that would maintain noise levels below 85 *A-weighted decibels* (dBA) at a distance of 3 meters (10 feet). The Occupational Safety and Health Administration standard for the maximum permissible continuous noise level for workers, without the use of controls, is 90 dBA for a duration of 8 hours per day [29 CFR 1910.95(b)(2)]. The regulation, in calculating the permissible exposure level, uses a 5-dB time-over-intensity trading relationship, or exchange rate. For a person to be exposed to noise levels of 95 dBA, the permissible amount of time at this exposure level must be halved to be within the permissible exposure level. Conversely, a person who is exposed to 85 dBA is allowed twice as much time at this level (16 hours). The National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists both recommend an exposure limit of 85 dBA for an 8-hour exposure, with a 3-dB exchange rate. Therefore, a worker can be exposed to 85 dBA for 8 hours, but to 88 dBA for only 4 hours or 91 dBA for only 2 hours.

DECIBELS

A-weighted decibels (dBA):
A measurement of sound that approximates the sensitivity of the human ear, which is used to characterize the intensity or loudness of sound.

Vibration velocity decibels (VdB):
Vibration velocity in decibels with respect to 1 microinch per second. A measurement of root-mean-square velocity for the evaluation of ground vibration as an average or smoothed vibration amplitude on a logarithmic scale.

The point on the boundary of the analyzed land withdrawal area nearest to noise sources at the North Portal area would be about 11 kilometers (7 miles) due west. The distance and direction from the South

Portal development area to the nearest point on the boundary would also be about 11 kilometers due west. The point on the boundary closest to a Ventilation Shaft Operations Area would be about 7 kilometers (4 miles) due west.

To establish the propagation distance of repository-generated noise for this analysis, DOE used a maximum sound level of 132 dBA. It is unlikely that construction activities would generate noise at this high level. For comparison, heavy trucks generate sound levels of 70 to 80 dBA at 15 meters (50 feet). However, the analysis determined that this high level of noise would attenuate to the lower limit of human hearing (20 dBA) at a distance of 6 kilometers (3.7 miles). Therefore, noise impacts to the public would be unlikely outside the analyzed land withdrawal area boundary.

Because the distance between repository noise sources and a hypothetical individual at the land withdrawal area boundary would be large enough to reduce the noise to background levels or below, and because there would be no residential or community receptors at the boundary [the nearest housing is in the town of Amargosa Valley about 22 kilometers (14 miles) from the repository site], DOE expects no noise impacts to the public due to activities at Yucca Mountain under the Proposed Action.

Construction noise is transitory in nature. At times, workers at the repository site would be exposed to elevated levels of noise. Small impacts to workers such as speech interference and annoyance would occur. However, DOE would control noise levels and worker exposures such that impacts (such as hearing loss) would be unlikely. Engineering controls would be the primary method of noise control. Workers would use personal hearing protection as necessary to supplement engineering controls.

Noise impacts during the closure period would be similar to those during construction and operations.

4.1.9.2 Noise Impacts from Construction of Offsite Infrastructure

Sources of noise impacts outside the analyzed land withdrawal area would include construction of the access road from U.S. Highway 95 and multiple facilities south of the Yucca Mountain site near Gate 510. Offsite facilities would include the Sample Management Facility, a training facility, a marshalling yard and warehouse, and temporary housing for construction workers. Construction activities would involve typical construction equipment (for example, bulldozers, graders, loaders, and pavers). This type of construction equipment generates noise levels of about 85 dBA at 15 meters (50 feet). Noise and sound levels would be typical of new construction activities and would be intermittent. The nearest permanent residents would be in the town of Amargosa Valley, which is southwest of the intersection of U.S. Highway 95 and Nevada State Route 373. The closest offsite construction activities to the residents would take place at this intersection, where DOE would relocate the current Gate 510 road intersection with U.S. Highway 95 to line up with the intersection of State Route 373 and U.S. Highway 95. Because of the distance between construction activities and receptors and the temporary and intermittent nature of construction noise, DOE does not anticipate noise impacts to the public from construction of the access road or offsite facilities.

Traffic noise on the access road would not exceed or significantly add to the existing traffic noise on U.S. Highway 95. Noise from operation of the offsite facilities would be typical of commercial environments and would not cause impacts.

4.1.9.3 Vibration Impacts from Construction, Operations, Monitoring, and Closure

Construction activity can result in various degrees of ground vibration dependent on the equipment and construction methods. Construction equipment causes vibrations that spread through the ground and diminish in strength with distance. Activities that typically generate the most severe vibrations are blasting and impact pile driving. DOE could use blasting in the excavation of the shafts and the turnouts to the emplacement drifts. Blasting activity results in a typical velocity level of slightly less than 100 vibration velocity in decibels with respect to 1 microinch per second (VdB) at 15 meters (50 feet). Use of bulldozers and other heavy tracked construction equipment results in typical velocity levels around 93 VdB at 15 meters. However, generalized surface vibration curves show that a vibration with a velocity level of 95 VdB at 3 meters (10 feet) drops to a velocity level of 67 VdB at 91.4 meters (300 feet). The approximate threshold for human perception of vibration is 65 VdB (DIRS 177297-Hanson et al. 2006, all). The point on the analyzed land withdrawal boundary closest to blasting activity would be about 7 kilometers (4 miles) due west. Groundborne vibration during the operations, monitoring, and closure analytical periods would be imperceptible at the boundary. Because of the large distances between Proposed Action activities and sensitive structures, there would be no adverse vibration impacts.

4.1.10 AESTHETIC IMPACTS

This section describes potential aesthetic impacts from the Proposed Action. The region of influence for aesthetics includes the approximate boundary of the analyzed land withdrawal area, an area west of the boundary where ventilation stacks could be seen, and the area south of the boundary where DOE would construct the access road from U.S. Highway 95 and several offsite facilities. The analysis considered the natural and manmade physical features that give a particular landscape its character and value as an environmental factor. It gave specific consideration to scenic quality, visual sensitivity, and distance from observation locations. This section provides a new analysis of the aesthetic impacts of the Proposed Action.

4.1.10.1 Approach

Because of the limited visibility of Yucca Mountain from publicly accessible locations, DOE identified two general locations from which the public could see facilities: one to the south of the repository near the intersection of Nevada State Route 373 and U.S. Highway 95, and the other to the west of the repository where repository ventilation exhaust stacks could be visible. There would be no public access to the north or east of the site to enable viewing of the facilities. DOE used the Bureau of Land Management criteria in Table 4-27 to rate the predicted contrast between existing conditions and conditions DOE expects from the Proposed Action at the two locations. To determine potential aesthetic impacts, the analysis considered if the predicted contrast at these locations would be consistent with the Bureau of Land Management visual resource management objectives in Table 4-28. Depending on the visual resource management objective for a particular location, various levels of contrast are acceptable.

4.1.10.2 Aesthetic Impacts from Construction, Operations, Monitoring, and Closure

The low elevation of the southern end of Yucca Mountain and Busted Butte would obscure the view of repository facilities from the south near the intersection of Nevada State Route 373 and U.S. Highway 95 (location 1), approximately 22 kilometers (14 miles) away. Therefore, from this location, the proposed

Table 4-27. Criteria for determining degree of contrast.

Degree of contrast	Criteria
None	The element contrast is not visible or perceived.
Weak	The element contrast can be seen but does not attract attention.
Moderate	The element contrast begins to attract attention and begins to dominate the characteristic landscape.
Strong	The element contrast demands attention, will not be overlooked, and is dominant in the landscape.

Source: DIRS 173053-BLM 1986, Section III.D.2.a.

Table 4-28. Bureau of Land Management visual resource management classes and objectives.

Visual resource class	Objective	Acceptable changes to land
Class I	Preserve the existing character of the landscape	Provides for natural ecological changes but does not preclude limited management activity. Changes to the land must be small and must not attract attention.
Class II	Retain the existing character of the landscape	Management activities can be seen but should not attract the attention of the casual observer. Changes must repeat the basic elements of form, line, color, and texture of the predominant natural features of the characteristic landscape.
Class III	Partially retain the existing character of the landscape	Management activities can attract attention but cannot dominate the view of the casual observer. Changes should repeat the basic elements in the predominant natural features of the characteristic landscape.
Class IV	Provide for management activities that require major modifications of the existing character of the landscape	Management activities can dominate the view and be the major focus of viewer attention. An attempt should be made to minimize the impact of activities through location, minimal disturbance, and repeating the basic elements.

Source: DIRS 101505-BLM 1986, Section V.B.

repository would cause a weak degree of contrast that is consistent with the management of the Class III lands that surround U.S. Highway 95 (Figure 4-8).

During construction of the access road from U.S. Highway 95 and offsite facilities south of the analyzed land withdrawal boundary, construction-related equipment, facilities, and activities would be potential sources of impacts to visual resources. The presence of workers, vehicles, equipment, temporary accommodations for construction workers, and the generation of dust and vehicle exhaust could be visible or could attract the attention of a casual observer at location 1. Considering the effect of best management practices for construction projects, construction activities would be noticeable but would not dominate the attention of a viewer and, therefore, would create a weak degree of contrast at this location.

A weak degree of contrast is compatible with the Bureau of Land Management objectives for all classes of lands and would cause small project-related visual impacts during construction of the access road and offsite facilities.

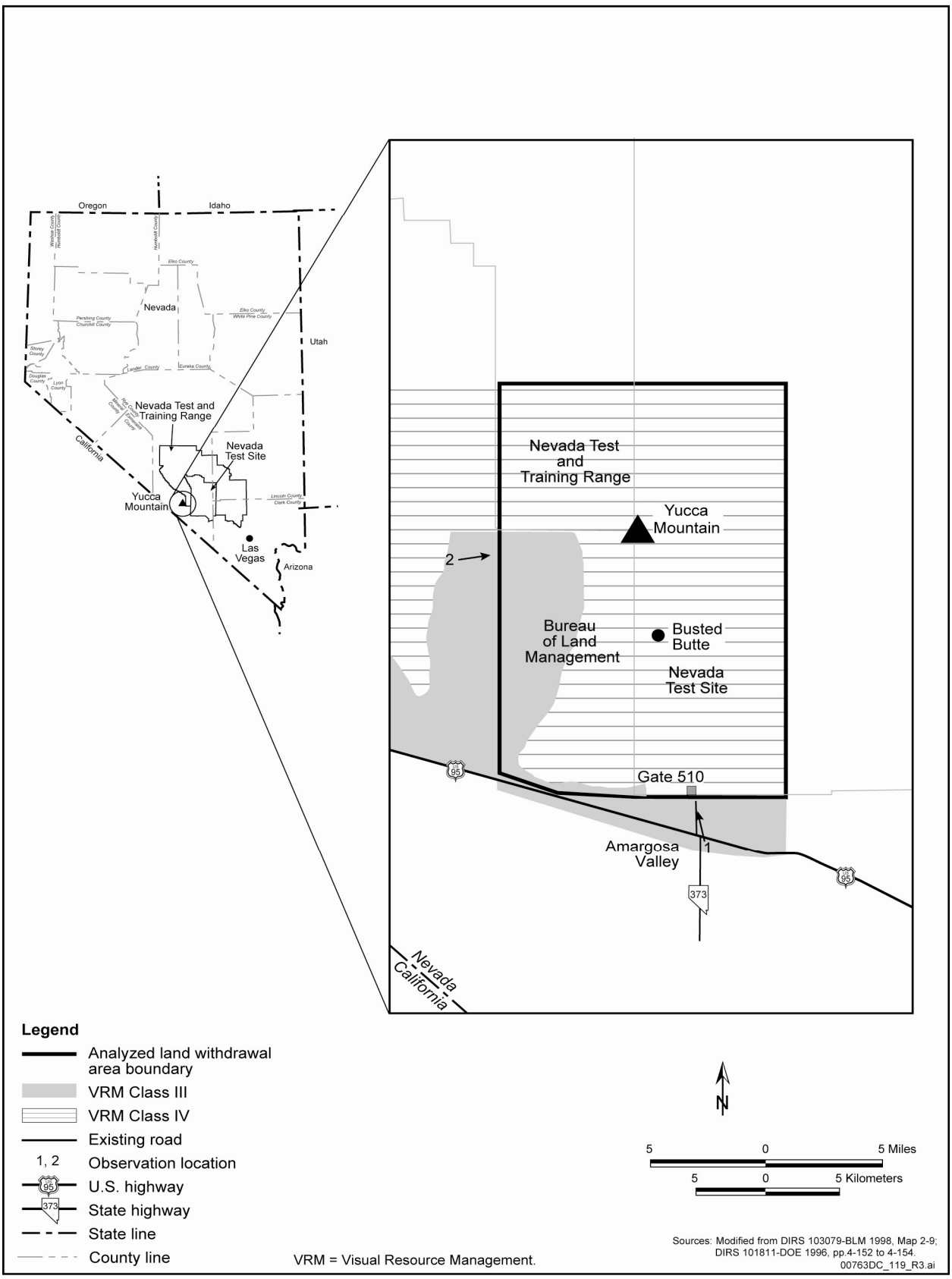

Figure 4-8. Visual resource management classifications in potentially affected areas.

The new access road would intersect U.S. Highway 95 approximately 0.39 kilometer (0.24 mile) to the southeast of the existing access road intersection with U.S. Highway 95 and would line up with the existing intersection of Nevada State Route 373 and U.S. Highway 95. DOE would use simple acceleration and deceleration lanes at the new intersection. Only about 0.049 square kilometer (12 acres) of new land would be necessary for the intersection and approximately 0.097 square kilometer (24 acres) would be necessary for 1.6 kilometers (1 mile) of new road that would be 61 meters (200 feet) wide. The temporary accommodations would occupy about 0.10 square kilometer (25 acres) and would include housing for construction workers; a utility zone for power supply, temporary trash storage, wastewater, and potable water treatment; eating facilities; laundry facilities; and office space. DOE would use gravel fill for roads and parking areas and would install lighting for security and parking. The most visible structures would be the housing facilities. The training facility would require approximately 0.02 square kilometer (5 acres) of land for the facility and associated parking, landscaping, and access. The Sample Management Facility would require approximately 0.012 square kilometer (3 acres). The marshalling yard and warehouse would require some fencing, offices, warehousing, open laydown, and shops on approximately 0.2 square kilometer (50 acres). The access road and offsite facilities would cause a weak degree of contrast against the landscape passing motorists could observe. A weak degree of contrast is consistent with the management of the Class III lands that surround U.S. Highway 95 and would result in small impacts to the visual setting. DOE would remove the temporary accommodations for construction workers and reclaim disturbed areas after they were no longer necessary.

The only structures that could be visible from the west (location 2) and exceed the elevation of the southern ridge of Yucca Mountain would be the ventilation exhaust shafts. The ventilation system would include intake and exhaust stacks, support structures, and access roads near the crest of Yucca Mountain on 0.243 square kilometer (60 acres) of land. The construction of pads and roads to the pads would be on 0.08 square kilometer (20 acres) of undisturbed land. The remaining 0.16 square kilometer (40 acres) is existing disturbed dirt roads that would access these locations. The design includes three intake shafts and six exhaust shafts. The exhaust shafts would contain 15.2- to 18.3-meter (50- to 60-foot) stacks (DIRS 185329-Morton 2007, all). The height of the ventilation intake structures would be lower than the exhaust stacks, and DOE would build these structures at lower elevations. Therefore, the intake stacks would not be as likely as the exhaust stacks to cause aesthetic impacts. The presence of exhaust ventilation stacks on the crest of Yucca Mountain would be seen as an adverse aesthetic impact by American Indians and would cause a moderate degree of contrast. Because of the height of the ventilation stack structures at the top of Yucca Mountain, the U.S. Air Force might require flashing beacon lights at the tops of the stacks. Such beacons could be visible for several miles, especially west of Yucca Mountain, but would not be visible in Death Valley National Park.

DOE would provide lighting for operations areas at the proposed repository and at the offsite facilities. Lighting would be typical for commercial properties except there would be no advertising lighting. Outdoor lighting would be high-intensity-discharge, sodium-vapor lights for roadways, perimeter fencing, and area lighting. Lighting levels would be as low as possible to save operating costs and avoid degradation of the dark character of the night sky, but high enough for security. Repository lighting could be visible outside the analyzed land withdrawal area, especially from the west (location 2) due to the ventilation structures at the top of Yucca Mountain. Repository lighting would be unlikely to affect users of Death Valley National Park. Because the towns of Amargosa Valley, Beatty, and Pahrump lie between the park and the repository, they probably would cause greater impact to the nightly viewshed than operations lighting at the repository. Lighting at the offsite facilities would be visible from location 1

near the intersection of Nevada State Route 373 and U.S. Highway 95. The use of shielded or directional lighting as a best management practice would minimize the amount of light that could be visible from outside the lighted areas and mitigate light pollution and the degradation of the dark character of the night sky. Overall, impacts from lighting would be small.

Closure activities, such as dismantling of facilities and site reclamation, would reduce the project-related contrast. Adverse impacts to visual quality from closure activities would be unlikely.

4.1.11 IMPACTS TO UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

This section updates the potential impacts to residential water and sewer, energy, materials, and site services from construction, operations, monitoring, and closure activities at the proposed repository. DOE based its reanalysis of impacts to utilities, energy, materials, and site services for this Repository SEIS on the modified design that Chapter 2 describes. The scope of the analysis included the use of electric power; fossil fuels, oil, and lubricants; construction materials; and onsite services such as emergency medical support, fire protection, and security and law enforcement. The analysis compared repository needs to available regional capacity and to anticipated regional demands. It used engineering estimates of requirements for construction materials, utilities, and energy. Construction activities would occur during the construction and operations analytical periods. The region of influence includes the local, regional, and national infrastructure that would supply the needs.

Section 4.1.14 discusses impacts in relation to TAD canister, waste package, and drip shield fabrication. Overall, DOE expects only small impacts from demand on residential water and sewer, energy, materials, and site services from the Proposed Action.

4.1.11.1 Residential Water

The repository facilities would not use water utilities from outside the analyzed land withdrawal area. DOE would use permitted wells to supply water for repository activities. DOE could build facilities (including the Sample Management Facility, training facility, marshalling yard, and warehouse) outside the land withdrawal area and would evaluate the most appropriate water sources once the locations and designs were final.

Population growth that resulted from the Proposed Action could affect regional water resources. The Proposed Action would result in an estimated maximum population increase in Clark County of approximately 1,300 persons in 2034 and an estimated maximum population increase in Nye County of approximately 1,000 persons in 2039. Other counties would be unlikely to have measurable population increases as a result of the Proposed Action. (Section 4.1.6 describes the estimated maximum population increases in Clark and Nye counties in greater detail.) Whether predominantly surface-water sources, as is the case for most of Clark County, or groundwater sources, as for most of Nye County, satisfied domestic water needs, these relatively small increases in population would have small impacts on existing water demands.

The maximum project-related population increase for Clark County would be less than 0.07 percent of the baseline 2005 population of 1.8 million (Chapter 3, Section 3.1.7.1, Table 3-10) and less than 0.04 percent of the county's estimated population in 2034, the year of the maximum population impact

from the Proposed Action. The associated increase in water demand in the county as a result of the project would be correspondingly small.

The maximum project-related population increase for Nye County would be less than 3 percent of the baseline 2005 population of 41,000 (Chapter 3, Section 3.1.7.1, Table 3-10) and about 1.2 percent of the county's estimated population in 2039, the year of the maximum population impact from the Proposed Action. For Nye County, estimates of domestic water demand from public water supplies are about 1.32 cubic meters (350 gallons) per day per person (DIRS 173226-Buqo 2004, p. 48). At this rate, the project-related increase in Nye County population would result in an additional water demand of about 500,000 cubic meters (410 acre-feet) of water during the maximum year (2039). This represents about 0.4 percent of the total water use of 120 million cubic meters (101,000 acre-feet) in Nye County in 2000. If 100 percent of the project-related growth in Nye County occurred in Pahrump (the upper bound condition), this would equate to adding about 500,000 cubic meters to Pahrump's annual water demand. This represents about 1.8 percent of the 2000 Pahrump Valley total water use of 28 million cubic meters (23,000 acre-feet). By 2039, when project-related population growth would peak, Pahrump Valley's water demand will have increased above its 2000 level due to growth unrelated to the Proposed Action. The project-related increase in water demand of 500,000 cubic meters would be an even smaller percentage of the total Nye County and Pahrump water usage in 2039 than in 2000.

4.1.11.2 Residential Sewer

The repository facilities would not use sewer utilities from outside the analyzed land withdrawal area. DOE would use septic tanks and leach fields for the sanitary waste system.

Population growth due to the Proposed Action could affect sewer utilities. In Clark County, the maximum project-related population increase would be less than 0.07 percent of the 2005 baseline population. Impacts to the populous areas of the county such as the Las Vegas Valley would be small.

In Nye County, the maximum project-related population increase (in 2039) would be less than 3 percent of the 2005 baseline population. Growth in Nye County from the Proposed Action would likely be primarily in the Pahrump area. Pahrump has no community-wide wastewater treatment system. Individual septic tank and drainage field systems would provide the primary wastewater treatment capacities.

4.1.11.3 Electric Power

During the construction analytical period, the demand for electricity would increase as DOE operated tunnel boring machines and other electrical equipment. The estimated peak demand for electric power during the construction period would be about 32 megawatts. Table 4-29 lists projected electric energy use during the different analytical periods.

The current electric power supply line has a peak capacity of only 10 megawatts. Upgrades to the site electrical system would be part of the Proposed Action.

During the operations analytical period, the development of emplacement drifts would continue in parallel with emplacement activities. During this period, the peak electric power demand would be about 110 megawatts. Construction activities during the period would account for 30 percent of the peak load

Table 4-29. Electricity and fossil-fuel use for the Proposed Action.

Analytical period	Use (years)	
Construction	5	
Operations	Up to 50	
Monitoring	50	
Closure (overlaps last 10 years of Monitoring)	10	
Total	Up to 105	
Peak electric power	(megawatts)	
Construction[a]	32	
Operations[a]	110	
Monitoring[b]	7.7	
Closure[b]	10	
Maximum	110	
Electricity use: annual maximum	(1,000 megawatt-hours)	
Construction	280	
Operations	940	
Monitoring[c]	63	
Closure[c]	72	
Maximum	940	
Fossil fuel	(million liters)	(million gallons)
Construction[d,e]	19	5.0
Operations[d,e]	690	180
Monitoring[e]	53	14
Closure[b]	5.2	1.4
Totals	770	200
Oils and lubricants[b]	(million liters)	(million gallons)
Construction	2.6	0.69
Operations	8.5	2.2
Monitoring	9	2.4
Closure	2	0.53
Totals	22	5.8

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. Source: DIRS 185429-BSC 2008, Table 5.
b. Source: DIRS 155970-DOE 2002, p. 4-73.
c. Calculated based on average usage per year as stated in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-73).
d. Source: DIRS 182211-Morton 2007, p. 2.
e. Source: DIRS 182210-Morton 2007, all.

and operation of the repository would account for the remaining load of about 75 megawatts. The maximum annual electric power use would be about 940,000 megawatt-hours.

After the completion of construction activities, the peak demand for electric power would drop to about 75 megawatts. The peak demand would continue to decrease after the operations analytical period. The peak demand during the monitoring analytical period would be much less than the 75-megawatt demand during operations. The closure analytical period would last for 10 years, during which the peak electric power demand would be much less than that during operations.

For 2021, during the operations analytical period, Nevada Power Company projects a peak demand of 8,763 megawatts (including planning reserve requirement) (DIRS 185100-Gecol 2007, p.33). The maximum 110-megawatt demand the repository would require would be about 1.2 percent of the projected peak demand in 2021. Although Nevada Power Company has demonstrated the ability to meet customer demand in a high-growth environment through effective planning, it has stated that a projected shortfall between demand and available resources could occur after 2011 and forecasts that additional resources will be necessary. It expects system demand to grow by more than 37 percent from 2007 to 2021 [from 23 million to more than 31 million megawatt-hours (DIRS 185100-Gecol 2007, p. 33)]. DOE did not attempt to identify the specific resources that could be required to meet the projected regional demand. Rather, DOE compared the estimated repository electricity use with the projected electricity requirements of the region to determine the impact the additional repository use would have on regional demands. The repository requirements would be a small percentage of Nevada Power Company's projected electricity demands. The estimated maximum annual power use of 940,000 megawatt-hours for the repository would be about 3 percent of the projected 2021 regional energy requirements.

4.1.11.4 Fossil Fuels and other Petroleum Products

Fossil-fuel use during the construction analytical period would include diesel fuel and gasoline. DOE would use diesel fuel primarily to operate surface construction equipment and equipment to maintain the excavated rock storage pile. Site trucks and automobiles would be the primary users of gasoline. During construction, the estimated maximum annual use of diesel fuel and gasoline would be about 5.5 million and 180,000 liters (1.5 million and 47,000 gallons), respectively. Total fossil-fuel use during the construction period would be about 19 million liters (5.0 million gallons). The supply capacity of diesel fuel is about 1.8 billion liters (480 million gallons) per year for the State of Nevada (DIRS 176397-EIA 2005, Table 4). This value is based on distillate fuel sales from 2004. The supply capacity of gasoline is about 4.1 billion liters (1.1 billion gallons) per year for the state (DIRS 182203-EIA 2006, all). This value is based on gasoline consumption in 2004. About half of the State of Nevada fossil-fuel consumption is in the three-county region of Clark, Lincoln, and Nye counties, with the highest consumption in Clark County (DIRS 155970-DOE 2002, p. 4-76). Table 4-29 lists fossil-fuel and oil and lubricant use during the different analytical periods.

During the construction analytical period, maximum yearly repository consumption of diesel fuel would be about 0.3 percent of the 2004 statewide consumption. Maximum yearly repository consumption of gasoline would be less that 0.005 percent of the 2004 statewide consumption.

DOE would use fossil fuels during the operations analytical period for construction activities, emplacement activities, onsite vehicles, boilers, and electrical generators. Maximum annual diesel fuel use would be about 20 million liters (5.3 million gallons) and maximum annual gasoline use would be about 850,000 liters (220,000 gallons). Total fossil-fuel usage during the operations period would be about 690 million liters (180 million gallons). The maximum annual use of diesel fuel and gasoline would be about 1.1 percent and 0.021 percent, respectively, of the 2004 capacities. The annual use would be highest during full repository operations and would decrease substantially during the monitoring analytical period.

During the closure analytical period, annual fossil-fuel use would be about 27 percent of that for the construction analytical period. During all periods, the projected use of diesel fuel and gasoline would be within the regional supply capacity and would cause little impact.

DOE would use hydraulic oils and lubricants and non-fuel hydrocarbons to support operation of equipment during all periods of the project. Consistent with the analysis in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 4-77), the quantities of these materials used would be about 22 million liters (5.3 million gallons). DOE would recycle and reuse these materials.

4.1.11.5 Construction Material

The primary materials for construction of the repository would be concrete, steel, and copper. DOE would use concrete—which consists primarily of cement, fine and coarse aggregate, and water—for liners in the main tunnels and ventilation shafts in the subsurface and for construction of surface facilities. The Department would use aggregate available in the region for the concrete and would purchase cement regionally. Table 4-30 lists the amounts of concrete and cement. During the construction analytical period, the estimated use of concrete would be about 320,000 cubic meters (420,000 cubic yards). The amount of cement required would be about 130,000 metric tons (about 140,000 tons).

Table 4-30. Construction material use for the Proposed Action.

Analytical period	Use (years)	
Construction	5	
Operations	up to 50	
Monitoring	50	
Closure (overlaps last 10 years of Monitoring)	10	
Total	up to 105	
Concrete	(1,000 cubic meters)	(1,000 cubic yards)
Construction[a]	320	420
Operations[a]	170	220
Monitoring[b]	0	0
Closure[b]	3	3.9
Totals	490	640
Cement	(1,000 metric tons)	(1,000 tons)
Construction[a]	130	140
Operations[a]	65	72
Monitoring[b]	0	0
Closure[b]	1.2	1.3
Totals	190	210
Carbon steel[c]	280 (1,000 metric tons)	310 (1,000 tons)
Copper[c]	0.67(1,000 metric tons)	0.74 (1,000 tons)

Notes: Section 4.1.14 discusses titanium requirements from the manufacture of drip shields. Numbers are rounded to two significant figures; therefore, totals might differ from sums.

a. Source: DIRS 182713-Morton 2007, all.
b. Source: DIRS 155970-DOE 2002, p. 4-74.
c. Source: DIRS 182197-Morton 2007, all.

The average yearly concrete demand for the construction analytical period would be about 65,000 cubic meters (about 85,000 cubic yards). Annual production of concrete in Nevada equals approximately 6.7 million cubic meters (8.8 million cubic yards) per year (DIRS 173400-NRMCA 2004, p. 2). The annual quantity of concrete required during the construction period represents less than 1 percent of concrete use in Nevada in 2004. Cement would be purchased through regional markets and shipped to the site. Regional suppliers of cement have demonstrated the ability to keep pace with the annual production

of concrete in Nevada. DOE expects little or no impact from increased demand for concrete and cement in the region.

For the Proposed Action, DOE would need as much as 280,000 metric tons (310,000 tons) of carbon steel for uses that would include rebar, piping, and track and about 670 metric tons (740 tons) of copper for uses that would include electrical cables. DOE did not categorize the requirements for carbon steel and copper by analytical period in Table 4-30 because total use would be very small in relation to annual domestic production. The total use of carbon steel at the repository would be less than 0.3 percent of the annual domestic production capability of about 100 million metric tons (about 110 million tons). The total use of copper at the repository would be less than 0.07 percent of the annual domestic mine production. Although worldwide demand for steel is increasing due to economic growth overseas (primarily in China), the markets for steel and copper are worldwide in scope. DOE anticipates little or no impact from increased demand for steel and copper in the region.

4.1.11.6 Site Services

DOE would rely on the existing support infrastructure during an emergency at the proposed repository (Chapter 3, Section 3.1.11.3) until it completed new onsite facilities during the construction analytical period. Once completed, the new facilities would provide onsite services.

The primary onsite response would occur through the multifunctional Fire, Rescue, and Medical Facility, which would provide space for fire protection and firefighting services, underground rescue services, emergency and occupational medical services, and radiation protection. The facility would have the capability to provide complete response to most onsite emergencies. A helicopter pad would enable emergency medical evacuation. DOE would coordinate the operation of this facility with facilities in Nye County and at the Nevada Test Site to increase response capability, if necessary. Nye County developed the *Nye County Public Safety Report* to recommend that Nye County and DOE integrate public safety services for the repository site and the area just beyond the repository boundary to mitigate potential repository impacts to public safety services. The report is summarized and incorporated by reference (DIRS 182710-NWRPO 2007, all).

As stated in the Yucca Mountain FEIS, a site security and safeguards system would include surveillance and safeguards functions to protect the repository from unauthorized intrusion and sabotage (DIRS 155970-DOE 2002, p. 4-78). The system would include site security barriers, gates, and badging and automated surveillance systems operated by trained security officers. Support would be available from the Nevada Test Site security force and the Nye County Sheriff's Department, if necessary.

The emergency response system would provide responses to accident conditions at or near the repository site. The system would maintain emergency and rescue equipment, communications, facilities, and trained professionals to respond to fire, radiological, mining, industrial, and general accidents above or below ground.

The planned onsite emergency facilities would be able to respond to and mitigate most onsite incidents, which would include underground incidents, without outside support. Therefore, there would be no meaningful impacts to the emergency facilities of surrounding communities or counties.

4.1.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

This section describes the management of waste that DOE could generate as a result of construction, operations, monitoring, and closure activities. The region of influence for waste and hazardous materials consists of on- and offsite areas that include landfills and hazardous and radioactive waste processing and disposal sites, in which DOE would dispose of waste it generated under the Proposed Action. The evaluation of waste management impacts used available information to consider the potential for the generation of particular waste types and estimates of the quantities that these activities could generate. The types of waste the Proposed Action would generate would include sanitary and *industrial waste*, *industrial wastewater*, low-level radioactive waste, sanitary sewage, and hazardous waste. DOE based the estimates for the amount of generated waste in this section on construction and operating experience, engineering data, material use estimates, and number of workers. The Department did not generate estimated quantities for mixed and *transuranic waste* because it anticipates that routine operations would not produce these waste types. However, this section does discuss the management of such waste, if generated.

DOE determined that modifications in the repository design and operational plans would require a new analysis of repository-generated waste. Therefore, DOE has revised the construction and demolition debris, sanitary sewage, and low-level radioactive waste estimates since completion of the Yucca Mountain FEIS to reflect the modified design and operational plan changes. These changes have resulted in the proposed construction of more but smaller facilities and slight changes in the estimated number of workers for the project. DOE has also revised the low-level radioactive waste estimates to reflect the implementation of the use of TAD canisters. The Department extrapolated revised waste estimates from a variety of sources, including the FEIS, to calculate total waste over the duration of the project. The industrial wastewater and sanitary and industrial waste estimates have not changed because the operational aspects DOE used to generate these estimates for the FEIS are essentially the same. Therefore, the estimates for these waste types are incorporated by reference from the Yucca Mountain FEIS.

This section analyzes impacts from the disposal of repository-generated waste against current disposal waste capacities for offsite and regional waste facilities.

4.1.12.1 Waste and Hazardous Materials Impacts from Construction, Operations, Monitoring, and Closure

Table 4-31 lists the waste and hazardous materials that DOE could generate during the construction, operations, monitoring, and closure analytical periods. The estimates reflect the repository design and operations aspects that are in the application DOE has submitted to NRC. The construction and demolition debris estimates include the dismantling of the temporary structures at the North Portal and the existing Sample Management Facility at the Field Operations Center.

DOE would use one or more of the following to manage construction and demolition debris: disposal at existing landfills at the Nevada Test Site, nearby municipal landfills, or a State-permitted landfill on the Yucca Mountain site. In addition to the landfills at the Nevada Test Site, there are 20 operating municipal solid waste landfills, which include four industrial landfills, in Nevada (DIRS 184969-NDEP 2007, Appendix 3).

Table 4-31. Total waste quantities expected to be generated.

Waste type	Total amount
Construction and demolition debris[a]	476,000 cubic meters (620,000 cubic yards)
Industrial wastewater[b]	1.2 million cubic meters (320 million gallons)
Sanitary sewage	2.0 million cubic meters (530 million gallons)
Sanitary and industrial waste[b,c]	100,000 cubic meters (130,000 cubic yards)
Hazardous waste[b]	8,900 cubic meters (12,000 cubic yards)
Low-level radioactive waste[d]	74,000 cubic meters (97,000 cubic yards)

a. Estimate based on materials used.
b. Value remains unchanged from the Yucca Mountain FEIS.
c. Does not include construction and demolition debris.
d. Estimate includes liquid low-level waste and emptied dual-purpose canisters managed as low-level waste.

DOE would use four onsite evaporation ponds or a wastewater treatment facility to manage industrial wastewater. Industrial wastewater from surface facilities would flow to an evaporation pond in the vicinity of the surface geologic repository operations area; wastewater from the subsurface would flow to evaporation ponds at the South Portal development area and the North Construction Portal; and wastewater from oil-water separators and superchlorinated water from maintenance of the drinking water system would flow to evaporation ponds at the central operations area. The evaporation ponds would be lined; DOE would test, treat, and dispose of residual sludge as appropriate, depending on the results of the testing. Section 4.1.3 discusses the evaporation ponds. A wastewater treatment facility is not an element of the modified design; if DOE did incorporate this facility, it could use it to treat specifically identified industrial wastewater streams and sanitary sewage. The discharges would be permitted; DOE would test, treat, and dispose of the associated sludge as appropriate, depending on the results of the testing. Appendix A discusses the benefits and potential environmental impacts of a wastewater treatment facility.

DOE would use septic systems or possibly a wastewater treatment facility to manage sanitary sewage. DOE would test, treat, and dispose of sludge from the septic systems as appropriate, depending on the results of the testing. DOE would manage sanitary and industrial waste in the same manner it would manage construction and demolition debris.

DOE would manage hazardous waste by shipment off the site for treatment and disposal. Hazardous waste would be primarily from laboratories, health clinics, and vehicle maintenance shops; examples include solvents, fuels, paints, corrosives, and cleansers. DOE would treat, store, and dispose of waste from these substances appropriately in accordance with federal and state regulations. The Department would not dispose of hazardous waste on the site. It would contract with permitted hazardous wastes transporters to ensure the safe transport of all hazardous wastes from its facilities to a permitted offsite hazardous waste facility for treatment or disposal. The transportation of hazardous materials would be in accordance with federal and state regulations. The U.S. Department of Transportation Office of Hazardous Materials Safety prescribes the regulations for the safe transportation of hazardous materials (40 CFR Part 49).

DOE would control and dispose of site-generated low-level radioactive waste in a DOE low-level waste disposal site, a site in an *Agreement State*, or an NRC-licensed site, subject to the completion of the appropriate review pursuant to the *National Environmental Policy Act* (NEPA). Disposal in an Agreement State site or in an NRC-licensed site would be consistent with applicable portions of 10 CFR Part 20. Low-level radioactive waste would be in the form of solids and liquids from operations such as

WASTE TYPES

Industrial waste:
Solid waste that is neither hazardous nor radioactive such as construction and demolition debris, rubber, and miscellaneous plastic products. Examples of construction and demolition debris include soil, rock, masonry materials, and lumber.

Industrial wastewater:
Liquid wastes from industrial processes that do not include sanitary sewage. Repository industrial wastewater would include water for dust suppression, rinse water from concrete production and transport, and process water from building heating, ventilation, and air conditioning systems.

Sanitary sewage:
Domestic wastewater from sinks, showers, kitchens, floor drains, restrooms, change rooms, and food preparation and storage areas.

Sanitary waste:
Solid waste that is neither hazardous nor radioactive. Sanitary waste streams include paper, glass, and discarded office material. (State of Nevada waste regulations define this waste stream as household waste.)

Hazardous waste:
Waste designated as hazardous by U.S. Environmental Protection Agency or State of Nevada regulations. Hazardous waste, defined under the *Resource Conservation and Recovery Act*, is waste that poses a potential hazard to human health or the environment when improperly treated, stored, or disposed of. Hazardous wastes appear on special EPA lists or possess at least one of the following characteristics: ignitability, corrosivity, toxicity, or reactivity. Hazardous waste streams from the repository could include certain used rags and wipes contaminated with solvents.

Low-level radioactive waste:
Radioactive waste that is not classified as high-level radioactive waste, transuranic waste, byproduct material containing uranium or thorium from processed ore, or naturally occurring radioactive material. The repository low-level radioactive waste would include personal protective clothing, air filters, solids from the liquid low-level waste treatment process, adiological control and survey waste, and used canisters (dual-purpose).

Transuranic waste:
Waste materials (excluding high-level radioactive waste and certain other waste types) contaminated with alpha-emitting radionuclides that are heavier than uranium with half-lives greater than 20 years and that occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from treatment and fabrication of plutonium and from research activities at DOE defense installations.

cask, facility, and equipment decontamination with wipes and chemicals; pool system skimming and filtration operations; used dual-purpose canisters; tooling and clothing; facility heating, ventilation, and air conditioning filtration; chemical sumps; and carrier and transporter washing (DIRS 179303-BSC 2006, pp. 5 to 27). Activities during the operations, monitoring, and closure analytical periods would generate about 74,000 cubic meters (97,000 cubic yards) of low-level waste. Dual-purpose canisters would make up about 9,800 cubic meters (13,000 cubic yards) of low-level waste.

DOE would either process liquid low-level radioactive waste to remove contamination until it met release limits for discharge to an evaporation pond or process the waste until it met applicable requirements for

shipping it offsite for treatment or disposal (DIRS 179303-BSC 2006, p. 26). This analysis assumed the Department would process liquid low-level radioactive waste for offsite shipment in order to generate a conservatively high quantity of waste for offsite disposal. The estimated quantity of liquid low-level waste is included in the 74,000-cubic-meter (97,000-cubic-yard) total. DOE does not anticipate the generation of mixed or transuranic waste during routine operations, but if unusual activities generated such waste it, would be minimal (DIRS 182319-Morton 2007, all), and DOE would dispose of it at an offsite permitted facility.

4.1.12.2 Overall Impacts to Waste Management

Impacts from construction and demolition debris and sanitary and industrial wastes would be small because of the number and capacity of offsite solid waste landfills. DOE could build onsite solid waste facilities to accommodate the nonhazardous waste that repository activities generated. In addition, the Department would implement best management practices to reduce waste generation and to avoid or minimize the amount of waste disposed of at the Nevada Test Site or regional solid waste facilities. Because DOE would minimize waste as much as possible, the additional waste disposed of at the Nevada Test Site or regional facilities would be small, and these facilities have enough capacity to accommodate such waste.

The regional capacity for treatment and disposal of hazardous waste is greater than the quantity that DOE would generate. The estimated disposal capacity for hazardous wastes in western states is about 50 times the demand for landfills and 7 times the demand for incineration until at least 2013 (DIRS 103245-EPA 1996, pp. 32, 33, 36, 46, 47, and 50). Based on this information, impacts to regional hazardous waste facilities from waste generated from repository activities would be small.

Impacts to licensed disposal facilities from low-level radioactive waste would be small because the amount of such waste would be small. Repository-related activities would generate approximately 638 cubic meters (834 cubic yards) of low-level waste annually over the life of the project. For comparison, this accounts for only about 0.5 percent of the low-level waste disposed of in 2005 at commercial low-level waste facilities nationwide (DIRS 182320-NRC 2007, all).

4.1.13 ENVIRONMENTAL JUSTICE

This section describes the DOE analysis of *environmental justice* (the potential for impacts to be disproportionately high and adverse to minority or *low-income populations*). The region of influence for environmental justice varies with resource area and corresponds to the region of influence for each resource area. Since completion of the Yucca Mountain FEIS, the NRC has issued *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040–52048, August 24, 2004). For this Repository SEIS, DOE has chosen to follow the NRC guidance. In addition, the analysis used 2000 Census data available since the Yucca Mountain FEIS to identify low-income population blocks.

4.1.13.1 Impact Assessment Methodology

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, and the associated implementing guidance establish the framework for identification of impacts to low-income and *minority populations*. The Executive Order directs federal

agencies to identify and consider disproportionately high and adverse human health, social, economic, or environmental effects of their actions on minority and low-income communities and American Indian tribes and provide opportunities for community input to the process, which includes input on potential effects and mitigation measures.

DOE performs environmental justice analyses to identify if any high and adverse impacts would fall disproportionately on minority or low-income populations in accordance with guidance from the Council on Environmental Quality. The potential for environmental justice concerns exists if the following occur (DIRS 177702-CEQ 1997, pp. 26 and 27):

> "Disproportionately high and adverse human health effects: When determining whether human health effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:
>
> a) Whether the health effects, which may be measured in risks and rates, are significant (as employed by NEPA [42 U.S.C. 4321 et seq.]), or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death; and
>
> b) Whether the risk or rate of hazard exposure by a minority population, low-income population, or Indian tribe to an environmental hazard is significant (as employed by NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group; and
>
> c) Whether health effects occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards
>
> Disproportionately high and adverse environmental effects: When determining whether environmental effects are disproportionately high and adverse agencies are to consider the following three factors to the extent practicable:
>
> a) Whether there is or will be an impact on the natural or physical environment that significantly (as employed by NEPA) and adversely affects a minority population, low-income population, or Indian tribe. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or Indian tribes when those impacts are interrelated to impacts on the natural or physical environment; and
>
> b) Whether environmental effects are significant (as employed by NEPA) and are or may be having an adverse impact on minority population, low-income populations, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group; and
>
> c) Whether the environmental effects occur or would occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards."

The DOE analysis of environmental justice for this Repository SEIS considered the results of analyses of potential impacts to the different resource areas that focused on consequences to resources that could affect human health or the environment for the general population. In addition, the Department determined if unique exposure *pathways*, sensitivities, or cultural practices would result in different impacts on minority or low-income populations. If either assessment identified impacts, the environmental justice analysis compared the impacts on minority and low-income populations to those on the general population. In other words, if significant impacts on a minority or low-income population would not appreciably exceed the same type of impacts on the general population, disproportionately high and adverse impacts would be unlikely.

The Repository SEIS definition of a minority population is in accordance with the Bureau of the Census racial and ethnic categories. The "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions" (69 FR 52040–52048; August 24, 2004) states:

> "…a minority or low-income community is identified by comparing the percentage of the minority or low-income population in the impacted area to the percentage of the minority or low-income population in the County (or Parish) and the State. If the percentage in the impacted area significantly exceeds that of the State or the County percentage for either the minority or low-income population then [environmental justice] will be considered in greater detail. "Significantly" is defined by staff guidance to be 20 percentage points. Alternatively, if either the minority or low-income population percentage in the impacted area exceeds 50 percent [environmental justice] matters are considered in greater detail."

Clark and Nye counties had a low-income population of 11 percent in the 2000 Census, as did the State of Nevada. Inyo County had a low-income population of 14 percent. Twenty census block groups are within the 84-kilometer (52-mile)-radius around Yucca Mountain. No census block group exceeded the 20 percentage-point poverty level and, therefore, no low-income population significantly exceeds that of the state or county. Analysis of block data demonstrated several blocks where the minority population equaled or exceeded 50 percent in all three counties (Chapter 3, Figure 3-19).

Regions of influence, and therefore potentially affected areas, vary with each resource area. If there would be no significant impacts in a resource area's region of influence, or if identified significant impacts would not fall disproportionately on low-income or minority populations, there would be no environmental justice impacts. DOE has identified land use, air quality, cultural resources, socioeconomics, and public health and safety as resources that could be of particular interest to minority or low-income populations. The following sections summarize the impacts to those resource areas.

4.1.13.2 Construction, Operations, Monitoring, and Closure

4.1.13.2.1 *Land Use*

Direct land use impacts from the Proposed Action would be small due to the existing and future restriction of site access for most affected areas (Section 4.1.1). There are no communities with high percentages of minority populations in the region of influence for land use.

4.1.13.2.2 *Air Quality*

Impacts to air quality from the Proposed Action would be small (Section 4.1.2). Further, DOE would use best management practices for all activities, particularly ground-disturbing activities that could generate fugitive dust.

4.1.13.2.3 *Cultural Resources*

DOE has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. The Department would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program. Before construction began, DOE would avoid archaeological resources or mitigate its actions, so any direct adverse impacts from construction and operation of the facilities would be small. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected areas. In addition, the Department would conduct such activities in a manner that would preclude improper disclosure of, or adverse impacts to, sensitive cultural sites or resources covered by applicable laws and regulations (Section 4.1.5).

4.1.13.2.4 *Socioeconomics*

Socioeconomic impacts from repository construction and operation would be small. Regional employment would increase an estimated 0.1 percent above baseline levels. Changes to the baseline regional population would be no greater than 0.06 percent. Potential impacts to the Gross Regional Product, real disposable personal income, and expenditures by state and local governments would be small. While several communities have minority populations greater than 50 percent, there would be no disproportionately high socioeconomic impacts on those communities (Section 4.1.6).

4.1.13.2.5 *Public Health and Safety*

The analysis determined that impacts that could occur to public health and safety would be small throughout the Proposed Action (Section 4.1.7). There would be no nonradiological adverse health effects for the public within the 84-kilometer (52-mile) radius around the repository. The elapsed time between initiation of repository construction and closure would be 105 years. No subsection of the population, including minority populations, would receive disproportionate impacts.

4.1.13.3 Environmental Justice Impact Analysis Results

As in the Yucca Mountain FEIS, this Repository SEIS analysis used information from Sections 4.1.1 to 4.1.12. DOE has not identified any high and adverse potential impacts to members of the general public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts would result from the Proposed Action.

4.1.13.4 An American Indian Perspective

In 1987, DOE initiated the Native American Interaction Program to solicit input from tribes and organizations on the characterization of the Yucca Mountain site and the possible construction and operation of a repository for spent nuclear fuel and high-level radioactive waste. These tribes and organizations—Southern Paiute; Western Shoshone; and Owens Valley Paiute and Shoshone people from Arizona, California, Nevada, and Utah—have declared traditional ties to the Yucca Mountain area. The Native American Interaction Program is part of DOE's implementation of the Council on Environmental Quality's *Environmental Justice Guidance Under the National Environmental Policy Act* that "agencies should recognize the interrelated cultural, social, occupational, historical, or economic factors that may amplify the natural and physical environmental effects of the proposed agency action" (DIRS 177702-CEQ 1997, all).

In the Yucca Mountain FEIS, DOE acknowledged that people from American Indian tribes have used the proposed repository area as well as nearby lands, and that lands around the site contain cultural, animal, and plant resources important to those tribes. The tribes presented their views in *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement*, which states (DIRS 102043-AIWS 1998, p.2-9):

> "…we have the responsibility to protect with care and teach the young the relationship of the existence of a nondestructive life on Mother Earth. This belief is the foundation for our holistic view of the cultural resources, i.e., water, animals, plants, air, geology, sacred sites, traditional cultural properties, and artifacts. Everything is considered to be interrelated and dependent on each other to sustain existence."

American Indian views on environmental justice are presented in Section 3.4.2.4. DOE acknowledges the concerns of the American Indians and has consulted with the tribes. The Department would continue to consult with the Consolidated Group of Tribes and Organizations throughout the life of the project. If DOE implemented the Proposed Action, the Department would work closely with American Indians to ensure that a Mitigation Action Plan was developed and to ensure compliance with Section 106 of the *National Historic Preservation Act*.

4.1.14 IMPACTS FROM MANUFACTURING REPOSITORY COMPONENTS

This section discusses the potential environmental impacts from the manufacture of components that DOE would require to move and dispose of spent nuclear fuel and high-level radioactive waste at a geologic repository at Yucca Mountain. Repository components would include canisters, waste packages, emplacement pallets, drip shields, aging overpacks, *shielded transfer casks*, and transportation casks. Other repository-related items (for example, cranes and other heavy equipment, miscellaneous mechanical components, electrical components, structural materials) are standard, commercially available components that DOE could buy from several vendors. As a result, there would be no offsite manufacturing environmental impacts specifically attributed to these other types of repository equipment and components and they are not included in this evaluation. This section updates information in the Yucca Mountain FEIS and summarizes and incorporates by reference Section 4.1.15 of the FEIS (DIRS 155970-DOE 2002, pp. 4-91 to 4-105). The primary updates or modifications since the FEIS evaluation are the addition of TAD canisters to the list of repository components, slight changes in the numbers of

other components, updated information on the environmental and socioeconomic settings of the reference manufacturing facilities, and expansion of the analysis of air quality impacts to include $PM_{2.5}$.

Section 4.1.14.1 provides an overview of the analysis basis. Section 4.1.14.2 discusses the components that offsite manufacturers would fabricate and the manufacturing schedule. Section 4.1.14.3 describes the components in detail. Section 4.1.14.4 discusses environmental settings for air quality, health and safety, and socioeconomics. Section 4.1.14.5 describes environmental impacts on air quality, health and safety, socioeconomics, waste generation, and environmental justice; in addition, this section contains an evaluation of materials use that addresses the potential for impacts to materials markets and supplies.

4.1.14.1 Overview

This analysis and the corresponding analysis in the Yucca Mountain FEIS used the overall approach, analytical methods and, in some cases, baseline data from the *Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel* (DIRS 101941-USN 1996, all). The evaluation addressed ways in which the manufacture of repository components could affect environmental attributes and resources at a representative manufacturing site. DOE did not perform a site-specific evaluation because more than one manufacturer probably would be necessary to meet the production schedule and, until competitive bidding was complete, the Department would not know the locations of specific manufacturing facilities.

The analysis used a representative manufacturing site based on five existing facilities that produce casks, canisters, and related hardware for the management of spent nuclear fuel with the use of NRC-certified designs. The facilities, which are the same as those the Navy used in its EIS (DIRS 101941-USN 1996, p. 4-17), are in Westminster, Massachusetts; Greensboro, North Carolina; Akron, Ohio; York, Pennsylvania; and Chattanooga, Tennessee. Although the analysis used the existing facilities from the earlier evaluation, it used updated information to characterize the environmental settings for the facility locations.

The analysis assumed that the manufacturing facilities and processes at these locations are similar to the facilities and processes that would be necessary to produce the repository components. Although the five reference facilities might not fabricate components from titanium (which DOE would use in the drip shields), the fabrication processes of rolling plate, forming, and welding that would be necessary to produce a drip shield would be similar to the processes for casks and canisters from other structural material. The analysis also assumed that manufacture of all components would occur at one representative site. Although this is unlikely, it is conservative because potential impacts would be concentrated and higher than if they were in several locations.

4.1.14.2 Components and Product Schedule

Table 4-32 lists the components and the quantities of components DOE included in the analysis; the table includes TAD canisters (Section 4.1.14.3), which the Yucca Mountain FEIS did not address. The table includes all repository components for naval spent nuclear fuel that the Department would emplace at Yucca Mountain, but does not include the transportation casks, which the Navy would manufacture as owner and manager of that spent fuel. The Navy EIS (DIRS 101941-USN, 1996, all) discusses these casks and the potential environmental impacts of their production.

Table 4-32. Quantities of offsite-manufactured components for the Yucca Mountain Repository.

Component	Description	Number to be manufactured[a]
Rail transportatoin casks or overpacks	Storage and shipment of SNF and HLW	79
Truck transportation casks	Storage and shipment of uncanistered fuel	30
Waste packages	Outside container for SNF and HLW emplacement in the repository	11,200
TAD canisters	TAD canisters for commercial SNF	7,400[b]
Emplacement pallets	Support for emplaced waste packages	11,200[c]
Drip shields	Titanium covers for waste packages	11,500
Aging overpacks	Metal and concrete storage vaults for aging[d]	2,500
Shielded transfer casks	Casks for transfer of canisters between and in site facilities	6–10

a. The number of components is an approximation based on the best available estimates.
b. Total number of empty TAD canisters includes those shipped to generator sites and to the repository.
c. The number of emplacement pallets includes about 10,030 of the standard length and 1,150 of the short length.
d. Only the metal components of the aging overpacks would be manufactured offsite.
HLW = High-level radioactive waste. TAD = Transportation, aging, and disposal (canister).
SNF = Spent nuclear fuel.

The analysis assumed the manufacture of all the components except drip shields would occur over 24 years to support the maximum rate of emplacement. The operations analytical period would last as long as 50 years (Chapter 2, Table 2-1), so component manufacturing likely would be on a longer schedule and still keep up with demand. However, the assumed faster pace is conservative because it concentrates estimated impacts into a shorter timeframe. Manufacturing activity would begin 2 years before repository operations started, would build up during the first 5 years, then would remain nearly constant through the remainder of the 24-year period. Because DOE would not need the drip shields until the closure analytical period, the analysis assumed the period for manufacture and delivery of them would be 10 years and would not coincide in any year with the manufacture of the other components.

4.1.14.3 Components

4.1.14.3.1 *Waste Packages*

The waste package (which the Yucca Mountain FEIS called the disposal container) would be the final outside container DOE would use to package the spent nuclear fuel and high-level radioactive waste for emplacement in the repository. The basic design remains as it was in the FEIS; that is, it would be a cylindrical vessel with an outer layer of corrosion-resistant, nickel-based alloy (*Alloy 22*) and an inner liner of Stainless Steel Type 316. Both the inner liner and the outer layer would have lids of the corresponding materials at both ends. The bottom lids would be welded to the cylindrical body at the fabrication shop and the top inner and outer lids would be welded in place at the repository after insertion of the canister (or canisters) with spent fuel or high-level radioactive waste. DOE has eliminated a third lid for the closure end from the design in the FEIS.

The Yucca Mountain FEIS described the proposed use of about 10 different waste package configurations to accommodate the different types of spent nuclear fuel and high-level radioactive waste. Although the basic waste package design would be the same for the various waste forms, DOE has reduced the number of configurations to six by standardizing the waste package for commercial spent nuclear fuel. The

Department accomplished this standardization through the introduction of a TAD canister, which is described below. In addition to waste package changes to accommodate the TAD canister and to eliminate the third closure lid, other changes in proposed waste package configurations resulted in changes to the size and mass of material. A notable change in several of the configurations was a slight elongation of the package to allow a thick inner lid that also serves as a shield plug. The discussions in this section incorporate these and other minor changes. The six waste package configurations range in length from 3.7 to 5.9 meters (12 to 19 feet), with outside diameters of 1.8 to 2.1 meters (6 to 7 feet). The mass of empty waste packages would range from 22 to 34.2 metric tons (24 to 38 tons).

4.1.14.3.2 *Transportation, Aging, and Disposal Canisters*

Management of commercial spent nuclear fuel would be more standardized by the use of TAD canisters, which the Yucca Mountain FEIS did not consider. TAD canisters would be cylindrical containers, approximately 5.4 meters (18 feet) long with an outer diameter of about 1.7 meters (5.5 feet). The shell of the canister would be stainless steel and the inner basket would be configured differently for different types of spent nuclear fuel. The inner basket would include borated stainless steel to act as a *neutron* absorber. The mass of an empty TAD canister would range from about 29 to 31 metric tons (32 to 34 tons) depending on the internal basket configuration. Under the Proposed Action, about 90 percent of the commercial spent nuclear fuel would travel to the repository in TAD canisters; generator sites would load and seal these canisters. The remaining 10 percent of the commercial spent fuel would be transported in other types of canisters, or as uncanistered fuel (in casks), and DOE would repackage it in TAD canisters at the repository site. This analysis includes TAD canisters as repository components because they are an element of the repository design and the commercial nuclear facilities would have to use them as appropriate.

4.1.14.3.3 *Casks for Rail and Truck Shipments*

DOE would mainly use rail casks to ship spent nuclear fuel and high-level radioactive waste to the proposed repository, but would also use some truck casks. The Department would tailor the design of a specific cask to the type of material it would contain. As in the Yucca Mountain FEIS, a typical rail or truck cask or overpack would consist of inner and outer cylinders of stainless or carbon steel with a depleted uranium or lead liner between the cylinders. The vessel bottom would have a similar layered construction of plates welded to the cylinder ends. A cask would probably have an inner structure to keep the contents secure, and an overpack would have no internal structures because it would be sized for a specific *disposable canister*. A polypropylene sheath would be around the outside of the cylinder for neutron *shielding*. After the spent nuclear fuel or high-level radioactive waste was placed inside the cask or overpack, a cover with lead or depleted uranium shielding would be bolted to the top of the cylindrical vessel. Large removable impact limiters of aluminum honeycomb or other crushable material would be placed over the ends of the casks or overpacks for added protection during *shipment*. Typical casks and overpacks would range from 4.5 to 6 meters (15 to 20 feet) long and about 0.5 to 2 meters (1.6 to 6.6 feet) in diameter. Empty truck casks could weigh from 21 to 22 metric tons (about 23 to 24 tons) and empty rail casks would typically weigh from 59 to 91 metric tons (65 to 100 tons).

4.1.14.3.4 *Emplacement Pallets*

The emplacement pallets would support the waste packages in the repository and would allow close spacing [to within 10 centimeters (4 inches)] of the end-to-end waste packages. The design of these

components is essentially unchanged from that in the Yucca Mountain FEIS. The pallets would have V-shaped supports at either end on which the waste package would rest, and the end pieces of the pallets would connect with structural tube members. The pallet assemblies would be a combination of Alloy 22 components (primarily plates) and stainless-steel tubes. Surfaces that would contact the waste package would be Alloy 22. The shorter pallet would be 2.5 meters (8.2 feet) long and have a mass of 1.7 metric tons (1.9 tons) (DIRS 184918-Morton 2007, all); DOE would use them only for the shortest waste package for DOE spent nuclear fuel and high-level radioactive waste. The longer pallet would be 4.15 meters (13.6 feet) long and have a mass of 2 metric tons (2.2 tons) (DIRS 184918-Morton 2007, all); DOE would use this pallet for all other waste packages.

4.1.14.3.5 *Drip Shields*

The drip shields would be rigid structures above the waste packages that would divert water around them and provide protection from rockfalls. It would consist of Titanium Grade 7 surface plates, Titanium Grade 29 structural members, and Alloy 22 for the base. DOE included palladium, a small-percentage constituent of Titanium Grade 7, in the evaluation of materials in Section 4.1.14.5.4 because of its potential market impact. DOE would install the continuous drip shield in sections, with one that overlapped and interlocked with the opposite end of the next section. Each section would be 5.8 meters (19 feet) long by 2.5 meters (8 feet) wide by 2.9 meters (9.5 feet) high with a mass of 4.9 metric tons (5.4 tons) (DIRS 184918-Morton 2007, all).

4.1.14.3.6 *Aging Overpacks*

Aging overpacks (which the Yucca Mountain FEIS called *dry storage* casks) would hold TAD canisters of commercial spent nuclear fuel for aging to meet waste package thermal limits. Vertical and horizontal aging overpacks would consist of an inner liner of about 5-centimeter (2-inch)-thick carbon steel surrounded by a roughly 76-centimeter (30-inch)-thick layer of reinforced concrete, which might, depending on the vendor, have an exterior carbon-steel shell of 2.5- to 5-centimeter (1- to 2-inch) thickness (DIRS 184918-Morton 2007, all). This evaluation considered as components only the carbon-steel shells that would be manufactured off the site. It assumed the carbon-steel elements of the aging overpack would weigh about 43 metric tons (47 tons).

4.1.14.3.7 *Shielded Transfer Casks*

DOE would use shielded transfer casks to transfer TAD canisters and other canisters between and in the site facilities. These components would essentially be transportation casks without impact limiters. The analysis took estimates of their size and materials of manufacture directly from information on casks that DOE would use for rail shipment, with a slight reduction to account for the fact that they would have no impact limiters.

4.1.14.4 Existing Environmental Settings at Manufacturing Facilities

DOE based the assessment of potential impacts from the manufacture of repository components, as it did in the Yucca Mountain FEIS, on the premise that existing facilities would meet the manufacturing requirements. Therefore, there would be no new or expansion construction. As a result, there would be no change in land use, and cultural, aesthetic, and ecological resources would remain unaffected. Minor increases in noise, traffic, or utilities would be likely, but would not result in impacts on the local environment. Water consumption and wastewater discharges would be typical of a heavy manufacturing

facility, and the proposed manufacturing of repository components would probably result in minor changes to existing rates. In the case of wastewater discharges, nothing unique would be likely as a result of the Proposed Action that could cause difficulty in compliance with applicable local, state, and federal regulatory limits. The following sections contain information on environmental settings for air quality, health and safety, and socioeconomics. Section 4.1.14.5 describes potential environmental impacts for a representative site.

DOE recognizes that the basic assumption of no new or expansion construction might not be the eventual situation because the number of components to manufacture is large. However, at the current stage of the Proposed Action, it would be highly speculative to assume construction would be necessary. In addition, there would be too much uncertainty to attempt to address specific facility impacts that could be associated with construction.

4.1.14.4.1 *Air Quality*

The analysis evaluated the ambient air quality status of the representative manufacturing location by examining the air quality of the areas of the existing reference facilities. As the Yucca Mountain FEIS described, most of the typical container and cask manufacturing facilities are in *nonattainment areas* for ozone; that is, locations where ambient air quality standards are not being met and, as a result, are subject to more stringent regulations. Since the completion of the FEIS, the EPA has established attainment and nonattainment designations for ambient air concentrations of $PM_{2.5}$. As of May 30, 2007, the EPA still identified the five counties of the reference manufacturing facilities as being in nonattainment for ozone and four of the five counties as being in nonattainment for $PM_{2.5}$ (DIRS 181914-EPA 2007, all). Each of the counties was in attainment for ambient air quality standards for the other criteria pollutants (carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead). Volatile organic compounds and nitrous oxides are precursors for ozone and are indicators of likely ozone production and, because ozone was the only nonattainment air pollutant at the time, they were the only air pollutants that DOE evaluated in the Yucca Mountain FEIS. DOE has expanded the current evaluation to include $PM_{2.5}$. The five counties released an average of approximately 2,730 metric tons (3,000 tons) of volatile organic compounds, 5,500 metric tons (6,100 tons) of nitrous oxides, and 1,140 metric tons (1,300 tons) of $PM_{2.5}$ to the environment in 1999 (DIRS 181916-EPA 1999, all; DIRS 181917-EPA 1999, all; DIRS 181918-EPA 1999, all; DIRS 181919-EPA 1999, all; DIRS 181920-EPA 1999, all).

4.1.14.4.2 *Health and Safety*

As in the Yucca Mountain FEIS, DOE based data on the number of accidents and fatalities in relation to cask and canister fabrication at the representative manufacturing location on national incident rates for the relevant sector of the economy. The FEIS used incident rates from 1992 of 3 fatalities per 100,000 workers and 6.3 incidents of reportable occupational illness or injury per 100 full-time workers. For this evaluation, DOE has updated these rates with more recent data from the U.S. Department of Labor Bureau of Labor Statistics. The incident rate for this Repository SEIS evaluation is 3.3 fatalities per 100,000 workers, which is the average of the 2003 to 2006 values for the standard industrial code for boiler, tank, and shipping container manufacturing (DIRS 181921-BLS n.d., all; DIRS 181922-BLS n.d., all; DIRS 181924-BLS n.d., all; DIRS 185184-BLS 2008, all). The analysis used an incidence rate for reportable occupational illness or injury in the evaluation of 9.1 per 100 full-time workers, which is the average of the 2001 to 2006 values for the same standard industrial code (DIRS 181925-BLS n.d., all;

DIRS 181926-BLS 2003, all; 181927-BLS 2005, all; DIRS 181928-BLS 2005, all; DIRS 181929-BLS 2006, all; DIRS 185185-BLS 2008, all).

As noted in the Yucca Mountain FEIS, facilities with extensive experience in similar types of work; well-established procedures; appropriate equipment for fabrication of large, *heavy metal* components; and experienced and trained personnel would perform the manufacture of repository components. As a result, DOE anticipates that injury and illness rates would be equal to or lower than industry rates.

4.1.14.4.3 *Socioeconomics*

The five reference manufacturing facilities are in U.S. Bureau of the Census Metropolitan Statistical Areas. Where available, this analysis used data for the Statistical Areas to define the affected socioeconomic environment for each facility. This differs slightly from the analysis in the Yucca Mountain FEIS, which used socioeconomic data for the counties of location. The populations of the *affected environments* for the five facilities ranged from about 410,000 to 780,000 in 2005 (DIRS 181931-Bureau of the Census 2006, all). In 2002, output (the value of sales, shipments, receipts, revenue, or business produced in the five areas) ranged from $21 billion to $50 billion (DIRS 182017-Bureau of the Census 2005, all; DIRS 182018-Bureau of the Census 2005, all; DIRS 182020-Bureau of the Census 2005, all; DIRS 182021-Bureau of the Census 2005, all; DIRS 182022-Bureau of the Census 2005, all; DIRS 182023-Bureau of the Census 2005, all; DIRS 182024-Bureau of the Census 2005, all; DIRS 182026-Bureau of the Census 2005, all; DIRS 182027-Bureau of the Census 2005, all; DIRS 182028-Bureau of the Census 2005, all). The income (wages, salaries, and property income) ranged from $11 billion to $26 billion in 2002, and the labor force ranged from 220,000 to 400,000 in 2004 (DIRS 181932-Bureau of the Census n.d., all; DIRS 181933-Bureau of the Census n.d., all). Based on averages of this information, DOE estimated the representative manufacturing location would have a population of about 610,000, a labor force of about 320,000, local income of about $18 billion in 2002, and local output of about $35 billion in 2002.

4.1.14.5 Environmental Impacts

As noted above, this evaluation assumed the use of existing manufacturing facilities, so DOE only analyzed environmental impacts to air quality, health and safety, socioeconomics, material use, waste generation, and environmental justice.

4.1.14.5.1 *Air Quality*

As in the Yucca Mountain FEIS, the analysis used the methods from the Navy EIS (DIRS 101941-USN 1996, Section 4.3) to estimate air emissions from manufacturing sites for the production of repository components. However, DOE updated baseline data if available rather than using those in the original methodology. The objective of the evaluation was to estimate emissions for comparison with typical regional or countywide emissions to determine potential impacts on local air quality.

The evaluation addressed air emissions in relation to the manufacture of repository components that were of most concern to the representative manufacturing location; that is, emissions that could aggravate ambient air conditions already in nonattainment of applicable air quality standards. Based on the reference locations, DOE assumed the representative manufacturing location would be in an area of nonattainment for ozone and $PM_{2.5}$ standards, but in compliance with standards for other criteria

pollutants (Section 4.1.14.4). Ozone normally forms in a reaction of precursor chemicals (which include volatile organic compounds and nitrous oxides) and sunlight, so this evaluation addresses emissions of these precursors as well as of $PM_{2.5}$.

DOE used the emissions from the manufacture of similar components to develop estimates for emissions of volatile organic compounds and nitrous oxides (DIRS 101941-USN 1996, p. 4-6) and normalized, or adjusted, them to the scale of the repository components in relation to the number of work hours for the manufacturing process, as it did in the Yucca Mountain FEIS analysis. The Navy EIS (DIRS 101941-USN 1996, all) did not include emissions of $PM_{2.5}$ in the record of emission from the manufacture of similar components; DOE found no applicable emission rates in normal sources for such data, so it developed an estimated emission rate from available local and national records. EPA maintains a database of air emissions that contains data sortable by geographic area, emissions sources, and standard industrial codes (DIRS 181916-EPA 1999, all; DIRS 181917-EPA 1999, all; DIRS 181918-EPA 1999, all; DIRS 181919-EPA 1999, all; DIRS 181920-EPA 1999, all). County emission records were queried for each reference manufacturing location and for sources that involve the manufacture of metal products. $PM_{2.5}$ emissions tended to vary in proportion to nitrous oxide emissions more consistently than with those of volatile organic compounds. Another query of the same records found that, on a nationwide basis, the standard industrial code for metal plate fabrication was responsible for emissions of 286 metric tons (315 tons) of $PM_{2.5}$ and 220 metric tons (240 tons) of nitrous oxides in 1999. Based on this information, the evaluation assumed a ratio of 315 to 240 (the original values) to that of nitrous oxide to estimate the $PM_{2.5}$ emissions.

Table 4-33 lists the estimated annual average and estimated total emissions from the manufacture of repository components. Estimated annual average emissions of volatile organic compounds would be 2.58 metric tons (2.8 tons) a year for the 24-year period and 0.646 metric ton (0.71 ton) per year for the

Table 4-33. Air emissions at the representative manufacturing location.

Period	Measure	Emissions (metric tons)[a] and de minimis values (percent)		
		Volatile organic compounds	Nitrous oxides	$PM_{2.5}$
24-year period[b]	Annual average	2.58	3.34	4.38
	24-year total	62	80	110
	Percent of de minimis[c]	28%	37%	4.8%
10-year period[d]	Annual average	0.646	0.837	1.1
	10-year total	6.5	8.4	11
	Percent of de minimis[c]	7.1%	9.2%	1.2%

a. To convert metric tons to tons, multiply by 1.1023.
b. The 24-year manufacturing period would be for all components except drip shields and would begin 2 years before emplacement.
c. De minimis level for an air quality region in extreme nonattainment for ozone is 9.1 metric tons (10 tons) per year of volatile organic compounds or nitrogen compounds, and for any nonattainment for $PM_{2.5}$ it is 91 metric tons (100 tons) per year of $PM_{2.5}$.
d. The 10-year manufacturing period would be for drip shields only and would occur at repository closure.

$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.

10-year drip shield manufacturing period. Nitrous oxide emissions would be 3.34 metric tons (3.7 tons) a year for the 24-year period and 0.837 metric ton (0.92 ton) a year for the 10-year drip shield manufacturing period. $PM_{2.5}$ emissions would be 4.38 metric tons (4.8 tons) a year for the 24-year period and 1.1 metric tons (1.2 tons) a year for the 10-year drip shield manufacturing period. Annual average

emissions from component manufacturing would be 0.09 percent, or less, of the typical regional emissions of volatile organic compounds of 2,730 metric tons (3,000 tons) per year (Section 4.1.14.4); 0.06 percent, or less, of regional nitrous oxide emissions of 5,500 metric tons (6,100 tons) per year; and 0.4 percent, or less, of regional $PM_{2.5}$ emissions of 1,140 metric tons (1,300 tons) per year. Emissions from the manufacture of repository components would contain relatively small amounts of ozone precursors and $PM_{2.5}$ in comparison to other sources.

If the emissions were from new sources, they would be subject to emission threshold levels (levels below which conformity regulations do not apply) set under 40 CFR 51.853. For an air quality region to be in extreme nonattainment for ozone (most restrictive levels), the emission threshold level for both volatile organic compounds and nitrous oxides is 9.1 metric tons (10 tons) per year and for any level of nonattainment for $PM_{2.5}$ the emission threshold level (for $PM_{2.5}$) is 91 metric tons (100 tons) per year. Table 4-33 lists the percentage of volatile organic compounds, nitrous oxides, and $PM_{2.5}$ from the manufacturing of repository components in relation to the applicable emission levels (the analysis assumed extreme nonattainment is the applicable threshold in the case of ozone). It is unlikely that component manufacturing would fall under the conformity regulations because the closest emission to the applicable threshold, or de minimis, levels is 37 percent. However, DOE would ensure the implementation of the appropriate conformity determination processes and written documentation for each manufacturing facility.

States with nonattainment areas for ozone or $PM_{2.5}$ could place requirements on stationary pollution sources to achieve attainment in the future. This could include a variety of controls on emissions of volatile organic compounds, nitrous oxides, and $PM_{2.5}$. Options such as additional scrubbers, afterburners, carbon filters, or physical filters would be available to control emissions of these compounds to comply with limitations.

4.1.14.5.2 *Health and Safety*

The analysis used updated data from the Bureau of Labor Statistics to compile baseline occupational health and safety information for industries that fabricate large metal objects similar to the repository components. It computed the expected number of injuries and fatalities by multiplying the number of work years by the injury and fatality rate for the applicable occupation. Table 4-34 lists the expected number of injuries and illnesses and fatalities. Estimated incidents of reportable injury and illness would be approximately 1,700 during the entire manufacturing period, but the probability of a fatality would be less than 1.

Table 4-34. Occupational injuries, illness, and fatalities at the representative manufacturing location.[a]

Parameter	Estimated values
Total work years (using 2,000 hours per labor year)	18,500
Injuries and illnesses	1,700
Fatalities	0.61

a. Impacts from 24 years for manufacture of all components except drip shields and 10 years for manufacture of drip shields.

The required number of repository components would not place unusual demands on existing manufacturing facilities, so the action would be unlikely to lead to a deterioration of worker safety and a resultant increase in accidents. In addition, nuclear-grade components are typically built to higher

standards and with methods that include detailed procedures, both of which lead to improved worker safety.

4.1.14.5.3 *Socioeconomics*

The assessment of socioeconomic impacts from manufacturing activities involved three elements:

- Per-unit cost and labor data for the components (Table 4-32),
- Total number of components (Table 4-32), and
- Economic data for the environmental setting for each facility to calculate direct and secondary economic impacts of repository component manufacturing on the local economy:
  - The local economy would be directly affected as manufacturing facilities purchased materials, services, and labor for manufacturing.
  - In addition, the local economy would experience secondary effects as industries and households that supplied the industries that were directly affected adjusted their own production and spending behavior in response to increased production and income, which would thereby generate additional socioeconomic impacts.

The analysis measured impacts in terms of output (the value of sales, shipments, receipts, revenue or business), income (wages, salaries, and property income), and employment (number of jobs).

For the Yucca Mountain FEIS, the socioeconomic analysis of manufacturing used state-level economic multipliers for fabricated metal products for each of the five states of the reference manufacturing plants. The multipliers of interest were for products, income, and employment (DIRS 155970-DOE 2002, Table 4-48); DOE used them to account for direct and secondary effects on an area's economy. For the FEIS analysis, DOE obtained the state multipliers (DIRS 152803-Bland 1998, all) in accordance with guidelines from the Bureau of Economic Analysis for use of the Regional Input-Output Modeling System, and averaged them to produce composite multipliers for a representative manufacturing location. The composite multipliers were as follows:

- Final demand multiplier for products (dollar value) – 2.2233
- Final demand multiplier for earnings (dollar value) – 0.6308
- Direct effect multiplier for number of jobs – 2.5705

The evaluation of manufacturing for this Repository SEIS included an informal run of the same Regional Input-Output Modeling System that used more recent, national level socioeconomic data as a sensitivity analysis for the economic multipliers used previously. The results indicated that the multipliers DOE used for the Yucca Mountain FEIS evaluation were still reasonable and that a formal modeling effort to update the numbers for each of the reference manufacturing locations would provide little value.

The analysis estimated the direct and secondary impacts of manufacturing activities, but did not include impacts on local jurisdictions such as county and municipal government and school district revenues and expenditures. Because the analysis assumed that manufacturing activities would occur at existing facilities alongside existing product lines, substantial population increases due to workers moving into the

vicinity would be unlikely. As a result, impacts to demographics (that is, to characteristics of the population) would be small and meaningful change in local government or school districts would be unlikely. The analysis did not consider impacts on other areas of socioeconomic concern that population increases would drive, such as housing and public services.

The analysis calculated average annual impacts for the manufacturing period of 10 years for drip shields and 24 years for all other components. It compared the impacts to the baseline information from Section 4.1.14.4, with escalation to 2006 dollars. Because the analysis was not site-specific, it made no attempt to forecast local population or economic growth or inflation rates for the reference locations. Table 4-35 lists impacts of component manufacturing on output, income, and employment at the representative manufacturing locations. The table includes a comparison, in terms of percent, of the values for component manufacturing to comparable baseline values for the representative location. As listed in Table 4-35, socioeconomic impacts at the representative manufacturing location would involve relatively minor increases to existing conditions. The largest forecasted increase would be an addition of as much as 4.7 percent to the area's output. Estimated impacts to the area's average income and average employment would be less.

Table 4-35. Socioeconomic impacts at the representative manufacturing location.

Economic parameter and descriptions of assessment values	24-year period[a]	10-year period[b]
Average annual output		
Baseline output escalated to 2006 dollars (in $ millions)[c]	39,200	39,200
Output associated with manufacture of components (in $ millions)	1,800	890
Percent impact	4.7	2.3
Average annual income		
Baseline income escalated to 2006 dollars (in $ millions)[c]	20,000	20,000
Income associated with manufacture of components (in $ millions)	520	250
Percent impact	2.6	1.3
Average annual employment		
Baseline labor force (persons)[c]	320,000	320,000
Employment associated with manufacture of components (persons)	2,000	500
Percent impact	0.63	0.16

a. The 24-year manufacturing period would be for all components except drip shields and would begin 2 years before emplacement.
b. The 10-year manufacturing period would be for drip shields only and would occur at repository closure.
c. Baseline output, income, and labor force values from Section 4.1.14.4. DOE applied an escalation factor of 1.12 to the 2002 baseline output and income dollars to obtain the 2006 dollars listed in the table.

4.1.14.5.4 *Impacts on Materials Use*

The Yucca Mountain FEIS analysis based calculations of the quantities of materials for the manufacture of each repository component, to the extent available, on engineering specifications for each hardware component. DOE obtained the information and applicable references from the manufacturers of systems either designed or under licensing review or from conceptual design specifications for technologies still in the planning stages. This Repository SEIS evaluation started with the same information and augmented it with preliminary design drawings of waste packages with minor modifications to the designs in the FEIS and with specifications (DIRS 185304-DOE 2008, all) for the TAD canisters and specific items of support hardware (transportation overpacks and aging overpacks). The analysis combined data on per-unit material quantities for each component with information on the required number of components. In addition, it assessed the impact of component manufacturing on total U.S. production (or availability if not produced in this country) of each relevant input material.

Table 4-36 lists the total quantities of materials DOE would need for the manufacture of repository components and the average annual requirement for each material. The largest materials requirement by weight would be steel at about 343,000 metric tons (378,000 tons). Table 4-36 also lists the annual U.S. production or import (nickel and titanium) quantities from 2007 (DIRS 185186-USGS 2008, all) for most of the materials. The exception is the quantity for depleted uranium, which is from the 1996 Navy EIS (DIRS 101941-USN 1996, p. 4-10). With the exceptions of nickel palladium, and titanium, the requirement for each material would be less than 2 percent of the annual U.S. production. Therefore, the use of aluminum, chromium, copper, lead, molybdenum, depleted uranium, or steel would not produce a noteworthy increased demand and would not have a meaningful effect on the supply of these materials. [Note: The Draft Repository SEIS presented the annual chromium demand as 3.4 percent of the annual U.S. production. This value has dropped significantly, as listed in Table 4-36, because the most recent source for the annual production values (DIRS 185186-USGS 2008, all) includes a change to the evaluation method for chromium production. The new source document shows revised, higher production values for past years as well as the higher value for 2007.]

Table 4-36. Total and annual materials use and comparison to annual production.

Materials	Annual U.S. production or ***imports***[a] (metric tons)[b]	Materials required for repository components		
		Total (metric tons)	Annual (metric tons)	Percentage of annual production
Aluminum	3,900,000	850	81	0.002
Chromium[c]	240,000	100,000	4,200	1.8
Copper	1,350,000	140	5.9	0.0004
Depleted uranium	14,700	1,500	61.4	0.42
Lead	1,310,000	1,100	47	0.004
Molybdenum[d]	59,400	27,000	1,100	1.9
Nickel[e, f]	***140,000***	120,000	5,000	3.6
Palladium[g]	13.5	80	8.0	59
Steel (and iron)[h]	97,800,000	343,000	14,300	0.015
Titanium[f, i]	***24,200***	54,000	5,400	22

Sources: Depleted uranium: DIRS 101941-USN 1996, p. 4-10; other materials: DIRS 185186-USGS 2008, year 2007 data, pp. 22, 48, 54, 94, 112, 114, 86, and 180.

a. Annual values include, as applicable, primary and secondary production.
b. To convert metric tons to tons, multiply by 1.1023.
c. Required chromium estimated as 18 percent of stainless steel and 22 percent of high-nickel alloy.
d. Required molybdenum estimated as 2.5 percent of stainless steel and 14.5 percent of high-nickel alloy.
e. Required nickel estimated as 57.2 percent of high-nickel alloy and 12 percent of stainless steel.
f. Production values for nickel and titanium are import quantities from 2007 (see explanation in text).
g. Required palladium estimated as 0.19 percent of Titanium Grade 7.
h. Required steel estimated as 100 percent of carbon steel and 52 percent of stainless steel. The data source identified steel and iron as a single category, but noted that more than 95 percent of produced iron moves in molten form to steelmaking furnaces at the same site, so the combined quantity is appropriate for comparison. The corresponding materials requirements are for steel.
i. Required titanium estimated as 100 percent of Titanium Grade 7 and 90 percent of Titanium Grade 29.

The estimated annual requirement for nickel as a component in stainless-steel and corrosion-resistant, high-nickel alloy would be about 3.6 percent of the annual use, which in this case is all imported material. The materials production data provide no U.S. production values for nickel, but rather lists a W, which indicates the values were withdrawn to avoid disclosure of proprietary data. This indicates U.S. production is limited and values could be easily tied to a specific production company (or companies). In addition to the quantity of imported nickel listed in Table 4-36, there is a relatively large

U.S. market for nickel scrap. In 2007, 207,000 metric tons (228,000 tons) of this scrap were purchased and about 57 percent of the nickel was recovered from it during the year (DIRS 185186-USGS 2008, p. 114). The sum of the imported nickel (Table 4-36) and the recovered nickel is 259,000 metric tons (285,000 tons). The annual requirement for nickel to support the manufacture of repository components would be 1.9 percent of that value. The world mine production for nickel was at an all-time high in 2007, but barely kept up with demand (DIRS 185186-USGS 2008, p. 114). Although 1.9 percent would be a small portion of the U.S. nickel market, potential impacts on supply would depend on the ability to maintain import levels. Canada is a major world supplier of nickel and the largest U.S. supplier.

The estimated annual requirement for palladium as a constituent in the titanium drip shields (specifically as a constituent of Titanium Grade 7) at only about 8.0 metric tons (8.8 tons) would be about 59 percent of the annual U.S. mine production. The sum of domestic production of palladium in 2007 (Table 4-36) and the amount imported in 2007 is 118 metric tons (130 tons) (DIRS 185186-USGS 2008, p. 126). The annual requirement for palladium to manufacture repository components would be only 6.8 percent of that value. Assuming imports remained at current levels, repository use of palladium would have a more moderate, though significant, effect on supply. As noted for the manufacture of drip shields, DOE would not need these materials until the repository closure analytical period, so there would be up to 90 years to complete production or import additional material in advance of the need. Therefore, the annual requirement for palladium listed in Table 4-36, which DOE based on an assumed 10-year production rate, could be less by almost a factor of 10, and potential impacts on markets would be small.

The annual requirement for titanium for drip shields would be approximately 5,400 metric tons (6,000 tons) and, at 22 percent, the most critical quantity, along with palladium, in terms of its available supply in 2007. As with nickel, the titanium production in Table 4-36 is all in the form of imported material. Similar to nickel, the materials production data provide no U.S. production values for titanium, but rather lists a W to indicate the companies withdrew the values to avoid disclosure of proprietary data, which in turn indicates limited U.S. production. The data indicate that the United States imports about 64 percent of the titanium it uses or exports (DIRS 185186-USGS 2008 p. 6), so the total quantity of titanium used in the United States in 2007 was about 38,000 metric tons (42,000 tons) and the annual amount required for production of repository components would decrease to 14 percent of the larger quantity. Because of increasing demand for titanium in the world market, producers are adding capacity. In the United States, two production facilities increased production in 2007, and a new facility should start production in 2008. Between these three facilities, estimated annual production would be about 31,000 metric tons (34,000 tons) by the end of 2008 in comparison to a 2007 U.S. capacity of about 20,200 metric tons (22,300 tons) per year (DIRS 185186-USGS 2008, p. 181). If the projected 2008 capacity represented all U.S. production and imports continued at current levels, titanium use in the United States would increase to about 55,200 metric tons (60,800 tons) per year and the annual amount for production of repository components would decrease to 9.8 percent. In addition, DOE would not need the drip shields until the repository closure analytical period, so there would be adequate time (up to 90 years) to complete production of titanium or import additional material in advance of the need. Taking advantage of this schedule, the assumed 10-year production rate for the annual titanium requirement could be less by almost a factor of 10, and potential impacts on markets would be small.

4.1.14.5.5 *Impacts of Waste Generation*

The primary materials for the manufacture of repository components would be stainless steel, carbon steel, high-nickel alloy, aluminum, copper, and titanium along with either depleted uranium or lead for

shielding. The manufacture of shielding would generate a hazardous waste or low-level radioactive waste, depending on the material. DOE has identified other types and quantities of waste the manufacturing activities would generate. The analysis based estimates of annual quantities of waste generation at the representative location on the methodology and data in the Navy EIS (DIRS 101941-USN 1996, p. 4-13). It evaluated potential impacts in terms of existing and projected waste handling and disposal procedures and regulations of relevant state and federal regulatory agencies. Manufacturers would comply with existing regulations to control the volume and toxicity of the liquid and solid waste they would produce. They would implement pollution prevention and reduction practices. The analysis evaluated only waste from the manufacture of repository components from component materials; it did not consider waste from mining, refining, and processing raw materials into component materials. The analysis assumed that component materials would be available from supplier stock regardless of the status of the repository project.

Liquid Waste

Liquid waste from manufacturing would consist of used lubricating and cutting oils from machining operations and cooling of cutting equipment. Consistent with typical existing facilities, manufacturers would recycle this material. They would treat water from cooling and washing operations and from ultrasonic weld testing by filtration and *ion* exchange, which would remove contaminants and permit its discharge to the sanitary sewer system. Table 4-37 lists the estimated amounts of liquid waste manufacturers would generate by shaping, machining, and welding the repository components. The average amount of liquid waste would be 7.5 metric tons (8.3 tons) per year during the 24-year manufacturing period and 4.5 metric tons (5.0 tons) per year during the 10-year period. The small quantities of waste from manufacturing would not exceed the capacities of existing equipment for waste stream treatment at the manufacturing facility.

Table 4-37. Annual average waste generated (metric tons) at the representative manufacturing location.

Measure		Liquid waste quantity		Solid waste quantity	
		(metric tons)	(tons)	(metric tons)	(tons)
24-year period[a]	Annual average	7.5	8.3	1.0	1.1
10-year period[b]	Annual average	4.5	5.0	0.62	0.68

a. The 24-year manufacturing period would be for all components except drip shields and would begin 2 years before emplacement.

b. The 10-year manufacturing period would be for drip shields only and would occur at repository closure.

Solid Waste

Table 4-37 lists the solid waste that manufacturing operations would generate. The average annual amount of solid waste would be about 1 metric ton (1.1 ton) per year during the 24-year manufacturing period and about 0.62 metric ton (0.68 ton) per year during the 10-year period. The primary waste constituents would probably be metals: steel, nickel, molybdenum, chromium, and copper. Manufacturers could add these metals to existing manufacturing waste streams for treatment and disposal or recycling.

The analysis assumed that depleted uranium would arrive at the manufacturing facility properly shaped to fit as shielding for a transportation cask. As a result, the representative manufacturing location would not generate or recycle depleted uranium waste and there would be no radiological health impacts. Lead for shielding would be cast between stainless-steel components for the transportation casks. It is unlikely that lead waste would occur in substantial quantities, and the manufacturers would recycle it.

4.1.14.5.6 *Environmental Justice*

DOE performed the environmental justice assessment to determine if high and adverse health or environmental impacts from the manufacture of repository components would disproportionately affect minority or low-income populations, as Executive Order 12898 requires. A disproportionately high impact (or risk of impact) in a minority or low-income community would be one that exceeded the corresponding impact on the larger community to a meaningful degree. This section summarizes the Navy EIS analysis (DIRS 101941-USN 1996, Section 4.8), which DOE adapted to the manufacturing of components for the proposed repository. It is the same analysis as that for the Yucca Mountain FEIS.

The assessment used demographic data from the areas of the five reference facilities to provide information on the degree to which minority or low-income populations could receive disproportionate effects. It used a geographic information system linked to 1990 Census data to define the composition of populations living within approximately 16 kilometers (10 miles) of the five facilities and to identify the percentage of minority and low-income individuals in each area. The assessment used the percentages of minority and low-income persons that comprise the population of the states in which the facilities are located as a reference.

The original analysis indicated that in one manufacturing facility location the proportion of minority population was higher than the proportion of the minority population in the state. The difference between the percentage of the minority population within the 16-kilometer (10-mile) radius and in the state was 1.5 percent (DIRS 101941-USN 1996, p. 4-18). DOE did not update the detailed evaluation in the Yucca Mountain FEIS, but evaluated more recent data to determine if there were notable changes to minority population distributions. According to Bureau of the Census data for 2003 (DIRS 181937-Bureau of the Census n.d., all; DIRS 181938-Bureau of the Census n.d., all), only one of the Metropolitan Statistical Areas in which the reference facilities are located had a higher percent minority population than the applicable state as a whole. The difference in minority populations between the smaller area and of the state was 1.6 percent. Based on this more current census data, distribution of minority populations has probably remained similar to that for the FEIS. The conclusion remains the same; that is, DOE anticipates small impacts for the total population from manufacturing activities, so there would be no disproportionately high and adverse impacts to the minority population near the location of the representative facility.

The original analysis indicated that in one reference manufacturing facility location the proportion of low-income population was higher than the proportion of the low-income population in the state. The difference was 0.9 percent (DIRS 101941-USN 1996, p. 4-18). As noted above, DOE did not update the evaluation in the Yucca Mountain FEIS, but evaluated more recent data. Bureau of the Census data for the 1999-to-2000 timeframe (DIRS 181939-Bureau of the Census 2006, Table C-2; DIRS 181940-Bureau of the Census n.d., Table 690) indicate none of the Metropolitan Statistical Areas had a percent of low-income individuals higher than the applicable state as a whole. Based on the more recent data, distribution of low-income populations probably has remained similar, and possibly even improved, in comparison to that for the FEIS assessment. DOE anticipates small impacts to individuals and to the total population, and no special circumstances would cause disproportionately high and adverse impacts to the low-income population near the representative facility.

The analysis for this Repository SEIS determined that no high and adverse health and environmental impacts would occur to the population as a whole from the manufacture of repository components.

Further, there were no identified impact pathways that would be specific to minority or low-income populations. Therefore, no high and adverse impacts to minority or low-income populations would be expected from these activities.

4.1.15 AIRSPACE RESTRICTIONS

The region of influence is the airspace over the analyzed land withdrawal area and airspace immediately adjacent, within approximately 48 kilometers (30 miles) of the repository's North Portal. This section describes DOE's requirement for airspace restrictions and the impacts of those restrictions.

4.1.15.1 Requirement for Airspace Restrictions

During the operations analytical period, there would be spent nuclear fuel in buildings, in transportation casks, or on aging pads in protective overpacks at the proposed repository. DOE evaluated the potential for an aircraft crash into these areas to determine the probability of a release of radioactive material from the repository (Section 4.1.8 and Appendix E). Aircraft flights in the vicinity of the site are an important consideration in the accident analysis DOE conducted as part of this Repository SEIS and in the safety analysis documentation that DOE has prepared to support the application for construction authorization. That analysis considered commercial, military, and general aviation aircraft activity in the area of the repository. It included specification of limits on military aircraft flight altitude and number of flights per year over the repository. Specifically, the analysis assumed that a maximum of 1,000 fixed-wing military aircraft flights per year would cross the airspace defined by a 9.0-kilometer (5.6-statute-mile) radius from the North Portal of the repository at an altitude of at least 4,300 meters (14,000 feet) above mean sea level. It also assumed that no aircraft fly below 14,000 feet mean sea level within a 9.0-kilometer (5.6-statute-mile) radius of the North Portal.

As Chapter 3, Section 3.1.1.4 describes and Figure 4-9 shows, much of the airspace in the vicinity of Yucca Mountain is special-use restricted airspace. DOE has controlling authority over restricted airspace R-4808N, shown in Figure 4-9. Controlling authority means that DOE authorizes and specifies the use of the airspace although it does not provide air traffic control. Less than one-quarter of the airspace defined by a 9.0-kilometer (5.6-statute-mile) radius from the North Portal of the repository is not presently designated as restricted airspace. This "triangle" covers approximately 48 square kilometers (19 square miles) and is denoted on Figure 4-9 as "proposed special-use airspace." This area is currently categorized as Class A and Class G airspace but is not subject to overflight by aviation traffic following point-to-point routes because such routes would infringe on the adjoining restricted areas. The Class A and Class G airspace between the restricted areas and the military operations area (Figure 4-9) where commercial, military, and general aviation aircraft fly point-to-point routes, is outside the 9.0-kilometer (5.6-statute-mile) radius of the North Portal.

As noted above, the majority of the airspace within a 9.0-kilometer (5.6-statute-mile) radius of the North Portal is already in DOE restricted airspace. Flight activities in the DOE restricted airspace are coordinated to accommodate the needs of the U.S. Air Force and DOE. Because the air traffic restrictions for the repository would not be required for a number of years, DOE would monitor and take into consideration any modifications or additions to flight activities with the special-use airspace over the repository during the construction analytical period.

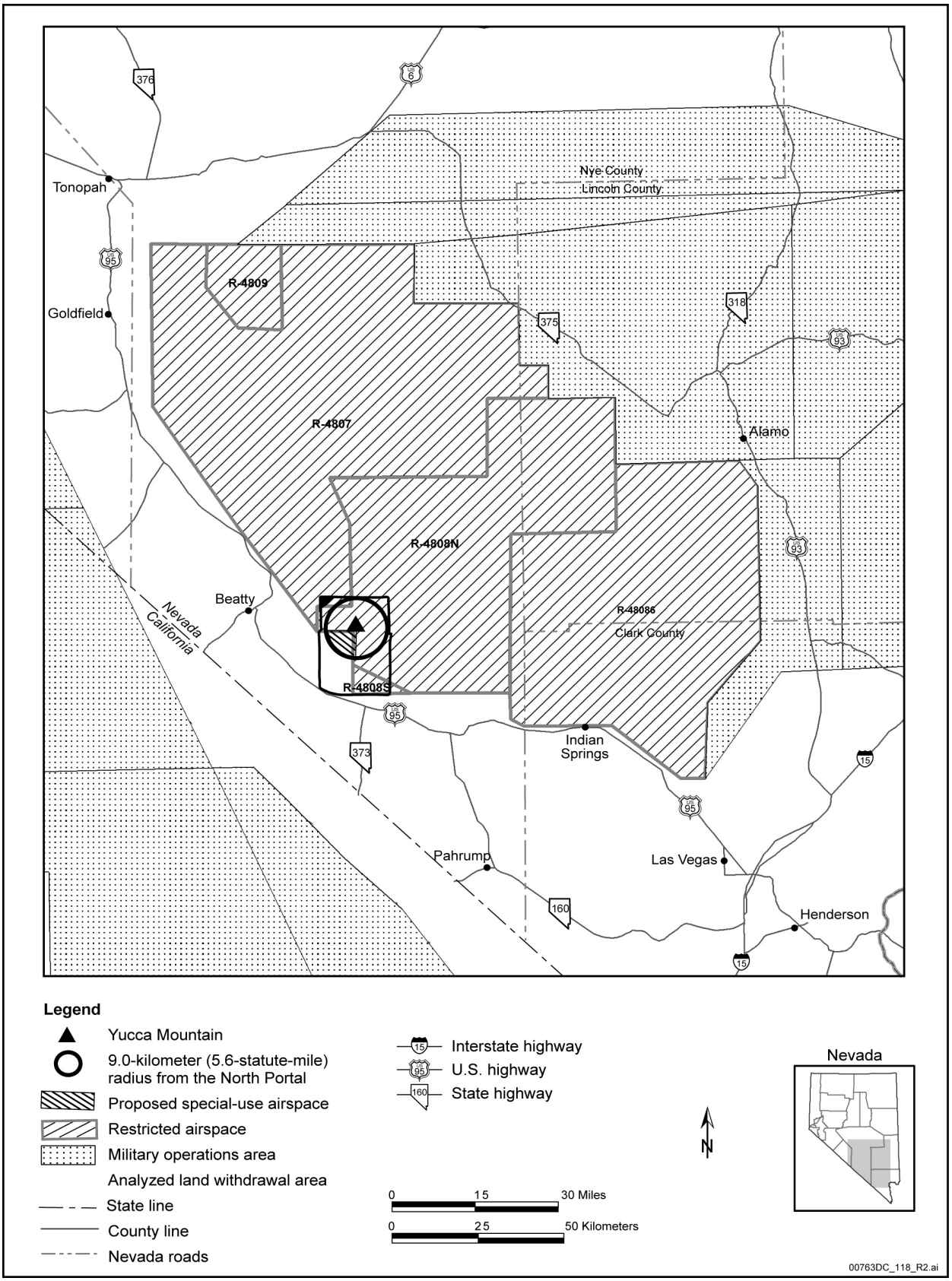

Figure 4-9. Proposed airspace use near Yucca Mountain.

If necessary to support repository operations, DOE would seek a special-use airspace designation from the Federal Aviation Administration for the 48-square-kilometer (19-square-mile) area described above. In addition, airspace restrictions could include agreements with the U.S. Air Force and other users to manage traffic in the vicinity of the repository. The accident analysis conducted as part of this Repository SEIS (Section 4.1.8 and Appendix E) assumed that such flight restrictions would occur.

Depending on the type of special-use airspace requested, Federal Aviation Administration regulations might not require additional analyses under NEPA. DOE has analyzed the impacts of designating the 48-square-kilometer area as special-use airspace in this Repository SEIS for completeness. The requested special-use airspace designation of the 48-square-kilometer (19-square-mile) resource area is not applicable to other resource areas.

4.1.15.2 Impacts to Airspace Use

If DOE acquired a special-use airspace designation as described above, the Department would gain exclusive control and use of the approximate 48-square-kilometer (19-square-mile) area in addition to the existing 4,400-square-kilometer (1,700-square-mile) restricted airspace of the Nevada Test Site (Chapter 3, Section 3.1.1.4). This would result in less than a 1.4-percent increase in DOE special-use airspace in the area, and less than a 0.3 percent increase in DOE and U.S. Air Force combined restricted airspace.

The designation of the proposed airspace as special-use airspace would prohibit flights in a small portion of the west low-altitude tactical navigation area used by U.S. Air Force A-10 aircraft and helicopters; there are currently about 30 flights per week.

Use of the airspace by the public is relatively light in comparison with other areas in Nevada due to the airspace being bounded on the north and east by the existing restricted areas of the Nevada Test and Training Range and the Nevada Test Site. Due to the small area of the proposed special-use airspace and the shape of the surrounding restricted areas, there would be little to no impact on general aviation aircraft that could fly within this area (small piston-engine aircraft, helicopters, and gliders). There would be no impact on commercial or general aviation flying point-to-point routes in the area, because these aircraft do not fly in this airspace. Overall, impacts to airspace use from designation of the proposed special-use airspace would be small.

In a separate action, DOE would continue to work with the U.S. Air Force to accommodate its need to fly through the Nevada Test Site airspace. DOE would authorize specific Air Force activities over the repository consistent with the repository safety analysis. DOE plans to continue to allow military flights over the repository by fixed-wing aircraft with the following restrictions:

- A maximum of 1,000 flights per year above 4,300 meters (14,000 feet) above mean sea level altitude;
- A prohibition of maneuvering of aircraft—flight is to be straight and level;
- A prohibition of carrying ordnance over the flight-restricted airspace; and
- A prohibition of electronic jamming activity over the flight restricted airspace.

Based on coordination with and input from the U.S. Air Force, impacts to military airspace use of the Nevada Test Site airspace from the restrictions listed above would be small.

4.2 Short-Term Environmental Impacts from the Implementation of a Retrieval Contingency

Section 122 of the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.) requires DOE to maintain the ability to retrieve emplaced spent nuclear fuel and high-level radioactive waste. The NRC specifies further that DOE must be able to maintain a retrieval period for at least 50 years after the start of emplacement [10 CFR 63.111(e)]. Although DOE does not anticipate the need to retrieve spent nuclear fuel or high-level radioactive waste and retrieval is not part of the Proposed Action per se, DOE would, as required, retain the ability to retrieve waste for at least 50 years after the start of emplacement or until there was a decision to close the repository permanently. For this reason, the Yucca Mountain FEIS analyzed potential impacts to environmental resources from retrieval.

According to *Concepts for Waste Retrieval and Alternate Storage of Radioactive Waste* (DIRS 182322-BSC 2007, all), the current concept for waste retrieval has not changed from that DOE analyzed in the Yucca Mountain FEIS. Operations to retrieve spent nuclear fuel and high-level radioactive waste from the repository to the surface would continue to be the reverse of those for emplacement using equipment, such as the transport and emplacement vehicle, as Chapter 2, Section 2.1.2.1.8 of this Repository SEIS describes. As before, DOE would move waste packages to the surface, load them into concrete storage modules, and move them to the Waste Retrieval and Storage Area. Because the concept of retrieval has not changed from that in the Yucca Mountain FEIS, the environmental impacts DOE reported in Section 4.2 of that document continue to represent those that could occur during retrieval.

4.3 Infrastructure Improvements

DOE identified the need to repair, replace, or improve certain elements of the infrastructure that currently exist on the site to help ensure safety under a high level of activity. The Department based these proposed safety improvements on assessments of the condition of the existing infrastructure; some parts of the infrastructure at Yucca Mountain are nearing, or in some cases have exceeded, their design and operational lifetimes. Because DOE has mandated operational restrictions on continued scientific activities, testing, and maintenance to maintain the safety of workers, regulators, and visitors, the infrastructure improvements would be necessary before construction of the Yucca Mountain Repository if DOE decided to lift current operational restrictions.

The proposed infrastructure improvements are subsets of larger actions DOE has defined as part of the Proposed Action. In the Proposed Action, DOE has identified the need for two 138-kilovolt transmission lines (with a capability of boosting to 230-kilovolts, if needed). Under the proposed infrastructure improvements, DOE would construct one 138-kilovolt transmission line. The Proposed Action defines a four-lane paved access road, while the proposed infrastructure improvements are for a two-lane road.

Section 4.3.2 summarizes the potential environmental impacts of the infrastructure improvements in the context of the larger elements of the Proposed Action. The applicable subsections of Section 4.1 address the corresponding Proposed Action elements. Because the infrastructure improvements would generally be smaller in scope and have shorter construction analytical periods, the potential impacts would generally be less than those for the corresponding actions under the Proposed Action. Because the proposed infrastructure improvements would occur before construction of the repository, the potential impacts would not be concurrent with those of construction and operation of the repository. Chapter 10

covers short-term uses, long-term productivity, and irreversible or irretrievable commitment of resources as part of the Proposed Action.

In June 2006, DOE issued the *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada* (DIRS 178817-DOE 2006, all). DOE has since decided not to finalize the environmental assessment, but rather to incorporate the actions it evaluated into this Repository SEIS. In the draft environmental assessment, DOE provided two route and construction options for the improvement of access roads and a 138-kilovolt transmission line (DIRS 178817-DOE 2006, all), as well as the improvement of several facilities. Since the issuance of the draft environmental assessment, DOE has identified additional transmission line routes but has developed little detail. In the draft environmental assessment, DOE identified two options for access road improvements. This Repository SEIS discusses only DOE's preferred option. The road improvement option to the preferred option differed only in the length of the road; it would be about 13 kilometers (8 miles) longer than that for the preferred option. The Department concluded that the second option in the draft environmental assessment would not be technically practicable or economically feasible. The draft environmental assessment serves as the basis for identification of proposed infrastructure improvements, but the design and operational plans for these improvements, along with any potential options, are under development.

DOE developed the following proposed infrastructure improvements after completion of the Yucca Mountain FEIS:

- The building of new and replacement roads that would include a two-lane access road from U.S. Highway 95 at its intersection with Nevada State Route 373 to Gate 510. This is the preferred option in the draft environmental assessment, but the preferred option did not align the access road with State Route 373, as is the current proposal. Chapter 2, Section 2.1.6.1 describes roads under the Proposed Action. DOE did not include Option B as described in the draft environmental assessment in the Repository SEIS because it no longer considers it a reasonable option.

- The building of a new 138-kilovolt transmission line to existing facilities from the Lathrop Wells switch station. This was the preferred option in the draft environmental assessment. Chapter 2, Section 2.1.4.4.1 describes the electrical power and distribution system under the Proposed Action. DOE has identified several other options to provide upgraded electrical services to the Yucca Mountain Repository before the start of construction, if needed. Other options could start on the Nevada Test Site and then move to the central operations area. Because DOE could require additional switchyards and substations, options would require further definition in cooperation with one or more electric power vendors and, therefore, are uncertain at this time.

- The development of a central operations area to replace the existing infrastructure that has outlived its design life. Chapter 2, Section 2.1.4.3.6 describes the central operations area under the Proposed Action.

- The repair of erosion damage to the existing 0.061-square-kilometer (15-acre) Equipment Storage Pad. This pad is not within either the North or South Portal areas and its improvement is not part of the Proposed Action.

- The building of a Sample Management Facility near Gate 510 of the Nevada Test Site on Bureau of Land Management land outside the analyzed land withdrawal area. Chapter 2, Section 2.1.6.2 describes the sample management facility under the Proposed Action.

If DOE did not implement these proposed infrastructure improvements in the near term, it would continue to use the existing infrastructure with appropriate mitigation measures to protect worker health and safety to operate the Yucca Mountain Project. The Department would continue maintenance and replacement of infrastructure on an as-needed basis only, until the NRC decided whether to authorize construction of a repository at Yucca Mountain.

4.3.1 PROPOSED INFRASTRUCTURE IMPROVEMENTS

Sections 4.3.1.1 through 4.3.1.5 describe each proposed infrastructure improvement.

4.3.1.1 Road Construction

DOE would build several new roads and replace several existing roads (Figure 4-10), which would total about 40 kilometers (25 miles) of new and replacement paved roads. DOE would first build a new 13.7-kilometer (8.5-mile), two-lane paved access road from a point 3.7 kilometers (2.3 miles) north of Gate 510 on the Nevada Test Site to a point about 0.8 kilometer (0.5 mile) east of Fortymile Wash. Second, the Department would build a new 2.1-kilometer (1.3-mile), two-lane paved road to the crest of Yucca Mountain. DOE would move the existing access road to Gate 510 approximately 0.39 kilometer (0.24 mile) to the southeast to line up with the State Route 373 and U.S. Highway 95 intersection (Figure 4-10). A total of about 0.55 square kilometer (135 acres) would be disturbed.

Road construction would require borrow material that DOE would obtain from the existing excavated rock storage pile near the North Portal, existing aggregate pits west of H Road along Fran Ridge, a new borrow site at an unspecified location, or a combination of these sources.

DOE would drill cores along the centerline of each new roadbed at intervals based on field conditions. Workers would remove vegetation and about 15 centimeters (6 inches) of topsoil by blading and would stockpile the soil for use in reclamation. Heavy machinery would level high points along the roadbeds and move the excess material to low points to balance cut and fill. DOE would install road shoulders, erosion controls, drainage culverts, *riprap*, and ditches in accordance with best management practices. Construction and safe operation of part of the new road to the crest of Yucca Mountain could require drilling and blasting and retaining walls. A strip 11 meters (36 feet) wide for the crest road and 15 meters (50 feet) wide for the access road would be compacted and paved. A 46-centimeter (18-inch)-thick layer of fill would be placed on the roadbed and compacted, after which a 41-centimeter (16-inch)-thick layer of aggregate would be placed over the fill and compacted; last, an 18-centimeter (7-inch)-thick layer of asphalt would be applied to the road surface. The total width of the disturbance for these new roads and shoulders would be about 37 meters (120 feet) for the access road and about 18 meters (60 feet) for the crest road.

DOE would replace about 19 kilometers (12 miles) of existing access road (H Road) and about 4.7 kilometer (2.9 mile) of the existing crest road with two-lane asphalt roads. The replacement would include construction of a culvert (generally designed to accommodate a 100-year flood) at Fortymile

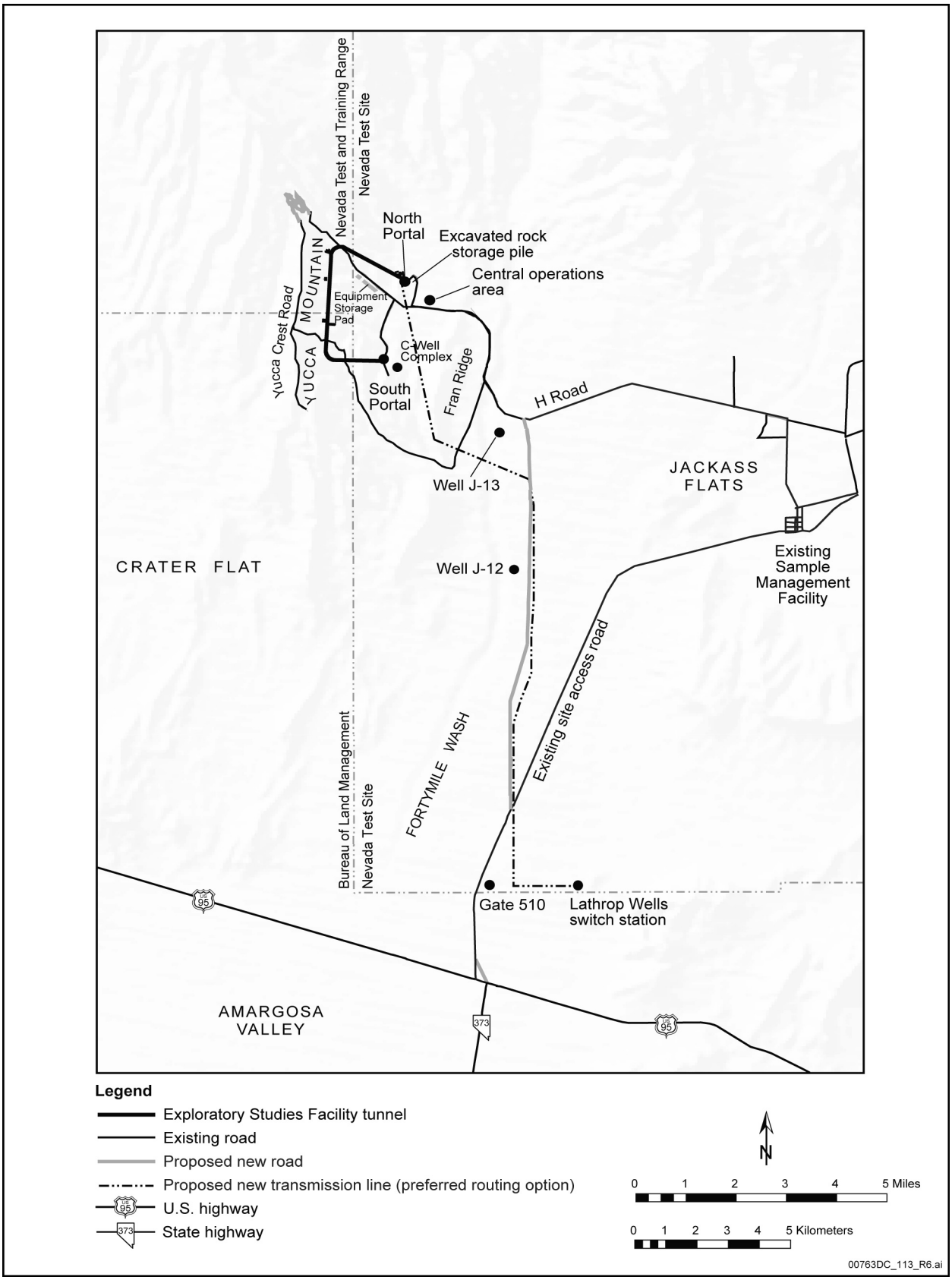

Figure 4-10. Proposed infrastructure improvements.

Wash. The existing asphalt roadbed would be excavated and stockpiled for possible use as fill material. A total of about 0.34 square kilometers (85 acres) would be disturbed.

4.3.1.2 Transmission Line Construction

DOE proposes to install a 138-kilovolt transmission line from the existing Lathrop Wells switch station to a proposed substation at the central operations area (Figure 4-10). DOE's preferred routing for the transmission line would follow utility corridors parallel to the site access road. The total length of the transmission line from the Lathrop Wells switch station to the central operations area would be about 29 kilometers (18 miles). From the switch station, the transmission line would extend due west about 2.4 kilometers (1.5 miles) before it intersected the proposed new access road. From this point, the transmission line would extend 14 kilometers (0.5 mile) east of Fortymile Wash. From this point, the transmission line would extend another 8.9 kilometers (5.5 miles) along the existing access road, cross Fortymile Wash, and end at the central operations area.

4.3.1.3 Central Operations Area

The Department would develop a central operations area about 0.8 kilometer (0.5 mile) southeast of the North Portal for all operations, which would include support and replacement of underground infrastructure in the Exploratory Studies Facility (Figure 4-10). Proposed construction would occur on about 0.12 square kilometer (30 acres) of land DOE has used for equipment storage and lay down. On completion of this construction, the Department would dismantle and dispose of existing temporary structures and utilities at the North Portal and the existing Field Operations Area, which would be obsolete. The improvements for the replacement of existing infrastructure would enhance the safety margins for continued near-term scientific exploration, testing, and maintenance.

DOE would transport as much as 115,000 cubic meters (150,000 cubic yards) of fill material to the area, compacted, and graded for proper drainage. The fill material would be from the excavated rock storage pile near the North Portal, existing aggregate pits (west of H road along Fran Ridge), a new borrow site at an unspecified location, or a combination of these sources. The fill would be crushed and screened at the source location. After placement and grading of the fill material, DOE would construct five new support buildings and install utilities (power, water, sewer, and communications). The five support buildings would include a 4,000-square-meter (43,000-square-foot) field operations center for offices, training, computer operations, and emergency facilities; a 930-square-meter (10,000-square-foot) incident-response station for fire and medical support; a 4,000-square-meter craft shop and annex for maintenance and repair operations; a fuel and vehicle wash facility; and a 3,300-square-meter (35,000-square-foot) warehouse and material storage yard. The fuel facility would have space for refueling islands to supply diesel, gasoline, propane, and compressed natural gas and a separate facility to wash vehicles. DOE would pave the areas around each building with asphalt to control dust. The entire site would be fenced and exterior lighting would be installed. These buildings would replace the more than 100 temporary structures (for example, storage containers, trailers, and tents) that DOE currently uses for workshops, equipment fabrication and repair, warehousing, and offices.

The existing options for the disposal of temporary structures would include the Nevada Test Site landfills in Areas 23 and 9, and the Crestline landfill in Lincoln County and Apex landfill in Clark County, which the counties operate. Nye County is in the process of siting new landfill locations, so DOE could work

cooperatively with the county to site and permit a new facility. Chapter 3, Section 3.1.12.1 provides information on solid waste disposal sites and their capacities.

4.3.1.4 Equipment Storage Pad

DOE would repair the 0.061-square-kilometer (15-acre) equipment storage pad approximately 1.6 kilometer (1 mile) southwest of the North Portal, which has been damaged over the years by natural erosion (Figure 4-10). The Department would repair this damage and improve drainage on the storage pad by leveling the area with up to 3,800 cubic meters (5,000 cubic yards) of borrow material from the existing excavated rock storage pile near the North Portal, existing borrow pits, a new borrow site at an unspecified location within 24 kilometers (15 miles), or a combination of these sources.

4.3.1.5 Sample Management Facility

DOE would construct a new Sample Management Facility near Gate 510 on Bureau of Land Management land outside the analyzed land withdrawal area. This facility would house a variety of samples from studies that included rock cores. Land disturbance would affect about 0.012 square kilometer (3 acres).

4.3.2 ENVIRONMENTAL IMPACTS

This section describes the potential environmental impacts for the proposed infrastructure improvements. Table 4-38 lists the estimated land disturbances, water requirements, and workforce for each proposed improvement.

Table 4-38. Estimated disturbances, water requirements, and workforce.

Infrastructure improvement	Disturbances[a] (square kilometers)	Disturbances[a] (acres)	Water requirements[b] (acre-feet)	Estimated new workers during construction[c]
Roads	0.89	220	200	40
Transmission line	0.12	30	6	16
Central operations area	0	0	47	100
Equipment storage pad	0	0	< 1	10
Sample Management Facility	0.012	3	< 1	30
Totals	1.0	253	255	196

Source: DIRS 178817-DOE 2006, p. 15.

a. Some of the land in this category has experienced small disturbances from previous activities.

b. The analysis assumed that construction would take 2 years, even though in some cases the activities would be completed sooner.

c. The workforce for the central operations area could include persons who already work on the Yucca Mountain Project.

4.3.2.1 Land Use and Ownership

Section 4.1.1 describes potential land use and ownership impacts from the Proposed Action. Under the Proposed Action, DOE would require a four-lane paved access road and two 138-kilovolt transmission lines; infrastructure improvements would require a two-lane access road and one 138-kilovolt transmission line.

The proposed infrastructure improvements would have negligible effects on existing or future land uses. Most of the affected land would be on the Nevada Test Site and the Nevada Test and Training Range. As Chapter 3, Section 3.1.2 describes, the U.S. Air Force has issued a right-of-way reservation that authorizes DOE to use certain land for the Yucca Mountain Project, which would include the crest road. The authorized use of Test Site land is based on a 2002 management agreement between DOE's Nevada Operations Office and Office of Repository Development. Because the improvements would not change the nature of current activities at Yucca Mountain, the actions would not affect operations at either the Test Site or the Range.

The proposed road upgrades could include the development of an aggregate pit at an unspecified location. The *Materials Act of 1947* governs access to and use of common varieties of sand, stone, and gravel on public lands by federal agencies; the Act authorizes the Bureau of Land Management to issue free-use permits for these materials. If the Department required the development of this pit, it would apply to the Bureau for a free-use permit. DOE would not open a new pit if an adequate quantity and quality of aggregate was available from the existing aggregate pits at Yucca Mountain west of H Road along Fran Ridge.

DOE would construct the Sample Management Facility near Gate 510 on Bureau of Land Management land outside the analyzed land withdrawal area, move the contents of the existing Sample Management Facility at the Field Operations Center, and dismantle the existing facility. The facility would require about 0.012 square kilometers (3 acres). Construction of the new facility would not affect the use of public land in the area.

4.3.2.2 Air Quality

Section 4.1.2 describes potential nonradiological air quality impacts from the Proposed Action. The potential environmental impacts from the infrastructure improvements would be smaller than those for the Proposed Action for criteria pollutants.

The potential impacts to air quality from the proposed infrastructure improvements would be small. Sources of air pollutants from the proposed improvements would be (1) dust from surface grading for roads, possible blasting for parts of the new road to the crest of Yucca Mountain, possible relocation or reuse of the existing excavated rock storage pile near the North Portal, vehicle travel on paved and unpaved roads, and wind erosion, and (2) combustion of fossil fuel by diesel- and gasoline-powered construction equipment.

Potential air quality impacts would result primarily from the disturbance of approximately 1 square kilometer (250 acres) of land (Table 4-38). Based on the results of dispersion modeling for this Repository SEIS, gaseous pollutants from fuel-burning equipment would be well below regulatory standards. Therefore, the primary criteria pollutant of concern would be PM_{10}. Emissions for the Proposed Action during the construction analytical period would result in concentrations of PM_{10} that would be no more than 40 percent of the standards. Therefore, the air quality impacts from infrastructure improvements would also be well within the PM_{10} standard.

Certain forms of hazardous silica dust could disperse into the atmosphere if DOE used the excavated rock storage pile near the North Portal for road or storage pad construction. Cristobalite is one of several forms of crystalline silica that occur in Yucca Mountain tuffs. Cristobalite is principally a concern for

involved workers who could inhale the particles while performing their tasks. The Department would monitor the environment at and near the storage pile to ensure that workers were not exposed to harmful concentrations of this dust. If engineering controls were unable to maintain safe dust concentrations, DOE would use administrative controls such as access restrictions or respiratory protection (dust suppression, air filters, and personal protective gear) until engineering controls could reestablish safe conditions. DOE would apply the same monitoring and engineering controls to the storage piles as it would to construction sites where the silica could be present. Section 4.1.2.1 discusses the potential impacts related to cristobalite.

4.3.2.3 Hydrology

Section 4.1.3 describes the potential environmental impacts to hydrological resources at Yucca Mountain from the Proposed Action. This infrastructure improvement analysis evaluated potential impacts to these resources in three areas: surface water, groundwater quality, and water demand.

Water demand for dust suppression would be smaller than that for the construction of the four-lane road to support repository construction and operation and would not be concurrent with water demand for repository construction. Potential contamination of groundwater and the volume of surface runoff would also be smaller than that under the Proposed Action.

4.3.2.3.1 *Surface Water*

Potential impacts to surface water, drainages, and floodplains from the infrastructure improvements would be small. Disturbed and loosened ground would generate less runoff and more infiltration and possibly be more susceptible to erosion during heavy precipitation, but this would occur only during construction. At the completion of construction, DOE would either cover most disturbed areas with impermeable surfaces (structures or asphalt) or compact them, at which time runoff rates could increase. In any case, changes to infiltration and runoff rates would be limited to relatively small areas of disturbed land; DOE would take precautions during construction to minimize erosion. DOE would control the use of petroleum, oil, lubricants, and other hazardous materials during construction; the Department would promptly clean up spills and remediate the soil and alluvium. The designs of road crossings at washes would maintain the flow of water through culverts and prevent erosion up- and downstream of the crossings. The proposed road upgrades would require improvement of the access road that crosses Fortymile Wash and would extend along Drill Hole Wash to near the point it is joined by Midway Valley (Sever) Wash. This construction would affect both Fortymile and Drill Hole washes, including their floodplains, but the impacts would be small. Appendix C contains the floodplain and wetlands assessment for this Repository SEIS. Section C.2.2 discusses proposed infrastructure improvements.

Improvement of the road that crosses Fortymile Wash would require placement of fill in the channels of the wash. Raising the road across Fortymile Wash would require about 0.00081 square kilometer (0.2 acre) of new fill. Replacement of the access road near the joined Drill Hole, Midway Valley, and Fortymile washes could require modification of the flow channel of Drill Hole Wash. Improvement of the access road in this area could have beneficial effects on surface-water flow because the drainage area design; construction would reduce erosion along the existing road and accommodate the combined flow from Drill Hole and Midway Valley washes more appropriately. Culverts (which would generally be designed to accommodate a 100-year flood) would have small impacts on surface water or other resources

because DOE would design and construct them to minimize erosion and the associated sediment transport and to accommodate the flow in the washes during storms.

DOE would, if required, obtain a permit from the U.S. Army Corps of Engineers for construction in waters that meet the criteria for jurisdictional waters of the United States. Fortymile Wash, a tributary of the *Amargosa River*, and some of its tributaries in and near the geologic repository operations area might be waters of the United States.

4.3.2.3.2 *Groundwater Quality*

The proposed infrastructure improvements would have small impacts on the quality of groundwater because the water table varies from 270 to 760 meters (900 to 2,500 feet) below the surface. DOE would remediate inadvertent spills of hazardous materials and would not allow such material to reach the water table.

4.3.2.3.3 *Water Demand*

The quantity of groundwater necessary for the proposed infrastructure improvements would be 315,000 cubic meters (255 acre-feet) over a 2-year period. DOE would pump the water from wells at Yucca Mountain in the western two-thirds of the Jackass Flats basin. Of the water demand over the 2-year period, an average of about 80 percent would be for access road construction, including water for compaction of material and dust suppression. Less than 1 percent of the total water demand at the site would be for construction worker consumption. Construction workers would generally not shower on the site .

The lowest estimate of perennial yield for this part of the Jackass Flats basin is 720,000 cubic meters (584 acre-feet). The impacts to regional water availability would be less than the estimated minimum perennial yield for the Jackass Flats basin. The water demand estimates in Section 4.1.3 include the estimates for construction of a four-lane access road and other site improvements.

4.3.2.4 Biological Resources and Soils

Section 4.1.4 describes potential environmental impacts from the Proposed Action on biological resources and soils. Potential impacts to biological resources from the proposed infrastructure improvements involve four areas: (1) vegetation, (2) wildlife, (3) special-status species, and (4) soils. Impacts to plants, animals, and special-status species would be the same or smaller than those under the Proposed Action in that there would be less land disturbance and habitat loss and construction analytical periods would be shorter.

4.3.2.4.1 *Vegetation*

Potential impacts to vegetation from the infrastructure improvements would be small. Construction of the access road and transmission line would remove vegetation on about 1 square kilometer (250 acres), (Table 4-38). Soil compaction would change the physical structure of the soil and would probably reduce the reestablishment of native species. Dust from construction would stress downwind plant communities by covering leaves and reducing photosynthetic capacity. This impact would be temporary and would end when sufficient rain and wind removed the dust from the leaves.

Clearing native vegetation and disturbing the soil would create habitat for nonnative invasive plant species. These plants often out-compete native species and generally have little or no value for native wildlife. The seeds of *nonnative species* can spread into surrounding undisturbed areas by wind and wildlife, as well as by workers and construction equipment. Because many nonnative plant species are annuals or grasses that generate large amounts of litter, the potential for fires is generally higher than in nearby areas of native vegetation. After construction was complete, DOE would revegetate unneeded disturbed areas (Section 4.1.4) and would control invasive species on those sites.

4.3.2.4.2 *Wildlife*

Potential impacts to wildlife from the proposed infrastructure improvements would be small. The proposed road and transmission line construction would disturb about 1 square kilometer (250 acres) much of which earlier activities had disturbed (Table 4-38). These are very small areas in comparison to the large amount of surrounding undisturbed, similar habitat.

Loss of habitat would adversely affect some large and small animals (for example, burros, mule deer, birds, and reptiles). Construction noise could startle birds and other animals, including game species, and they would tend to avoid contact with humans by moving to other areas. Construction equipment could crush or smother animals that use underground habitats, such as rodents, snakes, desert tortoises, kit foxes, and burrowing owls. Wildlife deaths could also occur from collisions with vehicles traveling to and from Yucca Mountain. New manmade structures would provide additional perches for raptors, which could result in an increase in predation of lizards, snakes, rodents, and tortoises.

If construction occurred during the migratory bird nesting season (generally May 1 to July 15 at Yucca Mountain), DOE would have a qualified biologist survey areas before it began activities in those areas. If the survey found active nests, DOE would delineate a buffer zone around the nests in which it would avoid disturbance until the young birds fledged. Therefore, the proposed activities would be unlikely to result in deaths or otherwise to disturb nesting migratory birds.

4.3.2.4.3 *Special-Status Species*

Potential impacts to special-status species from the proposed infrastructure improvements would be small. The desert tortoise is the only species (animal or plant) in the affected area that the U.S. Fish and Wildlife Service lists as threatened under the *Endangered Species Act*. There are no listed *endangered species*. The Fish and Wildlife Service concluded in a Biological Opinion issued in 2001 that construction activities at Yucca Mountain would be unlikely to jeopardize the Mojave population of the desert tortoise. DOE included that opinion in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix O). However, construction activities could kill or injure some tortoises, and there could be an increase in the number of ravens or other predators of tortoises due to additional perching sites on manmade structures. DOE would implement the terms and conditions in the Fish and Wildlife Service biological opinion to protect the desert tortoise.

Chapter 3, Table 3-7 lists other special-status animal species that do or might occur at Yucca Mountain. The proposed infrastructure improvements would result in the loss of habitat for a small number of chuckwallas, loggerhead shrikes, burrowing owls, and some other migratory birds. These species occur widely in neighboring undisturbed areas, so the overall impacts to these species would be small. The

described actions to protect migratory birds would also protect these species from direct mortality or destruction of active nests.

4.3.2.4.4 *Soils*

Construction and operation of the infrastructure improvements would result in disturbed land and expose soil materials to potential loss by wind and water erosion. DOE would stockpile topsoil to reclaim disturbed areas. To further minimize soil loss, the Department would control fugitive dust by water spraying, chemical treatment, and wind fences. Control of stormwater runoff would minimize soil erosion. Because the areas of disturbance would be smaller for the infrastructure improvements than for the Proposed Action, the potential for soil loss would be smaller.

4.3.2.5 Cultural Resources

Land disturbances for proposed infrastructure improvements could have impacts to cultural resources. DOE surveyed the *alignment* of the proposed new access road during 2005 and 2006 to determine the nature and extent of cultural resources. Because of these surveys, DOE moved the corridor for the access road east to avoid cultural sites near Fortymile Wash.

As Section 4.1.5 of this Repository SEIS states, the Yucca Mountain FEIS concluded that 51 archaeological sites were recommended as eligible for inclusion in the *National Register of Historic Places* by DOE. DOE has revised this number to 232 archaeological sites. The revised number reflects recent investigations for the U.S. Highway 95 access road and a reevaluation of the importance of obsidian artifacts. Recent studies suggest that obsidian artifacts can provide important information on prehistoric American Indian settlement systems. The large increase in the number of eligible archaeological sites since completion of the FEIS reflects this finding and includes extractive localities, processing localities, or manufacture stations where American Indians used obsidian as a stone tool material.

Before beginning other land disturbances (for example, expansions at existing sites and alignments), DOE would conduct preconstruction surveys to identify cultural sites in the affected areas. The Department would then evaluate identified sites for their importance and eligibility for inclusion in the *National Register of Historic Places*. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected areas. In addition, the Department has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. DOE would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program.

4.3.2.6 Socioeconomics

Section 4.1.6 describes the potential socioeconomic impacts of the Proposed Action. The socioeconomic impacts of the infrastructure improvements would be smaller than those under the Proposed Action because the associated construction workforce would be smaller and the construction analytical period would be shorter.

The proposed infrastructure improvements would have small socioeconomic impacts. Construction would require a maximum of 196 workers for 2 years (Table 4-38). Most of these workers would probably come from the metropolitan Las Vegas area. In comparison, construction employment at a

repository at Yucca Mountain would peak at 2,590 jobs, of which 1,090 would be newly created. That level of employment would be less than a 0.2-percent increase in total regional employment and, therefore, would have even smaller socioeconomic impacts.

Although Yucca Mountain site employment numbers have dropped significantly since late 1995, the estimated workers necessary for the infrastructure improvements could come from the existing workforce and would have little impact on the regional economy or on employment, economics, population, housing, and public services.

4.3.2.7 Occupational and Public Health and Safety

Section 4.1.7 describes the potential health and safety impacts to workers (occupational impacts) and to members of the public (public impacts) from the Proposed Action. It also reports the most recent accident rates from the CAIRS database. Infrastructure improvements would employ fewer people and have a shorter construction analytical period; therefore, the potential impacts would be smaller than those of the Proposed Action. There would be no radiological issues in relation to the improvements. In addition, the purpose of the infrastructure improvements would be to enhance and ensure that continued scientific testing, exploration work, and maintenance could occur safely.

From an occupational health and safety standpoint, the types of potential health and safety impacts workers encountered would include industrial hazards common to construction work sites and potential exposure to naturally occurring cristobalite.

The possibility that DOE would use material from the excavated rock storage pile near the North Portal for road construction and leveling of the site for the central operations area could result in exposure to cristobalite. Based on the content of cristobalite in the rock, the storage pile could have a cristobalite content between 18 and 28 percent. DOE would implement engineering controls to limit dust emissions, continually monitor concentrations and, if monitoring showed concentrations were too high or above the threshold limits, limit operations. If engineering controls were unable to maintain dust concentrations below the limits, DOE would use administrative controls such as access restrictions, employee rotations, and respiratory protection until engineering controls could reestablish safe conditions. DOE would apply the same engineering and administrative controls to construction sites where silica could be present as it would for the storage pile. Section 4.1.2.1 discusses potential impacts in relation to cristobalite.

Potential health impacts to members of the public would occur from emissions from fossil fuels and PM_{10}. In both cases the potential impacts would be small (Section 4.3.2.2).

4.3.2.8 Accident Scenarios

There would be no radiological impacts from any accident that involved the infrastructure improvements. The occupational health and safety impact discussions in Sections 4.3.2.7 and 4.1.7.1 include impacts from industrial accidents.

4.3.2.9 Noise

Section 4.1.9 describes potential noise impacts to workers and the public from the Proposed Action. Noise impacts from the infrastructure improvements would be similar to those estimated for the Proposed Action; however, these impacts would be temporary. Noise from construction activities for a two-lane

road would not be notably less than that for a four-lane road. The construction of the offsite facilities would also be similar to that of the Proposed Action.

Sources of noise would include construction of the access road from U.S. Highway 95 to Gate 510, an electrical transmission line, and the Sample Management Facility. Activities would involve typical construction equipment (such as bulldozers, graders, loaders, and pavers). This type of equipment generates noise at 85 dBA at 15 meters (50 feet). Noise and sound levels would be typical of new construction activities and would be intermittent. The distance from Gate 510 to the intersection of Nevada State Route 373 and U.S. Highway 95 is approximately 3.2 kilometers (2 miles). The nearest permanent residents would be in the town of Amargosa Valley, which is southwest of the intersection of U.S. Highway 95 and State Route 373. The analysis assumed the maximally exposed member of the public would be 100 meters (300 feet) from offsite construction activities. Section 4.1.2.1 discusses this individual. Because of the distance between construction activities and receptors, DOE does not expect noise impacts to the public from the construction of infrastructure improvements.

Traffic noise on the access road would not exceed or significantly add to the existing traffic noise on U.S. Highway 95. Noise from operations after construction would be typical of commercial environments and would have no impacts.

4.3.2.10 Aesthetics

Section 4.1.10 describes the potential aesthetics impacts of the Proposed Action. Aesthetics impacts from the infrastructure improvements would be similar to those DOE estimated for the Proposed Action because the landscape intrusions would be of the same type but could have a smaller scope. The transmission line would be a noticeable linear feature, but most of it would traverse remote areas.

Construction equipment, facilities, and activities would be potential sources of impacts to visual resources during construction of roads, a transmission line, and the Sample Management Facility. Casual observers might see or be attracted to the presence of workers, vehicles, and the generation of dust and vehicle exhaust. As Section 4.1.10 notes, the crest road would not be visible from offsite locations.

DOE would reclaim disturbed areas once construction was complete. Considering the effect of best management practices for construction projects, construction activities would be noticeable but would not dominate the attention of the viewer. Therefore, there would be small project-related visual impacts during construction.

4.3.2.11 Utilities, Energy, Materials, and Site Services

Section 4.1.11 discusses impacts to residential water, energy, materials, and site services from the Proposed Action. In all aspects, the impacts from the infrastructure improvements would be smaller than those from the Proposed Action because the scope of the activities would be smaller.

Section 4.3.2.3.3 discusses water demand for the proposed infrastructure improvements. The electricity demand for construction would be well within the supply capacity in the southern Nevada region (Chapter 3, Section 3.11.1). Nevada Power Company, which supplies electricity to southern Nevada, sold 21 million megawatt-hours in 2005. Construction would consume a variety of fossil fuels that included gasoline, heating oil, diesel fuel, propane, and kerosene. Overall, impacts on the regional supply of fossil

fuels would be small. The fossil-fuel system in the State of Nevada has sufficient capacity to meet normal Nevada demands.

Impacts to existing emergency services, law enforcement, fire protection, and medical services at Yucca Mountain would be negligible because construction would not involve a substantial increase in the number of workers.

4.3.2.12 Management of Repository-Generated Waste and Hazardous Materials

Section 4.1.12 describes quantities of waste the Proposed Action would generate. Wastes from construction of a four-lane access road and two transmission lines would be greater than the wastes for a two-lane access road and one transmission line. Estimates of generated waste for the Proposed Action include the debris from dismantlement of the temporary structures at the North Portal and the existing Sample Management Facility at the Field Operations Center.

The proposed infrastructure improvements would generate increased volumes of nonhazardous solid waste, construction debris, hazardous waste, recyclables, sanitary sewage, and wastewater, but the additions would be small in comparison with waste generation for the Proposed Action. Chapter 3, Section 3.1.12.1 provides landfill capacities within Nevada.

4.3.2.13 Environmental Justice

Section 4.1.13 describes the analysis of environmental justice in terms of the potential for disproportionately high and adverse impacts to minority or low-income populations. DOE has not identified any high and adverse potential impacts to members of the public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts would result from these improvements.

4.3.3 BEST MANAGEMENT PRACTICES AND MITIGATION MEASURES

DOE would implement a variety of environmental protection measures and best management practices for the infrastructure improvements to avoid or mitigate potential adverse effects. Table 4-39 summarizes these measures and practices for each resource area.

4.3.3.1 Unavoidable Adverse Impacts

With the successful implementation of the best management practices and mitigation measures, unavoidable adverse impacts would be small. The small impacts would occur to fossil fuels, building materials, and land disturbance.

Table 4-39. Best management practices and mitigation measures.

Resource	Practices and measures
Land use	DOE would consult with and obtain right-of-way from the Bureau of Land Management for activities on public land. It would follow the mitigation measures and stipulations.
	DOE would coordinate with Nye County in relation to the construction schedule and possible conflicts with any off-road vehicle events on public lands in the affected area.
Air quality	DOE would consult with the Nevada Bureau of Air Pollution Control about the possible need to modify the current air quality operating permit for operations. Stipulations in the permit would minimize impacts to air quality.
Hydrology	DOE would obtain a Construction Storm Water Permit from the Nevada Division of Environmental Protection that would include preparation of a Storm Water Pollution Prevention Plan. This plan would include established best management practices for the control of erosion and pollution while constructing crossings and working in dry washes.
	DOE would, as necessary, obtain a Section 404 permit from the U.S. Army Corps of Engineers for construction in washes that meet the Corps' criteria as jurisdictional waters of the United States and would implement mitigation measures and best management practices in the permit.
Biological resources	
Wildlife	If construction occurred during migratory bird-nesting season, a qualified biologist would survey areas before the start of construction. If the survey found active nests, DOE would delineate a buffer zone around nests, within which disturbance would not occur until the young birds fledged. The size of the protective buffer would depend on species-specific requirements.
Vegetation	Where appropriate, DOE would restore areas affected by grading, plowing, or trenching to their approximate original contours in accordance with the *Reclamation Implementation Plan* for Yucca Mountain (DIRS 154386-YMP 2001, all).
Special-status species	DOE would follow the mitigation measures for the protection of desert tortoises required by the U.S. Fish and Wildlife Service's 2001 Biological Opinion on Yucca Mountain (DIRS 155970-DOE 2002, Appendix O).
	DOE would clearly mark populations of special-status plant or animal species discovered during preconstruction surveys with flagging or caution tape and would require construction contractors to inform crews about the importance of avoiding flagged areas.
Cultural resources	DOE would conduct preconstruction surveys to identify cultural sites in the potentially affected areas. It would evaluate each site for eligibility for inclusion in the *National Register of Historic Places*. Where practicable, DOE would avoid sites or, if not practicable, would collect artifacts at eligible sites in accordance with Section 106 of the *National Historic Preservation Act* and document the findings. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected area. In addition, DOE has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. DOE would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program.
Occupational and public health and safety	If engineering controls were unable to maintain safe concentrations of silica dust during possible use of the excavated rock storage pile near the North Portal for road construction and surface leveling, DOE would use respiratory protection (air filters, or personal protective gear) until engineering controls could reestablish safe conditions.
Noise	DOE would conduct construction activities only during daylight hours.
Aesthetics	DOE would use shielded or down-directed and dark-sky-friendly lighting at the central operations area and at other new facilities at Yucca Mountain to minimize the amount of night lighting visible from offsite locations.

Table 4-39. Best management practices and mitigation measures (continued).

Resource	Practices and measures
Environmental justice	Through the ongoing Native American Interaction Program, DOE would continue to solicit input from the 17 tribes and organizations that have cultural and historic ties to the Yucca Mountain area. Through this program, the tribes and organizations can express their views and concerns about the management of cultural resources and related issues. DOE would include American Indian monitors in all surveys to identify cultural sites in the affected area. In addition, DOE has implemented a worker education program on the protection of archaeological sites and artifacts to limit direct and indirect impacts to them. DOE would work collaboratively with the Consolidated Group of Tribes and Organizations to involve tribal representatives in the worker education program.

4.3.4 CUMULATIVE IMPACTS

A cumulative impact is an impact on the environment that results from the incremental impact of the action when it is added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Chapter 8 provides more detail on cumulative impacts for the actions in the following sections.

4.3.4.1 Land Withdrawal To Study a Corridor for a Proposed Rail Line to Yucca Mountain

On December 28, 2005, acting on an application from DOE, the Secretary of the Interior published Public Land Order No. 7653 that withdrew for 10 years about 1,250 square kilometers (310,000 acres) of public land around the potential rail lines under study from the staking of new mining claims (70 FR 76854).

The withdrawal does not result in any surface disturbances, and it does not affect the development of existing valid mining claims. It does, however, preclude the staking of new claims on these public lands, which include lands in the vicinity of Yucca Mountain. Those lands are west of the area that infrastructure improvements would affect and are a subset of the broader analyzed land withdrawal area for the repository. This action would not result in cumulative impacts.

4.3.4.2 Activities on the Nevada Test and Training Range

The U.S. Air Force operates the Nevada Test and Training Range. The *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999, all) addressed potential environmental impacts of extending the land withdrawal for military activities by the Air Force. The land withdrawal renewal for the Range was approved, and activities on the Range have continued to evolve with changing military needs. In general, however, current and future developments at the Range would have small cumulative impacts with the proposed infrastructure improvements because the impacts would not occur on those Air Force lands that DOE uses for operations at Yucca Mountain.

On January 10, 2007, the Bureau of Land Management announced that DOE had filed an application to request a second land withdrawal (72 FR 1235). The application is for an additional 842 square kilometers (208,000 acres) from surface entry and mining to December 27, 2015.

4.3.4.3 Nevada Test Site Activities

The Nevada Test Site has been the nation's proving ground for the development and testing of nuclear weapons. From 1951 to 1992, DOE and its predecessor agencies conducted more than 900 tests at the site. Current activities at the Test Site include the management of radioactive and hazardous wastes; weapons stockpile, stewardship, and management; materials disposition; nuclear emergency response; and nondefense research and development. Past and present activities, specifically in Area 25 where many of the facilities for the Yucca Mountain Project are, would be part of the affected environment. Current and future Test Site activities in Area 25 that could have cumulative impacts with the infrastructure improvements include the continued withdrawal of groundwater for Test Site operations.

The small incremental cumulative impacts would include land disturbance, water use, waste generation, noise, and emissions from construction equipment and fugitive dust. The impacts would be temporary.

4.3.4.4 Yucca Mountain Project Gateway Area Concept Plan

Nye County has prepared a Yucca Mountain Gateway Area Concept Plan with proposed land use designations for the area around the proposed Yucca Mountain Repository entrance. Chapter 8 of this Repository SEIS contains Nye County's perspective on cumulative impacts and discusses the role of the land use concept plan as guidance for the management of development near the entrance area. Nye County proposed this plan to ensure land development would occur in an orderly manner while increasing the opportunities for industrial and commercial development. Nye County views this plan as a starting point for development of the infrastructure, institutional capacity, and facilities that would be consistent with the proposed repository land use.

There are no specific proposals for development, but incremental cumulative impacts could include additional disturbed land, water use, emissions from construction equipment, fugitive dust, waste generation, and noise.

4.3.4.5 Desert Space and Science Museum

Nye County proposes to construct a Desert Space and Science Museum and commercial facilities in the area of the Gateway Area Concept Plan. Under the proposal, the Bureau of Land Management would transfer 3.3 square kilometers (820 acres) to Nye County, of which 0.4 square kilometer (100 acres) would have permanent developed facilities. Nye County would manage the remaining 2.9 square kilometers (720 acres) for natural resource and habitat values.

The museum would result in some additional water use and employment that could affect the regional economy. Other incremental cumulative impacts would occur only during infrastructure construction and would include emissions from construction equipment, fugitive dust, and noise.

REFERENCES

102043	AIWS 1998	AIWS (American Indian Writers Subgroup) 1998. *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement.* Las Vegas, Nevada: Consolidated Group of Tribes and Organizations. ACC: MOL.19980420.0041.
152803	Bland 1998	Bland, J. 1998. "Cask Manufacturing Multipliers." E-mail from J. Bland (CRWMS M&O) to K. House, August 5, 1998 with attachments. Las Vegas, Nevada. ACC: MOL.2001101.0238.
178610	Bland 2007	Bland, J. 2007. "Baseline: REMI Policy Insight, Version 9, Last History Year 2004." E-mail from J. Bland to E. Gorsem, January 10, 2007, with attachment. ACC: MOL.20070119.0084.
182205	Bland 2007	Bland, J. 2007. "Staffing for the Repository: SEIS." E-mail from J. Bland to S. Walker, April 12, 2007, with attachment. ACC: MOL.20070806.0013; MOL.20070806.0014.
182642	Bland 2007	Bland, J.B. 2007. *SEIS Socioeconomic Inputs-Outputs: Residential Patterns of Changing Employment, Assume 20% of Site Workers Live in Nye County - Scenario One.* Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20070822.0018.
101505	BLM 1986	BLM (Bureau of Land Management) 1986. *Visual Resource Inventory.* BLM Manual Handbook 8410-1. Washington, D.C.: U.S. Bureau of Land Management. ACC: MOL.20010730.0378.
173053	BLM 1986	BLM (Bureau of Land Management) 1986. *Visual Resource Contrast Rating, BLM Manual Handbook 8431-1.* Washington, D.C.: Bureau of Land Management. ACC: MOL.20050406.0040.
103079	BLM 1998	BLM (Bureau of Land Management) 1998. *Proposed Las Vegas Resource Management Plan and Final Environmental Impact Statement.* Three volumes. Las Vegas, Nevada: Bureau of Land Management. ACC: MOL.20010724.0319.
176043	BLM 1998	BLM (Bureau of Land Management) 1998. *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement.* Las Vegas, Nevada: Bureau of Land Management, Las Vegas Field Office. ACC: MOL.20060313.0209.

181921	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2003.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0356.
181922	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2004.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0357.
181924	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. *Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2005.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0358.
181925	BLS n.d.	BLS (Bureau of Labor Statistics) n.d. "*Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Selected Case Types, 2001.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0351.
181926	BLS 2003	BLS (Bureau of Labor Statistics) 2003. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2002.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0352.
181927	BLS 2005	BLS (Bureau of Labor Statistics) 2005. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2003.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0353.
181928	BLS 2005	BLS (Bureau of Labor Statistics) 2005. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2004.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0354.
181929	BLS 2006	BLS (Bureau of Labor Statistics) 2006. *Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2005.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. ACC: MOL.20070724.0355.

185184	BLS 2008	BLS (Bureau of Labor Statistics) 2008. "Table A-1. Fatal Occupational Injuries by Industry and Event or Exposure, All United States, 2006." *Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed March, 4, 2008. ACC: MOL.20080306.0050. URL: http://www.bls.gov/iif/oshwc/cfoi/cftb0214.pdf
185185	BLS 2008	BLS (Bureau of Labor Statistics) 2007. "Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and Case Types, 2006." *Industry Injury and Illness Data.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed March 4, 2008. ACC: MOL.20080306.0051. URL: http://www.bls.gov/iif/oshwc/osh/os/ostb1765.pdf
169734	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Yucca Mountain Site Description*. TDR-CRW-GS-000001 Rev02 ICN 01, April 2004. Las Vegas, Nevada. ACC: DOC.20040504.0008.
179303	BSC 2006	BSC (Bechtel SAIC Company) 2006. *Low-Level Waste Management Plan.* 000-30R-MW00-00100-000 Rev 000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061218.0016.
177510	BSC 2007	BSC (Bechtel SAIC Company) 2007. *General Public Atmospheric Dispersion Factors.* 000-00C-MGR0-02800-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070329.0001.
180185	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Characteristics for the Representative Commercial Spent Fuel Assembly for Preclosure Normal Operations.* 000-PSA-MGR0-00700-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070521.0008.
183261	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Yucca Mountain Project Drainage Report and Analysis.* 000-CDC-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070924.0043.
182322	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Concepts for Waste Retrieval and Alternate Storage of Radioactive Waste.* 800-30R-HER0-00100-000 Rev 004. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070604.0013.
183160	BSC 2007	BSC (Bechtel SAIC Company) 2007. *General Public Atmospheric Dispersion Factors.* 000-00C-MGR0-02800-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070813.0003.

173226	Buqo 2004	Buqo, T.S. 2004. *Nye County Water Resources Plan*. Pahrump, Nevada: Nye County, Department of Natural Resources and Federal Facilities. ACC: MOL.20050418.0041.
181932	Bureau of the Census n.d.	Bureau of the Census n.d. "Metropolitan Areas - Personal Income and Earnings by Industry." Table B-8 of *State and Metropolitan Area Data Book: 2006.* Pages 162-167. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0366.
182017	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Worcester, MA Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0371. URL: http://www.census.gov/econ/census02/data/metro4/M49340.htm
182018	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Worcester, MA Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0372. URL: http://www.census.gov/epcd/nonemployer/2002/M14849340.htm
182020	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Greensboro-High Point, NC Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0373. URL: http://www.census.gov/econ/census02/data/metro2/M24660.htm
181933	Bureau of the Census n.d.	Bureau of the Census n.d. "Metropolitan Areas - Labor Force and Private Business Establishments and Employment." Table B-9 of *State and Metropolitan Area Data Book: 2006.* Pages 168-173. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0365.
181937	Bureau of the Census n.d.	Bureau of the Census n.d. "Metropolitan Areas - Population by Age, Race, and Sex." Table B-3 of *State and Metropolitan Area Data Book: 2006.* Pages 132-137. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0364.
181938	Bureau of the Census n.d.	Bureau of the Census n.d. "Resident Population by Race, Hispanic or Latino Origin, and State: 2005." Table 23 of *Statistical Abstract of the United States: 2007.* Page 26. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0363.

181940	Bureau of the Census n.d.	Bureau of the Census n.d. "Individuals and Families Below Poverty Level-Number and Rate by State: 2000 and 2004." Table 690 of *Statistical Abstract of the United States: 2007.* Page 457. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0361.
182021	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Greensboro-High Point, NC Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0374. URL: http://www.census.gov/epcd/nonemployer/2002/M26824660.htm
182022	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Akron, OH Metropolital Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0375. URL: http://www.census.gov/econ/census02/data/metro1/M10420.htm
182023	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Akron, OH Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0376. URL: http://www.census.gov/epcd/nonemployer/2002/M18410420.htm
182024	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS York-Hanover, PA Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0377. URL: http://www.census.gov/econ/census02/data/metro4/M49620.htm
182026	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics York-Hanover, PA Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0378. URL: http://www.census.gov/epcd/nonemployer/2002/M56449620.htm

182027	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Summary Statistics by 2002 NAICS Chattanooga, TN-GA Metropolitan Statistical Area." *2002 Economic Census, Geographic Area Series.* Washington, D.C.: U.S Census Bureau. Accessed July 18, 2007. ACC: MOL.20070724.0379. URL: http://www.census.gov/econ/census02/data/metro1/M16860.htm
182028	Bureau of the Census 2005	Bureau of the Census 2005. "2002 Economic Census, Nonemployer Statistics Chattanooga, TN-GA Metropolitan Statistical Area." *2002 Economic Census, Nonemployer Statistics.* Washington, D.C.: U.S. Census Bureau. Accessed July 2, 2007. ACC: MOL.20070724.0380. URL: http://www.census.gov/epcd/nonemployer/2002/M17416860.htm
181931	Bureau of the Census 2006	Bureau of the Census 2006. "Metropolitan Areas - Area and Population." Table B-1 of *State and Metropolitan Area Data Book: 2006.* Washington, D.C.: Bureau of the Census. ACC: MOL.20070724.0367.
181939	Bureau of the Census 2006	Bureau of the Census 2006. "Metropolitan Areas with Component Counties - Population Characteristics and Housing Units." Table C-2 of *State and Metropolitan Area Data Book: 2006.* Pages 208-227. Washington, D.C.: U.S. Census Bureau. ACC: MOL.20070724.0362.
177702	CEQ 1997	CEQ (Council on Environmental Quality) 1997. *Environmental Justice Guidance Under the National Environmental Policy Act.* Washington, D.C.: Council on Environmental Quality. ACC: MOL.19881123.0604
182821	Converse Consultants 2005	Converse Consultants 2005. *Water Resources Assessment Report, Task 3.4, Rev. 0.* Converse Project No. 04-33110-01. Las Vegas, Nevada: Converse Consultants. ACC: ENG.20070614.0005.
104523	CRWMS M&O 1999	CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1999. *Engineering File - Subsurface Repository.* BCA000000-01717-5705-00005 Rev 02, DCN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990621.0157; MOL.19990615.0230.
150174	CRWMS M&O 1999	CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1999. *Effects of Topsoil Stockpiling on Soil Viability at Yucca Mountain, Nevada*. B00000000-01717-5705-00054 Rev00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000329.0681.

145966	CRWMS M&O 2000	CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 2000. *Numerical Modeling of Groundwater Flow in the Death Valley Hydrographic Region: Basins 225-230*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000228.0518.
101811	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243. Las Vegas, Nevada: U.S. Department of Energy, Nevada Operations Office. ACC: MOL.20010727.0190; MOL.20010727.0191.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
162638	DOE 2002	DOE (U.S. Department of Energy) 2002. *Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0243-SA-01, July 2002. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office. ACC: MOL.20030409.0001.
172055	DOE 2004	DOE (U.S. Department of Energy) 2004. *Spill Prevention, Control, and Countermeasures Plan for Site Activities.* BAB000000-01717-4600-00009 Rev 02. Las Vegas, Nevada: U.S. Department of Energy, Office or Repository Development. ACC: DOC.20040329.0003.
178579	DOE 2004	DOE (U.S. Department of Energy) 2004. *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements*. Second Edition. Washington, D.C.: U.S. Department of Energy, Office of NEPA Policy and Compliance. ACC: MOL.20070111.0019.

182204	DOE 2004	DOE (U.S. Department of Energy) 2004. "*Quick Source Guide, Revised Occupational Injury and Illness Case Classification Terminology, Office of Corporate Performance Assessment, September 2004 Quick Source Guides.*" Washington, D.C.: U.S. Department of Energy, Office of Health, Safety and Security. Accessed July 30, 2007. ACC: MOL.20070806.0007. URL: http://www.hss.energy.gov/CSA/Analysis/cairs/quicksource.html
178817	DOE 2006	DOE (U.S. Department of Energy) 2006. *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada*. DOE/EA-1566. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.20060911.0011.
182198	DOE 2007	DOE (U.S. Department of Energy) 2007. "DOE and Contractor Injury and Illness Experience by Operation Type by Year and Quarter, 2001 through 2006, 4th Quarter." *DOE and Contractor Injury and Illness Experience by Year and Quarter, 2002 through 2007, 1st Qtr.* Washington, D.C.: U.S. Department of Energy. Accessed August 8, 2007. ACC: MOL.20070806.0010; MOL.20070810.0042. URL: https://cairs.hss.doe.gov/cairs/help/reports/dataqtr/menu.html
182199	DOE 2007	DOE (U.S. Department of Energy) 2007. "DOE and Contractor Injury and Illness Experience by Field Organization by Year by Quarter, 2001 through 2006, 4th Quarter." *DOE and Contractor Injury and Illness Experience by Year and Quarter, 2002 through 2007, 1st Qtr.* Washington, D.C.: U.S. Department of Energy. Accessed August 8, 2007. ACC: MOL.20070806.0011; MOL.20070810.0042.
185304	DOE 2008	DOE (U.S. Department of Energy) 2008. *Transportation, Aging and Disposal Canister System Performance Specification.* WMO-TADCS-000001, Rev. 1 ICN 1. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20080331.0001.
185316	EIA n.d.	EIA (Energy Information Administration) n.d. "Table 3. State Emissions by Year (Million Metric Tons of Carbon Dioxide)." *Energy Emissions Data & Environmental Analysis of Energy Data.* Washington, D.C.: U.S. Department of Energy, Energy Information Administration. Accessed March 27, 2008. ACC: MOL.20080414.0050. URL: http://www.eia.doe.gov/environmental.html

176397	EIA 2005	EIA (Energy Information Administration) 2005. *Fuel Oil and Kerosene Sales 2004*. DOE/EIA-0535(04). Washington, D.C.: U.S. Department of Energy, Energy Information Administration. ACC: MOL.20060216.0167.
182203	EIA 2006	EIA (Energy Information Administration) 2006. "Table F1: Motor Gasoline Consumption, Price, and Expenditure Estimates by Sector, 2004." *State Energy Consumption, Price, and Expenditure Estimates (SEDS)*. Washington, D.C.: U.S. Department of Energy, Energy Information Administration. Accessed May 24, 2007. ACC: MOL.20070806.0008. URL: http://www.eia.doe.gov/emeu/states/_seds_updates.html
103243	EPA 1996	EPA (U.S. Environmental Protection Agency) 1996. *Ambient Levels and Noncancer Health Effects of Inhaled Crystalline and Amorphous Silica: Health Issue Assessment.* EPA/600/R-95/115. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency. ACC: MOL.20010727.0172.
103245	EPA 1996	EPA (U.S. Environmental Protection Agency) 1996. *National Capacity Assessment Report: Capacity Planning Pursuant to CERCLA Section 104(c)(9).* EPA530-R-95-016. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010727.0171.
175452	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. EPA 402-R-99-001. Federal Guidance Report No. 13. CD Supplement. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. ACC: MOL.20020312.0287.
181916	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Worcester Co, MA." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0337. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=25027&geoinfo=co%7E25027%7EWorcester+Co%2C+Massachusetts&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25

181917	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Guilford Co, NC." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0338. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=37081&geoinfo=co%7E37081%7EGuilford+Co%2C+North+Carolina&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
181918	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Hamilton Co, TN." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0339. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=47065&geoinfo=co%7E47065%7EHamilton+Co%2C+Tennessee&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
181919	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: Summit Co, OH." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0340. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=39153&geoinfo=co%7E39153%7ESummit+Co%2C+Ohio&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
181920	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Facility SIC Report - Criteria Air Pollutants, Geographic Area: York Co, PA." *AirData.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed July 13, 2007. ACC: MOL.20070724.0341. URL: http://iaspub.epa.gov/airsdata/adnet.sic?geotype=co&geocode=42133&geoinfo=co%7E42133%7EYork+Co%2C+Pennsylvania&pol=NOX+VOC+PM25&year=1999&fld=cnt&fld=count_pct&fld=emis&fld=emission_pct&rpp=25
177709	EPA 2006	EPA (U.S. Environmental Protection Agency) 2002. *National Emissions Inventory: All-Sector Summary Data for Criteria Air Pollutants*. MO0607NEI2002D.000. Las Vegas, Nevada: U.S. Environmental Protection Agency. ACC: MOL. 20060807.0042.

181914	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. "8-Hour Ozone Nonattainment State/Area/County Report." *Green Book.* Washington, D.C.: U.S. Environmental Protection Agency. Accessed September 11, 2007. ACC: MOL.20071003.0194. URL: http://www.epa.gov/air/oaqps/greenbk/gncs.html
185248	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005.* Washington, D.C.: U.S. Environmental Protection Agency, Office of Atmospheric Programs. ACC: MOL.20080331.0109.
181232	Fitzpatrick-Maul 2007	Fitzpatrick-Maul, D. 2007. "SEIS Water Balance Revision 4." Electronic mail from D. Fitzpatrick-Maul to K. Davis, SEIS Team, dated April 16, 2007, with attachment. ACC: MOL.20070816.0027; MOL.20070808.0055.
185100	Gecol 2007	Gecol, H. 2007. *Status of Energy in Nevada, Report to Governor Gibbons and Legislature.* Carson City, Nevada: State of Nevada, Nevada State Office of Energy. ACC: MOL.20080304.0035.
177297	Hanson et al. 2006	Hanson, C.E.; Towers, D.A.; and Meister, L.D. 2006. *Transit Noise and Vibration Impact Assessment*. FTA-VA-90-1003-06. Washington, D.C.: U.S. Department of Transportation, Federal Transit Administration. ACC: MOL.20060814.0190.
103277	IAEA 1992	IAEA (International Atomic Energy Agency) 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards.* Technical Reports Series No. 332. Vienna, Austria: International Atomic Energy Agency. TIC: 243768.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publication 72. New York, New York: Elsevier. TIC: 255638.
185132	Parry et al. 2007	Parry, M.; Canziani, O.; Palutikof, J.; van der Linden, P.; and Hanson, C., eds. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. New York, New York: Cambridge University Press. TIC: 260104.

174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
182804	Maher 2006	Maher, M. 2006. "Nye County, Nevada Request to Initiate Transaction for Acquisition of 292.46 Acres of Land for Commercial Purposes Pursuant to Public Law #106-113." Letter from M. Maher (Nye County) to J. Palma (BLM), March 21, 2006, with enclosure. ACC: MOL.20070913.0510.
182197	Morton 2007	Morton, L. 2007. "Status of June 15 Data Call re: Utilities/electrical power." E-mail from L. Morton to J. Rivers, S. Walker, E. Harr, and L. Shaser, June 18, 2007. ACC: MOL.20070806.0019.
182210	Morton 2007	Morton, L. 2007. "Addt'l Input for 4/30/07 SEIS Air Quality." E-mail from L. Morton to J. Summerson, J. Rivers, and S. Walker, May 1, 2007, with attachment. ACC: MOL.20070910.0118; MOL.20070806.0016.
182211	Morton 2007	Morton, L. 2007. "SEIS Input for April 30, 2007." E-mail from L. Morton to J. Summerson, April 30, 2007, with attachment. ACC: MOL.20070910.0117; MOL.20070806.0018.
182319	Morton 2007	Morton, L. 2007. "Fw: BSC Technical Input Due 6/15/2007." E-mail from L. Morton to J. Summerson and J. Rivers, June 18, 2007, with attachment. ACC: MOL.20070809.0004; MOL.20070809.0005.
182713	Morton 2007	Morton, L. 2007. "SEIS Question RE: Concrete Usage." E-mail from L. Morton to (leroys@ageiss.com), July 16, 2007, with attachment. ACC: MOL.20070913.0504.
184918	Morton 2007	Morton, L. 2007. "Manufacturing Repository Components, Items 1-2." E-mail from L. Morton (BSC) to J. Summerson (DOE), dated April 30, 2007, with attachments. Las Vegas, Nevada. ACC: MOL.20070724.0360; MOL.20070816.0029.
185329	Morton 2007	Morton, L. 2007. "SEIS Deliverable Due 6/15/07 - Aesthetics." Email from L. Morton to J. Summerson and J. Rivers, June 14, 2007, with attachments. ACC: MOL.20080509.0016.
153066	Murphy 2000	Murphy, S.L. 2000. "Deaths: Final Data for 1998." *National Vital Statistics Reports*. Vol. 48, No. 11. Hyattsville, Maryland: National Center for Health Statistics. TIC: 249111.

100953	Napier et al. 1988	Napier, B.A.; Peloquin, R.A.; Strenge, D.L.; and Ramsdell, J.V. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System.* Three volumes. PNL-6584. Richland, Washington: Pacific Northwest Laboratory. ACC: NNA.19920626.0034; NNA.19920626.0036; NNA.19920626.0041
179907	Napier 2007	Napier, B.A. 2007. *GENII Version 2 Users' Guide.* PNNL-14583, Rev. 2. Richland, Washington: Pacific Northwest National Laboratory. ACC: MOL.20070314.0029.
174324	NatureServe 2004	NatureServe 2004. *Landcover Descriptions for The Southwest Regional Gap Analysis Project.* Arlington, Virginia: NatureServe. TIC: 257833.
184969	NDEP 2007	NDEP (Nevada Division of Environmental Protection) 2007. *State of Nevada Solid Waste Management Plan 2007.* Carson City, Nevada: State of Nevada, Nevada Division of Environmental Protection. ACC: MOL.20080514.0134.
182320	NRC 2007	NRC (U.S. Nuclear Regulatory Commission) 2007. "Low-Level Waste Disposal Statistics." Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed August 7, 2007. ACC: MOL.20070809.0006. URL: http://www.nrc.gov/waste/llw-disposal/statistics.html
173400	NRMCA 2004	NRMCA (National Ready Mix Concrete Association) 2004. *Industry Fact Sheet, U.S. Ready Mixed Concrete Production*. Silver Spring, Maryland: National Ready Mix Concrete Association. TIC: 257545.
182710	NWRPO 2007	NWRPO (Nuclear Waste Repository Project Office) 2007. *Nye County Public Safety Report.* NWRPO-2007-06. Las Vegas, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20070913.0315.
182189	Rhode 2007	Rhode, D. 2007. *Information About Cultural Resources that DRI Has Recorded Within the Potential Yucca Mountain Withdrawal Area.* Letter from D. Rhode (DRI) to H. Roberts (HRA), July 17, 2007, with enclosure. ACC: MOL.20070806.0009.
179923	Shroff 2006	Shroff, B. 2006. *CAP88-PC Version 3.0 User Guide*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. ACC: MOL.20070613.0036.

177399	SNL 2007	SNL (Sandia National Laboratories) 2007. *Biosphere Model Report.* MDL-MGR-MD-000001 Rev 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070830.0007.
182586	Spence 2007	Spence, R.E. 2007. "2006 Annual Report of Compliance Activities Conducted for the Biological Opinions for the Yucca Mountain Project (File Numbers 1-5-96-F-307R and 1-5-00-F-518)." Letter from R. Spence (DOE) to A. Lavoie (Fish and Wildlife Service) dated February 6, 2007. ACC: CCU.20070206.0005.
145962	Tucci and Faunt 1999	Tucci, P. and Faunt, C.C. 1999. *Simulated Effects of Potential Withdrawals from Wells Near Yucca Mountain, Nevada*. Water-Resources Investigations Report 99-4166. Denver, Colorado: U.S. Geological Survey. ACC: MOL.19991112.0127.
105034	Turnipseed 1992	Turnipseed, R.M. 1992. *Ruling #3870: In the Matter of Application 52338 Filed to Appropriate the Waters from an Underground Source Within the Forty Mile Canyon-Jackass Flats Groundwater Basin, Nye County, Nevada*. Carson City, Nevada: State of Nevada, Office of the State Engineer. ACC: HQX.19930511.0006.
103472	USAF 1999	USAF (U.S. Air Force) 1999. *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement.* Washington, D.C.: U.S. Department of the Air Force. ACC: MOL.20010726.0068.
185186	USGS 2008	USGS (U.S. Geological Survey) 2008. *Mineral Commodity Summaries 2008*. Washington D.C.: U.S. Government Printing Office. ACC: MOL.20080306.0052.
179926	USGS National Gap Analysis Program n.d.	SWReGAP (Southwest Regional Gap Analysis Project) n.d. "Landcover Data for Nevada." *SWReGAP Landcover Data - Nevada.* Denver, Colorado: U.S. Geological Survey. Accessed March 26, 2007. ACC: MOL.20070613.0011. URL: http://earth.gis.usu.edu/swgap/landcover_nv.php
101941	USN 1996	USN (U.S. Department of the Navy) 1996. *Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel.* DOE/EIS-0251. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010724.0299.
154386	YMP 2001	YMP (Yucca Mountain Site Characterization Project) 2001. *Reclamation Implementation Plan.* YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

5

Estimated Environmental Impacts of Postclosure Repository Performance

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5. ENVIRONMENTAL IMPACTS OF POSTCLOSURE REPOSITORY PERFORMANCE

This chapter presents the approach and analyses of potential human health *impacts* from releases of *radioactive* and nonradioactive materials to the environment after *closure* of the proposed *repository* at Yucca Mountain. In addition, it discusses estimates of potential biological and environmental impacts from radiological and chemical groundwater *contamination*, and potential biological impacts from the *postclosure* production of heat due to *decay* of the radioactive materials that the U.S. Department of Energy (DOE or the Department) would dispose of in the repository. This chapter of the *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) summarizes, incorporates by reference, and updates the information in Chapter 5 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 5-1 to 5-50) (Yucca Mountain FEIS).

Waste packages would be disposed of in dedicated emplacement *drifts*, supported on *emplacement* pallets, and aligned end-to-end on the drift floor (Chapter 2, Section 2.1.2.2.2, Figure 2-8).

Closure of a repository would include the following activities (Chapter 2, Section 2.1.6):

- Emplacement of the *drip shields* over the waste packages;
- Backfilling of *subsurface* ramps and subsurface-to-surface openings;
- Removal of surface facilities; and
- Creation of *institutional controls*, which would include land records and surface monuments, to identify the location of the repository and discourage *human intrusion*.

WASTE PACKAGE

A waste package would consist of the corrosion-resistant outer container, the waste form and any internal containers (such as the transportation, aging, and disposal canister), spacing structure or baskets, and shielding integral to the container. The waste package would be ready for emplacement in the repository when the outer lid welds were complete and accepted.

After *repository-closure*, few workers would be employed. There would be minimal use of water, utilities, energy, or services and minimal generation of waste. There would be no change in water quality other than those from the transport of *radionuclides* and chemical contaminants. Impacts to land use, noise, socioeconomics, cultural resources, aesthetics, utilities, or services after closure as a result of the *disposal* of radioactive materials in the repository or as a result of any currently envisioned postclosure monitoring program that could be approved by the U.S. Nuclear Regulatory Commission (NRC) would be small. At such time as the postclosure monitoring program is further detailed, the estimates of impacts would be updated. Chapter 4 discusses impacts from *construction*, *operations*, *monitoring*, and closure.

DOE assessed the processes by which radionuclides could be released from a repository at Yucca Mountain and transported to the environment. The analysis used computer programs to assess the release and movement of radionuclides and hazardous materials in the environment. Some of the programs analyzed the behavior of engineered components such as the waste package, while others analyzed natural

processes such as the movement of *groundwater*. DOE based the programs on the best available *geologic*, geochemical, and hydrologic data and current knowledge of the behavior of the materials DOE proposes for the system. The analysis used data from Yucca Mountain *site characterization* activities, material tests, and expert judgment as input parameters to estimate human health impacts. Many parameters that DOE used in the analysis cannot be exactly measured or known; therefore, DOE used a range of values. The analysis accounted for this type of uncertainty; the results are ranges of potential health impacts.

The analysis considered human health impacts during the first 10,000 years after repository closure and the radiation *dose* during the period from 10,000 years after closure to 1 million years after closure (the post-10,000-year period). Estimates of potential human health impacts included the effects on repository performance of such expected processes as *corrosion* of waste packages, degradation and dissolution of waste forms, flow through the saturated and *unsaturated zones*, and changing climate, in addition to early waste package and drip shield failure (a failure that could occur soon after closure due to defects in a waste package or drip shield) mechanisms and igneous and *seismic* events. Additional analyses examined the effects of such disturbances as inadvertent drilling and potential for criticality.

WHY 10,000 YEARS AND 1 MILLION YEARS?

The Total System Performance Assessment-License Application (TSPA-LA) model provides estimates of potential radiological impacts (doses) for two periods: the estimated dose at times for the first 10,000 years after closure and a dose at times after the first 10,000 years up to 1 million years after closure. The TSPA-LA model assessed annual individual doses in each of these periods.

DOE could have performed the analyses for this Repository SEIS for any number of periods. So why these two? The main reason is that the U.S. Environmental Protection Agency and the U.S. Nuclear Regulatory Commission have proposed dose limits for a maximum annual individual dose in each period. DOE has compared the results of the postclosure performance assessments with the proposed limits to provide a context in which to consider the potential environmental impacts of the Proposed Action.

The analysis of postclosure repository performance and environmental impacts considered all potential *pathways*, including airborne releases, through which radionuclides from *spent nuclear fuel* or *high-level radioactive waste*, and hazardous or carcinogenic chemicals could reach human populations and result in impacts to public health. U.S. Environmental Protection Agency (EPA) and NRC proposed regulations require evaluation of all potential paths. The principal *exposure pathway* would be groundwater. Rainwater could migrate down through the unsaturated zone into the repository, could dissolve or mobilize some of the material in the repository, and could carry *contaminants* from the dissolved material down through the unsaturated and saturated groundwater zones to locations where human *exposure* could occur. An atmospheric pathway could result from a volcanic conduit that intersected the repository, destroyed waste packages, and erupted at the surface. Depending on atmospheric conditions, the volcanic eruption at the ground surface could disperse volcanic tephra (solid material of all sizes explosively ejected from a volcano into the atmosphere) and entrained radionuclides (radionuclides that were bound to or captured by the volcanic tephra). The calculation of annual *radiation* dose included human health impacts from this latter pathway (Section 5.5).

Another atmospheric pathway could result from the escape of gaseous radionuclides, such as carbon-14, from the repository to the surface and their downwind transport. DOE analyzed these possible airborne

releases in the Yucca Mountain FEIS. Section 5.6 provides a summary of this analysis. Because DOE is not aware of significant new information or circumstances that bear on this analysis, DOE would not expect any change in the estimated impacts from the escape of gaseous radionuclides; therefore, DOE did not conduct a new analysis for this Repository SEIS.

10 CFR PART 63 AND 40 CFR PART 197

In 2001, both the U.S. Environmental Protection Agency (EPA) and the U.S. Nuclear Regulatory Commission (NRC) adopted public health and safety standards for any radioactive material to be disposed of in a Yucca Mountain Repository. In 2004, in response to legal challenges, the U.S. Court of Appeals for the District of Columbia Circuit struck down the portions of those standards that addressed the period for which compliance must be demonstrated and remanded the provisions to the federal agencies for revision.

In 2005, EPA proposed new standards to address the Court's decision. The proposed standards incorporate multiple compliance criteria applicable at different times for protection of individuals, the environment, and in circumstances involving human intrusion into the repository. The proposals also identify certain specific processes that must be considered in projecting repository performance. When finalized, these standards will be codified in 40 CFR Part 197, Subpart B.

Because Section 801 of the *Energy Policy Act of 1992* requires NRC to modify its technical requirements for licensing of a Yucca Mountain Repository to be consistent with the standards promulgated by EPA, NRC also proposed new standards in 2005 to implement the proposed EPA standards for doses that could occur after 10,000 years but within the period of geologic stability. The proposed NRC standards also specify a value to be used to represent climate change after 10,000 years, as required by EPA. When finalized, these standards will be codified in 10 CFR Part 63.

In developing the TSPA-LA model for the analysis in this Repository SEIS, DOE took into consideration the regulatory requirements in the proposed EPA and NRC standards to provide a perspective on potential radiological impacts during the postclosure period. For this SEIS, DOE based the analyses on the TSPA-LA model that serves as the basis for the compliance assessment included in DOE's application to the NRC for construction authorization and a license to receive and possess radioactive materials at the repository.

The analysis for this Repository SEIS estimated potential human health impacts from the groundwater and atmospheric transport pathways at the location of the *reasonably maximally exposed individual* (RMEI; 40 CFR 197.21), which is approximately 18 kilometers (11 miles) downgradient from the proposed repository. A hypothetical *reasonably maximally exposed individual* is defined with parameters that significantly affect exposure estimates set at high values so that the hypothetical individual is "reasonably maximally exposed" for the purpose of assessing potential doses that could result from releases of *radioactivity* from a repository. These impacts include both radiological doses and probabilities of resultant *latent cancer fatalities*. A latent cancer fatality is a death that results from *cancer* from exposure to *ionizing radiation* or other *carcinogens*.

DOE has made modifications to the repository design and operational plans since the completion of the Yucca Mountain FEIS. DOE has modified the *Total System Performance Assessment* (TSPA) model to account for these changes, as well as for additional data it has collected since the completion of the FEIS. Section 5.1 summarizes modifications that this Repository SEIS addresses in the TSPA model. For this Final Repository SEIS, DOE based the analyses on the TSPA-LA model that serves as the basis for the

WHO AND WHERE IS THE "RMEI"?

A hypothetical "reasonably maximally exposed individual (RMEI)" is defined for the purpose of assessing potential doses that could result from releases of radioactivity from a repository.

Under applicable regulations, the RMEI is located 18 kilometers (11 miles) from the repository.

compliance assessment it has included in its application to the NRC for construction authorization. The references in Appendix F, Section F.2 of this Repository SEIS provide further details.

Section 5.1a describes the differences between the TSPA-SEIS model for the Draft Repository SEIS and the TSPA-LA model for this Final Repository SEIS. Section 5.2 describes the inventory of materials that the postclosure performance assessment analyzed for potential releases from the repository; Section 5.3 provides an overview of the repository system; Section 5.4 discusses the locations for impact estimates; Section 5.5 provides the analysis of the postclosure performance for radiological impacts; Section 5.6 provides the analysis of atmospheric radiological materials in the repository; Section 5.7 describes impacts from chemically toxic materials; Section 5.8 describes the human intrusion calculations; Section 5.9 describes the evaluation of the potential for nuclear criticality in the repository and surrounding rock; Section 5.10 presents the impacts to biological resources and soils; and Section 5.11 summarizes the postclosure analyses.

5.1 Differences Between FEIS and SEIS Assessments of Postclosure Repository Performance

There are several differences between the assessments of postclosure repository performance for this Repository SEIS and those in the Yucca Mountain FEIS that accompanied the Secretary of Energy's recommendation to approve the *Yucca Mountain site* in 2002. Figure 5-1 shows the relationships between TSPA models and the FEIS and this SEIS. The major differences are summarized in this section.

5.1.1 RADIOLOGICAL IMPACTS

The results of assessments of postclosure repository performance for this Repository SEIS and those of the Yucca Mountain FEIS are different. The differences are largely due to the standards EPA has proposed, which specify how to calculate post-10,000-year repository performance. Specific requirements about how to make such a calculation did not previously exist. Furthermore, the calculation incorporates additional data and enhancements in the description of engineered and natural components. The Yucca Mountain FEIS results included contributions from the Nominal Scenario Class, limited contributions from the Seismic Scenario Class, and contributions from Waste Package Early Failure. Igneous Scenario Class impacts were not included in the calculation of total impacts. The projections of radiological impacts in the TSPA-LA include contributions from a Seismic Scenario Class, Igneous Scenario Class, Drip Shield Early Failure, Waste Package Early Failure, and the Nominal Scenario Class. As a result of these changes, several *qualitative* observations can be made about the FEIS results.

- The FEIS described future climates in terms of discrete alternating climate states with a precise timing of climate change. The spikes in the dose curves in the FEIS (for example, DIRS 155970-DOE 2002, Figure 5-4, p. 5-26) result from imposed climate changes at fixed times and assumed percolation fluxes. These spikes are responsible for the maximum levels of the individual dose. The

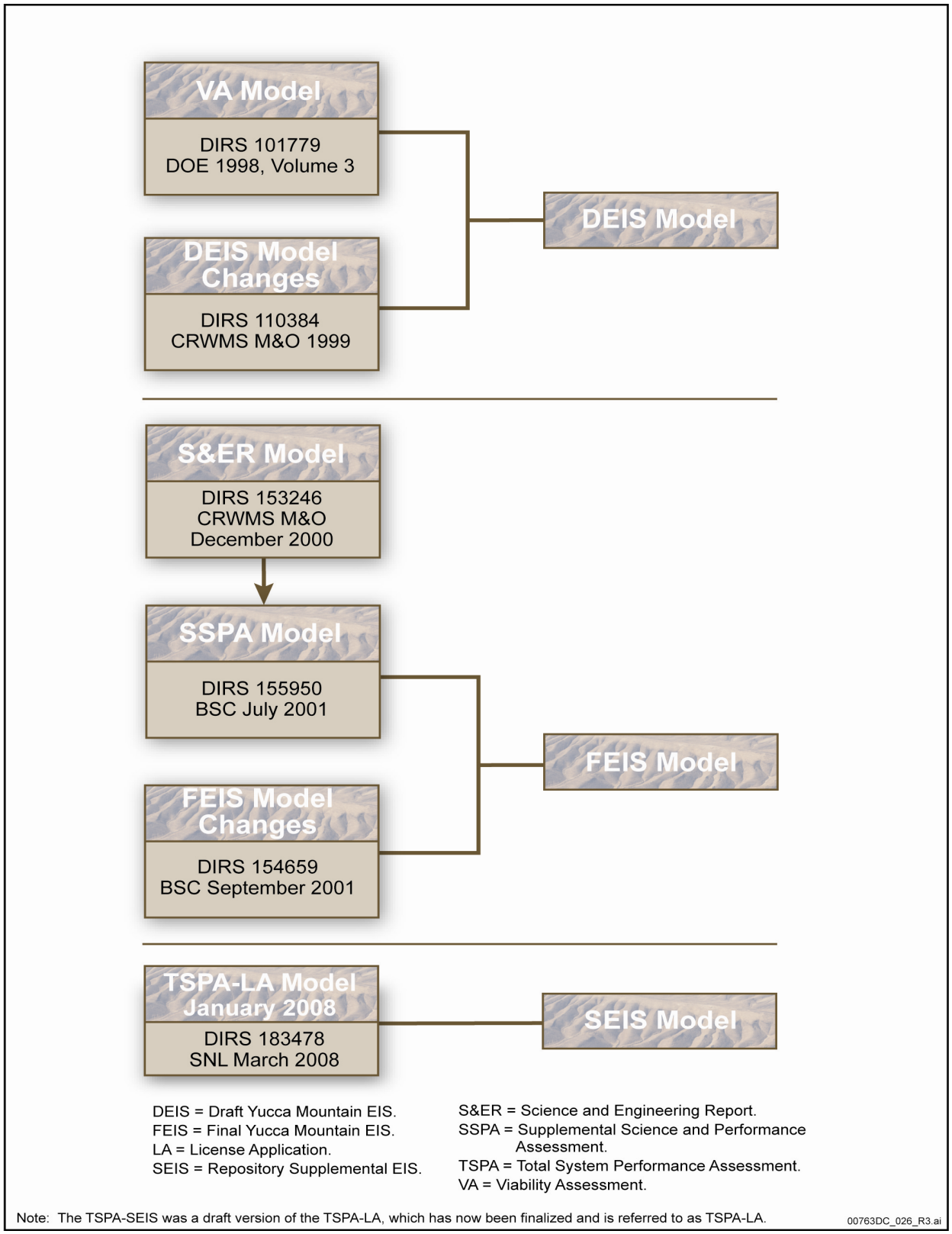

Figure 5-1. Relationship between the published TSPA models and models used for the Draft Yucca Mountain EIS, Yucca Mountain FEIS, and this Repository SEIS.

proposed EPA standards require DOE to assess the effects of long-term climate changes. This requirement allows the use of probabilistic *distribution* for a constant-in-time but uncertain long-term average climate for Yucca Mountain as specified by the NRC. Inclusion of these changes in the FEIS would have resulted in a significant lowering of the projected dose values.

- The proposed EPA standards require DOE to use revised International Commission on Radiological Protection weighting factors for calculation of individual doses. In general, using the revised weighting factors results in *biosphere* dose conversion factors for *actinides* that are lower, whereas biosphere dose conversion factors for *fission* products are higher. Actinides were the dominant contributors to dose in the FEIS. Notably, the biosphere dose conversion factors for neptunium, which was the dominant *nuclide* contributing to doses in the FEIS, decreased by approximately 80 percent from the FEIS to the SEIS with the Commission's revisions. Sensitivity studies that were referenced in the FEIS (DIRS 155970-DOE 2002, p. 5-31) indicate that dose estimates would be significantly lower if the revised methods were applied.

- Waste package and drip shield lifetimes are longer in the SEIS. The increase in waste package lifetimes is due in part to the increase in thickness of the *Alloy 22* outer *barrier* to accommodate the *transportation, aging, and disposal (TAD) canister*. Inclusion of temperature dependence of Alloy 22 corrosion rates in the SEIS resulted in substantially longer waste package lifetimes in the Nominal Scenario Class. Inclusion of new titanium corrosion data in the SEIS resulted in lower corrosion rates, reduced uncertainty, and longer drip shield lifetimes. Inclusion of these enhanced models in the FEIS would have resulted in a significant lowering of the projected dose values.

- For the Yucca Mountain FEIS, there was no explicit requirement for comparison to a compliance standard; the applicable NRC regulation at that time required DOE to calculate the annual dose to the RMEI if one would occur after 10,000 years after disposal but within the period of geologic stability. No regulatory standard applied to the results of this analysis nor did the regulations specify requirements for the estimate of repository performance. DOE was to include the results and their bases in the FEIS as an indicator of long-term disposal system performance.

- The proposed regulatory standards require that DOE's projection of postclosure radiological impacts to the RMEI include those scenario classes (future states of the repository) that resulted from the screening of features, *events*, and processes (Appendix F, Section F.2.1). Therefore, the TSPA-LA projections of radiological impacts to the RMEI include contributions from a Seismic Scenario Class, Igneous Scenario Class, Early Failure Scenario Class (Drip Shield Early Failure and Waste Package Early Failure), and the Nominal Scenario Class.

The proposed EPA and NRC standards identify specific processes, such as degradation of the Engineered Barrier System due to general corrosion and seismic and igneous events, to be included in the postclosure performance projection and guide the development of the *quantitative* approach that DOE should use in the post-10,000-year projection. As a result, DOE has made several changes to the TSPA model since completion of the Yucca Mountain FEIS. DOE has made other refinements to the TSPA model to improve the treatment of uncertainties, incorporate new data and understanding of processes, and reduce conservatism in the projection of repository performance (Table 5-1 contains further detail). The following factors, in addition to those above, are responsible for the major differences in projected repository performance between the Yucca Mountain FEIS and the Repository SEIS.

Table 5-1. Important changes to the TSPA since completion of the Yucca Mountain FEIS.

Component	Change	Estimated effect
Unsaturated zone flow	• Stronger basis for models – Evaluation of fast flow and transport of chlorine-36 – Justification of parameter sets used to model future climates – Evaluation of flow and transport sensitivity to hydrologic parameters	Neutral
	• Revised infiltration model and broader range of infiltration maps	Neutral
	• Revised calibration method to develop probability weights for infiltration maps	Neutral
	• NRC-specified percolation flux for post-10,000-year period per proposed rule	Moderate decrease in dose after 10,000-years
	• Basis on enhanced treatment of uncertainties in input parameters	Neutral
Engineered Barrier System environment—thermal hydrology and in-drift chemistry	• Thermal hydrology – Improved basis for model validation – In-drift condensation processes included	Neutral
	• Near-field/in-drift chemistry – Reevaluated data to constrain in situ water chemistry	Small decrease in dose
	• Improved model to represent composition of seepage entering emplacement drifts	
Abstraction of waste package and drip shield degradation	• Waste package outer barrier corrosion	
	– Additional data available	Supports model basis
	– Thermal dependency of general corrosion included	Large decrease in dose
	– Localized corrosion due to seepage included	Neutral
	• Waste package outer barrier stress corrosion cracking – Improved stress/stress intensity factor profiles	Neutral
	• Drip shield early failure included	Neutral
	• Additional drip shield general corrosion data available	Decrease in dose
Source term	• No credit taken for the ability of cladding to prevent or reduce degradation of commercial spent nuclear fuel	Increase in dose
	• Broader range of in-package chemistry conditions and resulting impacts on waste form degradation considered	Small decrease in dose
Engineered Barrier System radionuclide transport	• Improved representation of radionuclide transport through the waste package	Small decrease in dose
	• Improved representation of radionuclide mass release to fracture and matrix portions of the host rock under the Engineered Barrier System	Small decrease in dose
	• Representation of kinetic sorption of plutonium and americium on iron oxyhydroxide colloids and stationary corrosion products in the waste package	Small decrease in dose
	• Sorption on TAD canister corrosion products included	Small decrease in dose

Table 5-1. Important changes to the TSPA since completion of the Yucca Mountain FEIS (continued).

Component	Change	Estimated effect
Unsaturated zone radionuclide transport	• Transport model revised to reflect transport in a dual-continuum fracture/matrix system more accurately	Small decrease in dose
	• Updated analyses of sorption and diffusion parameters	Neutral
Saturated zone flow and transport	• Updated hydrogeologic framework model that incorporates new Nye County drilling data and updated USGS regional model	Neutral
	• Updated and recalibrated site-scale saturated zone flow model – Water-level measurements in new Nye County wells – New hydrochemical data in flow model validation analysis	Neutral
	• Updated saturated zone flow and transport abstraction model – Reevaluation of parameter uncertainty distributions in consideration of new information	Small decrease in dose
Biosphere	• Incorporation of additional pathways	Increase in dose
	• Inclusion of dosimetric inputs consistent with ICRP Publication 72[a] and based on the concepts recommended in ICRP Publication 60[b]	Moderate decrease in dose
	• Uncertainty in biosphere dose conversion factors included	Neutral
	• GoldSim-based model (GENII-S used in Yucca Mountain FEIS)	Neutral
Seismic scenario class	• Inclusion of the seismic scenario class	Increase in dose
	• Detailed damage analyses developed for degraded states of the Engineered Barrier System components including the TAD-bearing waste packages	Increase in dose
Igneous scenario class	• Assume all drip shields and waste packages destroyed by magma intrusion	Increase in dose
	• New parameter values based on analogue data – Dike length, width, and orientation and number of dikes – Conduit size and number and locations of conduits • Fraction of eruptive material in tephra, cone, and lavas	Neutral
Treatment of uncertainty and variability	• Improved guidelines and management controls for characterization of uncertainty consistently across component abstractions	Consistent treatment of uncertainty
	• Epistemic and aleatory uncertainty separated in the TSPA analyses	Consistent treatment of uncertainty
Features, events, and processes analysis	• Screening justifications updated and revised based on new technical information available since DOE published the TSPA for the Site Recommendation[c] (e.g., TAD canisters; seismic impacts; localized corrosion)	Improve defensibility of included scenario classes

Table 5-1. Important changes to the TSPA since completion of the Yucca Mountain FEIS (continued).

Component	Change	Estimated effect
TSPA model development and implementation	• Technical basis for TSPA planned for the license application builds on the technical foundation documented for the TSPA for the Site Recommendation and updates[d] for the FEIS	Improve defensibility
	• Additional confidence building (validation)	Improve defensibility
	• Additional rigor added to configuration and control processes	Improve defensibility

a. DIRS 172935-ICRP 2001, all.
b. DIRS 101836-ICRP 1991, all.
c. DIRS 153246-CRWMS M&O 2000, all.
d. DIRS 155950-BSC 2001, all; the Yucca Mountain FEIS referred to this model as the "Supplemental Science and Performance Analyses" model.

DOE = U.S. Department of Energy.
ICRP = International Commission on Radiological Protection.
NRC = U.S. Nuclear Regulatory Commission.
TAD = Transportation, aging, and disposal (canister).
TSPA = Total System Performance Assessment.
USGS = U.S. Geological Survey.

5.1.1.1 Drip Shield and Waste Package Corrosion

For this Repository SEIS, DOE included new Titanium Grade 7 corrosion data that were based on 2.5-year tests, which resulted in reduced uncertainty in corrosion rates, lower corrosion rates, and longer drip shield lifetimes. In the Yucca Mountain FEIS, drips shields did not start failing until approximately 20,000 years after emplacement and most of the drip shields failed by about 40,000 years. In the SEIS, drip shields did not start failing until approximately 260,000 years and most of the drip shields failed by 310,000 years.

DOE included temperature dependence of Alloy 22 corrosion rates for this Repository SEIS, which led to substantially longer waste package lifetimes in the Nominal Scenario Class. The following discussion summarizes waste package performance in the Nominal Scenario Class for the Yucca Mountain FEIS and the Repository SEIS. In the Yucca Mountain FEIS, the mean waste package failure behavior resulted in waste package failure from stress corrosion cracking beginning around 15,000 years, and about 50 percent of the waste packages failed by stress corrosion cracking and general corrosion by 100,000 years. For this Repository SEIS, the waste package failure initiated by stress corrosion cracking is estimated to begin around 100,000 years and about 50 percent of the waste packages are estimated to fail by stress corrosion cracking and general corrosion by 1 million years. General corrosion failures are estimated to start at around 400,000 years, and about 9 percent of the waste packages could experience a general corrosion breach within 1 million years. The increase in waste package lifetimes was also due in part to the increase in thickness of the Alloy 22 outer barrier for the *commercial spent nuclear fuel* waste packages from 20 millimeters (0.79 inch) in the FEIS to 25 millimeters (0.98 inch) in this SEIS to accommodate the *TAD canister*.

5.1.1.2 Seismic Scenario Class

The TSPA-LA implements damage models to simulate the response of drip shields, codisposal waste packages, and TAD canisters with commercial spent nuclear fuel waste packages to vibratory ground motion, drift collapse, and *fault* displacement.

5.1.1.3 Igneous Scenario Class

The TSPA-LA assumes all drip shields and waste packages in the repository would be destroyed if a basaltic dike intersected and magma intruded into one or more emplacement drifts. That is, all drip

shields and waste packages in the repository would lose their ability to limit or prevent the flow of water and the movement of radionuclides.

5.1.1.4 Impacts at Different Locations

In the Yucca Mountain FEIS the results for the RMEI, who would be located at 18 kilometers (11 miles), were scaled to two other distances: 30 kilometers (19 miles) and 60 kilometers (37 miles). The scaling used factors DOE developed from separate modeling for transport in the *alluvium* of Amargosa Valley. This separate modeling used a simple, dispersion-only model that did not account for any sorption or other attenuating phenomena other than hydrodynamic dispersion (spreading) of the radionuclide plume. New modeling since the FEIS indicates a considerably smaller plume width. Upon review of the basis for the dose calculations, DOE confirmed that if the plume were diluted into the 3.7 million cubic meters (3,000 acre-feet) of water use at the RMEI location, this large water use would likewise consume the entire plume at all other locations, beyond the specified RMEI location of 18 kilometers (11 miles). This is because the spreading of the plume would be insufficient for any of the radionuclides to escape capture in the water-use volume; however, as the plume moved downgradient from the RMEI location, it would be less likely that groundwater wells would capture all of the released radionuclides. Furthermore, the time delay from further transport in the alluvium would result in insignificant amounts of decay. Therefore, the estimated doses at downgradient locations would be no greater than those of the RMEI Thus, doses at distances other than the RMEI location were not calculated for this Repository SEIS. DOE did not assess population dose in this SEIS. It would be inappropriate to apply the lifestyle of the RMEI to the entire population surrounding the repository because the characteristics of the RMEI (a hypothetical individual) are defined in a manner that results in maximum annual and lifetime doses, which would not be applicable to all other members of the population. Further, in recommendations to the EPA in response to congressional direction, the National Academy of Sciences recommended only the use of a standard that sets a limit on the risk to individuals, concluding that an individual-risk standard would protect public health, and that there is no technical basis for a population risk standard by which to make such a judgment.

5.1.2 IMPACTS FROM TOXIC CHEMICALS

Since the FEIS, there has been a change in how chromium chemistry is treated both in the Engineered Barrier System (emplacement drift) environment and in the in-package environment. In the FEIS it was conservatively assumed that, when placed in solution, chromium would fully oxidize to the +6 valence state, chromium(VI). Additional research and analysis has shown that this is an unrealistic assumption for the chemical environments of the Engineered Barrier System and the internal components of the waste package. There is very strong evidence (Appendix F, Section F.5.1) that most or all of the chromium, dissolved from construction materials such as stainless steel and Alloy 22, would exist in the +3 valence state, chromium(III). An important distinction between these two valence states is that chromium(VI) is highly soluble in water and is considered toxic to humans, while chromium(III) is highly insoluble (on the order of less than 1×10^{-3} milligram per liter) and is considered nontoxic to humans. Based on these new findings, chromium was eliminated from further consideration in this Repository SEIS when evaluating impacts from chemically toxic substances (Appendix F, Section F.5.1).

5.1a Differences Between the Draft Repository SEIS and the Final Repository SEIS Assessments of Postclosure Repository Performance

DOE refined the TSPA model slightly between the time of issuance of the Draft Repository SEIS and this Repository SEIS. Two of the refinements resulted in very small changes to the calculated doses to the RMEI. One of the refinements addressed the way radium is treated in a *saturated zone* model. The TSPA-LA was refined to eliminate a small number of realizations that had produced unrealistic results by setting bounds on the previously unbounded range on longitudinal dispersivity (the way the radionuclides spread out as they migrate). The second refinement addressed the way that the time of first occurrence of stress corrosion cracking in the seismic ground motion case was modeled. The analyses for the Draft Repository SEIS assumed all waste packages of a given type (that is, commercial spent nuclear fuel waste package or codisposal waste package) would have degraded internal structural materials once the first waste package of that type was breached by stress corrosion cracking from nominal processes. Waste packages with degraded internal structural materials have reduced structural strength and less resilience to damage from seismic ground motions. This reduction in strength was included in the waste package damage models and, as a result, there was a tendency to overestimate waste package damage. Waste packages are now modeled as having degraded internal structural materials only when they would have actually been breached. Unbreached waste packages would maintain a higher level of structural strength for a longer period. Breaches could occur due to either stress corrosion cracking from nominal processes or seismic-induced damage. Of the two refinements, the second resulted in a greater change in terms of total dose. There were other minor differences in the TSPA-LA model, but their effects did not result in noticeable changes in total dose.

As a result of the refinements, there was no change in the reported value of the mean annual individual dose for the first 10,000 years or in the associated *probability* of a latent cancer fatality. There was a very small change in the reported value of the median annual individual dose for the post-10,000-year assessment; the projected dose was reduced from 0.98 to 0.96 *millirem*. The associated probability of a latent cancer fatality changed from 5.9×10^{-7} to 5.7×10^{-7}. Section 5.6 provides the results of the refined analyses.

5.2 Inventory for Performance Calculations

The postclosure analysis identified the inventory by the source category of waste material to be disposed of (commercial spent nuclear fuel, *DOE spent nuclear fuel*, surplus weapons-usable plutonium, and high-level radioactive waste). Note that the waste forms to be placed in the proposed repository would not exhibit the characteristic of toxicity, as measured by the Toxicity Characteristic Leaching Procedure (40 CFR 261.24). Therefore, the repository would be in compliance with the *Resource Conservation and Recovery Act* (40 CFR 261). For modeling purposes, the analysis averaged the inventory for each of the categories into an appropriate number of packages, each with identical contents. The modeled inventories consisted of two basic types of waste packages: a commercial spent nuclear fuel waste package and a codisposal waste package that would contain DOE spent nuclear fuel and high-level radioactive waste *canisters*.

5.2.1 INVENTORY OF RADIOACTIVE MATERIALS

There are more than 200 radionuclides in the analyzed waste inventory (DIRS 177424-SNL 2007, all). The analysis for this Repository SEIS used a subset of the 200 radionuclides. The number of radionuclides was determined by a screening analysis, the purpose of which was to eliminate from further consideration (screen out) radionuclides that are unlikely to contribute significantly to radiation dose to the RMEI. It would be impractical for DOE to model all of these radionuclides in a TSPA. The radionuclide screening analysis was recently revised to incorporate updated radionuclide inventory and screening factor data (DIRS 177424-SNL 2007, all). This screening analysis determined that 32 radionuclides have the potential to contribute an important fraction of the dose to the RMEI. This set of radionuclides forms the basis for the analysis this chapter discusses.

The analysis abstracted the total inventory into two types of representative waste packages:

1. A commercial spent nuclear fuel package.
2. A codisposal package with high-level radioactive waste in a glass *matrix* and DOE spent nuclear fuel.

For modeling purposes, DOE treated naval spent nuclear fuel as commercial spent nuclear fuel. This modeling approach was justified based upon the results from a suite of model comparisons as described in *Total System Performance Assessment Model/Analysis for the License Application* (DIRS 183478-SNL 2008, Section 7.5.6).

Appendix F, Table F-3 lists the abstracted inventory for the representative waste packages.

5.2.2 INVENTORY OF CHEMICALLY TOXIC MATERIALS

DOE would use several materials in the construction of the repository that are potentially chemically toxic. The Department performed an analysis of impacts from chemically toxic materials for the 10,000-year postclosure period. During that time, only a few waste packages would be likely to fail (Appendix F, Section F.2.4). Therefore, the analysis did not consider any chemically toxic materials inside waste packages. For the Yucca Mountain FEIS, DOE used a screening analysis to determine which, if any, of these materials would have the potential for transport to the *accessible environment* in quantities sufficient to be toxic to humans (DIRS 155970-DOE 2002, pp. I-52 to I-54). The results of that analysis showed that the remaining chemically toxic materials of concern would be chromium, molybdenum, nickel, and vanadium. DOE performed an additional screening analysis based on recent research (Appendix F, Section F.5.1). The additional analysis eliminated chromium from further concern, leaving molybdenum, nickel, and vanadium requiring further analysis. These elements would dissolve into solution as construction materials for the repository and waste packages corroded. As these elements dissolved, some portion of the material would precipitate as minerals and some would stay in solution. The quantities of these elements that remained in solution would be subject to continuous release from the repository.

Because there would be a large mass of construction materials, it would be unlikely that they would corrode completely during the first 10,000 years after closure. Therefore, DOE conservatively assumed that a constant release of material would occur for the entire period. The release rate would depend on the total surface area that was exposed to water, rather than on the total mass. The important sources of these materials would be the *exposed* surfaces available for corrosion. Appendix F, Section F.5.2.2 contains

estimates of the amounts available for transport from these surfaces. Table 5-2 lists the total surface areas of alloys of concern and their elemental compositions.

Table 5-2. Total surface area of construction materials and their compositions.

Alloy	Total surface area (square meters)	Total surface area (square feet)	Composition as weight percent: Molybdenum	Nickel	Vanadium
Stainless steel[a]	2,700,000	29,000,000	2.5	12	0
Alloy 22	640,000	6,900,000	14.5	57.2	0.35

Source: Appendix F, Section F.5.2.2

An important design modification since the completion of the Yucca Mountain FEIS is the addition of extensive stainless-steel ground support hardware (support sheets and rock bolts). This additional stainless steel would account for over 90 percent of the total exposed stainless steel in the proposed repository (Appendix F, Section F.5.2.2).

5.3 System Overview

DOE would emplace radioactive materials at least 200 meters (700 feet) beneath the surface in the proposed repository. The emplaced materials would be almost entirely in the form of solids with a very small fraction of the radioactive inventory in the form of trapped gases (Section 5.6). The primary means for the radioactive and chemically toxic materials to contact the biosphere would be along groundwater pathways. The materials could affect human health if the following sequence of events occurred:

- The waste packages and their contents were exposed to water either through nominal or disruptive processes.
- Radionuclides or chemically toxic materials in the package materials or wastes became dissolved or mobilized in the water.
- The radionuclides or chemically toxic materials were transported in water to an *aquifer*, and the water that carried these materials was withdrawn from the aquifer through a well or at a surface-water discharge point and used directly by humans for drinking or in the human food chain (such as through irrigation or watering livestock).

An atmospheric pathway could result from a volcanic conduit that intersected the repository, destroyed waste packages, and erupted at the surface. The eruption at the surface could disperse volcanic tephra and entrained radionuclides under atmospheric conditions. However, the probability of this event would be very low and its impacts would be extremely small (Appendix F, Section F.4.2.1.2). A second atmospheric pathway could result from gaseous radionuclides that leaked from the repository and were transported downwind. This would result in extremely small impacts (Section 5.6). Therefore, the access to and flow of contaminated water are the most important considerations in a determination of potential health effects.

5.3.1 COMPONENTS OF THE NATURAL SYSTEM

Figure 5-2 is a simplified schematic of a repository at Yucca Mountain. It shows the principal features of the natural system that could affect the postclosure performance of the repository. Yucca Mountain is in a

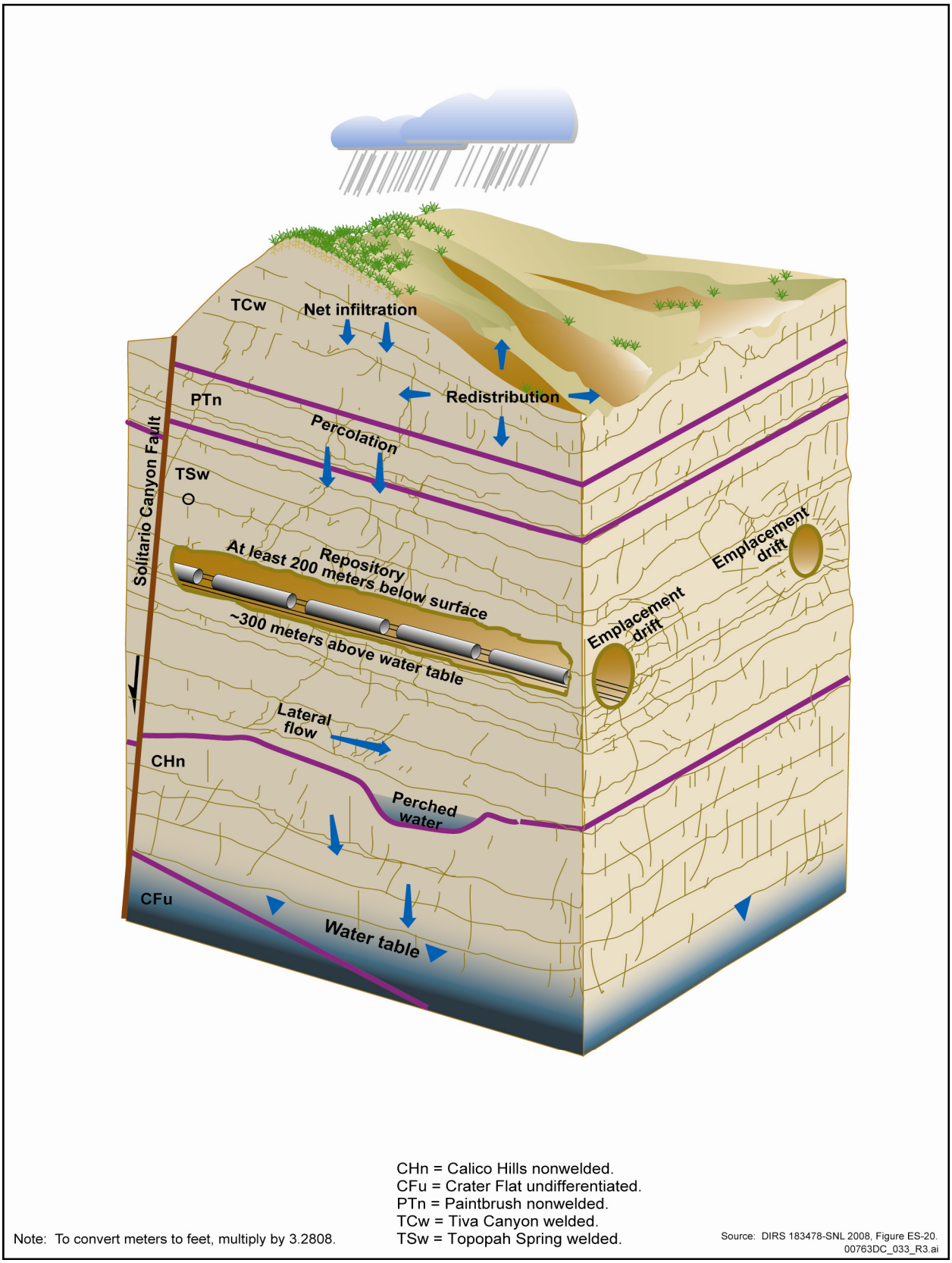

Figure 5-2. Components of the natural system.

semiarid desert environment where the current average annual precipitation over the unsaturated zone flow and transport model area is 170 millimeters (7 inches), which varies by specific location (DIRS 182145-SNL 2008, all). The *water table* is more than 600 meters (2,000 feet) below the surface of the mountain (DIRS 169855-BSC 2004, Figure 6-2). The proposed repository would be in unsaturated rock approximately midway between the desert environment and the water table (DIRS 179466-SNL 2007, Parameter 01-02).

The water table is the boundary between the unsaturated zone above and the saturated zone below. In the subsurface region above the water table, the rock contains water, but the water does not fill all the open spaces in the rock. Because the open spaces are only partially filled with water, this region is called the unsaturated zone. Water in the unsaturated zone tends to move generally downward in response to capillary action and gravity. In contrast, water fills all the open spaces in the rock below the water table, so this region is called the saturated zone. Water in the saturated zone tends to flow laterally from higher to lower pressures. Both zones contain several different rock types, as Figure 5-2 shows. The layers of major rock types in the unsaturated zone at the Yucca Mountain site are the Tiva Canyon welded, Paintbrush nonwelded, Topopah Spring welded, Calico Hills nonwelded, and Crater Flat undifferentiated *tuffs* (DIRS 169734-BSC 2004, Section 3.3). The figure shows the Solitario Canyon Fault, which forms the western boundary of the repository block (DIRS 169734-BSC 2004, Section 3.2.2). Faults are slip zones where seismic events have displaced rock units vertically, laterally, or diagonally, which results in discontinuous rock layers. These slip zones tend to form a thin plane in which there is more open space that acts as a channel for water. Some faults tend to fill with broken rock that forms as they slip, so they have a very different flow property from that of the surrounding rock. The proposed repository would be in the Topopah Spring *welded tuff* in the unsaturated zone, at least 200 meters (700 feet) below the surface and approximately 300 meters (1,000 feet) above the water table (DIRS 169734-BSC 2004, Section 3.3.5.1; DIRS 179466 SNL-2007, Parameter 01-06).

When rain falls at Yucca Mountain, most of the water runs off, is lost to evaporation, or is taken up by plants growing on the mountain (DIRS 182145-SNL 2008, Table 6.5.7.1-3[a]). A small amount infiltrates the rock on the surface. The small amount of water that infiltrates the rock percolates down through the mountain to the saturated zone. If there was a breach in the package containment, water that flowed through the unsaturated zone into the proposed repository could dissolve some of the waste material and carry it through the groundwater system to the accessible environment where exposure to humans could occur.

5.3.2 COMPONENTS OF THE WASTE PACKAGE AND DRIP SHIELD

The waste packages would consist of two concentric cylindrical containers sealed with an outer welded lid. The inner cylinder, which is the structural support member of the waste package, would be stainless steel. The outer cylinder would be a relatively thin, nickel-based alloy (Alloy 22) that would protect the underlying stainless-steel structural material from corrosion. In addition, spent nuclear fuel and high-level radioactive waste would be in their own sealed containers. Commercial spent nuclear fuel waste packages would contain a stainless-steel TAD canister. DOE codisposal waste packages would contain *disposable canisters*. The current design calls for emplacement of titanium drip shields over the waste packages just before repository closure. With the drip shield in place, the Alloy 22 outer cylinder would be the second corrosion barrier that protected the waste from contact with water. The use of two distinctly different corrosion-resistant materials would reduce the probability that a single environmental condition could cause the failure of both materials. Before the double-walled waste package was sealed,

helium would be added as a fill gas. The helium would prevent corrosion of the waste form and help transfer heat from the waste form to the inner wall of the waste package prior to failure of the Alloy 22 outer cylinder. The movement of heat away from the waste form would be an important means to control waste package temperatures.

5.3.3 VISUALIZATION OF THE REPOSITORY SYSTEM FOR ANALYSIS OF POSTCLOSURE IMPACTS

In general, DOE modeled the repository system as a series of processes linked together, one after the other, spatially from top to bottom in the mountain. From a computer modeling standpoint, it is important to break the system into smaller components that relate to the information collection method. An operating repository system would be completely interconnected, and virtually no process would be independent of other processes. However, the complexity of such a system demands some idealization of the system for the performance of an analysis.

The first step in the visualization is the development of a list of all possible features, events, and processes that could apply to the behavior of the system. An example of a feature is the existence of a fault, an example of an event is a seismic event (*earthquake*), and an example of a process is the gradual degradation of the waste package wall by general corrosion. DOE used various types of analyses to screen the list to determine the features, events, and processes it should include in the modeling. The Department assembled the chosen features, events, and processes into scenario classes, which are descriptions of how features, events, and processes link together to result in a certain outcome (Appendix F, Section F.2.1 contains more detail on features, events, and processes).

The elements of the repository system model, referred to in this chapter as the TSPA-LA model, fall into the following categories, which generally relate to parts of the system:

- Unsaturated zone flow,
- Engineered Barrier System environments,
- Waste package and drip shield degradation,
- Waste form degradation,
- Engineered barrier flow and transport,
- Unsaturated zone transport,
- Saturated zone flow and transport, and
- Biosphere.

Appendix F, Sections F.2.2 through F.2.9 discuss the individual models associated with these elements. Sections F.2.10, F.2.11, F.4.1.2, and Sections 5.8 and 5.9 discuss the following scenario classes and assessments, respectively:

- Igneous Scenario Class,
- Seismic Scenario Class,
- Early Waste Package and Drip Shield Failure Scenario Class,
- Human intrusion, and
- Nuclear criticality.

During the development of the TSPA-LA model, DOE had to make assumptions in addition to those mandated by regulation, primarily to account for situations for which there were limited data. If data are limited, the use of appropriate assumptions and associated conservative data values is necessary. The EPA and NRC rulemaking processes acknowledged that uncertainty about physical processes over the large space and time scales of interest will remain, even after many years of site characterization. This postclosure analysis does not seek an exact prediction but rather a cautious but reasonable projection (or estimate) of what could occur, which includes a quantitative evaluation of uncertainty in that projection.

ASSUMPTIONS

The assessment of postclosure impacts sometimes used assumptions in the formulation of models. An assumption is a premise taken as a starting point for some element of the modeling for which there usually is no absolute proof. Assumptions normally account for qualitative uncertainties (where an absolute probability cannot be assigned). There are two types of assumptions: (1) if there is a high certainty (although unquantified) that the premise will hold true and (2) if the assumption is conservative (that is, all alternative assumptions would lead to a smaller impact). A conservative assumption is often used if there is considerable uncertainty about the alternative premise that is more likely. Some assumptions are mandated by regulations that prescribe how the modeling is to occur. A set of assumptions defines the conceptual model used for the analysis. A set of alternative assumptions would represent an alternative model. DOE conducted sensitivity studies to compare alternative models to help define the importance of certain assumptions, especially if there was considerable uncertainty (Section 5.3.4.2.3).

Each assumption has a basis, which can be the reason the assumption represents a condition of high certainty, a statement that it is mandated by regulations, or a statement that it is conservative in relation to the outcome of impact analysis.

5.3.4 UNCERTAINTY

As with any impact estimate, there is a level of uncertainty, especially for estimations of impacts over thousands and hundreds of thousands of years. In this context, uncertainty is the measure of confidence in the calculation in relation to a determination of how a system will operate or respond. The amount of uncertainty in an impact estimate is a reflection of several factors, including the following:

- An understanding of the components of a system (such as human, societal, hydrogeologic, or engineered) and how those components interact.

- The time scale over which estimates are made. Longer time scales for projections produce greater potential for uncertainty. This is particularly true for events that might or might not occur in the future and how a system evolves in response to these future events.

- The available computation and modeling tools. Models are based on a set of working hypotheses, assumptions, and parameters that are inherently uncertain because of the complexity and variability of a natural system.

DOE recognizes that uncertainties exist from the onset of an analysis; however, projections are valuable in the decisionmaking process because they provide insight based on the best information and scientific

judgments available. This section discusses uncertainties in the context of possible effects on the impact estimates in this chapter.

5.3.4.1 Uncertainty in Societal Changes and Climate

The analysis this chapter presents is consistent with the regulatory requirements in the proposed EPA and NRC standards. Therefore, this analysis used an approach that involves estimation of radiological exposure to a defined RMEI. EPA and the NRC based the characteristics of the RMEI on societal conditions as they exist today and included consideration of current population distributions, groundwater use, and food consumption patterns. The proposed standards also specify a value to be used to represent climate change after 10,000 years.

DOE based estimates of future climatic conditions on what is known about the past and considered climate impacts due to human activities. Calcite in Devils Hole, a fissure in the ground about 40 kilometers (25 miles) southeast of Yucca Mountain, provides the best record of climate changes over the past 500,000 years. The record shows continual variation, often with rapid jumps, between cold glacial climates (for the *Great Basin* these are called pluvial periods) and warm interglacial climates similar to the present (DIRS 169734-BSC 2004, Sections 6.4 and 6.5). The analysis assumed that the current climate is the driest it will ever be at Yucca Mountain; this is reasonable based on the climatological record that has been projected for the next 10,000 years.

5.3.4.2 Uncertainty in Models and Model Parameters

The postclosure performance model that DOE used to assess the impacts from migration of radionuclides in groundwater includes a number of submodels, each of which must account for features of the system, likely and unlikely events, and processes that would contribute to the release and migration of materials. Because of the long periods to be simulated, the complexity and variability of the natural system, and other factors, the performance modeling must deal with uncertainty. This section discusses the nature of the uncertainties, how DOE accounted for them in this Repository SEIS, and their implications to interpretation of impact results.

5.3.4.2.1 *Relationship Between Variability and Uncertainty*

Uncertainty in model projections of repository performance comes from two major sources: (1) variability in what could happen in the future (*aleatory* uncertainty), and (2) lack of knowledge about quantities that have fixed values in the calculation of either the likelihood of future events at the proposed repository or impacts of these events (*epistemic* uncertainty). Alternative terminology includes the use of stochastic, variable, and irreducible as alternatives to aleatory, and the use of subjective, reducible, or state of knowledge as alternatives to epistemic.

Uncertainty and variability are, in general, related. The exact nature of the variability in a natural system cannot be known because all parts of the system cannot be observed. For example, DOE cannot dig up all the rock in Yucca Mountain and determine that the positioning of the rock layers is exactly as core sample data have suggested. Therefore, there is uncertainty about the properties of the rock at specific locations in the mountain because properties change with distance and it is not known how much they change at any given location. For example, if a function $f(x,y)$ characterizes the two-dimensional variability of some quantity, such as thermal conductivity, there are most likely many possible values for this function

of varying levels of credibility. Thus, the function *f(x,y)* characterizes spatial variability, but a lack of knowledge of how to define *f(x,y)* exactly is epistemic uncertainty. If the variability can be appropriately quantified or measured, a model usually can be developed to include this variability in addition to the uncertainty in the representation of variability. However, the ability to model some types of spatial variability can be limited not only by lack of data but also by the capacity of a computer to complete calculations (for example, if one simulation took weeks or months to complete). In these instances, variability must be simplified to be reasonable and appropriate.

The analysis used two basic tools to deal with uncertainty and variability: alternative conceptual models and probability theory. It used alternative conceptual models to examine uncertainty in the understanding of a key physical-chemical process that controls system behavior. For example, different conceptual models of how water in *fractures* interacts with water in the smaller pores or matrix of the rock in the unsaturated zone lead to different flow and transport models. Sometimes conceptual models are not mutually exclusive (for example, both matrix and fracture flow can occur), and sometimes they do not exhaustively cover all possibilities. The analysis used conservatism at the subsystem and total system levels to select the best alternative conceptual model to use rather than to propagate quantitatively multiple conceptual models through the TSPA-LA model.

The analysis used probability theory to understand the impacts of uncertainty in specific model parameters (that is, would results change if the parameter value was different) and to characterize how the repository system might evolve in time due to the occurrence of disruptive events. It used the *Monte Carlo sampling technique* to handle uncertainty in specific model parameters. This technique involves random Latin hypercube sampling of ranges of likely values, or distributions, for all uncertain input parameters. Distributions describe the probability of a particular value falling in a specific range. A common type of distribution is the familiar bell-shaped curve, known as the *normal distribution*. Many different types of distributions describe parameters in the consequence analysis that are appropriate to the understanding of the values and their probabilities. The analysis calculated many realizations of repository system behavior, each based on one set of samples of all the inputs. Each total system realization had an associated probability, so there is some perspective on the likelihood that set of circumstances would occur. The Monte Carlo method yields a range for any chosen performance measure (for example, annual individual dose in a given period at a given location) and a probability for each value in the range. In other words, it gives estimates of repository performance and determines the uncertainties in those estimates. This chapter expresses the impact estimates as the mean, median, and 95th-percentile values (that is, the value for which 95 percent of the results were smaller).

5.3.4.2.2 *Uncertainty in Data*

Some uncertainties for input parameters or models result from a lack of data. Such data gaps can be due to the status of research (perhaps with more data expected later) or conditions that restrict or prevent collection of certain data (for example, data that would require tests over impracticably long periods or the necessity for minimal disturbance of the emplacement site). Uncertainty in data is a subset of parameter and model uncertainty.

The use of parameter distributions and studies of alternative models can help improve the understanding of how data uncertainty can affect the range of the impact results. Further, sensitivity studies can provide insight into the sensitivity of the model to particular parameters. Sensitivity studies identify data that are important to the modeled results, which can help identify those areas for which the study needs additional

data. DOE has generated additional data since the completion of the Yucca Mountain FEIS that help improve its ability to characterize the range of impacts in this Repository SEIS. The following are examples of additional data and their uses:

- DOE has measured concentrations of chemical components in the rock, such as chloride, bromide, and sulfate, and the results have helped to identify fast paths for water flow. Ongoing analyses of the isotopic ages of fracture-lining minerals have provided additional information about the history of water movement. These studies have improved the understanding of flow paths and flow rates for water that moves through the unsaturated zone, and have revealed certain characteristics of the water, such as chemical composition and temperature. The analysis has used this new information to model the unsaturated zone more accurately (DIRS 184614-SNL 2007, all).

- DOE has investigated the effects of heat on the seepage of water into emplacement drifts in a drift-scale thermal test and laboratory experiments; these studies have provided additional data for models that predict the effects of coupled processes (DIRS 179590-SNL 2007, all).

- Accelerated corrosion testing of Alloy 22 has enabled more complete estimates of corrosion rates; DOE has used these data to improve the waste package degradation model (DIRS 178519-SNL 2007, all).

5.3.4.2.3 *Consideration of Alternative Conceptual Models*

There were three possible approaches to the incorporation of discrete alternative models in the performance analysis: (1) weighting alternative models into one comprehensive Monte Carlo simulation ("lumping"), (2) performing multiple Monte Carlo simulations for each discrete model, and (3) keeping the discrete models separate and evaluating them individually at the subsystem level to assess uncertainties and conservatisms and, through the use of expert judgment, implementing the reasonable and sometimes conservative models in the Monte Carlo simulation. The analysis used the third alternative to develop the main results in Section 5.5.

5.3.4.2.4 *Uncertainty and Postclosure Analysis*

The TSPA-LA analysis accounted for aleatory and epistemic uncertainties. Both aleatory and epistemic uncertainties were quantified with probability distributions that were propagated through the *probabilistic* Monte Carlo analysis. Using this technique, uncertainties in TSPA-LA projections were quantified via multiple sampling of aleatory and epistemic probability distributions and corresponding model simulations or realizations. The benefits of this probabilistic approach included: (1) obtaining a representative range of possible outcomes to quantify uncertainty of TSPA-LA projections, and (2) analyzing the relationship between the uncertain inputs and uncertain outputs to provide understanding of the effects of uncertainties on TSPA-LA projections.

5.3.4.2.5 *Uncertainty and Sensitivity*

In addition to accounting for the uncertainty, there is a need to understand characteristics of the engineered and natural systems (such as the unsaturated and saturated zones of the groundwater system) that would have the most influence on repository performance. This information helps define uncertainty in the context of what would influence results the most. This concept is called sensitivity analysis, which uses a number of methods to explain the results and quantify sensitivities. The overall postclosure

performance of the repository would be a function of sensitivity (if a parameter was varied, how much would the performance measures change) and uncertainty (how much variation of a parameter would be reasonable). For example, the postclosure performance results could be sensitive to a certain parameter, but the value for the parameter is exactly known. The uncertainty analysis techniques described below would not identify that parameter as important. However, many parameters in the analyses have associated uncertainties and become highly important to performance. On the other hand, the level of their ranking can depend on the range of uncertainty.

WHY IS THE TSPA-LA MODEL PROBABILISTIC?

The TSPA-LA model uses statistical sampling of many parameters and generates 300 realizations (that is, "future states of the repository system"), each with a unique sampling of parameter values. Such a model is known as a probabilistic model. (Other text boxes describe how this is applied to obtain results.)

Many parameters are not known exactly but rather are represented as a distribution of values, with a probability assigned to each value (one well-known type of distribution is the "bell-shaped curve" or "normal" distribution). A probabilistic model is an appropriate way to produce results that reflect these parameter uncertainties.

In developing the TSPA-LA model used for the analysis in this Repository SEIS, DOE took into consideration the regulatory requirements in the proposed U.S. Environmental Protection Agency and U.S. Nuclear Regulatory Commission standards to provide a perspective on potential radiological impacts during the postclosure period.

At the system level, certain design features of the repository, such as the layout, are not treated as variable. These are modeled without an associated uncertainty. The sensitivities to performance for certain parameters of this type, such as waste package thickness, have been examined in subsystem models and factored into the selection of the parameter. The determination of the parameters or components that are most important depends on the particular performance measure. The 1993 and 1995 TSPAs (DIRS 100111-CRWMS M&O 1994, all; DIRS 100191-Wilson et al. 1994, all; DIRS 100198-CRWMS M&O 1995, all) demonstrated this point. These analyses showed, for example, that the important parameters would be different for 10,000-year doses than for post-10,000-year period doses.

There are several techniques for the analysis of uncertainties, which include the use of scatter plots where the results (for example, annual individual dose) are plotted against input parameters and visually inspected for trends. In addition, performance measures can be plotted against various subsystem outputs or surrogate performance measures (for example, waste package lifetime) to determine if that subsystem or performance surrogate would be important to performance. There are several formal mathematical techniques for evaluation of the sets of realizations from a Monte Carlo analysis to extract information about the effects of parameters. Such an analysis determined the principal factors that would affect the performance of the repository.

5.3.4.3 Uncertainty Analysis for the TSPA-LA

The *Total System Performance Assessment Model/Analysis for the License Application* (DIRS 183478-SNL 2008, all) documented the methodology used to develop a comprehensive quantitative analysis of the possible future behavior of a *Yucca Mountain Repository*. The methodology combined detailed

conceptual and numerical models of each individual and coupled process in a single probabilistic model for use in assessment of how a repository might perform over long periods.

DOE has always recognized that uncertainties will remain in any assessment of the performance of a repository over thousands to hundreds of thousands of years. For this reason, one part of the DOE approach to uncertainty relies on multiple lines of evidence that can contribute to the understanding of the performance of the repository. Another part of the DOE approach is a commitment to continual testing, monitoring, and analysis beyond the licensing of the repository.

DOE performed a sensitivity analysis to determine the parameters that contribute most to the uncertainties in the postclosure performance results in Section 5.5. These parameters are the main contributors to variations in calculated impacts. In any case, the range of values in the distribution for these parameters exerts the strongest influence on the uncertainty of the results.

DOE used regression analysis as a tool to quantify the strength of input-output relationships in the TSPA-LA model. The analysis fitted an incremental linear rank regression model between individual dose at a given time (or some other performance measure) and all randomly sampled input variables. It ranked parameters on the basis of how much their exclusion would degrade the explanatory power of the regression model. The importance-ranking measure that DOE used for this purpose was the partial rank correlation coefficient. This uncertainty importance factor quantifies the proportion of the total spread (variance) in total dose explained by the regression model that can be attributed to the variable of interest.

5.3.5 SENSITIVITY ANALYSIS RESULTS

For different time frames in the analysis, different epistemic parameters emerge as important to the overall uncertainty in the results (DIRS 183478-SNL 2008, all). Table 5-3 lists the results of the sensitivity analysis. The important parameters, which the table lists, are as follows:

- IGRATE. This parameter is the probability of an igneous event, which is the annual frequency, as a cumulative distribution function, of an intersection of the repository by a volcanic dike. As discussed in Appendix F, Section F.4.2.1.1, DOE assumed that an igneous intrusion event would destroy all drip shields and waste packages and, therefore, they would offer no barrier to seepage and radionuclide transport.

- SCCTHRP. This parameter is the residual stress threshold for the Alloy 22 waste package outer barrier. If the residual stress in the waste package outer barrier exceeded this threshold value, stress corrosion cracks could form, which could allow radionuclides to migrate from the waste package. The primary causes of residual stresses in the waste package outer barrier would be low-frequency, high-peak ground velocity seismic ground motions, which could cause impacts from waste package to waste package, from waste package to emplacement pallet, and from waste package to drip shield. These impacts could cause dynamic loads that dent the waste package, which could result in structural deformation with residual stress.

- WDGCA22. This parameter relates to the temperature dependence for the general corrosion rate of the Alloy 22 waste package outer barrier. It determines the magnitude of this temperature dependence and directly influences the short-term and long-term general corrosion rates of the Alloy 22; the larger this value is, the higher the earlier general corrosion rates during the thermal period and

Table 5-3. Top-ranking uncertainty importance parameters.

Time after closure (years)	Two most important parameters	
3,000	SCCTHRP	IGRATE
5,000	SCCTHRP	IGRATE
10,000	SCCTHRP	IGRATE
125,000	IGRATE	SCCTHRP
250,000	WDGCA22	IGRATE
500,000	IGRATE	WDGCA22
1,000,000	IGRATE	WDGCA22

Source: DIRS 183478-SNL 2008, Section 8.1.1.7[a].

the lower the long-term corrosion rates when the repository temperatures were near *ambient* in-situ temperature.

The parameters in Table 5-3 that most affect the total uncertainty in the TSPA-LA model are factors that would govern degradation of the waste packages or the rate at which igneous intrusion would destroy all waste packages.

5.4 Locations for Impact Estimates

Yucca Mountain is in southern Nevada in the Mojave Desert. It is in a semiarid region with linear mountain ranges and intervening valleys, current average rainfall that ranges from about 100 to 250 millimeters (4 to 10 inches) a year, sparse vegetation, and a low population. This section describes the regions where possible human health impacts could occur.

Figure 5-3 shows the general direction of groundwater movement from Yucca Mountain. Shading indicates major areas of groundwater discharge through a combination of springs and *evapotranspiration* by plants. The general path of water that infiltrates through Yucca Mountain is south toward Amargosa Valley into and through the area around Death Valley Junction in the lower *Amargosa Desert*. Natural discharge of groundwater from beneath Yucca Mountain probably occurs farther south at Franklin Lake Playa (DIRS 100376-Czarnecki 1990, pp. 1 to 12), and spring discharge in Death Valley is a possibility (DIRS 100131-D'Agnese et al. 1997, pp. 64 and 69). Although groundwater from the Yucca Mountain vicinity flows under and to the west of Ash Meadows in the volcanic tuff or alluvial aquifers, the carbonate aquifer feeds the surface discharge areas at Ash Meadows and Devils Hole (Figure 5-3). While these two aquifers are connected at some locations, the carbonate aquifer has a hydraulic head that is higher than that of the volcanic or alluvial aquifer. Because of this pressure difference, water from the volcanic aquifer does not flow into the carbonate aquifer; rather, the reverse occurs. Therefore, contamination from Yucca Mountain is not likely to mix with carbonate aquifer waters and discharge to the surface at Ash Meadows or Devils Hole (DIRS 104983-CRWMS M&O 1999, all) under current conditions.

Because there would be no contamination of this discharge water under current conditions, no human health impacts would be expected. Further, no impacts to the endangered Ash Meadows Amargosa pupfish (*Cyprinodon nevadensis mionectes*) or Devils Hole pupfish (*Cyprinodon diabolis*) at those locations would be expected.

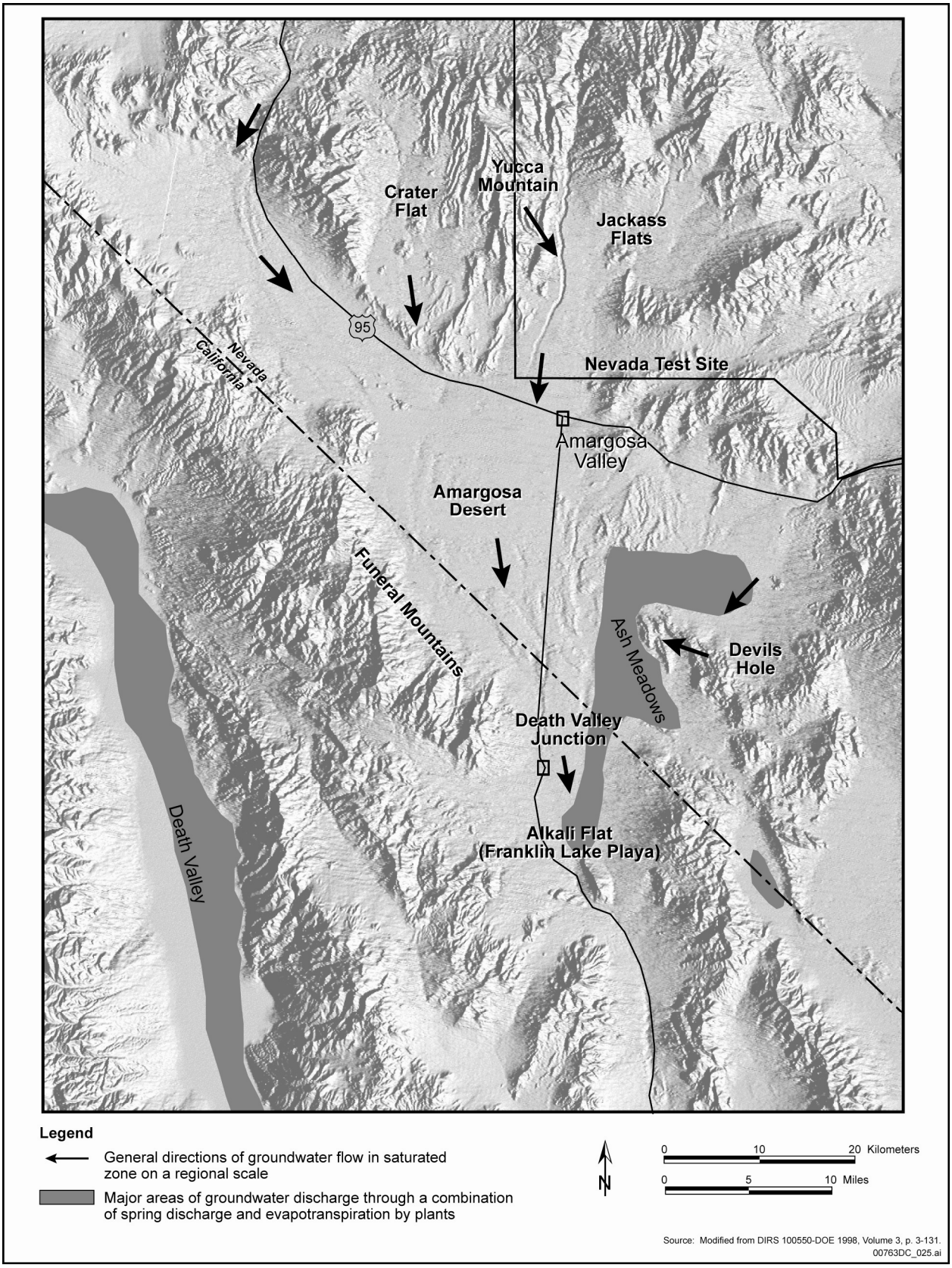

Figure 5-3. Saturated groundwater flow system.

5.5 Postclosure Radiological Impacts

The following sections discuss the annual committed effective *dose equivalent* to the RMEI, a hypothetical individual who would live south of Yucca Mountain. DOE assumed that this individual would use contaminated groundwater and have lifestyle characteristics that EPA defined in 40 CFR 197.21. By definition, because of the highly conservative nature of the criteria to be applied to the RMEI, the RMEI would receive the high end of the range of potential dose distribution for the exposed population. The following criteria apply, by regulation, to the RMEI:

1. Lives in the accessible environment above the highest concentration of radionuclides in the plume of contamination. The accessible environment is any point outside the *controlled area,* which is defined as the surface area identified by passive institutional controls, that would encompass no more than 300 square kilometers (120 square miles) (40 CFR 197.2). It must not extend farther south than 36 degrees, 40 minutes, 13.661 seconds north latitude, in the predominant direction of groundwater flow, and no more than 5 kilometers (3 miles) from the repository footprint in any other direction. The southernmost point of the controlled area, which is approximately 18 kilometers (11 miles) south of the repository, is the location of the RMEI in the TSPA-LA.

2. Has a diet and living style representative of the people who now reside in the town of Amargosa Valley. DOE must use projections based on surveys of the people who live in the town of Amargosa Valley to determine their diets and living styles and use the mean values of these factors in the assessments for 40 CFR 197.20 and 40 CFR 197.25.

3. Drinks 2 liters (0.5 gallon) of water per day from wells at the location criterion 1 specifies.

The analysis converted the annual committed effective dose equivalent, referred to as the annual individual dose, to the probability of contracting a fatal cancer (a latent cancer fatality) due to exposure to radioactive materials in the water. DOE based the analysis on the radionuclide inventories that would be transported to the RMEI location. The analysis included the entire carbon-14 inventory of the commercial spent nuclear fuel as a solid in the groundwater release models. This approach is conservative (tends to overstate the risk) because 2 percent of the carbon-14 is in the fuel as a gas (Section 5.6). Therefore, the groundwater models slightly overestimate (by approximately 2 percent) the potential impacts from carbon-14.

DOE performed probabilistic model simulations using the TSPA-LA model for the RMEI location [18 kilometers (11 miles) from Yucca Mountain]. Each of the probabilistic simulations used 300 separate sampled values for epistemic uncertain parameters and generated 300 realizations of annual individual dose as a function of time for up to 1 million years after repository closure. These annual individual dose histories were used to determine the mean, median, and 95th-percentile annual dose projections for the RMEI.

DOE estimated doses and groundwater impacts in this section for the RMEI location using the representative volume of 3.7 million cubic meters (3,000 acre-feet) of groundwater (10 CFR 63.332) to calculate the concentration of radionuclides. The TSPA-LA model collected all the radionuclides released to the groundwater in the representative volume.

Development of the TSPA-LA model started with completion of the features, events, and processes screening analysis and forming of the scenario classes for inclusion in the performance assessment (Appendix F, Section F.2). This produced the Nominal Scenario Class, Early Failure Scenario Class, and two disruptive event scenario classes that describe possible igneous and seismic events. Appendix F, Section F.2 describes these scenario classes and the modeling cases that represent them in the TSPA-LA in greater detail.

The Nominal Scenario Class includes a single modeling case that considers the expected corrosion degradation processes of the drip shields and waste packages. The Early Failure Scenario Class considers the possible early failure of drip shields and waste packages due to manufacturing, material defects, or preemplacement operations that include improper heat treatment. This class includes two modeling cases, one for drip shield early failure and one for waste package early failure. DOE used modeling cases to represent different modes of degradation of the Engineered Barrier System features for separate analysis and then combined them to evaluate the total dose to the RMEI and groundwater impacts.

DOE used the Seismic Scenario Class to analyze possible seismic disruption of the repository and its effect on repository performance (Appendix F, Section F.2.11). This class includes (1) a modeling case that addresses features, events, and processes for the effects of ground motion damage to Engineered Barrier System features, and (2) a modeling case that addresses features, events, and processes for the effects of fault displacement damage to Engineered Barrier System features.

CALCULATION OF MEAN, MEDIAN, AND 95TH-PERCENTILE RESULTS

Because of the probabilistic nature of the TSPA-LA results, it is informative to examine the mean and median results, which are measures of central tendencies or average values, and the 95th percentiles, which represent the high extreme values.

The Igneous Scenario Class includes features, events, and processes that describe the possibility that low-probability igneous activity could affect repository performance (Appendix F, Section F.2.10). This class includes the Igneous Intrusion Modeling Case, which addresses the features, events, and processes for the possibility that magma (molten rock), in the form of a dike (ridge of material), could intrude into the repository and disrupt expected repository performance. The Igneous Scenario Class also includes a Volcanic Eruption Modeling Case that includes features, events, and processes that describe an eruptive conduit that would rise through the repository, damage a number of waste packages, and erupt at the surface. This low-probability volcanic eruption could disperse volcanic tephra and entrained radionuclides into the atmosphere and deposit it on land surfaces where soil and near-surface geomorphic processes would redistribute it. In this Repository SEIS, the total annual dose to the RMEI includes the contribution of dose from the igneous eruption event (Appendix F, Section F.4.3).

All modeling cases are for groundwater release with the exception of the single atmospheric release case, the Volcanic Eruption Modeling Case. The TSPA-LA model implemented the various modeling cases separately to calculate annual doses and groundwater impacts at the RMEI location. It then combined the performance quantities from each modeling case appropriately to calculate total groundwater impacts and the total annual dose to the RMEI (Sections 5.5.1 and 5.5.2 for the first 10,000 years and post-10,000 years, respectively). The analysis evaluated the impacts of a Human Intrusion Scenario that involves inadvertent drilling separately (Section 5.8).

The following two sections summarize the results of annual dose and groundwater performance analysis. Table 5-4 summarizes the estimated radiological impacts to the RMEI during the first 10,000 years after repository closure and for the post-10,000-year period up to 1 million years.

Table 5-4. Estimated radiological impacts to the RMEI—combined scenario classes.

	Mean		Median		95th-percentile	
Period	Annual individual dose would not exceed (millirem)	Probability of LCF per year	Annual individual dose would not exceed (millirem)	Probability of LCF per year	Annual individual dose would not exceed (millirem)	Probability of LCF per year
First 10,000 years	0.24	1.4×10^{-7}	0.13	7.7×10^{-8}	0.67	4.0×10^{-7}
Post-10,000-year	2.0	1.2×10^{-6}	0.96	5.7×10^{-7}	9.1	5.4×10^{-6}

LCF = Latent cancer fatality.

5.5.1 POSTCLOSURE RADIOLOGICAL IMPACTS FOR THE FIRST 10,000 YEARS AFTER CLOSURE

This section presents the combined radiological results from all scenario classes that DOE considered in the assessment of repository performance. Appendix F, Section F.4.1 (for undisturbed repository performance) and Section F.4.2 (for disruptive events) summarize the radiological impacts from different scenario classes and modeling cases. Section F.4.3 summarizes the calculation of combined annual dose results.

The performance analysis for the combined scenario classes indicated that for the first 10,000 years after closure there would be very limited combined releases from all scenario classes with small radiological impacts for the total of all classes (Figure 5-4). The values in Table 5-4 indicate that for the first 10,000 years after repository closure, the mean annual individual dose to the RMEI could be approximately 0.2 millirem. This is about 1 percent of the EPA standard, which allows up to a 15-millirem annual committed effective dose equivalent during the first 10,000 years. The median and 95th-percentile values are well below the EPA standard as well. (The remainder of this chapter refers to the "annual committed effective dose equivalent" as the "annual individual dose.")

COLOR FIGURES

The figures illustrating results of the performance analysis presented in Chapter 5 and Appendix F can be found in color on the CD on the inside back cover of the Summary of this Repository SEIS and the Office of Civilian Radioactive Waste Management Web site: http://www.ocrwm.doe.gov. Some of the figures can also be found in color in the Summary.

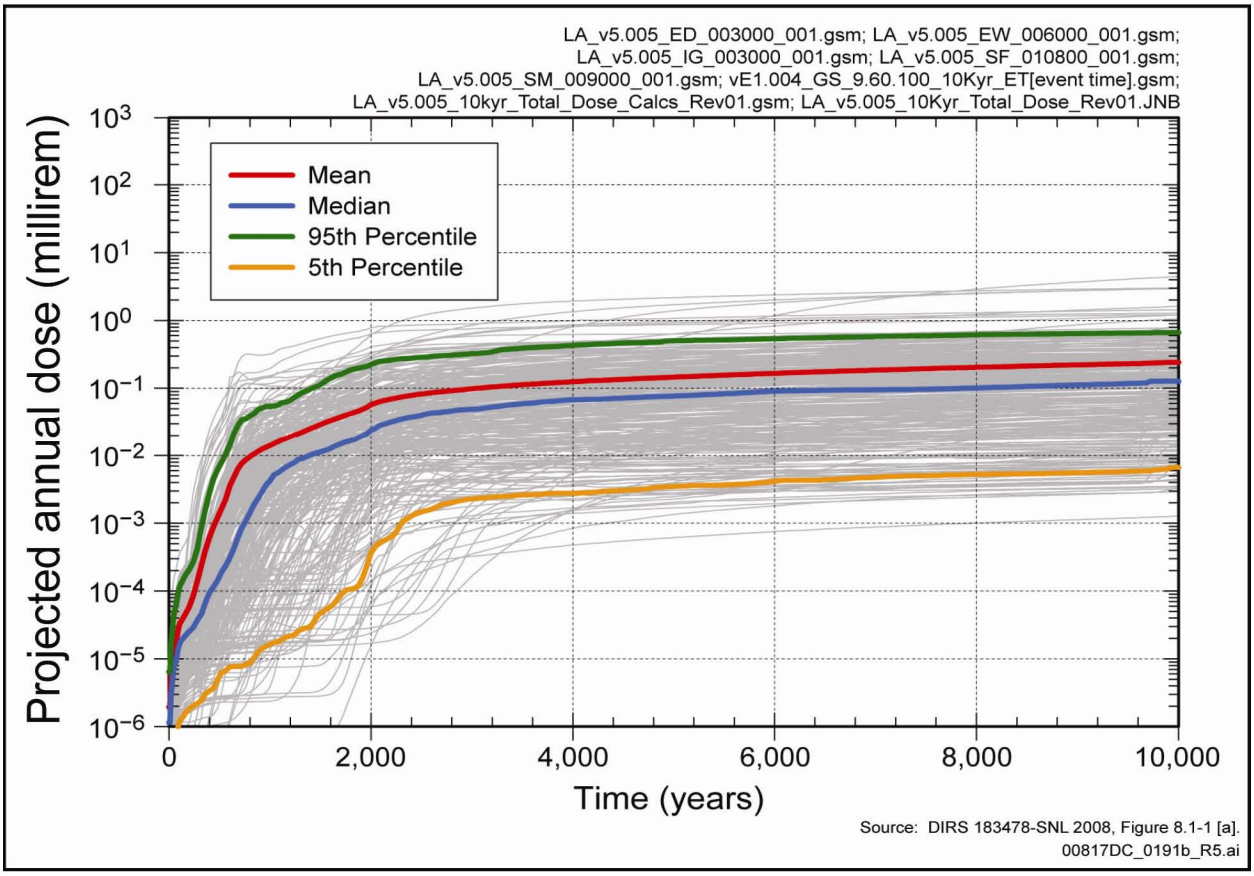

Figure 5-4. Total projected annual dose for the first 10,000 years after repository closure—combined scenario classes.

COMPARISON OF RESULTS WITH THE YUCCA MOUNTAIN FEIS

In the radiological dose calculations for this Repository SEIS, the impacts are for the combination of all scenario classes (nominal + seismic + early failure + igneous intrusion + volcanic eruption). The comparable section of the Yucca Mountain FEIS reported the results for the nominal scenario class and reported the additional scenario classes in separate subsections. Further, the nominal scenario class in the Yucca Mountain FEIS included damage to commercial spent nuclear fuel cladding due to seismic vibratory ground motion. Appendix F discusses the results for all scenario classes in this Repository SEIS.

The radionuclides that would contribute the most to individual dose in the first 10,000 years would be dissolved technetium-99, carbon-14, plutonium-239, and iodine-129 in groundwater (Figure 5-5). The mean consequence at 18 kilometers (11 miles) has technetium-99 contributing more than 50 percent of the total annual individual dose rate, carbon-14 contributing approximately 15 percent, and plutonium-239 and iodine-129 each contributing approximately 10 percent. Plutonium-240, chlorine-36, selenium-79, and neptunium-237 would provide additional, smaller contributions. The groundwater modeling for this waterborne radiological impacts analysis conservatively assumed that all carbon-14 migrated in the groundwater.

MULTI-REALIZATION PLOTS

The main result of the Monte Carlo simulation process is a set of realizations for the expected annual dose histories of the reasonably maximally exposed individual, which are generally plotted in the form of a multi-realization plot. The multi-realization plots developed for demonstrating compliance with the Individual Protection Standard are in Figures 5-4 and 5-6.

Curves for the mean, median, and 5th- and 95th-percentile dose histories are superimposed on each multi-realization plot. The total mean annual dose history, which is plotted as the red curve (second curve from the top), was computed by taking the arithmetic average of the 300 expected annual dose values for the individual time planes along the curves. Similarly, the median dose history, plotted as the blue curve (third curve from the top), was constructed from points obtained by sorting the 300 expected values from the lowest to highest, and then averaging the two middle values. Curves for the 5th- and 95th-percentile dose histories are also plotted to illustrate the spread in the expected annual dose histories; 90 percent (or 270 of the 300 epistemic realizations) of the protected dose histories fall between these two percentile curves. For a detailed description of the calculation of the total annual dose, see the *Total System Performance Assessment Model/Analysis for the License Appilcation* (DIRS 183478-SNL 2008, Section 6.1.2.2).

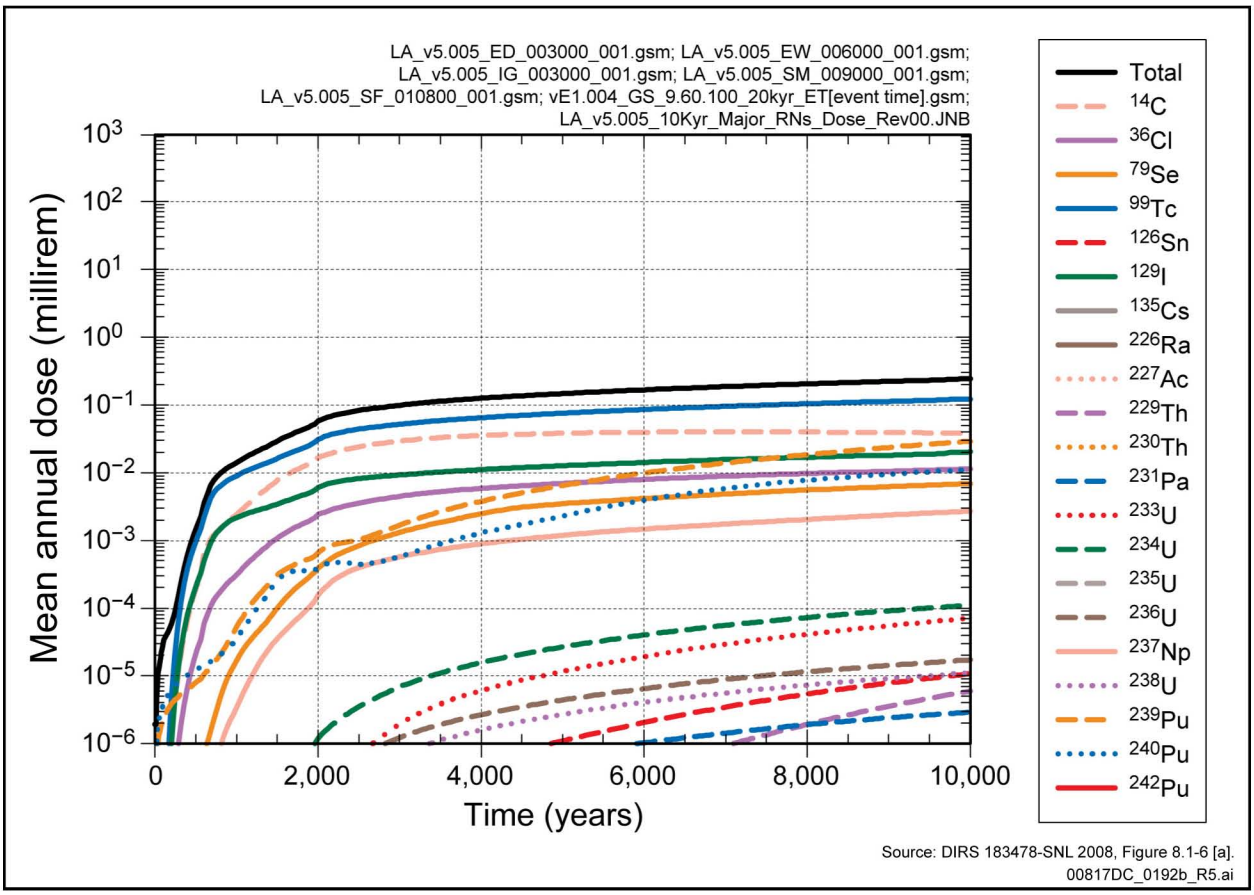

Figure 5-5. Contribution of individual radionuclides to total mean annual dose for the first 10,000 years after repository closure—combined scenario classes.

In relation to the groundwater protection standards in 40 CFR 197.30, both the mean and 95th-percentile estimated levels during the 10,000-year regulatory period are estimated to be substantially less than the

regulatory limits (Table 5-5). As shown in the table, the 95th-percentile value for the combined radium concentration is less than the mean value. This result was a consequence of a few realizations that projected relatively high, but still small, radium concentrations that skewed the distribution of radium concentrations and caused the mean value to be higher than the 95th-percentile value. The groundwater protection standards in 40 CFR 197.30 require exclusion of unlikely natural processes and events in the performance assessment evaluation for the groundwater protection standard. Unlikely events are those that have less than 1 chance in 10 and at least 1 chance in 10,000 of occurring within 10,000 years of disposal. Likely events are those that have a 10-percent chance of occurring within 10,000 years of disposal. Therefore, the assessment of groundwater protection included the Nominal Scenario Class, the Early Failure Scenario Class, and the likely portion of the Seismic Ground Motion Modeling Case, which extends across the likely-unlikely boundary. That is, ground motions potentially occur with recurrence frequencies that are both above and below 1 chance in 10 within 10,000 years of disposal.

Table 5-5. Comparison of postclosure impacts at the RMEI location with groundwater protection standards during the first 10,000 years after repository closure—combined Nominal, Early Failure, and Seismic (seismic ground motion events with exceedance frequencies greater than 1×10^{-5} per year) scenario classes.

Radionuclide or type of radiation emitted	EPA limit	Mean would not exceed	95th-percentile would not exceed	Mean background
Combined radium-226 and radium-228 (picocuries per liter)	5	1.3×10^{-7}	9.9×10^{-8}	0.5
Gross alpha activity (including radium-226 but excluding radon and uranium) (picocuries per liter)	15	6.7×10^{-5}	3.2×10^{-3}	0.5
Combined beta- and photon-emitting radionuclides (millirem per year) to the whole body or any organ, based on drinking 2 liters (0.5 gallon) of water per day from the representative volume	4	0.3	0.8	Background not included in limit

Source: DIRS 183478-SNL 2008, all.
EPA = U.S. Environmental Protection Agency.

5.5.2 POSTCLOSURE RADIOLOGICAL IMPACTS FOR THE POST-10,000-YEAR PERIOD AFTER CLOSURE

Table 5-4 lists estimated individual doses to the RMEI for the post-10,000-year period in mean, median, and 95th-percentile values. Figure 5-6 shows the mean, median, 5th- and 95th-percentile annual individual doses at the RMEI location up to 1 million years after repository closure. The values in Table 5-4 indicate that, for the post-10,000-year period, the mean and median annual individual doses could be approximately 2.0 millirem and 0.96 millirem, respectively. The estimated median value is about 0.3 percent of the proposed EPA standard, which allows up to a 350-millirem annual committed effective dose equivalent for the post-10,000-year period. In addition, the mean and 95th-percentile values are well below the EPA standard.

The radionuclides that DOE estimated to contribute the most to the mean annual individual dose would be plutonium-242, iodine-129, neptunium-237, radium-226, and technetium-99 (Figure 5-7). The estimated mean annual individual dose at the RMEI location would consist of approximately 30 percent from

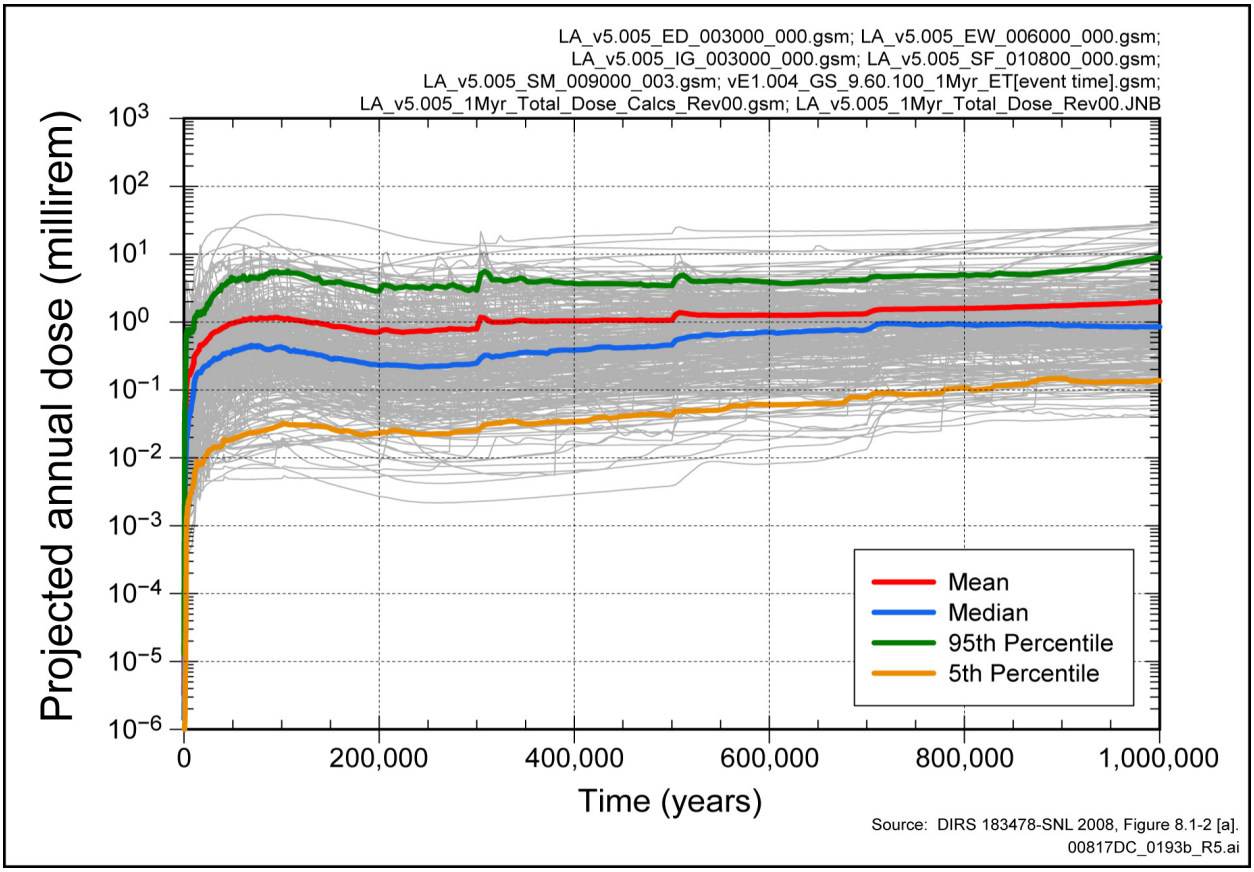

Figure 5-6. Total projected annual dose for the post-10,000-year period—combined scenario classes.

plutonium-242, about 20 percent from each of iodine-129 and neptunium-237, about 15 percent from radium-226, and about 8 percent from technetium-99.

5.6 Atmospheric Radiological Impacts from Other than Volcanic Eruption

The Yucca Mountain FEIS contained an analysis of the radiological impacts of atmospheric release from other than volcanic eruption. There are no changes to the *Proposed Action* that would have a significant effect on *source terms* or release rates. Because the results showed extremely small effects, there would be no significant change to the information the FEIS presented if DOE performed a new analysis. This section summarizes the analysis and results from the FEIS. DOE did not update the results to the new latent cancer fatality conversion factor or the increase in population; these adjustments would have resulted in about a 50-percent increase but would not significantly change the low order of magnitude quantities. DOE has incorporated the more detailed discussion on atmospheric radiological impacts by reference to Appendix I, Section I.7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. I-62 to I-67).

After DOE closed the repository, there would be limited potential for releases to the atmosphere because the waste would be isolated far below the ground surface. Still, the rock is porous and does allow gas to flow. Therefore, in the Yucca Mountain FEIS, DOE analyzed possible airborne releases. In the FEIS, a

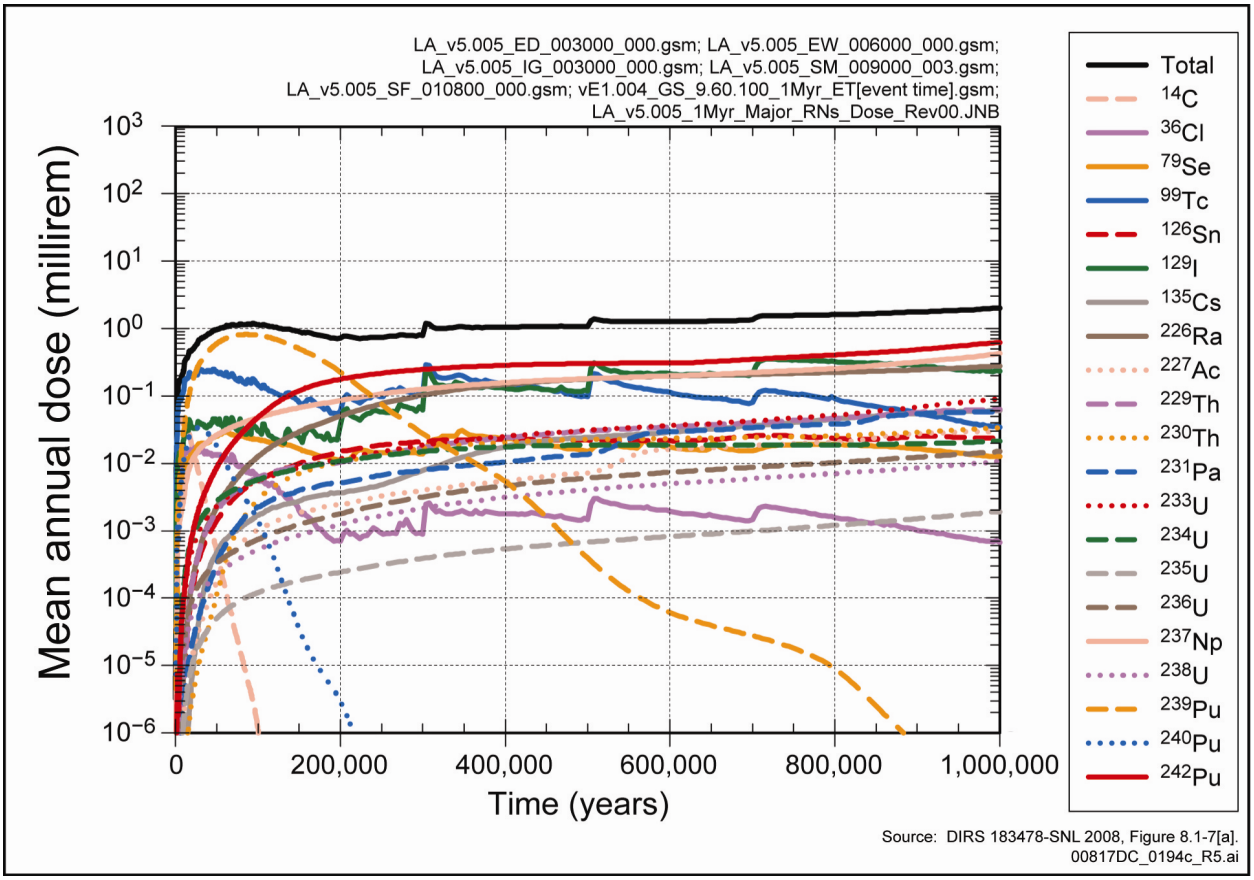

Figure 5-7. Contribution of individual radionuclides to total mean annual dose for the post-10,000-year period—combined scenario classes.

screening analysis showed that a full analysis was necessary only for carbon-14. Iodine-129 can exist in a gas phase, but it is highly soluble and, therefore, would be more likely to dissolve in infiltrating water rather than migrate as a gas. The screening analysis in Appendix I, Section I.3.3 of the FEIS eliminated other gas-phase isotopes (DIRS 155970-DOE 2002, p. I-29), usually because they have short half-lives and are not decay products of long-lived isotopes. Because the radioactive decay constant for radon-222 is 0.18145 per day, radioactive decay would reduce the amount of radon-222 in the air by approximately 90 orders of magnitude to negligible levels in the time it took the air to travel from the repository horizon through 200 meters (700 feet) of overlying rock. Therefore, DOE anticipates no human effects from the atmospheric release of radon-222 in the waste package.

DOE used the GENII program (DIRS 100953-Napier et al. 1988, all) to model human health impacts in the Yucca Mountain FEIS for the population in the 80-kilometer (50-mile) region around the repository. About 2 percent of the carbon-14 in commercial spent nuclear fuel is in a gas phase in the space (or gap) between the fuel and the *cladding* around the fuel (DIRS 103446-Oversby 1987, p. 92). This means that there would be 0.122 *curie* of carbon-14 per waste package of commercial spent nuclear fuel at the time of emplacement.

The Yucca Mountain FEIS reported a maximum 80-kilometer (50-mile) annual population dose on the order of 1×10^{-8} *person-rem*. This dose corresponds to about 1×10^{-12} latent cancer fatality in the regional population during each year at the maximum carbon-14 release rate. This annual population

radiological dose corresponds to a 70-year lifetime radiological population dose on the order of 1×10^{-6} person-rem, which corresponds to about 1×10^{-10} latent cancer fatality during the 70-year period of the maximum release.

The location for airborne releases would depend on wind speed and direction, and the analysis considered it only for those locations where people currently reside (it is not a predetermined location). The analysis showed that the maximum dose to individuals would occur at 24 kilometers (15 miles) south of the repository. For a maximum release rate, the individual maximum radiological dose rate is estimated to be on the order of 1×10^{-13} *rem* per year, which corresponds to about a 1×10^{-17} probability of a latent cancer fatality. The 70-year lifetime dose is estimated to be on the order of 1×10^{-11} rem, which represents about a 1×10^{-15} probability of a latent cancer fatality.

5.7 Impacts from Chemically Toxic Materials

DOE performed an analysis that conservatively assumed a constant rate of release of chemically toxic materials (Appendix F, Section F.5.2.4). The analysis conveyed this release rate directly to the well at the RMEI location and calculated concentrations that ignored any attenuating effects from transport through the groundwater. Table 5-6 summarizes impacts estimated from this analysis. Note that this table does not contain values for chromium because it was screened out (Sections 5.1.2 and 5.2.2). The table lists the bounding well concentrations and compares the resulting intake with the oral reference dose. The oral reference dose is described in the EPA Integrated Risk Information System (DIRS 148228-EPA 199, all). It expresses dose as an intake based on water consumption of 2 liters (0.5 gallon) per day by a 70-kilogram (154-pound) person. The oral reference dose represents a daily exposure that is likely to be without an appreciable risk of deleterious effects during a lifetime. All estimated impacts are below the oral reference dose.

Table 5-6. Estimated impacts and applicable standards for waterborne chemically toxic materials release during 10,000 years after repository closure.

Material	Estimated concentration (milligram per liter)	Intake[a] (milligram per kilogram of body mass per day)	Intake standard: Oral Reference Dose (milligram per kilogram of body mass per day)
Molybdenum	0.042	0.0012	0.005[b]
Nickel	0.19	0.0054	0.02[c]
Vanadium	0.00019	0.0000054	0.007[d]

Source: Appendix F, Section F.5.2.5.
a. Assumes daily intake of 2 liters (0.5 gallon) per day by a 70-kilogram (154-pound) individual.
b. DIRS 148228-EPA 1999, all.
c. DIRS 148229-EPA 1999, all.
d. DIRS 103705-EPA 1997, all

5.8 Impacts from Human Intrusion

This section presents the estimated radiological impacts of a hypothetical Human Intrusion Scenario of inadvertent drilling into the repository. EPA's proposed standard specifies the presentation of the performance assessment for the Human Intrusion Scenario separately; the proposed standard does not include this scenario as part of the TSPA requirements (Section 5.5) for the individual protection standard. The proposed EPA standard for human intrusion, however, parallels the individual protection

standard in that the doses must not exceed the annual dose limits of 15 millirem for the first 10,000 years and 350 millirem for the post-10,000-year period.

5.8.1 HUMAN INTRUSION SCENARIO

DOE used the TSPA-LA model to analyze the radiological impacts of a Human Intrusion Scenario. The scenario assumed an inadvertent drilling into the repository that penetrated a drip shield and waste package and created a direct pathway to the groundwater. The NRC defines the Human Intrusion Scenario, which includes the following drilling event characteristics (10 CFR 63.322):

- There would be a single human intrusion as a result of exploratory drilling for groundwater [10 CFR 63.322(a)].
- The intruders would drill a *borehole* directly through a degraded waste package and into the uppermost aquifer that underlies the repository [10 CFR 63.322(b)].
- The drillers would use the common techniques and practices for exploratory drilling for groundwater in the Yucca Mountain region [10 CFR 63.322(c)].
- Careful sealing of the borehole would not occur; natural degradation processes would gradually modify the borehole [10 CFR 63.322(d)].
- No particulate waste material would fall into the borehole [10 CFR 63.322(e)].
- The exposure scenario includes only radionuclides that water would transport to the saturated zone (for example, water would enter the waste package, release radionuclides, and transport them by way of the borehole to the saturated zone) [10 CFR 63.322(f)].
- No releases would be due to unlikely natural processes and events [10 CFR 63.322(g)]. The regulation defines unlikely natural processes and events as those with a probability of less than 1 chance in 10 and at least 1 chance in 10,000 of occurring in a 10,000-year period (10 CFR 63.342).
- The conceptualization of the drilling event includes vertical transport through the unsaturated zone, horizontal transport along the saturated zone, and then withdrawal at the RMEI location. [10 CFR 63.312(a) through (e) define the RMEI exposure characteristics.]

The EPA standard specifies that the DOE must: (1) determine the earliest time after disposal that a waste package would degrade sufficiently that a drilling intrusion could occur, (2) demonstrate a reasonable expectation that the RMEI would not receive an annual dose of 15 millirem within the first 10,000-year period after closure or 350 millirem within the post-10,000-year period, and (3) perform a consequence analysis that includes all potential environmental pathways of radionuclide transport and exposure (40 CFR 197.25).

To address the first requirement of the human intrusion standard [40 CFR 197.25(a)], DOE performed a detailed technical analysis of the drilling intrusion scenario (DIRS 177432-SNL 2007, Section 6.7). The analysis indicated that an inadvertent penetration of a waste package without recognition by the driller was difficult to envision because of the design of the *engineered barriers* (drip shields and waste

packages). The materials that would be used to fabricate the drip shields and waste packages would have very high strength and resistance to a variety of degradation mechanisms. It is more plausible that the engineered barriers would deflect or divert a borehole that penetrated the repository. Moreover, based on considerations such as drill penetration rates (in rock versus the engineered barriers) and loss of drilling fluids, it is also more plausible that the drillers would recognize the intrusion.

The findings of the detailed analysis notwithstanding, DOE adopted a simple conservative calculational method to estimate the earliest time for drilling intrusion. The Department based the method on the fact that the waste package would be susceptible to drilling once the drip shield failed, which is defined as loss of structural integrity by plate thinning (degradation by corrosion processes) or rupture or puncture (seismic-induced damage). Therefore, if there was a drip shield failure, DOE conservatively assumed that there would be a simultaneous waste package failure and loss of structural integrity such that the driller would not recognize the intrusion.

The features, events, and processes screening analysis concluded that seismic ground motion events would be insufficient to significantly alter the mechanical properties of the drip shield, so that inadvertent intrusion would be noticed by a driller within the first 10,000 years after closure. Therefore, the estimate of time the earliest drip shield failure could occur was based on the time nominal general corrosion would cause the drip shield to fail. The earliest time at which a drip shield could fail was estimated using a very high predicted titanium corrosion rate (0.999 quantile rate for the topside and underside of 75.44 nanometers per year). Using this conservative rate, the first failures of the drip shields due to general corrosion would not occur until approximately 200,000 years after repository closure under nominal conditions (using a drip shield thickness of 15 millimeters (0.6 inch) (DIRS 183478-SNL 2008, Section 8.1.3.1). Based on this analysis, the earliest time after repository closure that a waste package would degrade sufficiently such that a drilling intrusion could occur would be 200,000 years.

5.8.2 HUMAN INTRUSION IMPACTS

To address the second requirement of the human intrusion standard [40 CFR 197.25(b)], DOE conducted a TSPA-LA calculation for the drilling intrusion scenario. The Department used a probabilistic approach analogous to that used to evaluate conformance with the individual protection and groundwater protection standards to evaluate the dose *risk* for the human intrusion standard. It performed dose calculations for all environmental pathways, as 40 CFR 197.25(c) specifies.

Figure 5-8 shows the mean, median, and 5th- and 95th-percentile values for the annual individual doses for the post-10,000-year period that could result from a human intrusion 200,000 years after repository closure for the set of 300 epistemic realizations. The values in Figure 5-8 represent the dose from a single waste package; they are not combinations of releases from other waste packages that would fail due to other processes. The mean and median annual individual doses from human intrusion are estimated to be approximately 0.01 millirem and occur approximately 2,000 years after intrusion (DIRS 183478-SNL 2008, Section 8.1.3.2[a]). These results indicate that the repository would be sufficiently robust and resilient to limit releases from human intrusion to values well below the individual protection standard for human intrusion of 350 millirem of annual individual dose for intrusions in the post-10,000-year period (10 CFR 63.321).

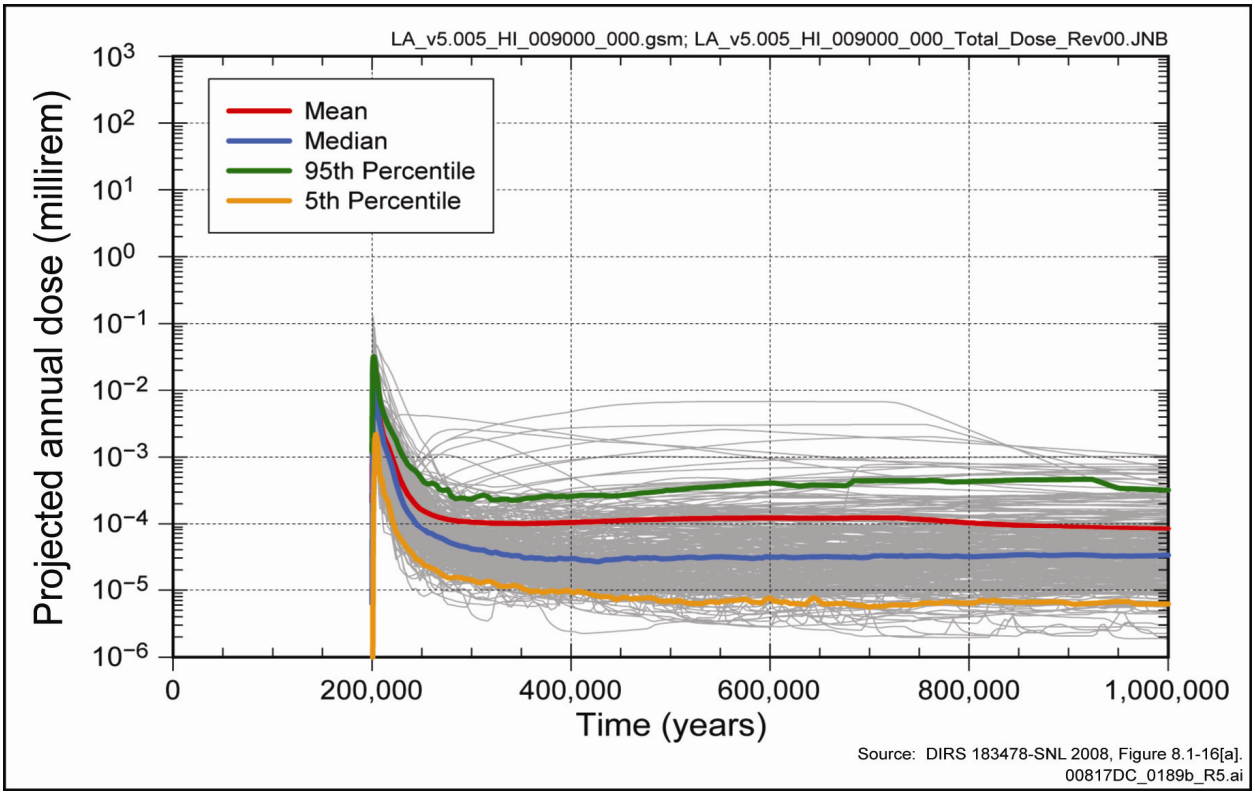

Figure 5-8. Estimated annual individual dose at the RMEI location from human intrusion 200,000 years after repository closure.

5.9 Nuclear Criticality

The Yucca Mountain FEIS contained a detailed discussion of nuclear criticality. Since the completion of the FEIS, there have been no significant changes in the waste package design or contents that would change the nuclear criticality analysis. Further, there has been no new information about the chemistry in the package or host rock environment that suggest changes to the criticality analysis should be made. Therefore, this section summarizes studies of the probability of isolated nuclear criticality events in waste packages and in surrounding rock. It incorporates by reference the more detailed discussion of criticality in Section 5.8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 5-38 to 5-41).

One of the necessary conditions for nuclear criticality is the presence of a moderator such as water. Water could enter the waste package only if the package failed. The combination of natural and engineered barriers would greatly limit the ability of water to enter a specific package; therefore, any configuration of a waste package filled with water is very conservative.

DOE analyzed the probability of internal criticality in commercial spent nuclear fuel packages. The analysis considered factors such as package failure with water entry, loss of *neutron* absorbers, and degradation of internal components that would lead to a loss of internal configuration. The calculated probability of a criticality in the total inventory of the waste packages that contained commercial spent nuclear fuel is estimated to be below the regulatory screening criteria for consideration (that is, less than 1 chance in 10,000 of occurring over 10,000 years) [10 CFR 63 Part 114(d)]. In other words, criticality would not be required to be included in the TSPA model for estimating repository performance.

DOE evaluated the criticality potential of waste packages that would contain high-level radioactive waste glass (which could include immobilized plutonium waste) and certain types of codisposed DOE spent nuclear fuel. The probability of criticality for these fuel types is estimated to be below the regulatory screening criteria for consideration (that is, less than 1 chance in 10,000 of occurring over 10,000 years) [10 CFR 63 Part 114(d)]. In comparison to a waste package for commercial spent nuclear fuel, a DOE spent fuel package would have lower fissile loading and greater flexibility in the use of a neutron absorber.

DOE also evaluated the probability of external criticality. This event, while highly unlikely, could occur if there was a release of enough fissile material from the waste package. The probability of an external criticality in the repository or the rock beneath it after repository closure is estimated to be much less than the regulatory criteria for excluding it from consideration.

DOE analyzed the potential effects of a steady-state criticality on the radionuclide inventory. If a steady-state criticality occurred, it would be unlikely to have a power level greater than 5 kilowatts. As the power level increased, the temperature would rise, which would evaporate any water. Water would be a moderator for neutrons so, as the water evaporated, the power would tend to decrease. In other words, the power would be self-limiting. For a typical commercial spent nuclear fuel waste package, a steady-state criticality would result in an increase of the inventory of certain radionuclides in that waste package. For the conservative duration of 10,000 years, this increase is estimated at less than 30 percent for the radionuclides in that package. DOE evaluated the incremental effect of steady-state criticality events in a single package on the total inventory for the repository, and estimated that the change to the total inventory of the repository would be extremely small.

In the extremely unlikely event that a transient criticality occurred, a rapid initiating event could produce a peak power level of up to 10 megawatts for less than 60 seconds. After this brief period, rapid boiling of the water moderator would shut down the criticality. The short duration would limit the increase in radionuclide inventory to a factor of 100,000 smaller than that of the 10,000-year steady-state criticality. Other impacts of a transient criticality would be a peak temperature of 233°C (451°F) and a peak overpressure of 20 atmospheres. Both conditions would last 10 seconds or less and would be unlikely to cause enough damage to the waste package or change its environment enough to have a significant impact on repository performance.

In the case of autocatalytic criticality, there would have to be such a high concentration of fissile material that there would be an excess of critical mass and high rates of fission could occur before any of the shutdown mechanisms occurred. The result could be a "runaway" *chain reaction*, which could result in a steam explosion or, in the case of a nuclear bomb, a nuclear explosion. Such a configuration is extremely difficult to achieve and requires very deliberate engineering. An autocatalytic criticality is not credible for the proposed repository. Because the igneous rock at Yucca Mountain is unlikely to contain deposits that could efficiently accumulate fissile material, the probability of creating such a critical mass would be so low as to be not credible.

In addition, DOE studied the potential impacts of disruptive natural events, such as seismic activity or igneous intrusion, on the risk of criticality in the repository and concluded that no sufficiently probable mechanisms for the accumulation of a critical mass would occur. In summary, criticality was therefore excluded from the TSPA-LA analysis.

5.10 Impacts to Biological Resources and Soils

DOE considered whether the proposed repository would affect biological resources in the Yucca Mountain vicinity after closure through heating of the ground surface and radiation exposure as the result of radionuclide migration through groundwater to discharge points.

Table 5-7 lists the results of soil temperature analysis for a heat loading of 85 *metric tons of heavy metal* (MTHM) per acre, as analyzed in the Yucca Mountain FEIS. The Proposed Action for this Repository SEIS calls for a heat loading of 57 with a design that accommodates up to 79 MTHM per acre, so the soil temperature changes would be considerably less than those the FEIS analyzed. Therefore, DOE performed no additional analyses for biological resources and soils for the repository design and operational plan modifications made after the completion of the FEIS because DOE would expect the potential impacts to biological resources and soils to be no greater than those the FEIS discussed. This section summarizes and incorporates by reference Section 5.9 of the FEIS, which discussed in detail the postclosure impacts to biological resources and soils (DIRS 155970-DOE 2002, pp. 5-41 to 5-43).

Surface soil temperatures would start to increase about 200 years after repository closure and would peak more than 1,000 years after closure. The temperature would then gradually decline and would approximate prerepository conditions after 10,000 years (DIRS 103618-CRWMS M&O 1999, Figure 4-13). The maximum increase in temperature would occur directly in soils above the repository and would affect approximately 5 square kilometers (1,250 acres). The effects of repository heat on

Table 5-7. Estimated temperature changes of near-surface soils under an 85-MTHM-per-acre thermal load scenario.

	Estimated temperature increase	
Soil depth [meters (feet)]	Dry soil [°C (°F)]	Wet soil [°C (°F)]
0.5 (1.6)	1.5 (2.7)	0.2 (0.36)
1.0 (3.3)	3.0 (5.4)	0.4 (0.72)
2.0 (6.6)	6.0 (10.8)	0.8 (1.4)

Source: DIRS 103618-CRWMS M&O 1999, p. 45.
°C = degrees Celsius.
°F = degrees Fahrenheit.

surface soil temperatures would gradually decline with distance from the repository (DIRS 103618-CRWMS M&O 1999, p. 49). The estimated increase in temperature would extend as far as 500 meters (1,600 feet) beyond the edge of the repository. A shift in the plant species composition, if any, would be limited to the area within 500 meters of the repository footprint [that is, as much as 8 square kilometers (2,000 acres)]. A shift in the plant community probably would lead to localized changes in the animal communities that depended on it for food and shelter.

Impacts to biological resources probably would consist of an increase of heat-tolerant species over the repository and a decrease of less tolerant species. In general, areas that could be affected by repository heating could experience a loss of shrub species and an increase in annual species.

Some reptiles, including the desert tortoise (*Gopherus agassizii)*, exhibit temperature-dependent sex determination (DIRS 103463-Spotila et al. 1994, pp. 103 to 116). Temperature increases of clutches at that depth based on modeling results (DIRS 103618-CRWMS M&O 1999, pp. 44 to 48) would be less than 0.5°C (0.9°F). Given the ranges of critical temperatures that were reported in *Effects of Incubation*

Conditions on Sex Determination, Hatching Success, and Growth of Hatchling Desert Tortoises, Gopherus Agassizii (DIRS 103463-Spotila et al. 1994), an increase of this magnitude would be unlikely to cause adverse effects such as sex determination.

Dose rates to plants and animals are estimated at much less than 100 millirad per day. The International Atomic Energy Agency concluded that chronic dose rates less than 100 millirad per day are unlikely to cause measurable detrimental effects in populations of the more radiosensitive species in terrestrial *ecosystems* (DIRS 103277-IAEA 1992, p. 53).

The desert tortoise is the only threatened or *endangered species* in the *analyzed land withdrawal area* (DIRS 104593-CRWMS M&O 1999, p. 3-14). Desert tortoises are rare or absent on or around playas (DIRS 101914-Rautenstrauch and O'Farrell 1998, pp. 407 to 411; DIRS 103160-Bury and Germano 1994, pp. 64 and 65); therefore, DOE anticipates no impacts to this species from contaminated water resources at Franklin Lake Playa in the future.

Impacts to surface soils would be possible. Changes in the plant community as a result of the presence of the repository could lead to an increase in the amount of rainfall runoff and, therefore, an increase in the erosion of surface soils, which would increase the sediment load in ephemeral surface water in the immediate Yucca Mountain vicinity. The exact secondary impact of this sediment load is undetermined.

5.11 Summary

Impacts from radioactive materials in the waterborne pathway under the Proposed Action would dominate potential postclosure impacts to human health from a repository at Yucca Mountain. Tables 5-4 and 5-5 list estimated impacts from groundwater releases of radionuclides after repository closure. Table 5-4 summarizes the mean, median, and 95th-percentile annual individual doses to the RMEI. The estimated mean annual individual dose of 0.24 millirem at the RMEI location in Table 5-4 is about 2 percent of the limit of the 15-millirem standard in 40 CFR Part 197 for the first 10,000 years after closure. The estimated median annual individual dose of 0.96 millirem for the post-10,000-year period is less than 1 percent of the proposed limit of 350 millirem. Table 5-5 compares concentrations with groundwater protection standards and shows that the concentrations are well below the standard values.

EPA has proposed annual dose limits of 350 millirem to an individual for human intrusion (40 CFR Part 197) if it were to occur after 10,000 years following closure. The estimated mean annual dose from a human intrusion 200,000 years after repository closure is less than 0.01 millirem, or about 0.003 percent of the EPA limit.

As Table 5-6 demonstrates, significant human impacts from chemically toxic materials would be unlikely.

Atmospheric releases of carbon-14 would yield an estimated 80-kilometer (50-mile) population impact on the order of 1×10^{-10} latent cancer fatality (Section 5.6) during the 70-year period of maximum release.

As discussed in Section 5.10, DOE does not anticipate adverse impacts to biological resources from repository heating effects or the migration of radioactive materials.

REFERENCES

155950	BSC 2001	BSC (Bechtel SAIC Company) 2001. *FY 01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses*. TDR-MGR-MD-000007 Rev 00 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010801.0404; MOL.20010712.0062; MOL.20010815.0001.
169734	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Yucca Mountain Site Description.* TDR-CRW-GS-000001 Rev 02 ICN 01. Two volumes. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040504.0008.
169855	BSC 2004	BSC (Bechtel SAIC Company) 2004. *Development of Numerical Grids for UZ Flow and Transport Modeling.* ANL-NBS-HS-000015 Rev 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040901.0001.
103160	Bury & Germano 1994	Bury, R.B. and Germano, D.J., eds. 1994. *Biology of North American Tortoises.* Fish and Wildlife Research Report 13. Washington, D.C.: U.S. Department of the Interior. ACC: MOL.20010803.0373.
100111	CRWMS M&O 1994	CRWMS M&O 1994. *Total System Performance Assessment - 1993: An Evaluation of the Potential Yucca Mountain Repository.* B00000000-01717-2200-00099 Rev 01. Las Vegas, Nevada: CRWMS M&O. ACC: NNA.19940406.0158.
100198	CRWMS M&O 1995	CRWMS M&O 1995. *Total System Performance Assessment - 1995: An Evaluation of the Potential Yucca Mountain Repository.* B00000000-01717-2200-00136 Rev 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960724.0188.
103618	CRWMS M&O 1999	CRWMS M&O 1999. *Impact of Radioactive Waste Heat on Soil Temperatures.* BA0000000-01717-5700-00030 Rev 0. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990309.0403.
104593	CRWMS M&O 1999	CRWMS M&O 1999. *Geology/Hydrology Environmental Baseline File.* B00000000-01717-5700-00027 Rev 01 DCN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990609.0156.
104983	CRWMS M&O 1999	CRWMS M&O 1999. *Geology/Hydrology Environmental Baseline File.* B00000000-01717-5700-00027 Rev 01 DCN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990609.0156.

153246	CRWMS M&O 2000	CRWMS M&O 2000. *Total System Performance Assessment for the Site Recommendation.* TDR-WIS-PA-000001 Rev 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.
100376	Czarnecki 1990	Czarnecki, J.B. 1990. *Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California*. Open-File Report 90-356. Denver, Colorado: U.S. Geological Survey. ACC: NNA.19901015.0195.
100131	D'Agnese et al. 1997	D'Agnese, F.A.; Faunt, C.C.; Turner, A.K.; and Hill, M.C. 1997. *Hydrogeologic Evaluation and Numerical Simulation of the Death Valley Regional Ground-Water Flow System, Nevada and California.* Water-Resources Investigations Report 96-4300. Denver, Colorado: U.S. Geological Survey. ACC: MOL.19980306.0253.
100550	DOE 1998	DOE (U.S. Department of Energy) 1998. *Total System Performance Assessment.* Volume 3 of *Viability Assessment of a Repository at Yucca Mountain.* DOE/RW-0508. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19981007.0030.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
103705	EPA 1997	EPA (U.S. Environmental Protection Agency) 1997. *Health Effects Assessment, Summary Tables, FY-1997 Update.* EPA 540/R-97-036. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010724.0301.
148228	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Molybdenum; CASRN 7439-98-7." IRIS (Integrated Risk Information System). Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0363. URL: http://www.epa.gov/iris/subst/0425.htm

148229	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Nickel, Soluble Salts; CASRN Various." IRIS (Integrated Risk Information System). Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0364. URL: http://www.epa.gov/iris/subst/0271.htm
103277	IAEA 1992	IAEA (International Atomic Energy Agency) 1992. *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards.* Technical Reports Series No. 332. Vienna, Austria: International Atomic Energy Agency. TIC: 243768.
101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP.* ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publication 72. New York, New York: Elsevier. TIC: 255638.
100953	Napier et al. 1988	Napier, B.A.; Peloquin, R.A.; Strenge, D.L.; and Ramsdell, J.V. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System.* Three volumes. PNL-6584. Richland, Washington: Pacific Northwest Laboratory. ACC: NNA.19920626.0034; NNA.19920626.0036; NNA.19920626.0041.
103446	Oversby 1987	Oversby, V.M. 1987. "Spent Fuel as a Waste Form – Data Needs to Allow Long Term Performance Assessment under Repository Disposal Conditions." *Scientific Basis for Nuclear Waste Management X, Symposium held December 1-4, 1986, Boston, Massachusetts.* Bates, J.K. and Seefeldt, W.B., eds. *84,* 87-101. Pittsburgh, Pennsylvania: Materials Research Society. TIC: 203663.
101914	Rautenstrauch and O'Farrell 1998	Rautenstrauch, K.R. and O'Farrell, T.P. 1998. "Relative Abundance of Desert Tortoises on the Nevada Test Site." *Southwestern Naturalist, 43,* (3), 407-411. Lubbock, Texas: Southwestern Association of Naturalists. TIC: 242257.
177424	SNL 2007	SNL (Sandia National Laboratories) 2007. *Radionuclide Screening.* ANL-WIS-MD-000006 Rev 02. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070326.0003.

177432	SNL 2007	SNL (Sandia National Laboratories) 2007. *Number of Waste Packages Hit by Igneous Events.* ANL-MGR-GS-000003 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071002.0001.
178519	SNL 2007	SNL (Sandia National Laboratories) 2007. *General Corrosion and Localized Corrosion of Waste Package Outer Barrier.* ANL-EBS-MD-000003 Rev 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070730.0003; DOC.20070807.0007.
179466	SNL 2007	SNL (Sandia National Laboratories) 2007. *Total System Performance Assessment Data Input Package for Requirements Analysis for Subsurface Facilities.* TDR-TDIP-PA-000001 Rev 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20070921.0007.
179590	SNL 2007	SNL (Sandia National Laboratories) 2007. *Output for ANL-EBS-MD-000049 Multiscale Thermohydrologic Model for the Mean Host-Rock Thermal Conductivity, 10-Percentile Percolation Flux, Collapsed-Drift, High and Low Rubble Thermal Conductivity Cases*. LL0702PA027MST.082. Submittal date: 02/15/2007.
184614	SNL 2007	SNL (Sandia National Laboratories) 2007. *UZ Flow Models and Submodels.* MDL-NBS-HS-000006 Rev 03 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080108.0003; DOC.20080114.0001.
182145	SNL 2008	SNL (Sandia National Laboratories) 2008. *Simulation of Net Infiltration for Present-Day and Potential Future Climates*. MDL-NBS-HS-000023 Rev 01 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080201.0002.
183478	SNL 2008	SNL (Sandia National Laboratories) 2008. *Total System Performance Assessment Model /Analysis for the License Application.* MDL-WIS-PA-000005 Rev 00 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080312.0001.
103463	Spotila et al. 1994	Spotila, J.R.; Zimmerman, L.C.; Binckley, C.A.; Grumbles, J.S.; Rostal, D.C.; List, A., Jr.; Beyer, E.C.; Phillips, K.M.; and Kemp, S.J. 1994. "Effects of Incubation Conditions on Sex Determination, Hatching Success, and Growth of Hatchling Desert Tortoises, Gopherus Agassizii." *Herpetological Monographs,* (8), 103-116. Champaign, Illinois: Herpetologists' League. TIC: 242868.

100191 Wilson et al. 1994 Wilson, M.L.; Gauthier, J.H.; Barnard, R.W.; Barr, G.E.; Dockery, H.A.; Dunn, E.; Eaton, R.R.; Guerin, D.C.; Lu, N.; Martinez, M.J.; Nilson, R.; Rautman, C.A.; Robey, T.H.; Ross, B.; Ryder, E.E.; Schenker, A.R.; Shannon, S.A.; Skinner, L.H.; Halsey, W.G.; Gansemer, J.D.; Lewis, L.C.; Lamont, A.D.; Triay, I.R.; Meijer, A.; and Morris, D.E. 1994. *Total-System Performance Assessment for Yucca Mountain – SNL Second Iteration (TSPA-1993)*. SAND93-2675. Executive Summary and two volumes. Albuquerque, New Mexico: Sandia National Laboratories. ACC: NNA.19940112.0123.

6

Environmental Impacts of Transportation

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6. ENVIRONMENTAL IMPACTS OF TRANSPORTATION

The U.S. Department of Energy (DOE or the Department) completed the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) in February 2002. In the Yucca Mountain FEIS, DOE evaluated two national transportation scenarios, referred to as the mostly legal-weight truck scenario and the mostly rail scenario, and three Nevada transportation *alternatives*—shipment by legal-weight truck, by rail, and by *heavy-haul truck*. After DOE completed the FEIS in 2002, it issued a Record of Decision that selected the mostly rail scenario for the transportation of *spent nuclear fuel* and high-level *radioactive* waste to the proposed *repository* (69 FR 18557, April 8, 2004). Since completing the FEIS, DOE has continued to develop the repository design and associated operational plans. The Department now plans to operate the repository with the use of a *primarily canistered approach* that calls for the packaging of most *commercial spent nuclear fuel* at the commercial sites in *transportation, aging, and disposal* (TAD) *canisters* and most DOE materials in *disposable canisters* at the DOE sites.

DOE has prepared this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS) to evaluate the potential environmental *impacts* of the repository design and operational plans. This chapter describes the potential environmental impacts of the transportation of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the *Yucca Mountain site* under the mostly rail scenario.

DOE has assessed potential transportation impacts of the *Proposed Action*, which include all activities necessary to transport spent nuclear fuel and high-level radioactive waste, from loading at the commercial and DOE sites to delivery at the proposed repository. Most, but possibly not all, rail shipments to the repository would use *dedicated trains* (see Section 2.1) (DIRS 182833-Golan 2005, all). Two examples of when DOE would use trucks include (1) shipments from generator sites that cannot handle rail *casks* would use trucks to transport truck casks to the repository, and (2) shipments from generator sites that can handle rail casks but that lack rail access would use heavy-haul trucks or barges to carry rail casks to nearby railheads for shipment to the repository.

The decision to ship most spent nuclear fuel and high-level radioactive waste to the repository by rail would require construction of a *railroad* in Nevada. In the Rail Alignment EIS, DOE considers *alignments* for the *construction* and *operation* of a *railroad* in the Caliente and Mina *rail corridors*. Therefore, in this Repository SEIS, national rail routes from the generator sites to the repository would connect to the new DOE railroad at one of two locations in Nevada—Caliente or Hawthorne. Routes that connected in the Caliente area would continue to the repository on a railroad that DOE would construct in the Caliente rail *corridor*. Routes that connected in the Hawthorne area would continue to the repository on a DOE-built railroad in the Mina rail corridor.

Section 6.1 summarizes changes reflected in the impacts presented in this Repository SEIS chapter from the methods and data DOE used in the Yucca Mountain FEIS to evaluate transportation impacts. Section 6.2 summarizes the impacts from loading operations at the generator sites. Section 6.3 summarizes the impacts of national transportation of spent nuclear fuel and high-level radioactive waste from the 72 commercial and 4 DOE sites to Yucca Mountain. Section 6.4 summarizes and incorporates by reference Chapter 4 of the Rail Alignment EIS. Chapter 4 of the Rail Alignment EIS discusses the

impacts of transportation in Nevada and discusses the impacts of the construction and operation of a railroad in the Caliente or Mina rail corridor. Section 6.4 also discusses the impacts of the transportation of materials and personnel for the construction and operation of the repository, which would include workers, construction materials, *waste packages*, and *drip shields.*

Chapter 8 discusses the *cumulative impacts* related to the transportation activities described in this chapter. The following appendices present further information and analyses on the transportation of spent nuclear fuel and high-level radioactive waste:

- Appendix A presents sensitivity analyses related to transportation activities,
- Appendix G contains details on methods and data DOE used to evaluate transportation impacts, and
- Appendix H provides information that could help readers understand the subject of nuclear waste transportation and lists regulations related to the transportation of spent nuclear fuel and high-level radioactive waste.

6.1 Changes since Completion of the Yucca Mountain FEIS

Since it completed the Yucca Mountain FEIS, DOE has acquired new information and analytical tools to estimate the potential impacts associated with transportation of spent nuclear fuel and high-level radioactive waste. There have also been changes to some of the data DOE used to estimate *radiation* doses and radiological impacts. The following sections describe the changes that most affect the estimates of potential impacts.

6.1.1 LATENT CANCER FATALITY CONVERSION FACTORS

In the Yucca Mountain FEIS, DOE based the estimates of *latent cancer fatalities* on the received radiation *dose* and on radiation dose-to-health effect conversion factors from International Commission on Radiological Protection Publication 60 (DIRS 101836-ICRP 1991, all). The Commission estimated that, for the general population, a collective radiation dose of 1 *person-rem* would yield 0.0005 excess latent *cancer* fatality. For radiation workers, a collective radiation dose of 1 person-rem would yield an estimated 0.0004 excess latent cancer fatality.

Since the completion of the Yucca Mountain FEIS, the Interagency Steering Committee on Radiation Standards has updated its recommended radiation dose-to-health effect conversion factors (DIRS 174559-Lawrence 2002, p. 2). The recommended conversion factor is 0.0006 excess latent cancer fatality per person-rem for workers and the general population (DIRS 174559-Lawrence 2002, p. 2); DOE has used this factor in this Repository SEIS to estimate the number of latent cancer fatalities.

For workers, an increase in the radiation dose-to-health effect conversion factor from 0.0004 to 0.0006 excess latent cancer fatality per person-rem increases the estimates of radiological impacts by 50 percent. For the general population, an increase in the conversion factor from 0.0005 to 0.0006 excess latent cancer fatality per person-rem increases the estimates of radiological impacts by 20 percent.

6.1.2 RADIATION DOSIMETRY

Releases of radioactive material into the *environment* can affect persons who come in contact with it. Mechanisms for transport of radioactive material include air, water, soil, and food. The ways an individual or population can come into contact with radioactive material are known as *exposure pathways*. DOE evaluated five pathways in the Yucca Mountain FEIS:

- Inhalation of radioactive material,
- Ingestion of radioactive material,
- Inhalation of previously deposited radioactive material resuspended from the ground (*resuspension*),
- External *exposure* to radioactive material deposited on the ground (*groundshine*), and
- External exposure to radioactive material in the air (*immersion* or *cloudshine*).

Dose coefficients are the factors used to convert estimates of *radionuclide* intake (by inhalation or ingestion) or exposure (by groundshine or immersion) to a radiation dose. In the Yucca Mountain FEIS, DOE used the inhalation and ingestion dose coefficients from Federal Guidance Report No. 11 (DIRS 101069-Eckerman et al. 1988, all) and the groundshine and immersion dose coefficients from Federal Guidance Report No. 12 (DIRS 107684-Eckerman and Ryman 1993, all). These dose coefficients are based on recommendations in International Commission on Radiological Protection Publication 26 (DIRS 101075-ICRP 1977, all).

The International Commission on Radiological Protection has updated its recommended dose coefficients. In this Repository SEIS, DOE uses the updated inhalation and ingestion dose coefficients from *The ICRP Database of Dose Coefficients: Workers and Members of the Public* (DIRS 172935-ICRP 2001, all) and the updated groundshine and immersion dose coefficients from *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides* (DIRS 175544-EPA 2002, all) to estimate the radiation doses from transportation *accidents*. These dose coefficients are based on the recommendations in International Commission on Radiological Protection Publication 60 (DIRS 101836-ICRP 1991, all) and incorporate the dose coefficients from International Commission on Radiological Protection Publication 72 (DIRS 152446-ICRP 1996, all).

6.1.3 ADDITIONAL ESCORTS

In the Yucca Mountain FEIS, DOE based the estimates of transportation impacts on one escort in rural areas and two escorts in urban and suburban areas. In this Repository SEIS, the Department based estimates of transportation impacts on additional escorts in all areas (urban, suburban, and rural). DOE considers these escorts to be workers, and the presence of additional workers increases the estimates of transportation impacts.

6.1.4 DEDICATED TRAINS

This Repository SEIS reflects DOE's policy to use dedicated trains for most shipments (DIRS 182833-Golan 2005, all). For commercial spent nuclear fuel, the Department based transportation impacts on three casks per train. For *DOE spent nuclear fuel* and high-level radioactive waste, it based transportation impacts on five casks per train. In both cases, the trains would include two *buffer cars*, two locomotives, and one *escort car*. In the Yucca Mountain FEIS, DOE based impacts on the use of general freight trains with one escort car and one cask car in each shipment; the buffer cars would be the other cars in a general

freight train. In general, the use of dedicated trains would reduce the impacts to members of the public because there would be fewer delays in rail yards. The only significant source of radiation exposure for escorts would be from the last cask in the train. Therefore, impacts to escorts would generally be smaller because there would be more casks in a single train rather than one cask per train. Nonradiological impacts would be greater because estimates of impacts would account for all railcars in the train (locomotives, buffer cars, cask cars, and escort cars), not just the cask cars and the escort cars.

6.1.5 AVAILABILITY OF 2000 CENSUS POPULATION DENSITY DATA AND UPDATED RAIL AND TRUCK TRANSPORTATION NETWORKS

In the Yucca Mountain FEIS, DOE used the HIGHWAY and INTERLINE computer programs to determine representative transportation routes to the repository (DIRS 104780-Johnson et al. 1993, all; DIRS 104781-Johnson et al. 1993, all) and based transportation impacts on census data it extrapolated to 2035. The TRAGIS computer program (DIRS 181276-Johnson and Michelhaugh 2003, all) has replaced HIGHWAY and INTERLINE.

USE OF REPRESENTATIVE ROUTES IN IMPACT ANALYSIS

At this time, before receipt of a construction authorization for the repository and years before a possible first shipment, DOE has not identified the actual routes it would use to ship spent nuclear fuel and high-level radioactive waste to Yucca Mountain. However, the highway and rail routes that DOE used for analysis in this Repository SEIS are representative of routes that it could use. The highway routes conform to U.S. Department of Transportation regulations (49 CFR 397.101). These regulations, which the Department of Transportation developed for Highway Route-Controlled Quantities of Radioactive Materials, require such shipments to use preferred routes that would reduce the time in transit. A preferred route is an Interstate System highway, bypass, beltway, or an alternative route designated by a state routing agency. Alternative routes can be designated by states and tribes under U.S. Department of Transportation regulations (49 CFR 397.103) that require consideration of the overall risk to the public and prior consultation with local jurisdictions and other states. Federal regulations do not restrict the routing of spent nuclear fuel and high-level radioactive waste shipments by rail. However, for this analysis and to be consistent with rail industry practice, DOE assumed routes for rail shipments by giving priority to the use of rail lines that have the most rail traffic (which are the best maintained and have the highest quality track), giving priority to originating railroads, minimizing the number of interchanges between railroads, and minimizing the travel distance.

For this Repository SEIS, DOE used the TRAGIS computer program (DIRS 181276-Johnson and Michelhaugh 2003, all) to determine representative transportation routes to the repository. The Department used 2000 Census data to estimate population densities along the routes. The projected start date for repository *operations* would be 2017. Because the analysis considered that the repository would operate for 50 years, DOE extrapolated population densities along the routes from 2000 to 2067. The Department used a two-step process to do this; it used (1) Bureau of the Census population estimates for 2000 through 2030 and (2) population estimates for 2026 through 2030 to extrapolate population densities for 2031 to 2067. In Nevada, DOE used the *Regional Economic Model, Inc.* (REMI) computer model and data from the Nevada State Demographer to extrapolate population densities.

For this Repository SEIS, DOE evaluated the impacts of severe transportation accidents and sabotage *events* for an urban area. The Department based the population density in this urban area on the

population densities in the 20 most populous urban areas with the use of 2000 Census data. The 2000 Census data do not include Las Vegas, Nevada, among the 20 most populous urban areas. Therefore, DOE included the Las Vegas resident and tourist populations in the urban population density. Because the analysis considered that the repository would operate for 50 years, DOE extrapolated the population density in this urban area to 2067.

6.1.6 OVERWEIGHT TRUCKS

In the Yucca Mountain FEIS, DOE estimated that the trucks that carried truck casks would have gross vehicle weights less than 80,000 pounds (36,300 kilograms) and were therefore "legal weight" (23 CFR 658.17). DOE has determined that trucks that carried truck casks would be more likely to have gross vehicle weights in the range of 36,300 to 52,200 kilograms (80,000 to 115,000 pounds). Events that could cause the weight of the truck to exceed 36,300 kilograms include adding non-fuel-bearing components to the payload, weight growth during design and fabrication of the tractor-trailer, tractor or trailer modifications after testing, and regulatory requirements that increase the weight of tractors (DIRS 185236-Hill et al. 1993, p. 286). Figures 6-0a and 6-0b illustrate a legal-weight truck and an overweight truck, respectively. As can be seen in Figure 6-0b, the length of the *overweight truck* would likely be in the range of 17.4 to 18.3 meters (57 to 60 feet), while the length of the legal-weight truck would be about 17.1 meters (56 feet) (Figure 6-0a).

These overweight trucks are not the same as the heavy-haul trucks that DOE would use to transport rail casks from commercial generator sites to nearby railheads. These heavy-haul trucks would have gross vehicle weights of as much as 227,000 kilograms (500,000 pounds), and their impacts would differ from the impacts of overweight or legal-weight trucks. Figure 6-0c illustrates a heavy-haul truck transporting a rail cask. As can be seen in Figure 6-0c, the length of the heavy-haul truck would be about 67.1 meters (220 feet).

Trucks with gross vehicle weights that exceeded 36,300 kilograms (80,000 pounds) would be overweight and would be subject to the permitting requirements in each state through which they traveled. Permit requirements typically address such matters as the time of day when overweight trucks can travel and whether they can travel on holidays and weekends. Seasonal frost restrictions might apply in some areas.

DOE has previously studied a marginally overweight truck operating scenario (DIRS 185236-Hill et al. 1993, all). In this study, DOE defined a marginally overweight truck as a truck that exceeded the gross vehicle weight limit of 36,300 kilograms (80,000 pounds) but weighed less than 43,500 kilograms (96,000 pounds) that followed axle and axle group weight limits from the *Surface Transportation Assistance Act of 1982* (Public Law 97-424, 96 Stat. 2097) and conformed to dimensional restrictions to operate on most major highways and the Federal Bridge Formula (which relates to the number of axles, axle and axle group spacing, and the weight on axles and axle groups). This study found that overweight truck shipments would be more complex because states independently set policy and regulations for such shipments.

DOE's marginally overweight truck study (DIRS 185236-Hill et al. 1993, p. 290) found that the design, features, and overall performance of the vehicle would affect driver recruitment and retention. The driver's work environment (the vehicle) could affect employee satisfaction, safety, or equipment

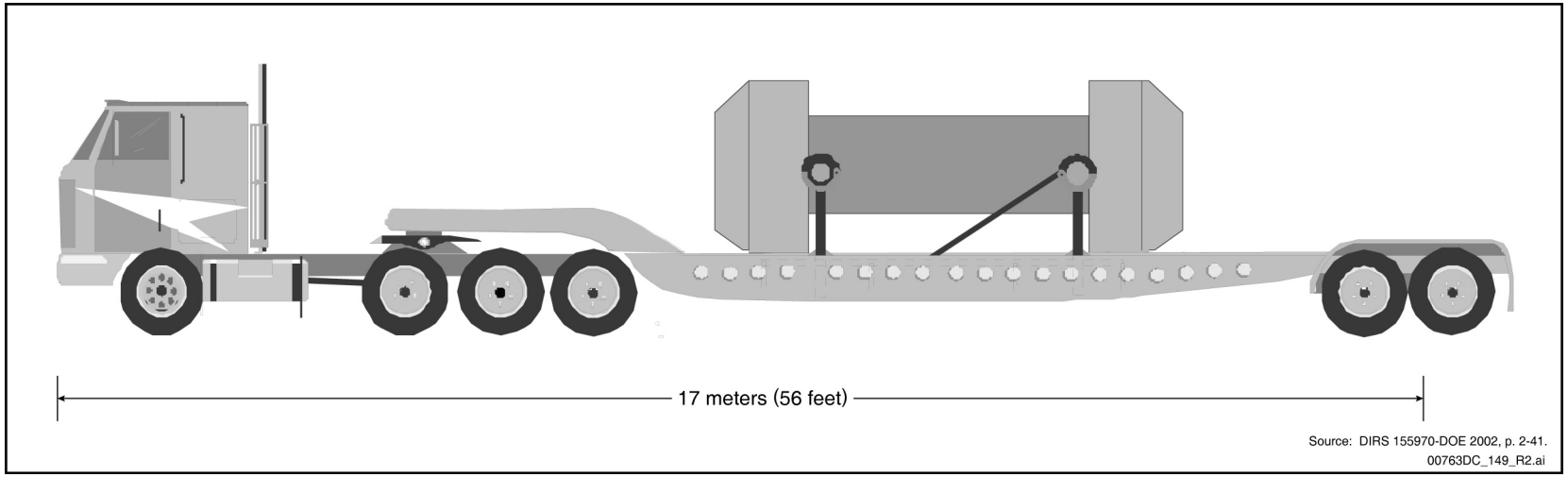


Figure 6-0a. Truck cask on a legal-weight tractor-trailer truck.

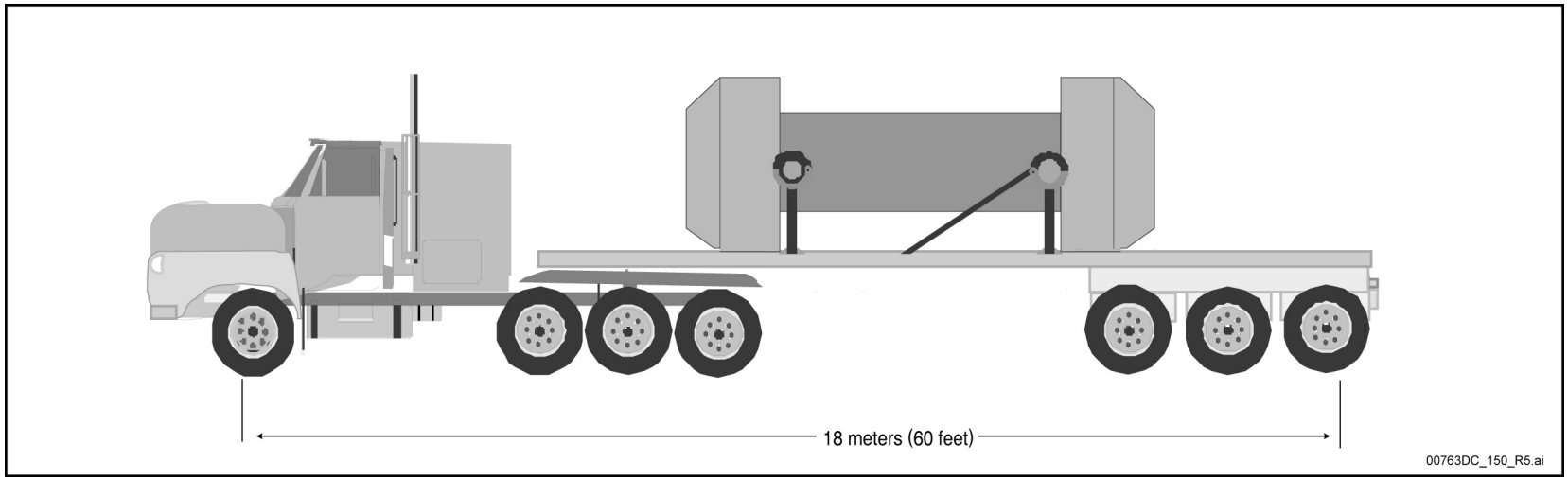
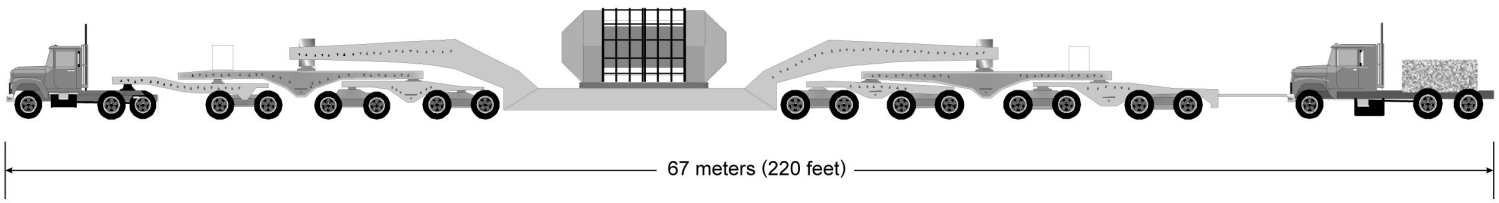


Figure 6-0b. Marginally overweight vehicle concept .



Source: DIRS 104782-Kelderhouse (1999, p. 2).
00763DC_157.ai

Figure 6-0c. Heavy-haul truck transporting a rail cask.

reliability. Adding weight to the tractor would increase the feasibility of adding options to improve the work environment (for example, more powerful engine, larger sleeper berth). The study (DIRS 185236-Hill et al. 1993, p. 290) also examined the worker radiation exposure from overweight truck shipments and found that they would result in 13 percent less radiation exposure for workers than legal-weight trucks. However, another study found 12 percent higher radiation doses because of increased restrictions on travel that slightly increased the transport times and associated doses (DIRS 101747-Schneider et al. 1987, pp. 5.5 and 5.6). Based on these two studies, it is likely that the radiation doses from overweight truck shipments would be similar to the radiation doses for legal-weight trucks.

Cask behavior in a truck accident environment has been analyzed for legal-weight trucks, and because DOE would use the same cask for both the overweight and legal-weight truck transport, there should be no effect on the accident severity distribution (consequence of the crash) in relation to the cask size and weight. After an accident, recovery of an overweight truck would be expected to use equipment similar, if not identical, to that for recovery of a legal-weight truck.

6.1.7 SHIPMENT ESTIMATES

DOE has developed updated estimates of shipments that incorporate the use of TAD *canisters* at each commercial *reactor* site. The Department based shipment estimates on 90 percent [by *metric tons of heavy metal* (MTHM)] of the commercial spent nuclear fuel being shipped in rail casks that contained TAD canisters. Shipment of the remaining 10 percent of the commercial spent nuclear fuel would be in rail casks that contained other types of canisters such as *dual-purpose canisters* or as *uncanistered spent nuclear fuel* in truck casks. Appendix A, Section A.2 also evaluates shipment estimates based on 75 percent of commercial spent nuclear fuel shipments in rail casks that contained TAD canisters.

These new estimates project the shipment of approximately 9,500 rail casks and 2,700 truck casks of spent nuclear fuel and high-level radioactive waste to the repository (DIRS 181377-BSC 2007, all). Shipment of 9,500 rail casks would require about 2,800 trains. The increase in estimated truck shipments over that analyzed in the Yucca Mountain FEIS was primarily a result of using recent data regarding the handling capabilities at the generator sites.

6.1.8 RADIONUCLIDE INVENTORIES

Appendix A of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. A-1 to A-71) provided the basis for the radionuclide inventory that DOE used in the transportation analysis in the FEIS (DIRS 155970-DOE 2002, Chapter 6 and Appendix J). Since the completion of the FEIS, the Department has updated these inventories through additional data collection and analyses:

- The radionuclide inventory for DOE spent nuclear fuel, to incorporate the inventories from *Source Term Estimates for DOE Spent Nuclear Fuels* (DIRS 169354-DOE 2004, all), and

- The radionuclide inventory for high-level radioactive waste, to incorporate the inventories from *Recommended Values for HLW Glass for Consistent Usage on the Yucca Mountain Project* (DIRS 184907-BSC 2008, all).

DOE has updated the radionuclide inventory for commercial spent nuclear fuel to incorporate the inventories from *Characteristics for the Representative Commercial Spent Nuclear Fuel Assembly for*

Preclosure Normal Operations (DIRS 180185-BSC 2007, all), in which the representative *pressurized-water-reactor* spent nuclear *fuel assembly* had a burnup of 50,000 megawatt-days per MTHM (DIRS 180185-BSC 2007, p. 47). In this Repository SEIS, DOE increased the burnup of the representative pressurized-water-reactor spent nuclear fuel assembly from 50,000 to 60,000 megawatt-days per MTHM and reduced the enrichment from 4.2 percent to 4.0 percent. This is the same burnup as the representative pressurized-water-reactor spent nuclear fuel assembly that DOE used for repository *shielding* and waste package design (DIRS 161120-BSC 2002, Section 5.5.2) and yields slightly higher estimates of impacts than the spent nuclear fuel used for *preclosure* normal operations or the spent nuclear fuel DOE used in the Yucca Mountain FEIS. Table 6-1 lists the characteristics of the representative pressurized- and *boiling-water-reactor* spent nuclear fuel that DOE analyzed for the Yucca Mountain FEIS and for this Repository SEIS. Appendix G, Section G.4 contains radionuclide inventories for commercial and DOE spent nuclear fuel and high-level radioactive waste.

Table 6-1. Characteristics of representative spent nuclear fuel.

	Yucca Mountain FEIS[a]		Repository SEIS[b]	
Characteristic	PWR spent nuclear fuel	BWR spent nuclear fuel	PWR spent nuclear fuel	BWR spent nuclear fuel
Burnup (MWd/MTHM)	50,000	40,000	60,000	50,000
Enrichment (weight percent)	4.3	3.5	4.0	4.0
Decay time (years)	15	14	10	10

a. DIRS 155970-DOE 2002, pp. A-21 and A-22.
b. DIRS 180185-BSC 2007, p. 47, with burnup increased from 50,000 MWd/MTHM and enrichment reduced from 4.2 percent to 4.0 percent.

BWR = Boiling-water reactor.
FEIS = Final environmental impact statement.
MTHM = Metric ton of heavy metal.
MWd = Megawatt-day.
PWR = Pressurized-water reactor.
SEIS = Supplemental environmental impact statement.

6.1.9 TRUCK AND RAIL ACCIDENT RATE AND FATALITY RATE DATA

In the Yucca Mountain FEIS, DOE used state-specific accident and fatality rate data for 1994 to 1996 (DIRS 103455-Saricks and Tompkins 1999, all) to estimate transportation impacts. For trucks, the FEIS used accident and fatality rate data from the U.S. Department of Transportation, Federal Motor Carrier Safety Administration's Motor Carrier Management Information System. Since completion of the FEIS, the Federal Motor Carrier Safety Administration has evaluated the data in the Motor Carrier Management Information System. For 1994 through 1996, it found that accidents were underreported by about 39 percent and fatalities were underreported by about 36 percent (DIRS 181755-UMTRI 2003, Table 1, p. 4, and Table 2, p. 6). Therefore, in this Repository SEIS, DOE increased the state-specific truck accident and fatalities rates by factors of 1.64 and 1.57, respectively, to account for the underreporting.

In this Repository SEIS, DOE updated rail accident rates to reflect data from 1995 to 1999 and estimated these rates from data for Class 3 track (DIRS 180220-Bendixen and Facanha 2007all). Higher classes of track have lower accident rates, and the use of Class 3 track is conservative if the track is actually rated higher (Class 4 or 5). DOE anticipates that most of the distance rail shipments would travel would be on higher classes of track.

Because DOE has adopted a policy to use dedicated trains that it expects would contain 8 to 10 cars on average for most shipments to the repository, this Repository SEIS uses a combination of rail accident rates based on both train kilometers and railcar kilometers to estimate rail accident *risks*. DOE also

updated rail fatality rates to reflect data from 2000 to 2004 (DIRS 178016-DOT 2005, all). These fatality rates were in terms of fatalities per railcar kilometer.

6.1.10 SHIPPING PERIOD AND REPOSITORY OPERATIONAL PERIOD

In the Yucca Mountain FEIS, DOE based transportation impacts on shipments of 70,000 MTHM of spent nuclear fuel and high-level radioactive waste to the repository over 24 years. Because the repository could operate for up to 50 years, in this Repository SEIS the Department based transportation impacts on the shipment of the same amount of spent nuclear fuel and high-level radioactive waste over a period of up to 50 years that would start in 2017 and end in 2067.

6.1.11 SABOTAGE RELEASE FRACTIONS

In the Yucca Mountain FEIS, DOE referred to *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* for estimates of the fraction of spent nuclear fuel materials that a sabotage event could release (*release fractions*) (DIRS 104918-Luna et al. 1999, all) to estimate the impacts of possible sabotage events that involved spent nuclear fuel in truck or rail casks. In this Repository SEIS, the Department used more recent estimates of release fractions from *Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack* (DIRS 181279-Luna 2006, all) to estimate the impacts of such events that involved spent nuclear fuel in truck or rail casks. The more recent estimates of release fractions (DIRS 181279-Luna 2006, all) are based on the release fractions in *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all), but incorporated data from additional tests sponsored by *Gesellschaft für Anlagen - und Reaktorsicherheit* in Germany and conducted in France in 1994 that were not available for the earlier report. The information the German investigators provided was useful because the fuel pins used in the tests were pressurized to simulate the gas pressure in commercial spent nuclear fuel pins. As a consequence, these tests provided additional information that had not yet been considered and that allowed a determination of the effects of aerosol blowdown from pin-plenum gas release after a breach of the fuel pin *cladding*. These additional test data suggest that the consequences of a sabotage event in the Yucca Mountain FEIS could be overstated by a factor of between 2.5 and 12.

6.2 Impacts from Loading Activities at Generator Sites

In the Yucca Mountain FEIS, the impacts from loading activities at the generator sites were limited to placement of spent nuclear fuel into rail or truck casks; most of the commercial spent nuclear fuel was not placed in canisters before shipment. In this Repository SEIS, most commercial spent nuclear fuel would be placed in TAD canisters before shipment in rail casks, and the impacts from loading activities would include the impacts from loading these canisters. Chapter 8 addresses the impacts of loading commercial spent nuclear fuel into dual-purpose canisters as cumulative impacts. The impacts from storing commercial or DOE spent nuclear fuel or high-level radioactive waste are also addressed as cumulative impacts in Chapter 8 of this SEIS.

For rail shipments of commercial spent nuclear fuel from the generator sites, loading operations would include placement of the spent nuclear fuel into TAD canisters, placement of the TAD or other types of canisters into a rail *transportation cask*, and placement of the transportation cask on a railcar or heavy-haul truck. For truck shipments of commercial spent nuclear fuel, the generator sites would place uncanistered spent nuclear fuel in a truck transportation cask and place the truck cask on a truck trailer.

DOE would load its spent nuclear fuel and high-level radioactive waste into disposable canisters at the four DOE sites. Therefore, loading operations at the DOE sites would consist of placement of the canisters into a rail transportation cask and placement of the transportation cask on a railcar. DOE would also load a small amount of uncanistered commercial spent nuclear fuel into truck casks at the DOE sites.

This section summarizes the potential impacts to workers and members of the public of loading of spent nuclear fuel into TAD canisters, loading the TAD and other canisters into transportation casks, and loading the transportation casks onto transportation vehicles at the 72 commercial sites. It includes the potential impacts to workers and members of the public of loading canisters that contained DOE spent nuclear fuel and high-level radioactive waste into transportation casks and loading the casks onto transport vehicles at the four DOE sites.

6.2.1 TRANSPORTATION OF CANISTERS TO GENERATOR SITES

DOE would operate the repository with the use of a primarily canistered approach in which most commercial spent nuclear fuel would be packaged at the generator sites into TAD or other types of canisters. This would require shipment of about 6,500 empty TAD canisters to the commercial generator sites. These shipments of empty canisters would be made by truck. About 1,000 additional empty TAD canisters would be shipped directly to the repository to package commercial spent nuclear fuel that could not be shipped from the generator sites using rail casks. The impacts of shipping these 1,000 empty TAD canisters to the repository were included in Section 6.4.2. Prior to the loading of a truck or rail transportation cask, equipment used in the handling and loading of the cask, known as a campaign kit, would also be shipped to the generator sites. There would be about 4,900 of these shipments, which would be by truck.

The shipments of canisters would not be radioactive material shipments, so there would be no radiation dose to the public or to workers from the shipments. The campaign kits could become contaminated during use, but would be decontaminated before shipment. Therefore, the radiation dose and radiological risks of the shipment of campaign kits would be negligible.

DOE based the estimates of the number of traffic fatalities that would result from these shipments on fatality rates for 2001 through 2005 for trucks (DIRS 182082-FMCSA 2007, Table 13) and based the estimates of the number of vehicle emission fatalities that would result from these shipments on a unit risk factor of 1.5×10^{-11} fatality per kilometer per person per square kilometer (9.3×10^{-12} fatality per mile per person per square mile) (DIRS 157144-Jason Technologies 2001, p. 98). The impacts from shipping the canisters or campaign kits were based on shipping the canisters or campaign kits a distance of 3,000 kilometers (1,900 miles).

DOE estimated that a total of 1.2 traffic fatalities and about 0.23 fatality from vehicle emissions would result from the shipment of the canisters and campaign kits.

6.2.2 RADIOLOGICAL IMPACTS TO THE PUBLIC FROM LOADING AT GENERATOR SITES

Radiation doses to members of the public near generator sites could occur due to the venting of radioactive gases during the handling of spent nuclear fuel in spent fuel pools and dry transfer casks. The estimated *population dose* to members of the public within 16 kilometers (10 miles) of the generator sites

would be 2.9 person-rem over the duration of loading operations (DIRS 104794-CRWMS M&O 1994, p. 3-7). The *probability* of a latent cancer fatality based on the estimated dose would be 0.0017, or about 1 chance in 600 that one member of the exposed population would develop a latent cancer fatality. The estimated radiation dose to the *maximally exposed individual* 800 meters (0.5 mile) from the generator site would be 7.7×10^{-6} *rem* (DIRS 104794-CRWMS M&O 1994, p. 3-6). The estimated probability of a latent cancer fatality for this individual would be 4.6×10^{-9} or about 1 chance in 200 million.

6.2.3 RADIOLOGICAL IMPACTS TO WORKERS FROM LOADING AT GENERATOR SITES

At commercial generator sites, impacts to *involved workers* would result from loading of spent nuclear fuel into canisters, loading of canisters into rail transportation casks and, at some sites, loading of spent nuclear fuel into truck casks. For DOE spent nuclear fuel and high-level radioactive waste, impacts would result from loading of canisters that contained these materials into rail transportation casks and a small amount of uncanistered commercial spent nuclear fuel into truck casks.

For the loading of spent nuclear fuel into canisters at commercial generator sites, DOE based radiation doses on utility data compiled by the U.S. Nuclear Regulatory Commission (NRC) for the loading of 87 *dry storage* canisters at four commercial sites (DIRS 181757-NRC 2002, Attachment 3; DIRS 181758-Spitzberg 2004, Attachment 2; DIRS 181759-Spitzberg 2005, Attachment 2; DIRS 181760-Spitzberg 2005, Attachment 2).

Lifetime Dose to the Maximally Exposed Worker

The lifetime radiation exposure for the maximally exposed individual worker is estimated to be 25 rem based on the assumption that he or she would receive an annual administrative limit of 500 millirem for a 50-year working life. The use of the maximum annual results based on the administrative dose limit of 500 millirem would tend to overestimate the actual exposure of the maximally exposed individual worker, even assuming that the worker remained in the same job for 50 years, which is unlikely.

Industry experience indicates that the worker radiation doses will be much lower. For example, Progress Energy has conducted a total of 210 shipments, which includes 375 casks and 5,205 spent fuel assemblies. All shipments were conducted by rail using IF-300 casks (DIRS 185461-Edwards 2008, all). Forty-four of those shipments were from the Robinson Plant to the Brunswick Plant. Thirty-seven shipments were from the Robinson Plant to the Harris Plant. One hundred twenty-nine shipments were from the Brunswick Plant to the Harris Plant. During these shipments, all shipment escorts, train crew, and passengers were monitored for radiation exposure using thermoluminescent dosimeters. Dose rates at 2 meters from the cask were measured at less than 2 millirem per hour, and during these shipments there was zero recordable radiation dose to escorts, crew, and passengers. The collective radiation dose for crews loading, unloading, and decontaminating the casks at the shipping and receiving plants is generally less than 0.250 person-rem for a shipment, which includes the combined dose for all workers supporting the shipping and receiving plants.

DOE used data from *Health and Safety Impacts Analysis for the Multi-Purpose Canister System and Alternatives* (DIRS 104794-CRWMS M&O 1994, pp. A-9 and A-24) to estimate radiation doses for the loading of (1) canisters that contained commercial spent nuclear fuel into rail casks and uncanistered spent nuclear fuel assemblies into truck casks, (2) canisters that contained high-level radioactive waste or DOE spent nuclear fuel into rail casks, and (3) rail casks onto railcars and truck casks onto truck trailers.

Table 6-2 lists estimated radiological impacts for workers who would perform loading activities. The estimated collective radiation dose for these workers would be 10,000 person-rem. In the exposed population of workers, this radiation dose would result in an estimated 6.0 latent cancer fatalities. Latent cancer fatalities from loading operations would not occur among *noninvolved workers* because these workers would not be exposed to radiation from the operations. Appendix G, Section G.1 contains more details on these estimated impacts.

Table 6-2. Estimated radiological impacts to involved workers from loading and storage operations.

Worker category/impact	Dose	LCFs
Maximally exposed individual (rem)	25[a]	0.015
Involved worker population (person-rem)		
Commercial spent nuclear fuel loading	8,300	5.0
High-level radioactive waste loading	1,300	0.77
DOE spent nuclear fuel loading	510	0.30
Total involved worker population[b]	10,000	6.0

a. Based on a radiation dose of 500 millirem per year for 50 years.
b. All involved workers at all facilities.
LCF = Latent cancer fatality.

It would be highly unlikely for a radiation worker to work for the entire period of operations (50 years) and receive the administrative dose limit of 500 *millirem* per year (DIRS 156764-DOE 1999, p. 2-3) during each year of employment. The radiation dose for this worker would be 25 rem. Even under such unlikely circumstances, the estimated probability of a latent cancer fatality for this worker would be about 0.015 or about 1 chance in 70.

Evaluation of loading activities at the generator sites resulted in radiological impacts to workers that were greater than the impacts DOE presented in the Yucca Mountain FEIS. The primary reasons for the increase in the impacts were the 50-percent increase in the latent cancer fatality conversion factor and the additional handling of the commercial spent nuclear fuel required when TAD canisters would be loaded at the generator sites rather than at the repository.

6.2.4 INDUSTRIAL SAFETY IMPACTS FROM LOADING AT GENERATOR SITES

Table 6-3 lists estimated impacts to involved workers from industrial (nonradiological) accidents at the 72 commercial sites and 4 DOE sites. DOE based incidence and fatality rates for involved workers on Bureau of Labor Statistics data for 2005 (DIRS 179131-BLS 2006, all; DIRS 179129-BLS 2007, all) for workers in the transportation and warehousing industries. For noninvolved workers, the Department based the rates on the professional and business services industries. From these data and estimates of the number of casks that would be shipped, the estimated probability would be about 0.25 that a fatality would occur among the involved and noninvolved workers. Appendix G, Section G.1 contains more details on these estimated impacts.

For involved and noninvolved workers who would commute to generator sites, DOE estimated that traffic fatalities would be unlikely to occur and no health impacts would result from exposure to vehicle emissions.

Table 6-3. Estimated industrial safety impacts to involved and noninvolved workers during loading operations.

Worker category/impact	Impact
Involved workers	
Total recordable cases	110
Lost workday cases	73
Industrial fatalities	0.24
Vehicle emission fatalities	0.00070
Traffic accident fatalities	0.13
Noninvolved workers	
Total recordable cases	8.1
Lost workday cases	4.0
Industrial fatalities	0.012
Vehicle emission fatalities	0.00018
Traffic accidentfatalities	0.031

6.2.5 IMPACTS OF LOADING ACCIDENTS AT GENERATOR SITES

In this Repository SEIS, DOE bases the impacts of accidents at the generator sites during the loading of TAD canisters and transportation casks on information in *A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant* (DIRS 181343-Bjorkman et al. 2007, all). The dry cask storage system this study analyzed consisted of a multipurpose canister that would confine the spent nuclear fuel, a transfer overpack that would shield workers from radiation during preparation of the canister for storage, and a storage overpack that would shield people from radiation and mechanically protect the canister during storage. A TAD canister would be similar to the multipurpose canister evaluated in this study.

The study covered all phases of the dry cask storage *process*: loading fuel from the spent fuel pools into dry storage canisters, preparing canisters for storage, transferring loaded canisters into dry storage overpacks, transferring the overpacks that contained canisters outside reactor buildings, moving the loaded overpacks from reactor buildings to storage pads, and storing the overpacks containing loaded canisters for 20 years on storage pads. The potential accidents considered in this study included dropping a spent nuclear fuel assembly, a transfer cask that contained a canister loaded with spent nuclear fuel, a canister that contained spent nuclear fuel, and a storage overpack that contained a canister loaded with spent nuclear fuel. In addition, the study considered the effects of *earthquakes*, floods, high winds, lightning strikes, aircraft crashes, and pipeline explosions. It based the radionuclide inventory of spent nuclear fuel on 10-year-cooled boiling-water-reactor spent nuclear fuel. The study considered weather conditions and the population *distribution* in the vicinity of a specific boiling-water-reactor site. The analysis based other parameters on characteristics of the Surry Nuclear Power Plant in Virginia.

This study quantified the impacts of accidents in terms of the probability of a latent cancer fatality within 16 kilometers (10 miles) of the site. It estimated that these probabilities would range from 1.5×10^{-12} (1 chance in 700 billion) for an accident that involved the drop of a spent nuclear fuel assembly to 3.6×10^{-4} (1 chance in 3,000) for an accident that involved the drop of a transfer cask (DIRS 181343-Bjorkman et al. 2007, p. 7-6).

6.3 Impacts Associated with National Transportation

This section presents estimates of the national impacts of the shipment of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the proposed repository. It presents the potential impacts to the public and workers that could occur from *incident-free* (routine) transportation, transportation accidents, and potential sabotage events along across-the-country shipping routes that the shipments could use. The section also presents an overview of the methods DOE used to estimate the impacts.

Shipments of spent nuclear fuel and high-level radioactive waste would travel an annual distance of 850,000 truck kilometers (530,000 truck miles) and 3.7 million railcar kilometers (2.3 million railcar miles) on existing highways and railroads. For comparison, the average annual total travel of trucks and trains in the United States is about 350 billion truck kilometers (220 billion truck miles) and 61 billion railcar kilometers (38 billion railcar miles) (DIRS 181280-DOT 2006, all; DIRS 181282-AAR 2006, all). Shipments of spent nuclear fuel and high-level radioactive waste would represent a very small fraction of total national highway and railroad annual traffic (0.0002 percent for trucks, 0.006 percent for railcars, and about 0.1 percent for trains).

With the exception of occupational and public health and safety impacts evaluated in this section, because shipments of spent nuclear fuel and high-level radioactive waste would comprise only small fractions of total national highway and rail traffic, the environmental impacts of the shipments on land use and ownership; *hydrology*; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; utilities, energy, and materials; and waste management would be small in comparison with the impacts of other nationwide transportation activities.

To determine if pollutants of concern from truck and rail transport would degrade *air quality* in areas not in compliance with U.S. Environmental Protection Agency (EPA) standards for *criteria pollutants* (*nonattainment areas*), DOE reviewed traffic volumes in those areas. The Department found that the numbers of vehicles (truck and rail) bound for Yucca Mountain would be small in relation to normal traffic volumes. Therefore, the impact on air quality in these areas would be small.

Radiological impacts of accidents on biological resources would be unlikely. A severe accident scenario in which a release of radioactive materials occurred, such as the maximum reasonably foreseeable accident discussed in Section 6.3.3.2, would be unlikely. The probability of the maximum reasonably foreseeable accident scenarios would be about 5 in 1 million per year and the probability of this accident in a specific location would be much less than 5 in 1 million per year. Because of the low probability of occurrence, the risk of an accident during the transport of spent nuclear fuel and high-level radioactive waste that caused adverse impacts to any endangered or *threatened species* or impacts to other plants and animals would be small.

6.3.1 METHODS TO ESTIMATE TRANSPORTATION IMPACTS

In this Repository SEIS, DOE estimates the impacts from incident-free transportation and from transportation accidents. Incident-free transportation impacts would be those from routine transportation if no accidents occurred to affect the shipment. These impacts could be from the radiation emitted from the transportation cask, which federal regulations restrict to 10 millirem per hour at a distance of 2 meters

(6.6 feet) from the truck or railcar (10 CFR 71.47), or they could be from the exhaust and *fugitive dust* emitted by the truck or train.

RADIATION LEVELS EMITTED FROM TRANSPORTATION CASKS

The radiological impact analysis for spent nuclear fuel and high-level radioactive waste transportation assumes that the external radiation levels emitted from each transportation cask would be at the regulatory limit of 10 millirem per hour at a distance of 2 meters (6.6 feet). This assumption would tend to overestimate the radiation dose to workers and the public because not all casks would be loaded with spent nuclear fuel or high-level radioactive waste that has the characteristics that would result in the cask external dose rate being at the regulatory limit. In its report *Assessment of Incident Free Transport Risk for Transport of Spent Nuclear Fuel to Yucca Mountain Using RADTRAN 5.5,* the Electric Power Research Institute noted that more than 40 percent of the spent nuclear fuel shipped is likely to have been stored for times greater than 20 years (DIRS 185330-EPRI 2005, p. 5-2). The longer spent nuclear fuel is stored, the lower the radiation dose rate would be when the spent nuclear fuel is shipped, and cask external dose rates would be lower than the regulatory limit. Appendix J of the Yucca Mountain FEIS discussed this issue (DIRS 155970-DOE 2002, Section J.1.3.2.4). The FEIS analysis estimated that the cask dose rate would be 50 to 70 percent of the regulatory limit. Based on this analysis, DOE expects that the radiological risks to workers and public from incident-free transportation would be 50 to 70 percent of the values estimated in this Repository SEIS.

Radiological impacts from transportation accidents would be a consequence of one of three possible situations. In declining order of the potential impacts that could occur:

1. A severe accident could release radioactive material from a cask.

2. A cask could emit higher levels of radiation if the shielding degraded during a severe accident.

3. As would be the case in more than 99.99 percent of all accidents, the casks and shielding would remain intact and the casks would emit normal radiation levels and remain stationary until accident recovery operations were complete.

Radiation doses were estimated for two groups, workers and members of the public. For each group, radiation doses were estimated for the collective population and maximally exposed individuals. For members of the public, the collective population was the population within 800 meters (0.5 mile) of the transportation routes and was determined using U.S. Census data. The 800-meter (0.5-mile) distance is based on the distance used to estimate radiation doses in *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants* (DIRS 185281-AEC 1972, p. 110). The distances of maximally exposed individuals from the transportation routes were based on the distances used in the Yucca Mountain FEIS (DIRS 157144-Jason Technologies 2001, all). Within Nevada, these distances were determined using geographic information system data and imagery.

For transportation accidents, radiation doses were estimated out to 80 kilometers (50 miles) from the accident. This distance is based on the distance used to estimate radiation doses from accidents in *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants* (DIRS 185281-AEC 1972, p. 94).

The nonradiological impacts from transportation accidents would be a consequence of traffic fatalities that involved truck shipments and from fatalities that involved rail shipments of spent nuclear fuel and

high-level radioactive waste. The rail-related fatalities would be primarily from highway-rail crossing incidents and trespassers on railroad property.

DOE used the following computer programs to estimate incident-free transportation impacts and impacts from transportation accidents for this Repository SEIS:

- The Total System Model program (DIRS 181377-BSC 2007, all) to estimate the number of truck and rail casks that DOE would ship to the repository,
- The TRAGIS program (DIRS 181276-Johnson and Michelhaugh 2003, all) to identify representative highway and rail routes that shipments could use and to provide estimates of the number of people who lived along these routes,
- The RADTRAN 5 program (DIRS 150898-Neuhauser and Kanipe 2000, all; DIRS 155430-Neuhauser et al. 2000, all) to estimate (1) radiation doses to populations and transportation workers during incident-free transportation and (2) radiological accident risks to populations and transportation workers from transportation accidents, and
- The RISKIND program (DIRS 101483-Yuan et al. 1995, all) to estimate (1) radiation doses to maximally exposed individuals and to the general population during incident-free transportation and (2) radiation doses to maximally exposed individuals and the general population from severe transportation accidents and from potential sabotage events.

6.3.2 IMPACTS OF INCIDENT-FREE TRANSPORTATION

This section discusses the national impacts of incident-free transportation of spent nuclear fuel and high-level radioactive waste by truck and rail from 72 commercial and 4 DOE sites to the proposed repository. Appendix G, Section G.5 contains more information on the methods and data that DOE used to estimate incident-free transportation impacts and the assumed conditions upon which these estimates were based. The analysis evaluated two categories of incident-free impacts: radiological impacts to involved workers and members of the public, and impacts from vehicle emissions. DOE evaluated two cases for transportation in Nevada. In the first, impacts were based on national rail routes that would terminate in the Caliente area; subsequent travel to the repository would use the Caliente rail corridor. In the second, impacts were based on national rail routes that would terminate in the Hawthorne area; subsequent travel to the repository would use the Mina rail corridor.

Figure 6-1 shows the truck and rail routes DOE used to estimate transportation impacts if it used the Caliente rail corridor for rail shipments. The figure also shows the locations of the 72 commercial and 4 DOE generator sites and Yucca Mountain. Figure 6-2 shows the truck and rail routes DOE used to estimate transportation impacts if it used the Mina rail corridor. In both cases, the selected rail and truck routes are representative of actual routes that DOE could use.

DOE based the identification of the representative national rail routes for the analysis in this Repository SEIS on historical railroad industry routing practices. The analysis selected routes by giving priority to the use of rail lines that have the most rail traffic (which are the best maintained and have the highest quality track), giving priority to originating railroads, minimizing the number of interchanges between

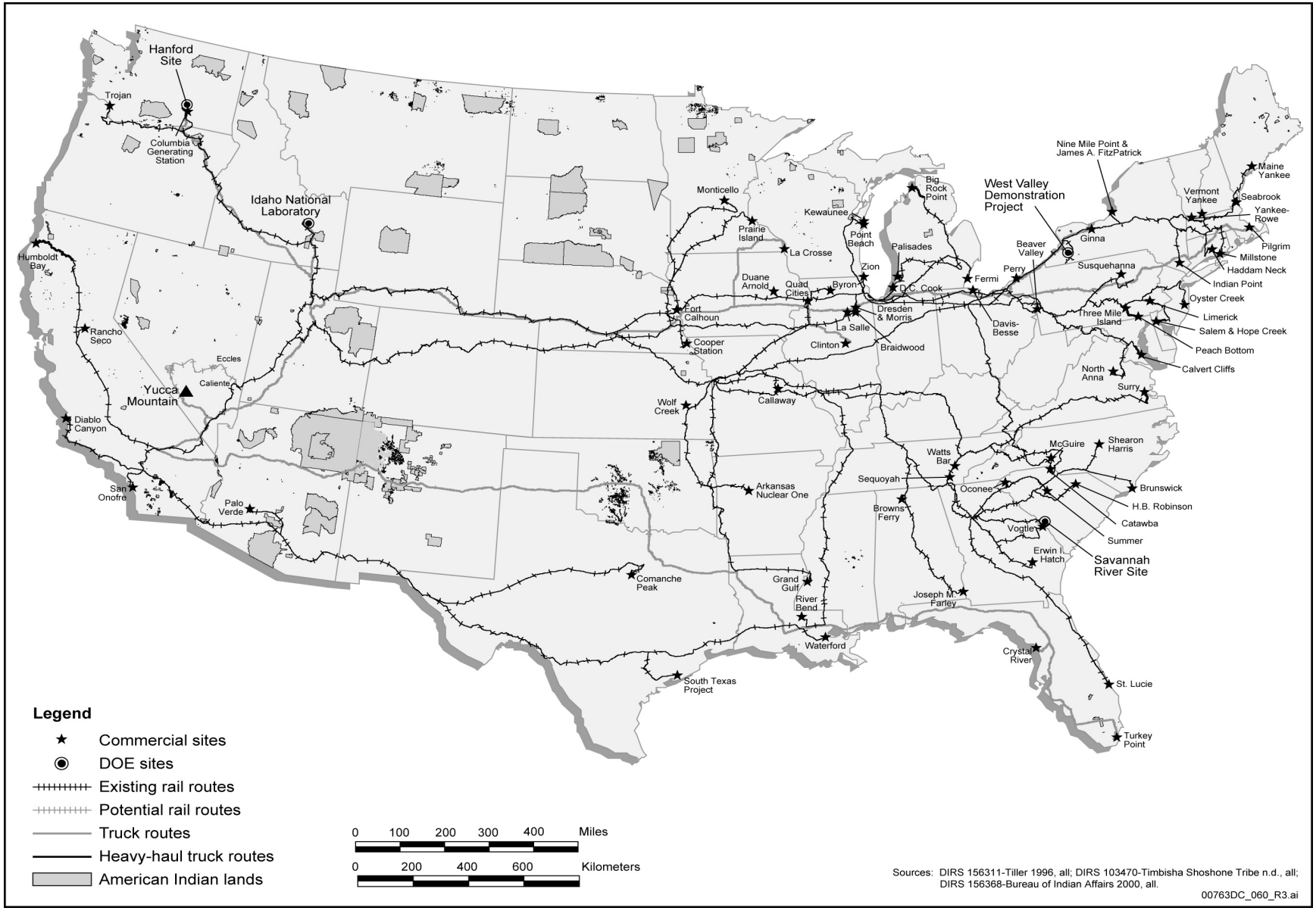


Figure 6-1. Representative rail and truck transportation routes if DOE selected the Caliente rail corridor in Nevada.

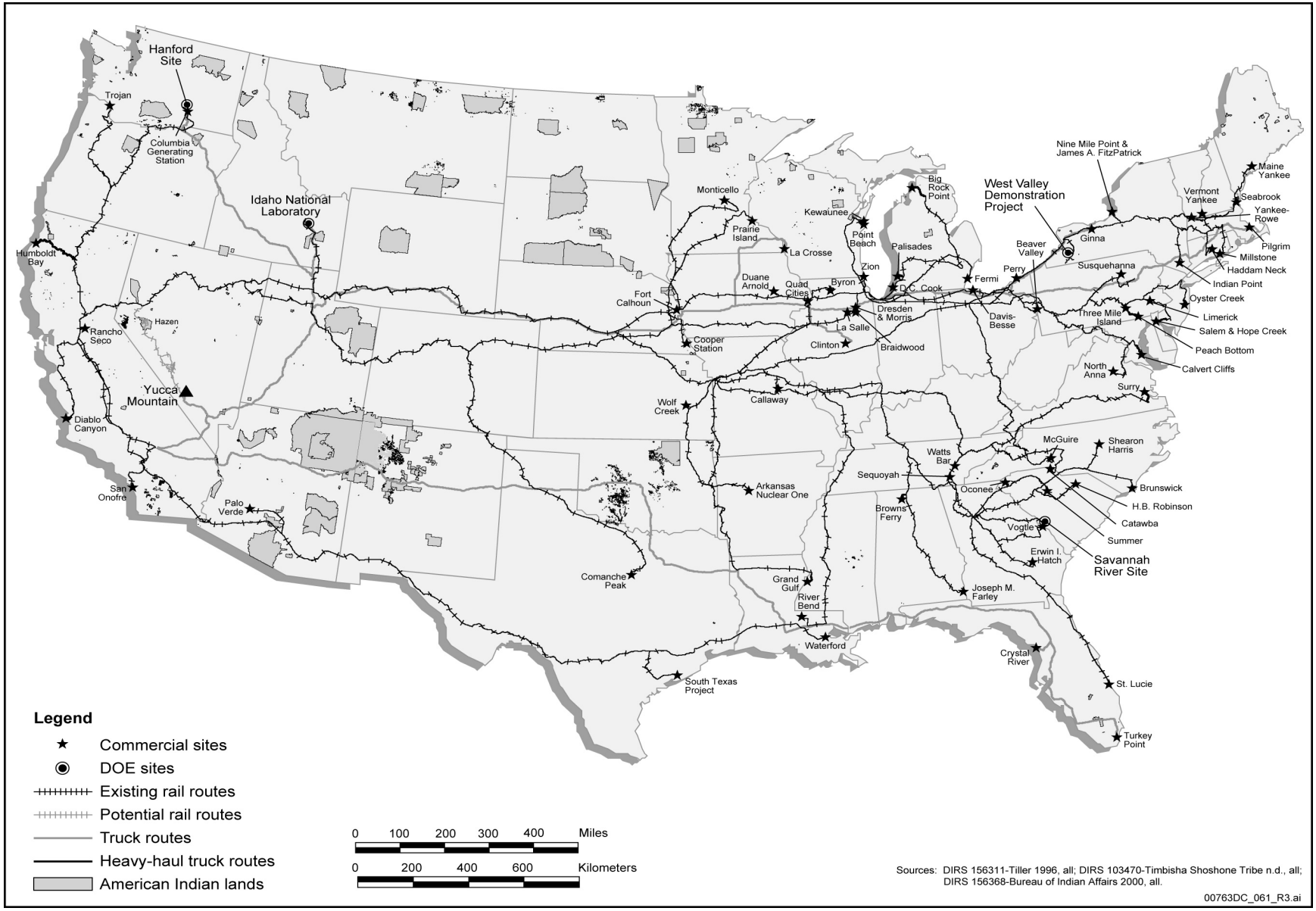


Figure 6-2. Representative rail and truck transportation routes if DOE selected the Mina rail corridor in Nevada.

railroads, and minimizing the travel distance. Highway routes would conform to the routing requirements of 49 CFR 397.101, "Requirements for Motor Carriers and Drivers."

Table 6-4 lists estimates of incident-free impacts for involved workers and members of the public. DOE estimated that about 4 latent cancer fatalities could occur in the population of transportation workers exposed to radiation from the shipments. Because many workers would be involved, the risk for an individual worker would be small. DOE estimated that there would be about 1 (0.7) latent cancer fatality among members of the public who would be exposed to radiation. Because this estimate is for the entire population of exposed individuals along the transportation routes over the course of shipments to the repository, the risk for a single individual would be small. Appendix G, Section G.5 contains more details on these estimated impacts.

Table 6-4. Estimated incident-free radiation doses and impacts for members of the public and involved workers from national transportation.[a]

Rail corridor	Members of the public radiation dose (person-rem)	Involved workers radiation dose (person-rem)	Members of the public (LCFs)	Involved workers (LCFs)	Vehicle emission fatalities	Total incident-free fatalities
Caliente						
Rail	800	4,700	0.48	2.8	0.99	4.3
Truck	350	880	0.21	0.53	0.13	0.87
Total	1,200	5,600	0.69	3.4	1.1	5.2
Mina						
Rail	700	5,100	0.42	3.0	0.88	4.3
Truck	350	880	0.21	0.53	0.13	0.87
Total	1,100	5,900	0.63	3.6	1.0	5.2

Note: Values are rounded to two significant figures; therefore, totals might differ from sums of values.

a. Impacts are for the entire duration (up to 50 years) of shipping spent nuclear fuel and high-level radioactive waste to the repository.

LCF = Latent cancer fatality.

For nonradiological impacts of shipments, DOE estimated that vehicle emissions would result in 1 fatality among members of the public over the course of shipments along the routes to the repository. The risk for any individual would be small.

Therefore, the total estimated impacts of incident-free shipment of spent nuclear fuel and high-level radioactive waste would be about 5 fatalities. This number of fatalities, which would occur over as many as 50 years, would not be discernable from the 600,000 people who die from cancer every year in the United States.

The estimates of incident-free transportation impacts in this Repository SEIS are higher than those in the Yucca Mountain FEIS primarily due to (1) the increase in the radiation dose-to-latent cancer fatality conversion factor, (2) the use of additional shipment escorts in all areas, and (3) extrapolation of impacts to 2067. The increase in impacts due to these factors is partially offset by a decrease in impacts from the use of dedicated trains (Section 6.1.4).

Table 6-5 lists estimates of impacts for maximally exposed workers and members of the public. These impacts are at the national level and would not depend on the Nevada rail corridor that DOE selected. Among workers, escorts and inspectors would receive the highest estimated radiation doses, in large part because of their proximity to casks and the amount of time they were exposed. The maximally exposed

Table 6-5. Estimated incident-free radiation doses and impacts for maximally exposed involved workers and members of the public from national transportation.[a]

Category	Dose (rem)	Probability of LCFs
Involved workers		
Escort	25[b]	0.015
Rail inspector	25[b]	0.015
Railyard crew member	4.8	0.0029
Truck driver	25[b]	0.015
Truck inspector	11	0.0065
Public		
Resident along rail route [18 meters (60 feet)]	0.0078	0.0000047
Resident near rail stop	0.030	0.000018
Resident along truck route	0.00061	0.00000037
Person in traffic jam	0.016	0.0000096
Person at service station	0.21	0.00013

a. Impacts are for the entire 50-year shipping period.
b. Based on a 500-millirem-per-year administrative dose limit.
LCF = Latent cancer fatality.

worker would receive an estimated radiation dose of 25 rem over as many as 50 years of repository operations, based on a 500-millirem-per-year administrative dose limit (DIRS 174942-BSC 2005, Section 4.9.3.3). The probability of a latent cancer fatality for this worker would be 0.015 or about 1 chance in 70.

Members of the public would receive lower estimated radiation doses than workers from incident-free transportation because they would not be as close to the casks as workers and would not be exposed for as long as workers. The member of the public with the highest estimated individual radiation dose would be a service station attendant who refueled the trucks during shipments of spent nuclear fuel and high-level radioactive waste. Under assumptions that tend to overstate the risks, the same person would refuel about 600 trucks and receive an estimated radiation dose of 0.21 rem over as many as 50 years of shipments. Under these assumptions, the probability of a latent cancer fatality for this individual would be 0.00013, or about 1 chance in 8,000.

6.3.3 IMPACTS OF TRANSPORTATION ACCIDENTS

Appendix G, Sections G.6 and G.7 describe the methods, data, and assumed conditions DOE used to estimate transportation accident risks and the consequences of severe transportation accidents, respectively. Radiological impacts from a transportation accident would be a consequence of one of three possible situations identified above in Section 6.3.1.

The analysis used estimates of the number of traffic fatalities that could occur to quantify the nonradiological impacts of accidents. Together, estimates of radiological and nonradiological accident risks provide perspective on the impacts of accidents in the shipment of spent nuclear fuel and high-level radioactive waste.

To estimate the potential radiological impacts of transportation accidents, DOE performed two types of analyses. The first estimated the radiological and nonradiological risks from accidents during the transportation of spent nuclear fuel and high-level radioactive waste. The analysis of radiological risks of

accidents considered a spectrum of accidents that ranged from high-probability accidents of low severity and consequences to severe accidents with radiological consequences that have a low probability of occurrence. They included accidents in which the functional performance of a cask would not be degraded, accidents in which no radioactive material would be released but shielding would be deformed because of lead shield displacement, and accidents that released radioactive material. Radiological accident risks are defined as the sum over a complete spectrum of transportation accidents of each accident's probability multiplied by its radiological consequences. For accidents in which the cask was not damaged and no radioactive materials were released, DOE based estimates of the radiation dose to the public on an estimate of the time required to recover from the accident and the radiation dose to the nearby public while recovery operations were under way.

In the second type of analysis, DOE developed estimates of the impacts of the most severe transportation accidents that could reasonably be expected to occur. These are called maximum reasonably foreseeable accidents. To be reasonably foreseeable, the transportation accident must have an expected frequency of occurrence that is greater than 1 in 10 million (0.0000001) per year (DIRS 172283-DOE 2002, p. 9). Accidents that are less frequent are not considered to be reasonably foreseeable.

Appendix G, Section G.7 describes the methods and data DOE used to estimate impacts from transportation accidents. The analysis included impacts of postulated accidents during the transportation of commercial spent nuclear fuel in truck casks by trucks from the seven commercial sites that cannot handle or load large rail casks, and from a small number of truck shipments of commercial spent nuclear fuel that would originate at the Hanford Site and the Idaho National Laboratory. The analysis considered the impacts from accidents that could involve the heavy-haul trucks that would transport spent nuclear fuel to nearby railheads from the 22 commercial sites that can load a rail cask but are not served by a railroad.

6.3.3.1 Risk of Accidents

Table 6-6 lists the radiological and nonradiological accident risks of the shipment of spent nuclear fuel and high-level radioactive waste to the proposed repository. The estimated radiological accident risk of a single latent cancer fatality for the entire population within 80 kilometers (50 miles) of the rail and truck transportation routes would be about 0.0025 (1 chance in 400) during as many as 50 years of shipments to the repository. Because this risk is for the entire population of individuals along the transportation routes, the risk for any single individual would be small.

The estimates of radiological accident risks in this Repository SEIS are higher than those in the Yucca Mountain FEIS, primarily due to (1) the increase in the radiation dose-to-latent cancer fatality conversion factor, (2) the extrapolation of impacts to 2067, (3) the use of updated accident rate data, and (4) the use of the radionuclide inventory contained in 10-year-old spent nuclear fuel instead of the 14- or 15-year-old spent nuclear fuel used in the Yucca Mountain FEIS.

The estimated nonradiological impacts of accidents (traffic fatalities) could be 3 fatalities during as many as 50 years of shipments to the proposed repository. For perspective, about 40,000 people die each year in traffic accidents in the United States.

Table 6-6. Estimated accident risks for national transportation.[a]

Rail corridor	Radiological accident dose risk (person-rem)	Radiological accident risk (LCFs)	Traffic fatalities	Total fatalities
Caliente				
Rail	4.1	0.0025	2.1	2.1
Truck	0.068	4.1×10^{-5}	0.57	0.57
Total	4.2	0.0025	2.7	2.7
Mina				
Rail	3.7	0.0022	2.2	2.2
Truck	0.068	4.1×10^{-5}	0.57	0.57
Total	3.7	0.0022	2.8	2.8

Note: Values are rounded to two significant figures; therefore, totals might differ from sums.
a. Impacts are for the entire 50-year shipping period.
LCF = Latent cancer fatality.

6.3.3.2 Impacts of the Maximum Reasonably Foreseeable Accident

About 99.99 percent of transportation accidents would not be severe enough to result in a release of radioactive material from the transportation cask or degradation in the cask's shielding. The 0.01 percent of accidents that could result in a release of radioactive material or degradation of shielding are known as severe transportation accidents.

SEVERE TRANSPORTATION ACCIDENTS: AN OPPOSING VIEWPOINT

The State of Nevada has provided analyses that indicate that the consequences of severe transportation accidents would be much higher than those in this Repository SEIS. For example, the State has estimated that a rail accident in an urban area could result in 13 to 40,868 latent cancer fatalities in the exposed population (DIRS 181756-Lamb et al. 2001, pp. 24 and 25), while DOE estimates that about 9 latent cancer fatalities would occur in the exposed population.

The State estimated these consequences using computer programs that DOE developed and uses. However, the State's analysis used values for parameters that would be at or near their maximum values. DOE guidance for the evaluation of accidents in environmental impact statements (DIRS 172283-DOE 2002, p. 6) specifically cautions against the evaluation of scenarios for which conservative (or bounding) values are selected for multiple parameters because the approach yields unrealistically high results.

DOE's approach to accident analysis estimates the consequences of severe accidents having frequencies as low as 1×10^{-7} per year (1 in 10 million) (DIRS 172283-DOE 2002, p. 9) using realistic yet cautious methods and data. DOE believes that the State of Nevada estimates are unrealistic and that they do not represent the reasonably foreseeable consequences of severe transportation accidents.

The most severe transportation accidents that would be likely to occur with a frequency of about 1×10^{-7} per year or greater are known as maximum reasonably foreseeable accidents. In general, DOE considers accidents with frequencies below 1×10^{-7} per year not to be reasonably foreseeable. Based on the 20 accident cases (Appendix G, Section G.7) the transportation accident that is reasonably foreseeable and that would have the highest (or maximum) consequences (the maximum reasonably foreseeable accident) would be expected to occur with a frequency of about 5×10^{-6} per year. This accident would involve a long-duration, high-temperature fire that would engulf a cask.

Table 6-7 lists estimates of the impacts of this maximum reasonably foreseeable accident. If the accident occurred in an urban area, the estimated population radiation dose would be about 16,000 person-rem. The number of latent cancer fatalities based on the estimated dose would be about 9. If the accident occurred in a rural area, the estimated population radiation dose would be about 21 person-rem, and the estimated probability of a single latent cancer fatality based on the estimated dose would be 0.012 (1 chance in 80). Because these risks are for the entire population exposed during the accident, the risk for any single individual would be small. In an urban area or rural area, the radiation dose from the accident for the maximally exposed individual would be 34 rem; this is based on the individual being 330 meters (1,100 feet) downwind from the accident, where the maximum dose would occur. The estimated probability of a latent cancer fatality for this individual would be 0.020 (1 chance in 50).

IMPACTS OF SEVERE ACCIDENTS

DOE has assumed for the purposes of estimating the radiological consequences of severe accidents and sabotage events that there would be no interdiction or cleanup for 1 year after the accident or sabotage event. However, DOE anticipates that for any significant release emergency response, interdiction, and cleanup actions would be initiated. Therefore, the assumption that no interdiction or cleanup would take place for 1 year after a severe accident or sabotage event would tend to result in overestimation of the impacts of severe accidents and sabotage events.

Table 6-7. Radiological impacts from the maximum reasonably foreseeable transportation accident in urban and rural areas.

Impact	Urban area	Rural area
Maximum reasonably foreseeable accident		
Population dose (person-rem)	16,000	21
LCF	9.4	0.012
Maximally exposed individual dose (rem)	34	34
Probability of LCF	0.020	0.020
First responder		
Maximally exposed responder dose (rem)	0.14 – 2.0	0.14 – 2.0
Probability of LCF	$8.2 \times 10^{-5} – 1.2 \times 10^{-3}$	$8.2 \times 10^{-5} – 1.2 \times 10^{-3}$

LCF = Latent cancer fatality.

First responders would normally approach a transportation accident from the upwind direction to minimize their potential exposures. Therefore, DOE based the radiation dose for the first responder on exposure to radiation from a cask with degraded shielding. This individual would be between 2 and 10 meters (6.6 and 33 feet) from the damaged cask for 30 minutes. The estimated radiation dose to this first responder would range from 0.14 to 2.0 rem. The estimated probability of a latent cancer fatality for this first responder would range from 8.2×10^{-5} (1 chance in 10,000) to 1.2×10^{-3} (1 chance in 800).

6.3.4 EVALUATION OF POTENTIAL SABOTAGE EVENTS

6.3.4.1 Transportation Sabotage Considerations

In response to the terrorist attacks of September 11, 2001, and to intelligence information that has been obtained since then, the U.S. Government has initiated nationwide measures to reduce the threat of sabotage. These measures include security enhancements to prevent terrorists from gaining control of commercial aircraft, such as (1) more stringent screening of airline passengers and baggage by the Transportation Security Administration, (2) increased presence of federal air marshals on many flights,

(3) improved training of flight crews, and (4) hardening of aircraft cockpits. Additional measures have been imposed on foreign passenger carriers and domestic and foreign cargo carriers, as well as charter aircraft.

Beyond these measures to reduce the potential for terrorists to gain control of an aircraft, DOE has adopted an approach that focuses on ensuring that safety and security requirements are adequate and effective in countering and mitigating the effects of sabotage events that would involve transportation casks. The Federal Government has greatly improved the sharing of intelligence information and the coordination of response actions among federal, state, and local agencies. DOE has been an active participant in these efforts; it has regular and frequent communications with other federal, state, and local government agencies and industry representatives to discuss and evaluate the current threat environment, to assess the adequacy of security measures at DOE facilities and, when necessary, to recommend additional actions. In addition to its domestic efforts, DOE is a member of the International Working Group on Sabotage for Transport and Storage Casks, which is investigating the consequences of sabotage events and exploring opportunities to enhance the physical protection of casks.

In addition, the NRC has promulgated rules (10 CFR 73.37) and interim compensatory measures (67 FR 63167, October 10, 2002) specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. The purposes of these security measures are to minimize the possibility of sabotage and to facilitate recovery of spent nuclear fuel shipments that could come under the control of unauthorized persons. These measures include the use of armed escorts to accompany all shipments, safeguarding of the detailed shipping schedule information, monitoring of shipments through satellite tracking and a communication center with 24-hour staffing, and coordination of logistics with state and local law enforcement agencies, all of which would contribute to shipment security. The Department has committed to following these rules and measures (see 69 FR 18557, April 8, 2004).

The Department, as required by the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.), would use *transportation casks* certified by the NRC. Each cask design must meet stringent requirements for structural, thermal, shielding, and criticality performance and confinement integrity for routine (incident-free) and accident events. Spent nuclear fuel is protected by the robust metal structure of the transporation cask, and by cladding that surrounds the fuel pellets in each fuel rod of an assembly. Further, the fuel is in a solid form, which would tend to reduce dispersion of radioactive particulates beyond the immediate vicinity of the cask, even if a sabotage event were to result in a breach of the multiple layers of protection.

Based on this knowledge, the Department has analyzed plausible threat scenarios, required enhanced security measures to protect against these threats, and developed emergency planning requirements that would mitigate potential consequences for certain scenarios. DOE would continue to modify its approach to ensuring safe and secure shipments of spent nuclear fuel and high-level radioactive waste, as appropriate, between now and the time of shipments.

For the reasons stated above, DOE believes that under generally credible threat conditions the probability of a sabotage event that resulted in a major radiological release would be low. Nevertheless, because of the uncertainty inherent in the assessment of the likelihood of a sabotage event, DOE has evaluated events in which a military jet or commercial airliner would crash into a spent nuclear fuel cask or a modern weapon (high-energy-density device) would penetrate a spent nuclear fuel cask (Section 6.3.4.2).

6.3.4.2 Consequences of Potential Sabotage Events

Whether acts of sabotage or terrorism would occur, and the exact nature and location of the events or the magnitude of the consequences of such acts if they were to occur, is inherently uncertain—the possibilities are infinite. Nevertheless, the Yucca Mountain FEIS and, consistent with Departmental guidance (DIRS 172283-DOE 2002, all), this Repository SEIS took a hard look at the consequences of potential acts of sabotage or terrorism during the transport of spent nuclear fuel and high-level radioactive waste by evaluating two fundamentally different scenarios: one involving aircraft and one involving a weapon or device that struck a transportation cask loaded with commercial spent nuclear fuel. DOE estimated the consequences of these scenarios without regard to their probability of occurrence; that is, DOE assumed the scenarios would occur and under conditions that would reasonably maximize the consequences.

To estimate the consequences of aircraft crashes, DOE identified the aircraft parts most likely to penetrate a transportation cask, identified the military and commercial aircraft most likely to be involved in a crash in an urban area (for example, Las Vegas, Nevada), and estimated the speed of the aircraft at impact (DIRS 155970-DOE 2002, Section J.3.3.1). DOE first considered the ability of aircraft parts to penetrate a transportation cask and concluded that the parts with the highest chance of penetration would be the engines and engine shafts. Based on flight information from Nellis Air Force Base, DOE selected the F-15 and F-16 high-performance jet fighters, which represent more than 70 percent of military flight operations. For the commercial aircraft analysis, DOE selected the B-767, a relatively large and widely used jet. Last, DOE selected aircraft impact speeds of 550 kilometers per hour (340 miles per hour). Based on this analysis, DOE determined that neither the engine nor engine shafts of any of the three aircraft would penetrate the wall of a transportation cask to a sufficient depth to cause a release of radioactive materials. Further analysis determined that if the impact and resultant fire caused a cask seal to fail, little radiation would escape and there would be less than 0.65 latent cancer fatality in the affected urban population.

In selecting the high-energy-density devices, DOE first performed a survey of weapons and devices that might be capable of penetrating a full-size spent nuclear fuel cask. From the many different types of weapons and devices the survey considered, the Department selected four general types for further evaluation: conical-shaped charges, contact-breaching charges, platter charges, and pyrotechnic torches. Analyses that subjected both simulated and actual spent nuclear fuel truck casks to the four types of high-energy-density devices provided data for selection of a high-energy-density device that would show the greatest potential to penetrate a full-size spent nuclear fuel cask and disperse its contents. As DOE reported in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Section 6.2.4.2.3), two specific high-energy-density devices were chosen for more detailed analysis. The first high-energy-density device was designed to produce the maximum cavity volume from its explosive impact, was near the weight limit that a single individual could carry, and had been used in the full-scale cask penetration test of a truck spent nuclear fuel cask. The second high-energy-density device was an anti-tank weapon that was designed to achieve maximum penetration depth in an armored vehicle and could be delivered remotely using a launch and guidance system. DOE then modeled the incidents and benchmarked the results against the physical tests.

To assess the consequences of a weapon or device (also referred to as a high-energy-density device) that penetrated a transportation cask, DOE selected a truck and rail cask and two possible high-energy-density devices, one of which had been shown through various physical tests to penetrate a cask. For this

analysis, DOE selected a state-of-the-art truck cask, the General Atomics GA-4 cask, which the NRC has certified for shipments of spent nuclear fuel. The rail cask for the analysis was based on a conceptual design similar in construction to casks the NRC has certified, such as the NAC-STC, NUHOMS MP187, NUHOMS MP197, HI-STAR 100, and others.

To estimate the potential consequences of a sabotage event in which a high-energy-density device penetrated a rail or truck cask, DOE, in the Yucca Mountain FEIS, referred to *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* to obtain estimates of the fraction of spent nuclear fuel materials that would be released (release fractions) (DIRS 104918-Luna et al. 1999, all). In this Repository SEIS, the Department used the more recent release fraction estimates from *Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack* (DIRS 181279-Luna 2006, all) to estimate the consequences of such events involving spent nuclear fuel in truck or rail casks. These more recent estimates of release fractions (DIRS 181279-Luna 2006, all) are based on the release fractions estimated in 1999 from *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all), but they also incorporate data from additional tests sponsored by *Gesellschaft für Anlagen - und Reaktorsicherheit* in Germany and conducted in France in 1994 that were not available for the 1999 report. These additional test data suggest that the consequences of the sabotage event DOE analyzed in the Yucca Mountain FEIS could be overstated by a factor of between 2.5 and 12.

Table 6-8 lists estimates of the impacts of potential sabotage events involving truck and rail casks. For truck casks, the analysis estimated that a sabotage event in an urban area could result in a population radiation dose of 47,000 person-rem. The number of latent cancer fatalities based on the estimated dose would be 28. If the event was in a rural area, the estimated population radiation dose would be 92 person-rem. The probability of a single latent cancer fatality based on the estimated dose would be 0.055 (1 chance in 20). Because these risks would be for the entire exposed population, the risk for any single individual would be small. The maximally exposed individual would receive an estimated radiation dose of 43 rem, and the probability of a latent cancer fatality for this individual would be 0.026 (1 chance in 40).

Table 6-8. Estimated impacts of sabotage events involving truck or rail casks.[a]

Impact	Urban area	Rural area
Truck cask		
Impacts to populations		
Population dose (person-rem)	47,000	92
LCF	28	0.055
Impacts to maximally exposed individuals		
Maximally exposed individual dose (rem)	43	43
Probability of LCF	0.026	0.026
Rail cask		
Impacts to populations		
Population dose (person-rem)	32,000	48
LCF	19	0.029
Impacts to maximally exposed individuals		
Maximally exposed individual dose (rem)	27	27
Probability of LCF	0.016	0.016

a. Impacts are based on a sabotage event with High Energy Density Device 1 (DIRS 181279-Luna 2006, all).
LCF = Latent cancer fatality.

For rail casks, the analysis estimated that a sabotage event in an urban area could result in a population radiation dose of 32,000 person-rem. The number of latent cancer fatalities based on the estimated dose would be 19. If the event was in a rural area, the estimated population radiation dose would be 48 person-rem. The probability of a single latent cancer fatality based on the estimated dose would be 0.029 (1 chance in 30). Because these risks would be for the entire exposed population, the risk for any single individual would be small. The maximally exposed individual would receive an estimated radiation dose of 27 rem, and the probability of a latent cancer fatality for this individual would be 0.016 (1 chance in 60).

The State of Nevada in its scoping comments and comments on the Draft Repository SEIS recommended that the DOE sabotage analysis address postulated attacks that involved, for example, multiple weapons, combinations of weapons that were designed to maximize release and dispersal of radioactive materials, environmental and population conditions unique to specific locations and locations with high symbolic value, large groups of well-trained adversaries, suicide attacks, and infiltration of trucking and railroad companies. The State of Nevada also suggested that DOE consider the potential for human error to exacerbate the consequences of such attacks on a transportation cask.

In support of the State of Nevada's contention that DOE has underestimated the potential consequences of a sabotage or terrorist attack, the State commissioned a study to reevaluate the DOE sabotage analysis and concluded that a scenario that used a high-energy-density device, such as an antitank missile, would result in consequences about 10 times greater than those DOE estimated (DIRS 181892-Lamb et al. 2002, p. 19). The State has asserted that the antitank missile would penetrate both sides of a truck or rail cask and cause a much greater release than that DOE estimated (DIRS 181892-Lamb et al. 2002, p. 18), but has provided no credible scientific evidence for this assertion.

Nevada's assertion of higher consequences is contrary to the results of the DOE computer modeling, which the Department benchmarked to physical test results and which demonstrated that a weapon such as that in the State's study would not perforate both sides of the cask (DIRS 104918-Luna et al. 1999, all). In addition, the higher consequences the State predicted were a result of the selection of parameter values that are either incorrect, are based on views not generally accepted by the scientific community, or when taken together inappropriately result in compounding the adverse consequences of the scenarios analyzed. To illustrate:

- Cesium is a key contributor to dose in a release from a cask. In a spent nuclear fuel rod, cesium may reside in three locations: in the gap between the cladding and the fuel pellet, at fuel grain boundaries, and in the fuel matrix. The amount of cesium in the gap between the cladding and the fuel pellet ranges from 0.21 to 10.50 percent of the total cesium inventory, with an average of about 2.95 percent (DIRS 169987-BSC 2004, Table 6-3). The amount of cesium at the fuel grain boundaries ranges from 0.19 to 1.23 percent of the total cesium inventory, with an average of about 0.19 percent of the total cesium inventory (DIRS 169987-BSC 2004, Table 6-3). Collectively, the cesium inventory for the gap between the cladding and the fuel pellet and at the fuel grain boundaries is often referred to as the "gap inventory" and ranges from 0.40 to 11.73 percent of the total cesium inventory, with an average of about 3.7 percent (DIRS 169987-BSC 2004, Table 6-3). In accidents involving spent nuclear fuel, this cesium can be rapidly released if the cladding is ruptured.

  In *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all), the release of cesium during a sabotage event had two components: the

release of the cesium gap inventory in the disrupted spent nuclear fuel rods, and the release of cesium from the fuel matrix in the disrupted spent nuclear fuel rods. All the cesium in the matrix of the disrupted rods was assumed to be released to the cask cavity during a sabotage event. Because much more cesium is present in the fuel matrix than in the gap, the release of cesium was dominated by the release of cesium from the matrix, not the release of cesium from the gap. This is in contrast to most accidents involving spent nuclear fuel, where often only the gap inventory is released when the cladding is ruptured, and there is no release from the fuel matrix.

To estimate its cesium release fraction, the State considered a DOE-funded study that estimated the cesium inventory in the gap to be as high as 9.9 percent, 33 times higher than the gap inventory the State said was used in *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments* (DIRS 104918-Luna et al. 1999, all). The State apparently assumed that the entire cesium release fraction was proportional to the gap inventory, and accordingly multiplied the total release fraction used by Luna by 33. The State's approach is incorrect because it does not recognize that all of the cesium inventory, that is, the cesium in the gap and that in the matrix, was released to the cask cavity in the Luna study. By increasing the total release fraction by a factor of 33, the State's analysis effectively released 33 times the entire amount of cesium in the disrupted spent nuclear fuel rods, which is clearly incorrect.

- In this Repository SEIS, DOE used the dose-to-health effect conversion factor of 0.0006 latent cancer fatality per person-rem that both the Interagency Steering Committee on Radiation Standards (DIRS 174559-Lawrence 2002, all) and current DOE guidance (DIRS 178579-DOE 2004, pp. 22 to 24) recommend. This value is consistent with the lethality adjusted cancer risk coefficients from the *2007 Recommendations of the International Commission on Radiological Protection*, 0.00041 per person-rem for workers and 0.00055 per person-rem for individuals among the general population (DIRS 182836-ICRP 2007, p. 53); the dose-to-health-effect conversion factors published by the National Research Council in the *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2* (DIRS 181250-National Research Council 2006, p. 15), which ranged from 0.00041 to 0.00061 latent cancer fatality per person-rem for solid cancers and 0.000050 to 0.000070 latent cancer fatality per person-rem for leukemia; and the age-specific dose-to-health-effect conversion factor published by the EPA, 0.000575 latent cancer fatality per person-rem (DIRS 153733-EPA 2000, Table 7.3, p. 179).

  The Dose and Dose Rate Effectiveness Factor is used to account for the lower cancer risks of radiation exposures at low doses and low dose rates as compared with radiation exposures at high doses and high dose rates. The State of Nevada used a dose-to-health effect conversion factor of 0.001 latent cancer fatality per person-rem, which the State estimated by not including a Dose and Dose Rate Effectiveness Factor (that is, by using a Dose and Dose Rate Effectiveness Factor of 1) (DIRS 181892-Lamb et al. 2002, p. 7). The State cites as support for this argument an article by Pierce and Preston. In response, DOE notes that the use of a Dose and Dose Rate Effectiveness Factor of 1.5 to 2 is supported by both the National Research Council (DIRS 181250-National Research Council 2006, p. 15) and the International Commission on Radiological Protection (DIRS 182836-ICRP 2007, p. 53).

  The State also points out that the dose-to-health effect conversion factor depends on age and gender. However, the dose-to-health effect conversion factors developed by the International Commission on

Radiological Protection, the National Research Council, and the EPA already consider age and gender and so no further adjustment to the dose-to-health effect conversion factor is necessary.

- The degree of dispersal of radioactive particles is proportional to the height at which the radioactive particles are released; the lower the height at which the particles are released, the less the dispersion and the higher the consequences. In its study, the State used a release height for all particles of 1.508 meters (4.95 feet) for a truck cask and 2.08 meters (6.82 feet) for a train cask (DIRS 181892-Lamb et al. 2002, p. 6). These release heights are not realistic because they do not account for plume rise as a result of the explosive action of a high-energy-density device. In contrast, DOE accounted for plume rise by using multiple release heights and estimated that 4 percent of the release would occur at a height of 1 meter (3.3 feet), 16 percent at 16 meters (52 feet), 25 percent at 32 meters (100 feet), 35 percent at 48 meters (160 feet), and 20 percent at 64 meters (210 feet) (DIRS 157144-Jason Technologies 2001, p. 189). Indeed, the State acknowledged that an increase in the release height would result "in a decrease in the dose to the MEI [maximally exposed individual]" (DIRS 181892-Lamb et al. 2002, p. 6).

- The meteorological conditions at the time of release from a cask have a bearing on the consequences. The State chose to use stable atmospheric conditions (Class F stability), which represent plume concentrations that would not be exceeded 95 percent of the time in its analysis (DIRS 181892-Lamb et al. 2002, p. 6). In contrast, because it is not possible to forecast the environmental conditions that might exist during an act of sabotage, DOE used neutral atmospheric conditions (Class D stability), which represent plume concentrations that would not be exceeded 50 percent of the time.

DOE recognizes that it could analyze scenarios with, for example, higher aircraft impact velocities or weapons with greater destructive capabilities, or it could postulate scenarios with combinations of factors, such as human error and suicide attacks, as the State suggested, that could produce a much broader range of consequences that are more detrimental than those this Repository SEIS estimates. As an initial matter, for an act of sabotage or terrorism to be carried out, the persons responsible for such acts would have to overcome the security measures in place. The intent of safeguards and security measures (Section 6.3.4) is to thwart such attacks and, in any event, the measures would tend to minimize the consequences of such an attack. The scenarios DOE analyzed are conservative because the Department did not consider the effectiveness of such measures, and that such measures would make the likelihood of a sabotage event even lower.

Further, and setting aside the security measures that would be in place, the effectiveness of a sabotage event would depend on a number of critical factors such as the ability to deliver the weapon perpendicular to the circular surface of a relatively small object [a rail cask is about 2.26 meters (7.4 feet) in diameter and 5.18 meters (17 feet) long], which might be in transit and thus a moving target, the extent to which the individual had the knowledge to select and the training to use the appropriate weapon, and whether the weapon was at the optimal distance from the cask.

As with any aspect of environmental impact analysis, it is always possible to postulate scenarios that could produce higher consequences than previous estimates. In eliminating the requirement that agencies conduct a worst-case analysis, the Council on Environmental Quality has pointed out that "one can always conjure up a worse 'worst case'" by adding more variables to a hypothetical event (50 FR 32234, August 8, 1985), and that "'worst case analysis' is an unproductive and ineffective method…one which can breed endless hypothesis and speculation" (51 FR 15620, April 25, 1986). As indicated in the

Council on Environmental Quality regulations that implement the *National Environmental Policy Act* (NEPA) (42 U.S.C. 4321 et seq.), an agency has a responsibility to address reasonably foreseeable significant adverse effects. The evaluation of impacts is subject to a "rule of reason" ensuring analysis based on credible scientific evidence useful to the decisionmaking process. In applying the rule of reason, an agency does not need to address remote and highly speculative consequences in its EIS. The crafting and analysis of the scenarios the State suggested would be based on conjecture and would not have the support of credible scientific evidence.

DOE has required enhanced security measures to protect against plausible threat scenarios and developed emergency planning requirements that would mitigate potential consequences for certain scenarios. For all the reasons discussed above, under general threat conditions, the probability of a sabotage event against a transportation cask that carried spent nuclear fuel or high-level radioactive waste that could result in a major radiological release would be low. Nevertheless, DOE has taken a hard look by examining potential, but fundamentally different, sabotage scenarios.

6.3.5 ENVIRONMENTAL JUSTICE

Shipments of spent nuclear fuel and high-level radioactive waste would use the nation's existing railroads and highways. DOE estimates that transportation-related impacts to land use; air quality; hydrology; biological resources and soils; cultural resources; socioeconomics; noise and vibration; aesthetics; utilities, energy, and materials; and waste management would be small. The small effect on the population as a whole would be likely for any segment of the population, which includes minorities, *low-income* groups, and members of American Indian tribes.

For this Repository SEIS, DOE analyzed the potential public health effects of incident-free transportation and transportation accidents. For incident-free transportation, DOE considered air emissions and doses from exposure to radioactive materials during transport. Although many people would be exposed nationwide over a long transportation campaign, the air emissions and radiation doses to an exposed individual would be low.

In this Repository SEIS, DOE estimated the impacts to the general public from accidents involving transportation of spent nuclear fuel and high-level radioactive waste. The two mechanisms for such impacts are bodily trauma from collisions and exposure to radiation or radioactive material if a sufficiently severe accident occurred. The analysis estimated the impacts of a national campaign to the general public from trauma sustained in collisions with vehicles that carried spent nuclear fuel or high-level radioactive waste. DOE does not consider such impacts to be large given the number of years involved over a long shipping campaign.

Only a severe accident that resulted in a considerable release of radioactive material could cause serious and adverse health effects to the affected population. Because the risk of such impacts would apply to the entire population along all transportation routes, it would not disproportionately affect any minority or low-income populations.

On the basis of the analysis of incident-free transportation and transportation accidents in this Repository SEIS and the results of the transportation analysis that DOE conducted in the Yucca Mountain FEIS, DOE has not identified any high and adverse potential impacts to members of the public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that

would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts would result from the national transportation of spent nuclear fuel and high-level radioactive waste to Yucca Mountain.

Section 6.4.1.16 discusses *environmental justice* in relation to transportation in Nevada.

6.3.6 GREENHOUSE GAS EMISSIONS

Transportation of spent nuclear fuel and high-level radioactive waste to the repository would result in emissions of carbon dioxide to the atmosphere. In addition, workers who commuted by bus and automobile to and from the repository; transport of construction materials, repository components, and consumables to the repository; and transport of waste from the repository for offsite disposal would result in emissions of carbon dioxide to the atmosphere.

Transport of these commodities would result in annual emissions of 37,000 to 38,000 metric tons (41,000 to 42,000 tons) of carbon dioxide to the atmosphere. In comparison, the overall 2005 emissions of carbon dioxide in the United States was 6.1 billion metric tons (6.7 billion tons) (DIRS 185248-EPA 2007, Table ES-2, p. ES-5). The total emissions of carbon dioxide would increase the overall national carbon dioxide emissions by less than 0.001 percent (about 0.0006 percent) over 2005 levels.

6.4 Impacts Associated with Transportation in Nevada

The following sections of this chapter summarize the potential impacts of transportation within Nevada alone. Section 6.4.1 focuses on the potential impacts of DOE's "mostly rail" scenario, under which most spent nuclear fuel and high-level radioactive waste would be shipped to the repository in dedicated trains. A tabular comparison of impacts from the transportation Proposed Action and its alternatives can be found in Section 2.3, Table 2-3, of this Repository SEIS. Section 6.4.2 examines transportation impacts associated with repository operations.

6.4.1 IMPACTS OF THE MOSTLY RAIL SCENARIO IN NEVADA

This section of the Repository SEIS summarizes and incorporates by reference Chapter 4 of the Rail Alignment EIS. In the Rail Alignment EIS, potential impacts are identified as either direct or indirect, and either short term or long term. Where practicable, DOE has quantified potential impacts. In other cases, it is not practical to quantify impacts and DOE provides a *qualitative* assessment of potential impacts. In the Rail Alignment EIS, DOE has used the following descriptors to characterize impacts qualitatively where quantification of impacts was not practical:

- Small. Environmental effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource.

- Moderate. Environmental effects would be sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

- Large. Environmental effects would be clearly noticeable and would be sufficient to destabilize important attributes of the resource.

Analyses used throughout the Rail Alignment EIS were designed to provide conservative estimates of the impacts that could occur. Where appropriate, cautious but reasonable assumptions were employed; thus, the analyses have a tendency to overestimate impacts. Unless otherwise noted, potential impacts described in this section would be adverse.

DOE would meet all applicable regulatory requirements during construction and operation of the railroad, and would implement an array of *best management practices* to help ensure compliance with requirements. In addition, DOE could implement measures to mitigate impacts remaining after final design and compliance with regulatory requirements and implementation of best management practices. The following sections summarize environmental impacts for each resource area DOE analyzed.

6.4.1.1 Land Use and Ownership

The *region of influence* for land use and ownership is the nominal width of the rail line *construction right-of-way* and includes all private land, American Indian land, and public land fully or partially within that area. It also includes lands outside the nominal width of the rail line construction right-of-way, where there would be facilities, quarries, borrow sites, and wells to support construction and long-term operation of the railroad.

DOE would need to gain access to private land—up to 1.25 square kilometer (310 acres) for the Caliente *rail alignment* and up to 0.81 square kilometer (200 acres) for the Mina rail alignment (Chapter 2 of this Repository SEIS, Section 2.1.7.3.1, discusses the proposed alignments and *alternative segments*, and the alignments are shown in Figure 2-13). For the Caliente rail alignment, another 0.93 square kilometers (230 acres) of private land would be required to accommodate support facilities. Neither rail alignment would displace existing or planned land uses over a substantial area, nor would they substantially conflict with applicable land-use plans or goals. The areas with the highest density of private land that either rail alignment would cross are the City of Caliente (Caliente rail alignment) and Goldfield (both rail alignments). For the Caliente alternative segment, some structures at the existing Union Pacific train yard and three structures along the former Pioche and Prince Branchline would need to be demolished or relocated. This Caliente alternative segment would also occupy portions of the access road and parking lot of the Caliente Hot Springs Hotel. The proximity of the rail line could adversely affect the hotel and the Department would work with the land owner to mitigate the impacts to the hotel through the process described in Chapter 7 (Best Management Practices and Mitigation) of the Rail Alignment EIS. Through this process, DOE would develop specific measures to avoid, reduce, or mitigate impacts to this property, including measures to maintain access to the motel during construction. Finally, DOE could also negotiate compensation with the land owner if design, construction, or operational accommodations are not sufficient to mitigate the impacts. Alternative segments near Goldfield would cross private (although vacant) land, including patented mining claims and state and county land.

In response to concerns from the Timbisha Shoshone Tribe, DOE avoided Timbisha Shoshone Trust Lands during the development of the Caliente and Mina rail alignments. The closest rail segment, common segment 5, would be approximately 3 kilometers (2 miles) east of Timbisha Shoshone Trust Lands near Scottys Junction. DOE initially studied the Mina rail alignment with the permission of the Walker River Paiute Tribe and the Department designed the Schurz alternative segments with the aim of

removing the existing Department of Defense Branchline through the town of Schurz in accordance with the Tribe's request. The Schurz alternative segments would utilize up to 0.5 percent of the land area of the reservation [up to 5.3 square kilometers (1,300 acres)].

The Caliente rail alignment would utilize up to 162 square kilometers (40,000 acres) of Bureau of Land Management-administered land out of a total construction footprint of approximately 170 square kilometers (41,000 acres), and the Mina rail alignment would utilize up to 113 square kilometers (28,000 acres) of Bureau of Land Management-managed land out of a total construction footprint of approximately 125 square kilometers (31,000 acres). A portion of the Eccles alternative alignment and Common Segment 1 would cross through Areas of Critical Environmental Concern under the Ely Proposed Resource Management Plan. These areas were designated after the issuance of the Draft Rail Alignment EIS and would be finalized after further study by the Bureau of Land Management. In consultation with the Bureau of Land Management, DOE would conduct preconstruction surveys and implement avoidance, minimization, and mitigation strategies to protect the resource values of these areas. If the Bureau of Land Management found that through these strategies there would be minimal conflict with the areas' resource values, then the right-of-way could be authorized.

The Mina rail alignment would cross 4.6 square kilometers (1,150 acres) of land within the Hawthorne Army Depot near its northern border, where it would not pose a conflict with the Depot's mission or land uses. Railroad construction would result in surface disturbance across a number of grazing allotments on Bureau of Land Management-administered land. Assuming all the vegetation in the construction right-of-way and support facility footprints across all affected allotments was unavailable for forage, the route with the greatest impact on grazing for either alignment would directly result in a less than 2-percent loss of animal unit months [1 animal unit month equates to approximately 360 kilograms (800 pounds) of forage and is a measure of the forage needed to support one cow, one cow/calf pair, one horse, or five sheep for 1 month]. Additional animal unit months could be lost due to the inaccessibility of forage in locations where the rail line acted as a barrier to livestock, though allotment management plans would be revised to minimize grazing impacts associated with the rail line and DOE would coordinate with permittees and the Bureau of Land Management to institute mitigation measures. The rail line could require livestock on some allotments to adjust to new routes to access water and forage. In most areas, livestock could learn new routes and acclimate to and cross the rail line. DOE would provide temporary feed, water, and assistance in livestock movement during rail line construction to assist with the adjustment of cattle to the presence of the rail line. The rail line could pose an additional risk to ranching operations because livestock could be struck by passing trains. DOE or the railroad's commercial operator would reimburse ranchers for such losses, as appropriate.

Most of the local mining activity along both the Caliente and Mina rail alignments would be outside the rail line construction right-of-way. DOE would need to negotiate the rights to cross the few affected unpatented mining claims the rail line would intersect. Along the Caliente rail alignment, the rail line would intersect unpatented mining claims along South Reveille alternative segments 2 and 3; Caliente common segment 3; Goldfield alternative segments 1, 3, and 4; Oasis Valley alternative segments 1 and 3; and common segment 6. The Mina rail alignment would intersect unpatented mining claims along Montezuma alternative segments 1, 2, and 3; Oasis Valley alternative segments 1 and 3; and common segment 6. Mining activities at the Gemfield deposit by Metallic Ventures Gold, Inc., should they occur, could create direct conflicts with the proposed routes of Goldfield alternative segment 4 and Montezuma alternative segment 2, and the Caliente Maintenance-of-Way Facility. DOE would employ mitigation and avoidance strategies as discussed in Chapter 7 to address this potential conflict. Should it be required,

there appears to be sufficient space to relocate both the alternative segment and the Maintenance-of-Way Facility to an area of unoccupied Bureau of Land Management land west of the currently proposed location. This Bureau of Land Management land has topography favorable to the construction of a rail line and Maintenance-of-Way Facility (DIRS 185098-Gehner 2008, p. 2). The rail line could be affected by or affect underground mining tunnels or shafts. During the final engineering design, DOE would perform a survey to verify the locations of mining tunnels and shafts and implement best management practices and mitigation measures to avoid adverse impacts.

The rail alignments have been developed to avoid Wilderness Areas and other scenic and recreational areas. Under either implementing alternative, DOE would construct crossings to prevent the rail line from obstructing access to private and public land. While there could be temporary road closures or detours during the construction phase, there would be no impact to land access during the operations phase. In addition, organized off-highway vehicle events permitted in the past by the Bureau of Land Management might need to alter their routes to avoid the rail line.

The rail alignments would cross a number of utility rights-of-way. DOE would negotiate crossing agreements with right-of-way holders and the Bureau of Land Management. DOE would protect existing utilities from damage so that disruption to utility service or damage to lines would be at most small and temporary. The project would require a Bureau of Land Management right-of-way outside existing Bureau of Land Management planning corridors for utilities; this right-of-way would be outside of right-of-way avoidance areas. Under the longest potential routes, approximately 25 percent of the Caliente rail alignment and 40 percent of the Mina rail alignment (new construction on Bureau of Land Management-managed land) would fall within existing planning corridors. In addition, to avoid the proliferation of new rights-of-way, the Bureau of Land Management could elect to grant future rights-of-way for new utilities adjacent to the proposed rail line.

6.4.1.2 Air Quality and Climate

The air quality and climate region of influence for the Caliente rail alignment encompasses Lincoln, Nye, and Esmeralda counties. The air quality and climate region of influence for the Mina rail alignment encompasses Lyon, Mineral, Esmeralda, and Nye counties, a small portion of Churchill County near Hazen, and the Walker River Paiute Reservation, the bulk of which lies within Mineral County with smaller portions within Lyon and Churchill counties. The Caliente and Mina rail alignments would cross desert and semi-desert areas that generally have abundant hours of cloud-free days, low annual precipitation, and large daily ranges in temperature. All portions of the Caliente and Mina rail alignments would be within areas classified by EPA as in attainment for all *National Ambient Air Quality Standards*

DOE examined emissions inventories to determine county-level increases in air pollutant emissions, and performed air quality simulations to determine potential changes in air pollutant concentrations at specific *receptor* locations (population centers). An adverse impact to air quality would occur if it were shown that a proposed action would conflict with or obstruct implementation of a state or regional air quality management plan, or would exceed a National Ambient Air Quality Standards primary standard or contribute to existing or projected exceedances. DOE determined air pollutant concentrations that could result from railroad construction and operation along the Caliente or Mina rail alignment using the EPA-recommended model for regulatory applications (AERMOD dispersion modeling system version 07026). To assess potential air quality impacts in the region of influence from railroad construction and operation along the Caliente rail alignment DOE modeled emissions and resultant concentrations of criteria air

pollutants where there are two population centers that would be near the rail line—Caliente in Lincoln County and Goldfield in Esmeralda County—and compared the modeling results to the National Ambient Air Quality Standards. DOE likewise modeled air quality for the Mina rail alignment near the population centers that would be relatively close to the rail line: Schurz, Hawthorne, and Mina in Mineral County; and in Silver Peak and Goldfield in Esmeralda County. DOE also performed modeling for the Caliente rail alignment for construction-related activities at a potential quarry site northwest of Caliente and a potential quarry site in South Reveille Valley, and for the Mina rail alignment at the potential Garfield Hills and Malpais Mesa quarry sites.

The analysis showed that criteria air pollutant concentrations along the Caliente or Mina rail alignment would not exceed the National Ambient Air Quality Standards during the construction or operations phases, with the following possible exceptions. During the construction phase for the Caliente rail alignment, the 24-hour National Ambient Air Quality Standards for PM_{10} could be exceeded during quarry operations in South Reveille Valley. During the construction phase for the Mina rail alignment, the 24-hour National Ambient Air Quality Standards for both PM_{10} and $PM_{2.5}$ (*particulate matter* with aerodynamic diameter less than or equal to 10 and 2.5 micrometers, respectively) could be exceeded near the construction right-of-way at Mina and Schurz during the relatively short (less than 6 months) construction period, at the Staging Yard at Hawthorne, and at the potential Garfield Hills quarry. However, DOE would be required to obtain a Surface Area Disturbance Permit Dust Control Plan issued by the State of Nevada Department of Environmental Protection prior to quarry and Staging Yard development. It is likely that requirements in the plan would reduce fugitive dust emissions, thus reducing the possibility of a National Ambient Air Quality Standards exceedance.

For the Caliente rail alignment, DOE determined that the highest increase in air pollutant emissions would occur during the construction phase. During the operations phase for the Caliente rail alignment, the highest increase would occur in the vicinity of the railroad operations support facilities. The highest increase in emissions would be for *nitrogen oxides* emissions in Nye County, where construction emissions could be as much as 8,100 metric tons (8,900 tons) per year over the county's 2002 annual nitrogen oxides emissions, which were 1,436 metric tons (1,600 tons). However, these emissions would be distributed over the entire length of the rail alignment in the county and no air quality standard would be exceeded. The peak year increase in carbon dioxide emissions during construction would increase the national carbon dioxide emission rate by less than 1,219,000 tons (0.02 percent) over 2005 levels. During the operations phase, the highest increase in criteria air emissions would occur in the vicinity of the railroad operations support facilities. Carbon dioxide emissions during operations would increase the national carbon dioxide emission rate by about 94,000 tons (0.001 percent) over 2005 levels.

For the Mina rail alignment, DOE determined that the highest increase in air pollutant emissions would occur during the construction phase. During the operations phase for the Mina rail alignment, the highest increase in air emissions from railroad operations would occur in the vicinity of the operations support facilities. The highest increase in criteria air pollutant emissions would be for nitrogen oxides in Esmeralda County during the construction phase, where emissions could be 3,570 metric tons (3,940 tons) per year higher than the 2002 county-wide nitrogen oxides emissions, which were 149 metric tons (160 tons). However, these emissions would be distributed over the entire length of the rail alignment in the county and no air quality standard would be exceeded. The peak year increase in carbon dioxide emissions during construction would increase the national carbon dioxide emission rate by less than 1,097,000 tons (0.02 percent) over 2005 levels. During the operations phase, the highest increase in criteria air emissions from railroad operations would occur in the vicinity of the railroad

operations support facilities. Carbon dioxide emissions would increase the national carbon dioxide emission rate by about 73,000 tons (0.001 percent) over 2005 levels.

DOE determined that railroad construction and operations along either the Caliente or Mina rail alignment would not cause conflicts with state or regional air quality management plans.

Under the Shared-Use Options for both the Caliente and Mina rail alignments, total emissions would be increased marginally. DOE anticipates that impacts to air quality along the Caliente or Mina rail alignment under the Shared-Use Option would be similar to those under the Proposed Action without shared use. Pollutant emissions and estimated concentrations resulting from construction and operations of the railroad within the repository region of influenceare detailed in Tables 6-9 through 6-14.

Table 6-9. Rail line construction pollutant release rates in the analyzed land withdrawal area from surface equipment during the construction period.

Pollutant	Period	Mass of pollutant per averaging period [kilograms (pounds)]	Emission rate[a] (grams per second)
Nitrogen dioxide	Annual	590,000 (1,300,000)	19
Sulfur dioxide	Annual	420 (930)	0.013
	24-hour	1.7 (3.7)	0.038
	3-hour	0.62 (1.4)	0.038
Carbon monoxide	8-hour	1,800 (4,000)	42
	1-hour	230 (510)	42
Carbon dioxide	Annual	44,000,000 (97,000,000)	1,400
PM_{10}	24-hour	140 (310)	3.2
$PM_{2.5}$	Annual	34,000 (75,000)	1.1
	24-hour	140 (310)	3.1

Note: Numbers are rounded to two significant figures.
a. Based on a 12-hour release for averaging periods of 24 hours or less.

Table 6-10. Rail line construction air quality impacts from construction equipment in the analyzed land withdrawal area during the construction period (micrograms per cubic meter).

Pollutant	Period	Maximum concentration	Regulatory limit	Percent of regulatory limit
Nitrogen dioxide	Annual	2.7	100	2.7
Sulfur dioxide	Annual	0.0019	80	0.0024
	24-hour	0.15	365	0.040
	3-hour	0.61	1,300	0.047
Carbon monoxide	8-hour	250	10,000	2.5
	1-hour	2000	40,000	5.1
PM_{10}	24-hour	12	150	8.2
$PM_{2.5}$	Annual	0.16	15	1.0
	24-hour	12	35	34

Notes: Numbers are rounded to two significant figures. Receptors at boundary of analyzed land withdrawal area.

Table 6-11. Rail Equipment Maintenance Yard and associated facilities pollutant release rates from surface equipment during the construction period in the analyzed land withdrawal area.

Pollutant	Period	Mass of pollutant per averaging period [kilograms (pounds)]	Emission rate[a] (grams per second)
Nitrogen dioxide	Annual	84,000 (190,000)	2.7
Sulfur dioxide	Annual	71 (160)	0.0022
	24-hour	0.28 (0.62)	0.0098
	3-hour	0.11 (0.24)	0.0098
Carbon monoxide	8-hour	300 (660)	11
	1-hour	38 (84)	11
Carbon dioxide	Annual	7,500,000 (17,000,000)	240
PM_{10}	24-hour	22 (49)	0.76
$PM_{2.5}$	Annual	5,300 (12,000)	0.17
	24-hour	21 (46)	0.73

Note: Numbers are rounded to two significant figures.
a. Based on an 8-hour release for averaging periods of 24 hours or less.

Table 6-12. Rail Equipment Maintenance Yard and associated facilities air quality impacts from construction equipment during the construction period in the analyzed land withdrawal area (micrograms per cubic meter).

Pollutant	Period	Maximum concentration	Regulatory limit	Percent of regulatory limit
Nitrogen dioxide	Annual	0.071	100	0.071
Sulfur dioxide	Annual	0.000058	80	0.000073
	24-hour	0.0084	365	0.0023
	3-hour	0.067	1,300	0.0052
Carbon monoxide	8-hour	27	10,000	0.27
	1-hour	220	40,000	0.54
PM_{10}	24-hour	0.65	150	0.43
$PM_{2.5}$	Annual	0.0044	15	0.030
	24-hour	0.63	35	1.8

Notes: Numbers are rounded to two significant figures. Receptors at boundary of analyzed land withdrawal area.

Table 6-13. Annual pollutant emissions (kilograms)[a] from the Rail Equipment Maintenance Yard and associated facilities and activities during the operations period in the analyzed land withdrawal area.

	Rail Equipment Maintenance Yard	Rail Equipment Maintenance Yard trucks	Rail Equipment Maintenance Yard switch train locomotives	Fuel oil storage	Total rail facility emissions
Nitrogen dioxide	34,000	170	360,000	0	400,000
Sulfur dioxide	800	1.0	210	0	1,000
Carbon monoxide	10,000	190	110,000	0	120,000
Carbon dioxide	930,000	110,000	41,000,000	0	42,000,000
PM_{10}	1,100	9.6	11,000	0	12,000
$PM_{2.5}$	1,000	8.9	9,600	0	11,000
Hydrocarbons	4,100	89	27,000	150	31,000

Note: Numbers are rounded to two significant figures; therefore, totals might differ from sums.
a. To convert kilograms to pounds, multiply by 2.2046.

Table 6-14. Air quality impacts from the Rail Equipment Maintenance Yard and associated facilities and activities during the operations period in the analyzed land withdrawal area (micrograms per cubic meter).

Pollutant	Period	Maximum concentration	Regulatory limit	Percent of regulatory limit
Nitrogen dioxide	Annual	0.33	100	0.33
Sulfur dioxide	Annual	0.00086	80	0.0011
	24-hour	0.12	365	0.034
	3-hour	0.98	1,300	0.075
Carbon monoxide	8-hour	42	10,000	0.42
	1-hour	340	40,000	0.84
PM_{10}	24-hour	1.4	150	0.94
$PM_{2.5}$	Annual	0.0089	15	0.060
	24-hour	1.3	35	3.6

Note: Numbers are rounded to two significant figures.

6.4.1.3 Physical Setting

DOE examined the region of influence for physical setting to determine the potential for impacts on physiography, geology, and soils. The region of influence for physical setting includes the areas that would be directly and indirectly affected by construction and operation of the proposed railroad, and incorporates the nominal width of the rail line construction right-of-way [300 meters (1,000 feet) centered on the rail alignment]. It also includes the footprints of construction camps, quarry sites, facility sites, access roads, and water wells that would be outside the nominal width of the construction right-of-way.

DOE determined that land disturbance would be 55 to 61 square kilometers (14,000 to 15,000 acres) for the Caliente rail alignment and 40 to 48 square kilometers (9,900 to 12,000 acres) for the Mina rail alignment. Lands that are currently relatively undisturbed would be extensively graded, which would result in topsoil loss and increased potential for erosion. However, DOE would implement best management practices to minimize erosion and sedimentation during construction activities. DOE assessed that impacts from soil erosion would be small.

Perlite, a locally important mineral, occurs in the area of the Caliente rail alignment Caliente and Eccles alternative segments, and other minerals, such as limestone, metallic commercial minerals, and geothermal resources, have been identified in some nearby mountains. Although no mineral resources would be removed, placement of the rail line could reduce the availability of perlite or limestone for mining. The Goldfield alternative segments would cross mining areas and could limit the boundaries for mining if mineral resources extended under the rail line.

Neither railroad construction nor operation would reduce the availability for mining of metallic minerals that have been identified in surrounding mountains. The Montezuma alternative segments would cross mining areas in the Goldfield Hills area, and could limit the boundaries for mining if mineral resources extended under the rail line.

Along the Caliente rail alignment, construction in the Caliente or Eccles alternative segment and Caliente common segment 1 would result in a small loss of up to 1.8 square kilometers (440 acres) of *prime farmland* soil. These prime farmland soils are found in isolated pockets and are unfarmed. In the Mina rail alignment, construction of Schurz alternative segment 1, 4, 5, or 6 would affect soils characterized as prime farmland directly adjacent to the banks of the Walker River. These areas are not farmed and DOE expects no change in their current agricultural land use. DOE expects that impacts to prime farmland

soils would be small [up to 0.014 square kilometer (3.5 acres) would be lost]. There would be a potential for leaks and spills that could contaminate soils during railroad operations; however, DOE would implement best management practices and consider *mitigation* measures to reduce any impacts.

The Shared-Use Option would require the construction of additional rail sidings within the rail line construction right-of-way in areas of relatively flat terrain. DOE determined that implementation of the Shared-Use Option would increase the surface disturbance area by less than 0.1 percent for either the Caliente or Mina rail alignment, and would add no impacts to physical setting beyond the permanent alterations already described.

6.4.1.4 Paleontological Resources

Paleontology is a science that uses fossil remains to study life in past geological periods. Paleontological resources are recognized as a fragile and nonrenewable record of the history of life on Earth and a critical component of America's natural heritage and, once damaged, destroyed, or improperly collected, their scientific and educational value can be greatly reduced or lost forever. The region of influence for paleontological resources along both rail alignments is the rail line construction right-of-way and the footprints of railroad construction and operations support facilities.

DOE used the Bureau of Land Management system to classify paleontological resource areas according to their potential for containing vertebrate fossils, or noteworthy occurrences of invertebrate or plant fossils. This classification system became the basis to analyze the magnitude of potential impacts from construction in the region of influence of the Caliente and Mina rail alignments.

DOE determined that there are no known paleontological resources along any of the Caliente or Mina rail alignments or at the proposed locations of railroad construction and operations support facilities. Therefore, the Department does not anticipate any impacts to paleontological resources during the construction or operations phase along either alignment. However, if DOE uncovered previously unknown paleontological resources during construction activities, the Department would consult with the Bureau of Land Management to develop appropriate conservation measures.

Under the Shared-Use Option for either rail alignment, impacts to paleontological resources would be similar to those for the Proposed Action without shared use.

6.4.1.5 Surface-Water Resources

The region of influence for surface-water resources would be limited in most cases to the nominal width of construction right-of-way within the Caliente or Mina rail alignment. Railroad construction and operations along either rail alignment would potentially result in both direct and *indirect impacts* to surface-water resources. Many of these impacts are common impacts that would occur along the entire length of the alignment. *Direct impacts* would include temporary or permanent grading, dredging, rerouting, or filling of surface-water resources. Indirect impacts would include potential increases in surface flow and non-point source pollution resulting from runoff from areas where surface grades and characteristics would be changed.

DOE anticipates that during the construction phase of the Caliente or Mina rail alignment, channelization of natural drainage features would be required. Changes in drainage patterns could result in changes in

erosion and sedimentation rates or locations. However, in all instances where the alignment would come close to or cross a surface-water feature, impacts would be substantially minimized by the implementation of engineering design standards and best management practices. The long-term (permanent) direct impacts to wetlands would be mitigated through onsite or offsite mitigation. DOE would develop a compensatory mitigation and monitoring plan for unavoidable impacts as part of its compliance with Section 404 of the *Clean Water Act*.

The Caliente alternative segment is adjacent to *wetlands* and some wetland fill would be unavoidable. DOE proposes to construct the Caliente alternative segment over the abandoned Union Pacific Railroad roadbed, in part to minimize filling wetlands. DOE would further avoid wetlands in the bottom of incised washes adjacent to the roadbed by shifting the roadbed away from the edge of the washes. New bridges would be constructed to span adjacent stream channels and avoid wetland areas. In addition, where the new rail roadbed crossed wetlands and other surface water features, DOE would avoid wetlands by increasing the slope and not constructing a permanent service road adjacent to the track through wetlands. The new rail roadbed would have a reduced footprint with a maximum width of about 17 meters (55 feet). Of the 0.096 square kilometer (23.8 acres) of wetlands delineated within the construction right-of-way, only 0.029 square kilometer (7.1 acres) would be filled to construct the rail line.

There are two options for siting the Staging Yard along the Caliente alternative segment. One option, the Indian Cove Staging Yard, would be constructed in a pasture located north of the City of Caliente. Construction of the Staging Yard in this area would require the wetlands to be filled above the level of the floodplain. It could also require an active drainage system and a channel around the eastern edge of the site to keep the area dry and in a stable condition. Approximately 0.19 square kilometer (47 acres) of wetlands would be filled for construction of the Staging Yard at Indian Cove near Caliente. These actions would require compliance with Section 404 of the Clean Water Act.

The second option (DOE's preferred option), the Upland site of the Staging Yard, is within and adjacent to an agricultural field in Meadow Valley. There is an isolated wetland immediately to the west of the Upland site, in a swale adjacent to the abandoned rail roadbed. DOE would avoid filling this wetland by constructing the staging yard to the west of the abandoned rail roadbed; therefore, no fill of wetlands or other waters of the United States would be required and there would be no impacts to wetlands from construction of the Staging Yard at the Upland site.

DOE identified two possible locations where ballast from quarry CA-8B could be loaded onto ballast trains, which would depend upon the location of the staging yard. If DOE were to select the Indian Cove Staging Yard, ballast would be loaded at that yard. If DOE were to select the Upland Staging Yard, it would construct a quarry siding immediately south of Beaver Dam Road and to the east of the mainline track. The total area of wetlands within the site is estimated to be 0.006 square kilometers (1.59 acres).

The Eccles alternative segment Interchange Yard would require portions of Clover Creek to be filled to elevate the site out of the floodplain. For a length of approximately 1,400 meters (4,600 feet) along the bed of this ephemeral creek (for construction of the interchange tracks), the fill would extend approximately 7.6 to 15 meters (25 to 50 feet) into the creek bed. For a length of approximately 900 meters (2,900 feet) on the east end and 600 meters (2,000 feet) on the west end of the interchange tracks (for construction of the interchange siding), the fill would extend approximately 8 meters (25 feet) into the creek. The total area that would be filled within the confines of Clover Creek would be approximately 0.033 to 0.042 square kilometer (8.2 to 11 acres), depending on the width of the fill.

Channelizing the creek bank and filling the creek bed could affect the velocity, sedimentation rates, and other hydraulic properties of the wash and could indirectly impact downstream riparian areas and associated wetlands, including the proposed Lower Meadow Valley Wash Area of Critical Environmental Concern. It could also impact riparian restoration efforts in Clover Creek required by the EPA.

Along the Mina rail alignment, there could be temporary impacts from disturbance of about 2,000 square meters (0.55 acre) of wetlands along Schurz alternative segments 1 and 4, and 3,000 square meters (0.73 acre) of wetlands along Schurz alternative segments 5 and 6 during construction of a bridge at the rail line crossing of the Walker River. Permanent fill or loss of wetlands would total about 20 square meters (0.005 acre) for Schurz alternative segments 1 and 4, or 28 square meters (0.007 acre) for emplacement of about 14 piers for Schurz alternative segments 5 and 6.

While some changes would be unavoidable, DOE would take steps to ensure the alterations to natural drainage, sedimentation, and erosion processes would not increase future flood damage, increase the impact of floods on human health and safety, or cause identifiable harm to the function and values of floodplains. The Department would implement best management practices, including erosion control measures such as the use of silt fences and flow-control devices to reduce flow velocities and minimize erosion.

6.4.1.6 Groundwater Resources

The generally dry climate characterizing the southern Nevada region is consistent with a lack of shallow *groundwater* underlying much of the length of the Caliente and Mina rail alignments. The region of influence for groundwater resources includes portions of the *aquifers* that would be affected by groundwater withdrawals DOE would make to obtain the water needed for railroad construction and operations. Groundwater resource features evaluated through impacts analysis include existing wells and nearby springs, seeps, and other surface-water-right locations (if present within the region of influence and potentially in hydraulic connection with proposed withdrawal well water-bearing zones). In a 1-mile (1.6-kilometer) region of influence surrounding the proposed Caliente rail alignment region of influence, groundwater withdrawals for domestic and irrigation purposes currently represent most of the groundwater use. In a 1-mile region of influence surrounding the Mina rail alignment region of influence, public supply-municipal, agricultural (stock watering), and mining and milling-related groundwater withdrawals currently represent most of the groundwater use.

To supply the approximately 7.5 billion cubic meters (6,100 acre-feet) of water needed during the construction phase along the Caliente rail alignment, DOE estimates that it would need to install approximately 150 to 176 new wells. To supply the approximately 7.4 billion cubic meters (5,950 acre-feet) of water needed during the construction phase along the Mina rail alignment, DOE estimates that it would need to install between approximately 77 and 110 new wells.

DOE analyses indicated that the effects of groundwater withdrawals from the proposed water-supply wells at the range of production rates that could be required to support a 4-year construction phase along either rail alignment would be localized in nature and extent, and hydrogeologic effects would be temporary. DOE determined that the short-term impacts caused by water withdrawals would be a series of localized drawdown cones of depression within the host aquifer surrounding each pumped well. DOE does not anticipate that proposed groundwater withdrawals would conflict with known regional or local aquifer management plans or the goals of governmental water authorities, and expects that the likelihood

of impacts from groundwater withdrawals occurring to downgradient groundwater basins (or *hydrographic areas*) would tend to be low. DOE expects that impacts to ground subsidence or groundwater quality that could result from railroad construction and operations along either rail alignment would be small.

Groundwater withdrawals from hydrographic basin 227A, where the regions of influence for the railroad and repository overlap, would be approximately 333,000 cubic meters (270 acre-feet) during the first year of construction, 311,000 cubic meters (252 acre-feet) during the second year, 37,000 cubic meters (30 acre-feet) during the third year, and 25,000 cubic meters (20 acre-feet) during the final year of construction. Groundwater withdrawal rates for permanent water wells to support rail sidings and railroad operations facilities would be very low [less than 4 liters (1 gallon) per minute of the permanent water wells to approximately 26 liters (7 gallons) per minute]. Groundwater withdrawals from hydrographic basin 227A during operations of the railroad would be approximately 7,400 cubic meters (6 acre-feet) per year, and would commence about 1 year after repository construction began.

DOE anticipates that the impact to groundwater resources from contaminants that might be released by construction equipment during the construction phase or during railroad operations would be small because of generally deep groundwater beneath most of the Caliente and Mina rail alignments.

Railroad operations along the Mina and Caliente rail alignments would result in small potential impacts to groundwater resources. The Department would discontinue operating most of the wells needed following the railroad construction phase because there would not be a continued need for large-scale water withdrawals to support railroad operations. Additionally, groundwater withdrawal rates for those wells left in place to support railroad operations would be expected to be very low.

Overall, water demands for railroad construction and operations along the Caliente or the Mina rail alignment would represent a small portion of current water use amounts in their respective regions of influence. Existing groundwater uses within a 1-mile (1.6-kilometer) region of influence would likely continue to be dominated by domestic and irrigation withdrawals for the Caliente rail alignment, and by public-supply/municipal agricultural, and mining and milling withdrawals for the Mina rail alignment, with possibly increasing urban use from water transfers to the Las Vegas area (Caliente alignment).

Under the Shared-Use Option for either rail alignment, commercial-only facilities would require water for daily operation. The additional impacts to groundwater resources would be small, and overall would be similar to those described for the Proposed Action without shared use.

6.4.1.7 Biological Resources

DOE considered two areas of assessment in analyzing the *affected environment* for biological resources: a region of influence consisting of the nominal width of the construction right-of-way and a larger study area consisting of a 16-kilometer (10-mile)-wide area extending 8 kilometers (5 miles) on either side of the centerline of the rail alignment to ensure the identification of sensitive *habitat* areas and transient or migratory wildlife. The Caliente and Mina rail alignments are situated within the “cold” *Great Basin* Desert that covers most of central and northern Nevada and the “hot” Mojave Desert that covers most of southern Nevada and much of southeastern California. Although the two deserts are distinguished climatically, they are also distinguished by their predominant vegetation and vegetation communities.

For both the Caliente rail alignment and the Mina rail alignment, DOE determined that there would be some indirect adverse impacts due to the potential for the introduction and spread of noxious and invasive weed species during construction activities; however, the Department would minimize or avoid impacts through implementation of best management practices and Bureau of Land Management-prescribed methods. DOE concluded that there would be a small mostly short-term indirect impact to game species during railroad construction and operations along either rail alignment, due to temporary displacement causing pressure on other areas for habitat and forage. There could be small direct impacts due to a small loss of forage from the removal of vegetation to construct the proposed railroad. In addition, railroad operations could result in possible wildlife collisions with trains and disturbance from noise caused by passing trains. However, these impacts would not affect the viability of any game species' population.

DOE determined that federally listed species potentially present along the Caliente and Mina rail alignments could include the Mojave population of the desert tortoise, the southwestern willow flycatcher, the yellow-billed cuckoo, the Lahontan cutthroat trout, and the Ute ladies' tresses orchid. There would likely be small short-term indirect impacts to some Bureau of Land Management and State of Nevada special-status animal species because they might avoid the area of the rail alignment or be displaced during construction activities. Any potential direct impact would be due to habitat fragmentation and disturbance and possible injury or loss of individuals of a species from collision with trains. There could be indirect impacts on small mammals as a result of possible changes to predator-prey interactions due to the construction of towers and other structures that would provide new perch habitat for raptors and other predatory birds. DOE determined that potential impacts from noise disturbance to migratory birds would be small and short-term during construction and small from permanent habitat loss during operations. Potential direct impacts to the desert tortoise would be due to fragmentation of habitat and the possible crushing of occupied burrows during construction of common segment 6 and the Rail Equipment Maintenance Yard. Although these losses would be a small decrease in the number if individual tortoises in the vicinity of the railroad, long-term survival of this species would not be affected. For both the Caliente and Mina rail alignments, DOE determined that impacts to herd management areas and potential impacts to individual wild horses or burros would be small and would not significantly affect the management strategies utilized within the herd management areas.

DOE anticipates that for the Caliente rail alignment there would be short-term and long-term impacts to wetlands and riparian habitats from construction of the Caliente alternative segment, either of the potential Staging Yard locations (Indian Cove and Upland), and the Eccles alternative segment. Impacts from constructing the Caliente alternative segment would be mostly short-term and small, because the rail line would be constructed over an abandoned rail roadbed and limited to existing bridge crossings that would require modifications. The Eccles alternative segment would result in a small short-term impact to riparian habitat and would be limited to bridge construction over Meadow Valley Wash. Construction of the Indian Cove Staging Yard could result in a moderate impact in comparison with the Upland Option due to topographic constraints that could require possible draining and filling of the wetland. The proposed Eccles Interchange Yard could result in mostly small direct short-term impacts due to a small loss of riparian vegetation and small short-term indirect impacts with the potential for change in stream flow and increase in sedimentation. DOE determined there would be a moderate impact to wildlife habitat along Garden Valley alternative segments 1 and 3. Localized and minor loss of roosting and foraging habitat for the southwestern willow flycatcher and western yellow-billed cuckoo could occur from construction of the Caliente alternative segment; however, because these species do not nest along the alignment, impacts would be small and limited to transient individuals.

DOE determined that for the Mina rail alignment there would be direct short-term impacts to riparian vegetation from construction of Schurz alternative segment 1, 4, 5, or 6 due to bridge construction over the Walker River. There would be no long-term impacts on riparian vegetation along the Walker River as a result of constructing any of the Schurz alternative segments. There would be short-term moderate impacts to wildlife habitat at the potential Malpais Mesa quarry site. Construction of the Walker River Bridge for Schurz alternative segments 1, 4, 5, or 6 could result in a moderate short-term indirect impact on Lahontan cutthroat trout; however, DOE could mitigate any anticipated impact.

Under the Shared-Use Option, there would be more train traffic; therefore, DOE anticipates wildlife interactions with train traffic (collisions, change in movement patterns, altered behavior, and nest abandonment) would be slightly increased. Nevertheless, DOE anticipates that this slight increase in train traffic would result in small impacts to the wildlife communities. The existing rail alignment design could accommodate shared use with little additional construction (a few sidings), and the Department does not anticipate additional impacts from shared use above those discussed.

6.4.1.8 Cultural Resources

The region of influence for cultural resources includes the construction right-of-way (the area of potential direct and indirect impacts) and a 3.2-kilometer (2-mile)-wide area centered on the rail alignment (the area of potential indirect impacts).

Because of the length of the proposed rail line along the Caliente and Mina rail alignments, DOE is using a phased cultural resource identification and evaluation approach, described in 36 CFR 800.4(b)2, to identify specific cultural resources. Under this approach, DOE would defer final intensive field surveys (known as Class III inventories) of the actual construction right-of-way, as provided in the Programmatic Agreement between DOE, the Bureau of Land Management, the Surface Transportation Board, and the Nevada State Historic Preservation Office. The Programmatic Agreement states that an appropriate level of field investigation—including on-the-ground intensive surveys, evaluations of all recorded resources listed on the *National Register of Historic Places*, assessments of adverse effects, and applicable mitigation of identified impacts—be completed before any ground-disturbing construction activities that could affect a specific resource could begin.

Railroad construction and operations could lead to unavoidable changes in cultural landscapes, such as changes to ethnographic, rural historic, and historic viewscapes. Cultural landscapes along the Caliente rail alignment include historic-period Western Shoshone villages and surrounding use areas in the Oasis Valley, the Goldfield area, and Stone Cabin and Reveille Valleys; early ranching operations in Stone Cabin and Reveille Valleys; the historic Mormon settlement of Meadow Valley Wash; and the Goldfield, Clifford, and Reveille Mining Districts. Cultural landscapes along the Mina rail alignment include historic-period Northern Paiute use of the Walker River and Walker Lake areas, historic period Western Shoshone villages and surrounding use areas in the Oasis Valley and Goldfield areas, and historic mining in the Luning, Mina, and Goldfield districts.

DOE completed literature reviews and a Class II inventory (sample field surveys within the construction right-of-way) for 20 percent of each alternative segment and common segment along the Caliente and Mina rail alignments and has thereby identified potential areas of specific impacts. In addition, DOE conducted an intensive Class III inventory along a 12-kilometer (7.4-mile) corridor within the *Yucca*

Mountain site boundary, which resulted in the identification of seven sites and five isolates (isolated artifacts).

Based on preliminary information and the sample surveys conducted to date, the magnitude of impacts along both the Caliente and Mina rail alignments would range from small to moderate due to the extensive effort DOE would undertake to avoid or mitigate impacts to cultural resources in accordance with the regulatory framework and with the terms of the cultural resources Programmatic Agreement.

Impacts to cultural resources under the Shared-Use Option for either the Caliente or Mina rail alignment would be approximately the same as those under the Proposed Action without shared use. However, construction of any additional commercial-use sidings would have the potential to affect cultural resources.

6.4.1.9 American Indian Interests

Based on information provided by the Consolidated Group of Tribes and Organizations, American Indians are concerned that substantial and high adverse effects to a number of American Indian interests could be caused within and adjacent to the Caliente rail alignment region of influence, which also encompasses the southern segments of the Mina rail alignment. The Consolidated Group of Tribes and Organizations is a forum consisting of officially appointed tribal representatives from 17 tribes and organizations who are responsible for presenting their respective tribal concerns and perspectives to DOE. At the time of discussions with the Consolidated Group of Tribes and Organizations, the Mina rail alignment was not under consideration as an implementing alternative and the views of the Northern Paiute peoples who traditionally occupied lands north of Goldfield and Tonopah are not presented by this group. As part of any Proposed Action, the Department would continue to consult with American Indian tribes with regard to their interests and beliefs.

The proposed Mina rail alignment would pass through and directly affect the Walker River Paiute Reservation. In a letter dated April 29, 2007, the Walker River Paiute Tribal Council officially informed the Department of their withdrawal from the *environmental impact statement* process. The Tribal Council made the decision to withdraw based on information obtained during the Tribe's involvement with the Rail Alignment EIS process and input from Tribal members. The Tribe determined that the impacts and risks associated with nuclear shipments through the reservation were too great and they reaffirmed a past objection to the transportation by any means of nuclear or radioactive material through the reservation.

American Indian views on construction and operation of a railroad along the Caliente rail alignment, as primarily expressed by the Consolidated Group of Tribes and Organizations, state that construction and operation of the proposed railroad would constitute an intrusion on the traditional lands of Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone people; would disturb cultural, biological, botanical, geological, and hydrological resources, including American Indian viewscapes, songscapes, storyscapes, and traditional cultural properties; would restrict the free access of American Indian people to their resources; and could cause substantial and high adverse effects to a number of American Indian interests within and adjacent to the region of influence. Within that forum of beliefs there would be an unavoidable impact to American Indian interests.

6.4.1.10 Socioeconomics

DOE assessed impacts to socioeconomic conditions in relation to population, housing, employment and income, and public service over the region of influence for the Caliente rail alignment in Lincoln, Esmeralda, Nye, and Clark counties, and over the region of influence for the Mina rail alignment in Churchill, Lyon, Mineral, Nye, Esmeralda, and Clark counties, the combined area of Washoe County and Carson City, and the Walker River Paiute Reservation.

The social and economic activities and changes associated with railroad construction along either rail alignment would include a brief elevation in project-related employment, increases in *real disposable income*, increases in state and local spending, increases in *Gross Regional Product*, population increases, slower rate of growth in the level of employment as railroad project activities moved from construction to operations, and possible small stresses on transportation including small traffic-delay impacts on road traffic at grade crossings. The percentage values of such changes would be low, as reported in Chapter 2, Table 2-3 of this Repository SEIS, and DOE has assessed such impacts to be generally small.

Changes associated with the railroad operations along either rail alignment would include increases in project-related employment (particularly associated with railroad facilities), slight population increases, possible small stresses on transportation, including small traffic-delay impacts on road traffic at grade crossings, some pressure on housing, and possible strains on public services (for example, schools, health care, and fire protection) in southern Nye County where the Cask Maintenance Facility, Rail Equipment Maintenance Yard, and possibly the Nevada Railroad Control Center and the National Transportation Operations Center would be located. The percentage values of such changes would be low, as shown in Chapter 2, Table 2-3. DOE has assessed such impacts to be generally small to moderate.

Under the Shared-Use Option for either rail alignment, there would be little increase in impacts beyond those described for the Proposed Action without shared use. Based on the lengths of track involved under the Shared-Use Option, the incremental impacts to traffic from constructing the additional sidings would be a small fraction of the overall impacts for rail line construction under the Proposed Action without shared use. Thus, impacts to the transportation *infrastructure* under the Shared-Use Option would be small. Traffic-delay impacts at highway-rail grade crossings from construction trains would be consistent with the delay impacts under the Proposed Action without shared use. These impacts would be small.

6.4.1.11 Occupational and Public Health and Safety

6.4.1.11.1 *Caliente and Mina Rail Corridors*

Nonradiological Impacts

DOE estimated nonradiological occupational health and safety impacts in relation to worker exposures to physical hazards and nonradioactive hazardous chemicals during the construction phase. DOE based these estimates on the number of hours worked and occupational incident rates for *total recordable cases*, *lost workday cases*, and fatalities.

Construction and operations workers could be exposed to physical hazards and to nonradiological hazardous chemicals related to operation and maintenance of construction equipment, rail line equipment, and facility equipment, including maintenance of casks and maintenance-of-way activities, which would include welding, metal degreasing, painting, and related activities. Occupational health and safety

impacts could also result from worker exposure to fuels, lubricants, and other materials used in railroad construction, operation, and maintenance.

The recorded incident rates of these exposure hazards during construction work at the Yucca Mountain site have been small and are anticipated to be small for railroad construction and operations. Dust and soils hazards include potential occupational exposure to hazardous inhalable dust. However, occupational impacts associated with exposure to dust would be expected to be small. DOE would implement measures, such as processing and engineering controls, to reduce exposure to dust. Impacts to construction or operations workers from unexploded ordnance would be small due to implementation of inspection procedures and mitigation measures. Workers might also be exposed to biological hazards including infectious diseases (such as Hantavirus or West Nile Virus) and other biological hazards (such as venomous animals). The recorded incident rates of these biological hazards are small, and DOE would expect small impacts to construction or operations workers from these biological hazards.

DOE used both qualitative and *quantitative* components to estimate transportation accident incidents and potential fatalities resulting from vehicular and train accidents.

DOE estimated the following:

- During the construction phase, along both the Caliente rail alignment and the Mina rail alignment, there would be 6 vehicle-related fatalities.
- During the operations phase along the Caliente rail alignment, there would be 8 vehicle-related fatalities; along the Mina rail alignment, there would be 7 vehicle-related fatalities.
- During railroad construction and operations along the Caliente and Mina rail alignments, modeling indicates that there would be 16 rail-related accidents and approximately 1 rail-related fatality.

For the Shared-Use Option, DOE estimated the following:

- During the operations phase along the Caliente rail alignment, there would be 8 vehicle-related fatalities; along the Mina rail alignment, there would be 7 vehicle-related fatalities.
- During the operations phase along the Caliente rail alignment, there would be 26 rail-related accidents and 4 rail-related fatalities; along the Mina rail alignment, there would be 36 rail-related accidents and 7 rail-related fatalities.
- Nonradiological fatality impacts to workers from industrial hazards from railroad and facility construction and operations along the Caliente rail alignment would be approximately 3, and for the Mina rail alignment would be approximately 2.

Radiological Impacts

DOE estimated radiological impacts to workers and the public for incident-free transportation, the risk from transportation accidents, and the consequences of severe transportation accidents. The region of influence for radiological impacts to members of the public during incident-free transportation includes the area 0.8 kilometer (0.5 mile) on either side of the centerline of the rail alignments. The region of influence for occupational radiological impacts during incident-free operation includes the physical

boundaries of railroad operations support facilities. For radiological accidents, the populations within the region of influence are based on the population within 80 kilometers (50 miles) on either side of the centerlines of the rail alignments.

DOE estimated the following:

- For workers, the radiological impacts were estimated to be 0.34 latent cancer fatality for the Caliente rail alignment and 0.35 latent cancer fatality for the Mina rail alignment.
- For workers at the Cask Maintenance Facility, the radiological impacts were estimated to be 0.43 latent cancer fatality. For workers at the Rail Equipment Maintenance Yard, the radiological impacts were estimated to be 0.0096 latent cancer fatality.
- For members of the public, the radiological impacts were estimated to be 1.4×10^{-4} latent cancer fatality for the Caliente rail alignment and 8.5×10^{-4} latent cancer fatality for the Mina rail alignment.
- For members of the public, the radiological impacts from the Cask Maintenance Facility were estimated to be 7.0×10^{-6} latent cancer fatality.
- The risk from transportation accidents was estimated to be 1.3×10^{-6} latent cancer fatality for the Caliente rail alignment and 7.7×10^{-6} latent cancer fatality for the Mina rail alignment.
- The consequences of the maximum reasonably foreseeable accident were estimated to be 0.0012 latent cancer fatality in rural areas and 0.46 latent cancer fatality in suburban areas along the Caliente rail alignment, and 0.0089 latent cancer fatality in rural areas and 1.2 latent cancer fatalities in suburban areas along the Mina rail alignment. The frequency of this severe accident ranged from 6×10^{-7} to 7×10^{-7} per year.

Sabotage

In response to the terrorist attacks of September 11, 2001, and to intelligence information that has been obtained since then, the United States Government has initiated nationwide measures to reduce the threat of sabotage. These measures include security enhancements intended to prevent terrorists from gaining control of commercial aircraft and additional measures imposed on foreign passenger carriers and domestic and foreign cargo carriers, as well as charter aircraft.

The Federal Government has also greatly improved the sharing of intelligence information and the coordination of response actions among federal, state, and local agencies. DOE has been an active participant in these efforts. In addition to its domestic efforts, DOE is a member of the International Working Group on Sabotage for Transport and Storage Casks, which is investigating the consequences of sabotage events and exploring opportunities to enhance the physical protection of casks.

The Department, as required by the *Nuclear Waste Policy Act*, would use transportation casks certified by the NRC. Spent nuclear fuel is protected by the robust metal structure of the transportation cask, and by cladding that surrounds the fuel pellets in each fuel rod of an assembly. Further, the fuel is in a solid form, which would tend to reduce dispersion of radioactive particulates beyond the immediate vicinity of the cask, even if a sabotage event were to result in a breach of the multiple layers of protection.

In addition, the NRC has promulgated rules (10 CFR 73.37) and interim compensatory measures (67 FR 63167, October 10, 2002) specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. The Department has committed to following these rules and measures (see 69 FR 18557, April 8, 2004).

For the reasons stated above, DOE believes that under general credible threat conditions the probability of a sabotage event that would result in a major radiological release would be low. Nevertheless, because of the uncertainty inherent in the assessment of the likelihood of a sabotage event, DOE has evaluated events in which a military jet or commercial airliner would crash into a spent nuclear fuel cask or a modern weapon (a high-energy-density device) would penetrate a spent nuclear fuel cask.

In the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix J, Section J.3.3.1), DOE evaluated the ability of large aircraft parts to penetrate transportation casks and found that neither the engines nor shafts would penetrate a cask and cause a release of radiological materials if an aircraft were to crash into a spent nuclear fuel cask. Further analysis determined that if the impact and resultant fire caused a cask seal to fail, little radiation would escape and there would be less than 0.65 latent cancer fatality in the affected urban population. In the rural and suburban areas along the Caliente or Mina rail alignments, the impacts would be even lower. In the FEIS, DOE estimated the potential impacts of a sabotage event in which a high-energy-density device penetrates a rail cask. For the Rail Alignment EIS, DOE obtained more recent estimates of the fraction of spent nuclear fuel materials that would be released (release fractions) (DIRS 181279-Luna 2006, all). Based on the more recent information DOE estimated that there would be 0.0028 latent cancer fatality in rural areas and 1.1 latent cancer fatalities in suburban areas along the Caliente rail alignment, and 0.021 latent cancer fatality in rural areas and 2.8 latent cancer fatalities in suburban areas along the Mina rail alignment.

DOE also used both qualitative and quantitative components to estimate transportation accident incidents and potential fatalities resulting from vehicular and train accidents.

6.4.1.11.2 *Other Nevada Transportation Impacts*

In addition to the impacts from constructing, operating, and closing a rail line within Nevada, there would also be transportation-related impacts from truck shipments of spent nuclear fuel and high-level radioactive waste within Nevada. For these shipments, DOE estimated the following:

- The number of latent cancer fatalities to workers from radiological impacts during the operations period would be 0.057 (about 1 chance in 20).
- The number of latent cancer fatalities to the public from radiological impacts during the operations period would be 0.012 (about 1 chance in 80).
- The number of fatalities from exposure to vehicle emissions would be 0.0046 (about 1 chance in 200).
- The radiological risk from transportation accidents would be 1.9×10^{-6} latent cancer fatality (about 1 chance in 500,000).
- The number of nonradiological traffic fatalities would be 0.050 (1 chance in 20).

- The total number of radiological and nonradiological fatalities from truck shipments of spent nuclear fuel and high-level radioactive waste within Nevada would be 0.12 (about 1 chance in 8).

Within Nevada, there would also be transportation-related impacts from rail shipments from the Nevada border to the beginning of the Caliente or Mina rail corridors. These impacts are not included in the estimates of impacts for the Caliente and Mina rail corridors but are included in the national impacts presented in Section 6.3 of this Repository SEIS.

Table 6-15 lists the impacts for maximally exposed workers and members of the public from transporting spent nuclear fuel and high-level radioactive waste in Nevada for both rail and truck shipments. Among workers, escorts and inspectors would receive the highest estimated radiation doses, in large part because of their proximity to casks and the amount of time they would be exposed. The maximally exposed worker would receive an estimated radiation dose of 25 rem over as many as 50 years of repository operations, based on a 500-millirem-per-year administrative dose limit (DIRS 174942-BSC 2005, Section 4.9.3.3). The probability of a latent cancer fatality for this worker is 0.015 or about 1 chance in 70.

Table 6-15. Estimated radiation doses for maximally exposed workers and members of the public from Nevada transportation.[a]

Category	Dose (rem)	Probability of LCFs
Workers		
Escorts and inspectors	25[b]	0.015
Railyard crew member	4.8	0.0029
Truck inspector	11	0.0065
Worker at maintenance-of-way trackside facility	0.00088	0.00000053
Worker located at siding	0.00013 – 0.00051	0.000000077 – 0.00000030
Public		
Resident along rail route at 18 meters (60 feet)	0.0078	0.0000047
Other individuals near the rail route in Las Vegas[c]		
Individual at 15 meters (49 feet)	0.00075	0.00000045
Individual at 20 meters (66 feet)	0.00055	0.00000033
Individual at 30 meters (98 feet)	0.00035	0.00000021
Individual at 35 meters (110 feet)	0.00029	0.00000018
Individual at 40 meters (130 feet)	0.00024	0.00000015
Individual at 100 meters (330 feet)	0.000067	0.000000040
Individual at 160 meters (520 feet)	0.000029	0.000000017
Other individuals near the rail route in Reno (Reno trench)	0.0049	0.0000029
Individual along U.S. Highway 95 in Indian Springs	0.0011	0.00000064
Person in traffic jam	0.016	0.0000096
Person at service station	0.21	0.00013
Person near Staging Yard		
Caliente-Indian Cove	0.0000030	0.0000000018
Caliente-Upland	0.0027	0.0000016
Eccles-North	0.0000034	0.0000000021
Mina-Hawthorne	0.00018	0.00000011

a. Impacts are for the entire 50-year shipping period.
b. Based on a 500-millirem-per-year administrative dose limit.
c. Locations identified by the Nevada Agency for Nuclear Projects (DIRS 158452-Nevada Agency for Nuclear Projects 2002, p. 123).
LCF = Latent cancer fatality.

Members of the public would receive lower estimated radiation doses than workers from incident-free transportation because they would not be as close to the casks as workers and would not be exposed for as long as workers. The member of the public with the highest estimated individual radiation dose would be a service station attendant who refueled the trucks during shipments of spent nuclear fuel and high-level radioactive waste. Using assumptions that tend to overstate the risks, the same person would refuel about 600 trucks and receive an estimated radiation dose of 0.21 rem over as many as 50 years of shipments. Using these assumptions, the probability of a latent cancer fatality for this individual is 0.00013, or about 1 chance in 8,000.

The impacts of severe transportation accidents involving rail shipments of spent nuclear fuel and high-level radioactive waste within Nevada would be similar to the impacts estimated in Section 6.3.3.2 of this Repository SEIS and in Sections 4.2.10 and 4.3.10 of the Rail Alignment EIS. The impacts of severe transportation accidents involving truck shipments of spent nuclear fuel and high-level radioactive waste within Nevada would be less than those involving rail shipments. In addition, the impacts of transportation sabotage events involving truck and rail shipments of spent nuclear fuel and high-level radioactive waste would be similar to the impacts estimated in Section 6.3.4 of this Repository SEIS and in Sections 4.2.10 and 4.3.10 of the Rail Alignment EIS.

6.4.1.12 Noise and Vibration

DOE analyzed potential impacts from noise based on current *ambient* noise levels, noise modeling for future activities (proposed railroad construction and operations), and identification of changes in noise levels at noise-sensitive receptors (such as residences, schools, libraries, retirement communities, nursing homes) within the regions of influence. The region of influence for noise and vibration for construction and operations of the railroad along either the Caliente or the Mina rail alignment includes the construction right-of-way and extends out to variable distances along each rail alignment (depending on several factors, including the number of trains per day, ambient noise level, train speed, and number of railcars).

For operation of trains during the construction and operations phases, DOE analyzed noise impacts under established Surface Transportation Board criteria (a noise level of 65-dBA *day-night average sound level* or greater, with a 3-dBA or greater increase from the baseline). For noise impacts from construction activities, DOE used U.S. Department of Transportation, Federal Transit Administration, methods and construction noise guidelines. To evaluate potential vibration impacts from construction and operation activities, DOE used Federal Transit Administration building vibration damage and human annoyance criteria.

DOE determined that railroad construction and operations along the Caliente rail alignment would lead to an unavoidable increase in ambient noise from construction activities and passing trains. Noise from trains might be noticeable as new noise in residential areas near the rail line in Caliente and Goldfield. Because there is already a substantial amount of train activity in Caliente, additional train noise would be less noticeable than in other areas where there is currently no train activity and no train noise. For construction activities, noise levels in Caliente would be higher than Federal Transit Administration construction noise guidelines and would result in a temporary unavoidable impact. Train noise during the construction phase would cause 34 receptors to be adversely impacted. These would be temporary adverse impacts because of the temporary nature of the construction phase. During the operation phase, three receptors would be adversely impacted by train noise. For these receptors, DOE would consider

mitigation, such as the development of a Quiet Zone, stationary warning horns, or building sound insulation treatments. A Quiet Zone refers to specific grade crossings that have sufficiently upgraded safety measures such that locomotive warning horns do not have to be sounded.

DOE determined that railroad construction and operations along the Mina rail alignment could lead to an unavoidable increase in ambient noise from passing trains in areas of Nevada that are mostly uninhabited. Noise from trains might be noticeable as new noise in residential areas near the rail line in Silver Springs, Silver Peak, Mina, and Goldfield. Because there is already some train activity in Silver Springs, additional train noise would be less noticeable there than in other areas where there is currently no train activity and no train noise. Construction of any of the Schurz alternative segments would eliminate future noise and vibration associated with operation of the existing Department of Defense Branchline through Schurz. However, there would be construction noise associated with removal of this existing rail line, although this noise would be temporary and no adverse impact would be expected.. For construction activities, noise levels along the Mina rail alignment would be lower than Federal Transit Administration construction noise guidelines. For train noise during the construction phase, there would be temporary adverse impacts at receptors in Silver Springs. For train noise during the operations phase, estimated noise levels at eight receptors in Silver Springs and one in Wabuska would be higher than impact criteria; therefore, there would be adverse impacts from noise associated with railroad operations at those locations. However, DOE would investigate mitigation methods for these nine locations. Mitigation methods could include building sound insulation, stationary warning horns, or the development of a Quiet Zone, which would allow the rail operator to reduce horn noise at specific crossings.

During the construction and operations phases along either the Caliente or Mina rail alignment, vibration levels would not exceed the Federal Transit Administration damage criteria for extremely fragile historic buildings. Therefore, DOE would expect no building damage due to vibration. In addition, train-generated vibration levels would be lower than Federal Transit Administration human annoyance criterion.

Under the Shared-Use Option for either rail alignment, increased rail traffic could result in noise impacts similar to the impacts described for the Caliente and Mina rail alignments without shared use. Increased operations would not affect vibration impacts because vibration is evaluated on a maximum-level basis only.

6.4.1.13 Aesthetic Resources

DOE considered the region of influence for aesthetic resources as the viewshed around all *common segments*, alternative segments, and facilities along the Caliente and Mina rail alignments. To ensure that seldom-seen views were included in this analysis, DOE used a conservative region of influence extending 40 kilometers (25 miles) on either side of the centerline of all common segments and alternative segments, and around facilities. Most of the lands that would be affected by the Proposed Action are Bureau of Land Management-administered public lands, including those on which the proposed railroad would be constructed. For this reason, DOE used Bureau of Land Management visual resource management classifications and contrast rating methodologies to evaluate aesthetic impacts to the surrounding viewshed. The Bureau of Land Management assigns visual resource management classes to lands under its jurisdiction, based on scenic quality and other factors, that range from Class I to Class IV, with Class I representing the highest visual values. Each class comes with specific visual resource management objectives that indicate the levels of project-related contrast that are acceptable. In this

analysis, the primary basis for identifying potential adverse impacts to aesthetic resources was inconsistency with these Bureau of Land Management visual resource management objectives. The Department assessed the potential visual contrast between existing conditions and conditions expected during the project from key locations and compared these levels of contrast with the visual resource management objectives associated with the Bureau of Land Management classifications of the surrounding viewshed.

Along both the Caliente and the Mina rail alignments, DOE found that the contrast that would be caused by the rail line and support facilities would remain consistent with Bureau of Land Management visual resource management objectives during the operations phase, but could be inconsistent in certain locations during the construction phase. Along the Caliente rail alignment, a conveyor crossing of U.S. Highway 93 near the Caliente-Indian Cove or Caliente-Upland location of the Staging Yard, the northern portion of the Caliente-Indian Cove Staging Yard, and along some portions of Garden Valley alternative segments 1, 2, 3, and 8, construction would temporarily not meet Bureau of Land Management visual resource management objectives for the surrounding Class II or III lands.

Along the Mina rail alignment, DOE determined that construction of Schurz alternative segment 6 crossing of U.S. Highway 95 on the Walker River Paiute Reservation would temporarily not meet Bureau of Land Management objectives for Class III areas.

Overall, DOE anticipates that short-term visual impacts during the construction phase would range from small to large, and long-term impacts during the operations phase would range from small to large, without mitigation, and would be consistent with applicable Bureau of Land Management visual resource management objectives.

Impacts to aesthetic resources during the construction phase under the Shared-Use Option would generally be the same as those under the Proposed Action without shared use. Construction of additional sidings would create small impacts to the visual setting because of the short duration of construction. Impacts to aesthetic resources during the construction phase under the Shared-Use Option for both the Caliente and Mina rail alignments would be generally the same as those under the Proposed Action without shared use. Construction of additional sidings would create small impacts to the visual setting because of the short duration of construction.

6.4.1.14 Utilities, Energy, and Materials

The Caliente rail alignment region of influence for public water systems and wastewater transported offsite for treatment and *disposal* is Lincoln, Nye, and Esmeralda counties. The Mina rail alignment region of influence for public water systems and wastewater transported offsite for treatment and disposal is Lyon, Mineral, Esmeralda, and Nye counties, and the Walker River Paiute Reservation, the bulk of which lies in Mineral County with smaller portions in Churchill and Lyon counties. The region of influence for telecommunications and electricity is limited to the companies that service the aforementioned counties. The region of influence for fossil fuels is limited to regional suppliers within the State of Nevada. The region of influence for construction materials is defined by the distribution networks and suppliers of that material to the general project area.

DOE determined that the demands placed on utilities, energy, and materials from constructing and operating the proposed rail line along either alignment would be met by existing supply capacities;

therefore, potential impacts would be small. Utility interfaces would have the potential for short-term interruption of service, but would experience no permanent or long-term loss of service or prevention of future service area expansions. Most water for construction along either rail alignment would be supplied by new wells, although public water systems could be slightly affected by population increases attributable to construction employees. Wastewater treatment systems would not be directly affected by construction activities because dedicated treatment systems would be provided at construction camps; however, there could be small impacts to wastewater treatment systems due to population increases attributable to construction employees. There would be very small impacts to telecommunications systems because, during the construction phase, DOE would utilize a dedicated telecommunications system and rely little on existing telecommunications systems.

Peak electricity demand would be within the capacity of regional providers. The demand for fossil fuels during construction would be approximately 6.5 percent and 6 percent of statewide use for the Caliente and Mina rail alignments, respectively, and could be met by existing regional supply systems and suppliers. During the operations phase, the demand for fossil fuels for either rail alignment would be less than 0.25 percent of statewide use. The primary materials that would be consumed during the construction phase would be steel; concrete, principally for rail ties, bridges, and drainage structures; and rock for ballast and subballast. DOE determined that ballast requirements for construction could be met with output from planned quarries along the rail lines and that subballast would be obtained from the materials excavated during rail roadbed construction or from crushing rock in quarries. DOE determined that other construction material requirements for the Caliente rail alignment and for the Mina rail alignment would be a small fraction of current production rates within the respective regions of influence.

Under the Shared-Use Option for either rail alignment, the incremental demands on utilities, energy, and materials for construction of commercial sidings and support facilities would be sufficiently small that the anticipated impacts on these resources would be effectively the same as those for the Proposed Action without shared use. Therefore, potential impacts to local, regional, or national suppliers of such resources under the Shared-Use Option along either rail alignment would be small.

Fossil-fuel requirements for transporting general freight under the Shared-Use Option would depend on the volume and distance of shared-use traffic. DOE estimated that the incremental annual diesel consumption for commercial shared-use traffic would be 5.5 million liters (1.5 million gallons), a rate that is less than 0.3 percent of current annual diesel fuel use in Nevada. Most, if not all, of this fuel consumption would be offset by diesel fuel that would otherwise be used if the goods or materials were shipped by truck. Therefore, the impact to the capacities of national and regional fuel producers and distributors under the Shared-Use Option would be small.

6.4.1.15 Hazardous Materials and Wastes

For both the Caliente and Mina rail alignments, the region of influence for the use of hazardous materials and the generation of hazardous and nonhazardous wastes includes the nominal width of the rail line construction right-of-way and the locations of railroad construction and operations support facilities; for the disposal of *hazardous wastes*, it includes the entire continental United States (commercial hazardous waste disposal vendors could utilize facilities throughout the country); and for the disposal of *low-level radioactive wastes*, it includes DOE low-level waste disposal sites, sites in Agreement States, and NRC-licensed sites. The region of influence for the disposal of nonhazardous waste for the Caliente rail

alignment includes the disposal facilities in Lincoln, Nye, Esmeralda, and Clark counties, and for the Mina rail alignment includes the disposal facilities in Mineral, Nye, Esmeralda, and Clark counties.

During railroad construction and operations, DOE would store and use hazardous materials such as oil, gasoline, diesel fuel, and solvents, primarily for the operation, maintenance, and cleaning of equipment and facilities, which would result in the generation of associated hazardous wastes. During the railroad construction and operations phases, the Department would implement an Environmental Management System and a Pollution Prevention/Waste Minimization Program, which would include an evaluation of methods to eliminate, reduce, or minimize the amounts of hazardous materials used and hazardous wastes generated. Each year, during the course of construction, approximately 20 tons of hazardous waste would be generated, and a total of 82 tons over the entire construction phase. Ample disposal capacity is available for the disposal of hazardous waste during both the construction and operations phases. DOE would implement appropriate planning measures for the storage and handling of hazardous materials and comply with applicable regulations.

DOE would dispose of nonrecyclable or nonreusable waste in permitted landfills. During construction it is likely that, if utilized, some of the larger landfills would not see an appreciable change in the amount of waste received; however, some of the smaller landfills, if utilized, might see a substantial, although manageable, change in daily receipt of solid, industrial, and special wastes.

Construction of the proposed railroad along the Caliente rail alignment would raise the disposal rate of nonhazardous waste to landfills in the region of influence by about 0.15 percent. DOE anticipates that impacts to local landfills from the disposal of solid and industrial and special wastes would be small (for the relatively large Apex Landfill) to moderate (for the smaller landfills such as Goldfield Class I).

DOE estimates that railroad construction along the Mina rail alignment could generate three times the amount of industrial and special waste as would railroad construction along the Caliente rail alignment. This is because of wastes from dismantling the Department of Defense Branchline through the town of Schurz. However, to the extent practicable, these wastes would be recycled to minimize waste volumes. Construction of the proposed railroad along the Mina rail alignment would raise the disposal rate of nonhazardous waste to landfills in the region of influence by about 0.34 percent. DOE anticipates that impacts to local landfills from the disposal of solid and industrial and special wastes would be small (for the relatively large Apex Landfill) to moderate (for the smaller landfills such as Goldfield Class I).

During railroad operations along either the Caliente or Mina rail alignment, the generation of wastes would be substantially less than during the construction phase. DOE anticipates railroad operations along either alignment would produce similar amounts of wastes. Therefore, impacts to landfills during operations would be small because ample disposal capacity would be available for either rail alignment.

Activities at the Cask Maintenance Facility would generate from 3,200 to 7,900 cubic meters (113,000 to 280,000 cubic feet) of Class A low-level radioactive waste throughout the railroad operations phase. Site-generated, low-level radioactive waste would be controlled and disposed of in a DOE low-level waste disposal site, an Agreement State site, or in an NRC-licensed site subject to the completion of the appropriate review pursuant to the National Environmental Policy Act. Disposal in an Agreement State site or in an NRC-licensed site would be in accordance with applicable provisions of 10 CFR Part 20. DOE low-level radioactive waste disposal sites such as the Nevada Test Site, and commercial low-level radioactive waste disposal sites such as Energy Solutions Barnwell Operations in Barnwell, South

Carolina; U.S. Ecology in Richland, Washington; and Energy Solutions Clive Operations in Clive, Utah, all currently have ample capacity to accept these wastes. Therefore, impacts to low-level radioactive waste disposal facilities would be small. For comparison, the total amount of waste estimated to be generated throughout the operations phase accounts for only about 6 percent of the low-level waste disposed of in 2005 at commercial low-level waste facilities nationwide (DIRS 182320-NRC 2007, all). No low-level radioactive waste is anticipated to be generated during construction activities; therefore, no impacts to disposal facilities would occur.

Under the Shared-Use Option for either rail alignment, waste characteristics, generation rates, and disposal requirements would increase only slightly; therefore, any additional adverse impacts associated with the Shared-Use Option would be small.

6.4.1.16 Environmental Justice

The region of influence for environmental justice encompasses the regions of influence for all other resource areas because impacts in other resource areas could result in environmental justice impacts.

DOE performed the analysis of potential environmental justice impacts in accordance with Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, Council on Environmental Quality guidance (DIRS 103162-CEQ 1997, all), and NRC policy. DOE followed the Council on Environmental Quality guidance to use the annual statistical poverty thresholds from the U.S. Bureau of the Census to identify low-income populations, and followed NRC's 2004 policy to identify low-income and minority populations. The policy states, in part:

> "Under current NRC [Nuclear Regulatory Commission] staff guidance, a minority or low-income community is identified by comparing the percentage of the minority or low-income population in the impacted area to the percentage of the minority or low-income population in the County (or Parish) and the State. If the percentage in the impacted area significantly exceeds that of the State or the County percentage for either the minority or low-income population then EJ [environmental justice] will be considered in greater detail. 'Significantly' is defined by staff guidance to be 20 percentage points. Alternatively, if either the minority or low-income population percentage in the impacted area exceeds 50 percent, EJ matters are considered in greater detail."

Following this policy, DOE identified low-income communities as those affected areas (by census block groups) where the percentage of people characterized as below the poverty threshold exceeded 31 percent, which is 20 percent above the state average of 11 percent of people below the poverty threshold.

Because the percentage of minorities in Nevada is approximately 34 percent (DIRS 173533-Bureau of Census 2005, all), adding 20 percentage points would provide a threshold of 54 percent to identify minority communities. Instead, DOE identified minority communities as those affected areas (by census blocks) where the minority population exceeded 50 percent.

DOE determined whether there would be minority or low-income populations in the Caliente or Mina rail alignment regions of influence for environmental justice, and assessed whether any high and adverse impacts could fall disproportionately on minority or low-income populations. DOE also considered whether minority or low-income populations would be affected by an alternative in different ways than

the general population, such as through unique exposure pathways or rates of exposure, special sensitivities, or different uses of natural resources.

For the Caliente rail alignment, the Department determined that railroad construction and operations would not result in disproportionately high and adverse impacts to minority or low-income populations. For the Mina rail alignment DOE determined that the Schurz population center and the Walker River Census County Division, which includes the Walker River Paiute Reservation, are the only locations where the minority populations exceed the threshold of 50 percent, and the Walker River Census County Division to be the only location where the low-income population exceeds the threshold of 31 percent. Because there would be no high and adverse impacts in these areas, constructing and operating the proposed railroad along the Mina rail alignment would not result in disproportionately high and adverse impacts to minority or low-income populations.

Similarly, the Department determined that under the Shared-Use Option for either rail alignment, there would be not disproportionately high and adverse impacts to minority or low-income populations.

6.4.1.17 Comparison of Proposed Action and Alternatives

Council on Environmental Quality implementing regulations (40 CFR Parts 1500 through 1508) for NEPA state that agencies should provide a comparison of the environmental impacts of the proposal and the alternatives to sharply define the issues and provide a clear basis for choice. The comparison referred to in this section is based on the information and analyses presented in the Rail Alignment EIS.

In Chapter 2 of this Repository SEIS, Table 2-3 highlights the differences in potential impacts under the Proposed Action for the Caliente and Mina Implementing Alternatives. The table lists the range of potential impacts under the Proposed Action for the Caliente and Mina Implementing Alternatives considering the largest and smallest potential impacts of the different alternative segments.

Potential impacts under the Shared-Use Option would be generally the same as impacts under the Proposed Action without shared use, unless noted otherwise in Table 2-3. Potential commercial sidings and facilities that could be constructed under the Shared-Use Option would likely be constructed within the operations right-of-way to the extent practicable; therefore, the impacts of their construction are included within those impacts presented for the Proposed Action. More detailed discussion of impacts resulting from the Shared-Use Option can be found in Chapter 4 of the Rail Alignment EIS.

Table 2-3 illustrates that the Mina Implementing Alternative would be environmentally preferable when compared with the Caliente Implementing Alternative. In general, the Mina Implementing Alternative would have fewer private land conflicts, less surface disturbance, smaller impacts to wetlands, and smaller impacts to air quality than the Caliente Implementing Alternative. However, the Mina Implementing Alternative remains the nonpreferred alternative due to the objection of the Walker River Paiute Tribe to the transportation of spent nuclear fuel and high-level radioactive waste through its Reservation.

6.4.2 TRANSPORTATION IMPACTS FROM REPOSITORY ACTIVITIES

DOE would transport construction materials, repository components, and consumables to the repository on trucks on Nevada highways, and on trains along the Caliente or Mina rail corridor. Shipments of construction materials would include 190,000 metric tons (210,000 tons) of cement; 280,000 metric tons (310,000 tons) of steel; and 670 metric tons (740 tons) of copper. Shipments of repository components would include 11,200 empty waste packages, 11,200 emplacement pallets, 11,500 drip shields, 2,500 *aging overpacks*, and about 1,000 TAD canisters. About 6,500 additional empty TAD canisters would be shipped directly to the generator sites. The impacts of shipping these 6,500 empty TAD canisters to the generator sites are included in Section 6.2.1. Most of the consumables would be fuel oil; about 8,100 railroad tank cars of fuel oil would be shipped to the repository during the operations period. In total, there would be about 29,000 railcar shipments of construction materials, repository components, and consumables to the repository. These shipments would account for 47 to 57 million railcar kilometers (29 to 35 million railcar miles) of round-trip travel in Nevada. Shipments of repository components would account for about 90 to 100 million railcar kilometers (56 to 62 million railcar miles) of round-trip travel on the national level. DOE would ship waste materials from repository activities off the site. This waste would include nonhazardous *solid waste* and hazardous, mixed, and low-level radioactive wastes. Workers would commute to the repository; DOE would provide bus service from Clark and Nye counties for these workers. In addition, the analysis assumed that 80 percent of the workers would live in Clark County and 20 percent would live in Nye County. During the construction, operations, *monitoring*, and *closure* periods, these workers would account for about 1.9 billion vehicle kilometers (1.2 billion vehicle miles) of round-trip travel from Nye and Clark counties in Nevada.

Table 6-16 lists the impacts from the transportation of these materials and from worker commutes. DOE estimated that there would be about 13 vehicle emission fatalities and 44 to 46 traffic fatalities. Pahrump, the largest city in Nye County, is closer to the repository than Las Vegas. If the workers lived in Pahrump, the impacts would be less because the commuting distance would be less.

Table 6-16. Impacts from transportation of material and people.

Category	Latent cancer fatalities	Vehicle emission fatalities	Traffic fatalities
Caliente rail corridor			
Construction materials, repository components, consumables, and waste materials	0.15	0.96	8.4
Commuting workers	0	12	36
Total	0.15	13	44
Mina rail corridor			
Construction materials, repository components, consumables, and waste materials	0.15	0.92	11
Commuting workers	0	12	35
Total	0.15	13	46

Notes: Includes impacts from the construction and operation of the Caliente and Mina rail corridors for the Shared-Use Option. Values are rounded to two significant figures; therefore, totals might differ from sums.

Evaluation of these transportation activities resulted in impacts that were greater than the impacts presented in the Yucca Mountain FEIS. The primary reasons for the increase were extrapolating impacts to 2067 instead of 2035, increasing the number of construction workers required to build the Nevada rail line, increasing the repository operations period from 24 years to up to 50 years, increasing rail shipments to account for the Shared-Use Option for the Caliente and Mina rail corridors, and including workers who work in Las Vegas in the estimates of vehicle emission and traffic fatalities.

6.4.3 IMPACTS TO REGIONAL TRAFFIC

DOE has used Transportation Research Board's *Highway Capacity Manual 2000* (DIRS 176524-TRB 2001, p. all) to characterize roadway performance in terms of level of service, which consists of a qualitative ranking of traffic conditions users experience. There are six levels of service that characterize the performance of roadways; level of service A represents the best operating conditions (that is, free flow) and level of service F represents the worst (DIRS 176524-TRB 2001, p. 2-3). The determination of the level of service of a roadway is based on factors that affect how users perceive the quality of service they receive on a roadway, such as speed, travel time, freedom to maneuver, traffic interruptions, and comfort.

In the area of the intersection of Nevada State Route 373 and U.S. Highway 95 near Gate 510 to the Nevada Test Site, the existing level of service is B, which represents almost free flow (DIRS 185463-Facanha 2008, all). During the construction and operations analytical periods, traffic would increase in this area with workers who commuted by bus and automobile to the repository and other facilities such as the Cask Maintenance Facility and Rail Equipment Maintenance Yard, transport of construction materials such as steel and concrete by truck for repository-related facilities, transport of fuel oil and gasoline by truck, shipments of spent nuclear fuel to the repository by truck, and truck shipments of repository-generated waste for offsite disposal. The primary effect would be that from commuting workers (DIRS 185463-Facanha 2008, all). DOE estimated about two-thirds of workers would commute by bus and one-third by automobile.

As a result of this traffic increase, the level of service at the intersection of Nevada State Route 373 and U.S. Highway 95 near Gate 510 would drop from level of service B to level of service D, which indicates high-density traffic but still stable conditions (DIRS 185463-Facanha 2008, all). Even if the share of workers that would commute by automobile were to increase to 80 percent, the level of service for that traffic increase would still be D. If U.S. Highway 95 was widened to four lanes, the level of service would improve to A if two-thirds of the workers commuted by bus, and the level of service would remain at B if 80 percent of workers commuted by automobile.

REFERENCES

181282	AAR 2006	AAR (Association of American Railroads) 2006. *Railroad Facts 2006 Edition.* Washington, D.C.: Association of American Railroads. TIC: 259612.
185281	AEC 1972	AEC (U.S. Atomic Energy Commission) 1972. *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants.* Oak Ridge, Tennessee: U.S. Atomic Energy Commission. ACC: MOL.20080313.0081.
180220	Bendixen and Facanha 2007	Bendixen, L. and Facanha, C. 2007. "Rail Accident Rate Calculation Methodology." Technical memo from L. Bendixen (ICF International) and C. Facanha (ICF International), to M. West (Potomac-Hudson Engineering), March 30, 2007. ACC: MOL.20070412.0014.

181343	Bjorkman et al. 2007	Bjorkman, G.; Chuang, T-J.; Einziger, R.; Malik, S.; Malliakos, A.; Mitchell, J.; Navarro, C.; Ryder, C.; Shaukat, S.; Ulses, A.; and Zigh, G. 2007. *A Pilot Probabilistic Risk Assessment Of a Dry Cask Storage System at a Nuclear Power Plant.* NUREG-1864. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20070913.0518.
179131	BLS 2006	BLS (Bureau of Labor Statistics) 2006. "Table 1. Incidence Rates of Nonfatal Occupational Injuries and Illnesses by Industry and by Case Types, 2005." *Occupational Injuries and Illnesses (Annual).* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed February 13, 2007. ACC: MOL.20070220.0267. URL: http://stats.bls.gov/news.release/osh.toc.htm
179129	BLS 2007	BLS (Bureau of Labor Statistics) 2007. "All Charts, Census of Fatal Occupational Injuries, 2005." *Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data.* Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics. Accessed February 12, 2007. ACC: MOL.20070220.0266. URL: http://stats.bls.gov/iif/oshcfoi1.htm
161120	BSC 2002	BSC (Bechtel SAIC Company) 2002. *Subsurface Shielding Source Term Specification Calculation.* 000-00C-WER0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021216.0076; ENG.20050815.0022.
169987	BSC 2004	BSC (Bechtel SAIC Company) 2004. *CSNF Waste Form Degradation: Summary Abstraction.* ANL-EBS-MD-000015 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040908.0001; DOC.20050620.0004.
174942	BSC 2005	BSC (Bechtel SAIC Company) 2005. *Project Design Criteria Document.* 000-3DR-MGR0-00100-000 REV 005. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20050826.0001.
180185	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Characteristics for the Representative Commercial Spent Fuel Assembly for Preclosure Normal Operations.* 000-PSA-MGR0-00700-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070521.0008.
181377	BSC 2007	BSC (Bechtel SAIC Company) 2007. *Calculation of Transportation Data for SEIS Analyses.* 000-00C-G000-01300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070523.0036.

184907	BSC 2008	BSC (Bechtel SAIC Company) 2008. *Recommended Values for HLW Glass for Consistent Usage on the Yucca Mountain Project*. 000-00A-MGR0-00200-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080122.0020.
173533	Bureau of Census 2005	Bureau of Census 2005. "Nevada QuickFacts, Clark County, Nevada." (Washington, D.C.) Bureau of Census. Accessed April 7, 2005. ACC: MOL.20050505.0098. URL: http://quickfacts.census.gov/qfd/states/32/32003.html
156368	Bureau of Indian Affairs 2000	Bureau of Indian Affairs 2000. "Indian Lands and Native Entities in the United States (IND3)." Lakewood, Colorado: U.S. Department of Interior, Bureau of Indian Affairs. Accessed September 19, 2001. ACC: MOL.20011112.0016. URL: http://data.gdsc.bia.gov/data.htm
103162	CEQ 1997	CEQ (Council on Environmental Quality) 1997. *Considering Cumulative Effects Under the National Environmental Policy Act.* Washington, D.C.: Council on Environmental Quality. TIC: 243482.
104794	CRWMS M&O 1994	CRWMS M&O 1994. *Health and Safety Impacts Analysis for the Multi-Purpose Canister System and Alternatives.* A00000000-01717-0200-00006 REV 02. Vienna, Virginia: CRWMS M&O. ACC: MOV.19950217.0043.
156764	DOE 1999	DOE (U.S. Department of Energy) 1999. *Radiological Control,* DOE-STD-1098-99. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20011210.0187.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
172283	DOE 2002	DOE (U.S. Department of Energy) 2002. *Recommendations for Analyzing Accidents under the National Environmental Policy Act.* Washington, D.C.: U.S. Department of Energy, Office of NEPA Policy and Compliance. ACC: MOL.20041122.0199.
169354	DOE 2004	DOE (U.S. Department of Energy) 2004. *Source Term Estimates for DOE Spent Nuclear Fuels.* DOE/SNF/REP-078, Rev. 1. Three volumes. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20040524.0451.

178579	DOE 2004	DOE (U.S. Department of Energy) 2004. *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements.* Second Edition. Washington, D.C.: U.S. Department of Energy, Office of NEPA Policy and Compliance. ACC: MOL.20070111.0019.
178016	DOT 2005	DOT (U.S. Department of Transportation) 2005. *Railroad Safety Statistics 2004 Annual Report.* Washington, D.C.: U.S. Department of Transportation, Federal Railroad Administration. ACC: MOL.20061031.0151.
181280	DOT 2006	DOT (U.S. Department of Transportation) 2006. *Freight in America.* Washington, D.C.: U.S. Department of Transportation, Research and Innovative Technology Administration. ACC: MOL.20070712.0049.
107684	Eckerman and Ryman 1993	Eckerman, K.F. and Ryman, J.C. 1993. *External Exposure to Radionuclides in Air, Water, and Soil, Exposure-to-Dose Coefficients for General Application, Based on the 1987 Federal Radiation Protection Guidance*. EPA 402-R-93-081. Federal Guidance Report No. 12. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. TIC: 225472.
101069	Eckerman et al. 1988	Eckerman, K.F.; Wolbarst, A.B.; and Richardson, A.C.B. 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. EPA 520/1-88-020. Federal Guidance Report No. 11. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010726.0072.
185461	Edwards 2008	Edwards, S. 2008. RE: SNF Shipment Data. Email from S. Edwards to J. Rivers, May 6, 2008. ACC: MOL.20080514.0314.
153733	EPA 2000	EPA (U.S. Environmental Protection Agency) 2000. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides.* EPA 402-C-99-001. Federal Guidance Report No. 13. CD Supplement. Washington, D.C.: U.S. Environmental Protection Agency. TIC: 249372.
175544	EPA 2002	EPA (U.S. Environmental Protection Agency) 2002. *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA.* EPA-402-C-99-001, Rev. 1. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20051013.0016.

185248	EPA 2007	EPA (U.S. Environmental Protection Agency) 2007. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Atmospheric Programs. ACC: MOL.20080331.0109.
185330	EPRI 2005	EPRI (Electric Power Research Institute) 2005. *Assessment of Incident-Free Transport Risk for Transport of Spent Nuclear Fuel to Yucca Mountain Using RADTRAN 5.5*. EPRI 1011821. Technical Update 1. Palo Alto, California: Electric Power Research Institute. TIC: 260103.
185463	Facanha 2008	Facanha, C. 2008. "Question regarding traffic analysis." Email from C. Facanha to S. Maheras, April 29, 2008, with attachment. ACC: MOL.20080514.0318.
182082	FMCSA 2007	FMCSA (Federal Motor Carrier Safety Administration) 2007. *Large Truck Crash Facts 2005*. FMCSA-RI-07-046. Washington, D.C.: U.S. Department of Transportation, Federal Motor Carrier Safety Administration. ACC: MOL.20070726.0013.
185098	Gehner 2008	Gehner, P. 2008. "Location for the Maintenance of Way (MOW) Combined Facility for Caliente Rail Corridor." Technical memo from P. Gehner (BSC) to M. West (PHE), February 15, 2008, with attachment. ACC: ENG.20080221.0020.
182833	Golan 2005	Golan, P. 2005. "Letter Informing Stakeholders of Policy Adopted by the Department to Use Dedicated Trains for its Shipment of Spent Nuclear Fuel and High-Level Radioactive Waste to the Yucca Mountain Repository." Letter from P. Golan to Stakeholder, July 18, 2005, with attachment. ACC: HQO.20051003.0001.
185236	Hill et al. 1993	Hill, C.V.; Loud, G.C.; and Heitzman, A.C. 1993. "Marginal Overweight Operating Scenario for DOE's Initiative I Highway Casks." *High Level Radioactive Waste Management, Proceedings of the Fourth Annual International Conference, Las Vegas, Nevada, April 26-30, 1993. 1,* 286-292. La Grange Park, Illinois: American Nuclear Society. TIC: 208542.
101075	ICRP 1977	ICRP (International Commission on Radiological Protection) 1977. *Recommendations of the International Commission on Radiological Protection.* Volume 1, No. 3 of *Annals of the ICRP*. ICRP Publication 26. Reprinted 1982. New York, New York: Pergamon Press. TIC: 221568.

101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
152446	ICRP 1996	ICRP (International Commission on Radiological Protection) 1996. *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*. Volume 26, No. 1 of Annals of the ICRP. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press. TIC: 235870.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publication 72. New York, New York: Elsevier. TIC: 255638.
182836	ICRP 2007	ICRP (International Commission on Radiological Protection) 2007. *Draft Recommendations of the International Commission on Radiological Protection.* New York, New York: Pergamon. ACC: MOL.20070918.0101; MOL.20071003.0192.
157144	Jason Technologies 2001	Jason Technologies. 2001. *Transportation Health and Safety Calculation/Analysis Documentation in Support of the Final EIS for Yucca Mountain Repository*. CAL-HSS-ND-000003. Las Vegas, Nevada: Jason Technologies. ACC: MOL.20020209.0097.
181276	Johnson and Michelhaugh 2003	Johnson, P.E. and Michelhaugh, R.D. 2003. *Transportation Routing Analysis Geographic Information System (TRAGIS) User's Manual.* ORNL/NTRC-006, Rev. 0. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOL.20070712.0024.
104780	Johnson et al. 1993	Johnson, P.E.; Joy, D.S.; Clarke, D.B.; and Jacobi, J.M. 1993. *HIGHWAY 3.1—An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual.* ORNL/TM-12124. D00000000-02268-2003-20012 REV 1. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOV.19960711.0024.
104781	Johnson et al. 1993	Johnson, P.E.; Joy, D.S.; Clarke, D.B.; and Jacobi, J.M. 1993. *INTERLINE 5.0—An Expanded Railroad Routing Model: Program Description, Methodology, and Revised User's Manual.* ORNL/TM-12090. D00000000-02268-2002-20015 REV 1. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ACC: MOV.19960711.0014.

104782	Kelderhouse 1999	Kelderhouse, S. 1999. "LWT, HH and Rail Transportation Graphics." E-mail from S. Kelderhouse to R. Best (CRWMS M&O), April 27, 1999, with attachment. ACC: MOL.19990526.0027.
181756	Lamb et al. 2001	Lamb, M.; Resnikoff, M.; and Moore, R. 2001. *Worst Case Credible Nuclear Transportation Accidents: Analysis for Urban and Rural Nevada.* New York, New York: Radioactive Waste Management Associates. TIC: 259574.
181892	Lamb et al. 2002	Lamb, M., Hintermann, B., Resnikoff, M. 2002. *Potential Consequences of a Successful Sabotage Attack on a Spent Fuel Shipping Container: An Analysis of the Yucca Mountain EIS Treatment of Sabotage*. New York, New York: Radioactive Waste Management Associates. TIC: 259556.
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from *Total Effective Dose Equivalents* (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
181279	Luna 2006	Luna, R.E. 2006. "Release Fractions from Multi-Element Spent Fuel Casks Resulting from HEDD Attack." *WM'06 Conference, February 26-March 2, 2006, Tucson, AZ.* Tucson, Arizona: WM Symposia. TIC: 259643.
104918	Luna et al. 1999	Luna, R.E.; Neuhauser, K.S.; and Vigil, M.G. 1999. *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments.* SAND99-0963. Albuquerque, New Mexico: Sandia National Laboratories. ACC: MOL.19990609.0160.
181250	National Research Council 2006	National Research Council. 2006. *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2.* Washington, D.C.: National Academies Press. TIC: 257529.
150898	Neuhauser and Kanipe 2000	Neuhauser, K.S. and Kanipe, F.L. 2000. *RADTRAN 5, User Guide.* SAND2000-1257. Albuquerque, New Mexico: Sandia National Laboratories. TIC: 249356.
155430	Neuhauser et al. 2000	Neuhauser, K.S.; Kanipe, F.L.; and Weiner, R.F. 2000. *RADTRAN 5, Technical Manual.* SAND2000-1256. Albuquerque, New Mexico: Sandia National Laboratories. ACC: MOL.20010724.0159.

158452	Nevada Agency for Nuclear Projects	Nevada Agency for Nuclear Projects 2002. "A Mountain of Trouble: A Nation at Risk, Report on Impacts of the Proposed Yucca Mountain High-Level Nuclear Waste Program." Volume 1. Carson City, Nevada: State of Nevada, Nuclear Waste Project Office. Accessed May 23, 2002. TIC: 252580. URL: http://www.state.nv.us/nucwaste/yucca/impactreport.pdf
148184	NRC 1998	NRC (U.S. Nuclear Regulatory Commission) 1998. "NRC Issues Certificate to General Atomics for Transportation Cask for Spent Nuclear Fuel." Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed March 16, 1999. ACC: MOL.20010725.0130. http://www.nrc.gov/OPA/gmo/nrarcv/nr98/98-197.htm
181757	NRC 2002	NRC (U.S. Nuclear Regulatory Commission) 2002. "NRC Inspection Report 50-312/2002-03; 72-11/2002-02." Letter from D.D. Chamberlain (NRC) to J. Shetler (Sacramento Municipal Utility District), September 18, 2002, with enclosures. ACC: MOL.20070712.0079.
182320	NRC 2007	NRC (U.S. Nuclear Regulatory Commission) 2007. "Low-Level Waste Disposal Statistics." Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed August 7, 2007. ACC: MOL.20070809.0006. URL: http://www.nrc.gov/waste/llw-disposal/statistics.html
103455	Saricks and Tompkins 1999	Saricks, C.L. and Tompkins, M.M. 1999. *State-Level Accident Rates of Surface Freight Transportation: A Reexamination.* ANL/ESD/TM-150. Argonne, Illinois: Argonne National Laboratory. TIC: 243751.
101747	Schneider et al. 1987	Schneider, K.J.; Ross, W.A.; Smith, R.I.; Daling, P.M.; Grinde, R.B.; Hostick, C.J.; Peterson, R.W.; Stiles, D.L.; Weakley, S.A.; and Young, J.R. 1987. *Analysis of Radiation Doses from Operation of Postulated Commercial Spent Fuel Transportation Systems, Main Report.* DOE-CH/TPO-001. Argonne, Illinois: U.S. Department of Energy, Chicago Operations Office. ACC: MOL.20010727.0163.
181758	Spitzberg 2004	Spitzberg, D.B. 2004. "NRC Inspection Report 050-00397/04-007; 072-00035/04-001." Letter from D.B. Spitzberg (NRC) to J.V. Parrish (Energy Northwest), April 23, 2004, with enclosure. ACC: MOL.20070712.0080.

181759	Spitzberg 2005	Spitzberg, D.B. 2005. "NRC Inspection Report 50-528/05-10; 50-529/05-10; 50-530/05-10; 72-44/05-01." Letter from D.B. Spitzberg (NRC) to G.R. Overbeck (Arizona Public Service Company), April 6, 2005, with enclosure. ACC: MOL.20070712.0082.
181760	Spitzberg 2005	Spitzberg, D.B. 2005. "NRC Inspection Report 050-00313/05-013; 050-00368/05-013; 072-00013/04-002." Letter from D. Spitzberg (NRC) to J.S. Forbes (Arkansas Nuclear One), March 31, 2005, with enclosure. ACC: MOL.20070712.0081.
156311	Tiller 1996	Tiller, V.E.V., ed. 1996. *Tiller's Guide to Indian Country, Economic Profiles of American Indian Reservations.* Albuquerque, New Mexico: BowArrow Publishing. TIC: 251237.
103470	Timbisha Shoshone Tribe n.d.	Timbisha Shoshone Tribe n.d. "The Timbisha Shoshone Tribal Homeland, A Draft Secretarial Report to Congress to Establish a Permanent Tribal Land Base and Related Cooperative Activities." Death Valley National Park, California: Timbisha Shoshone Tribe. Accessed June 12, 2000. ACC: MOL.20010727.0168. URL: http://www.nps.gov/deva/Timbisha_toc.html
176524	TRB 2001	TRB (Transportation Research Board) 2001. *Highway Capacity Manual 2000.* HCM2000. Washington, D.C.: National Research Council, Transportation Research Board. TIC: 258170.
181755	UMTRI 2003	UMTRI (University of Michigan, Transportation Research Institute) 2003. *Evaluation of the Motor Carrier Management Information System Crash File, Phase One.* UMTRI 2003-6. Ann Arbor, Michigan: University of Michigan, Transportation Research Institute, Center for National Truck Statistics. ACC: MOL.20070712.0083.
101483	Yuan et al. 1995	Yuan, Y.C.; Chen, S.Y.; Biwer, B.M.; and LePoire, D.J. 1995. *RISKIND - A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel*. ANL/EAD-1. Argonne, Illinois: Argonne National Laboratory. ACC: HQV.19930517.0008.

7

Environmental Impacts of the No-Action Alternative

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7. ENVIRONMENTAL IMPACTS OF THE NO-ACTION ALTERNATIVE

This chapter describes potential *impacts* for the *No-Action Alternative* that the U.S. Department of Energy (DOE or the Department) described in the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) and Chapter 2 of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). The purpose of the No-Action *Alternative* is to provide a basis for comparison with the impacts of the *Proposed Action*. Under the No-Action Alternative, DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate significant adverse environmental impacts. Commercial utilities and DOE would continue to store and manage *spent nuclear fuel* and *high-level radioactive waste* at 76 sites in the United States in a manner that protected public health and safety and the environment. This *Repository* SEIS updates the health and safety impacts of the No-Action Alternative in the Yucca Mountain FEIS to reflect updated *radiation* dosimetry and *latent cancer fatality* conversion factors. This Repository SEIS incorporates the more detailed discussion of the analysis and environmental impacts associated with the No-Action Alternative to the Proposed Action by reference to Chapter 7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 7-1 to 7-59).

7.1 Changes to the Analysis of the No-Action Alternative

DOE has performed an assessment of the analytical areas it evaluated for the No-Action Alternative in the Yucca Mountain FEIS to determine the areas that warranted updates. Throughout this Repository SEIS, DOE has used two updated analytical parameters in the determination of radiological health impacts: (1) radiation dosimetry and (2) latent cancer fatality conversion factors. To provide a basis of comparison with the Proposed Action, DOE has updated the radiological health impacts from the No-Action Alternative in the Yucca Mountain FEIS to reflect the changes in these parameters. The following sections provide the background on these changes.

7.1.1 RADIATION DOSIMETRY

Radioactive material released to the environment could affect persons who come in contact with it. Mechanisms for transport of radioactive material include air, water, soil, and food. The various ways an individual or population can come into contact with radioactive material are known as *pathways*. An individual can come into contact with radioactive material directly through the external and inhalation pathways or indirectly through the ingestion pathway. For this Repository SEIS, DOE evaluated five pathways for *exposure* to radioactive material:

- Inhalation,
- Ingestion,
- Inhalation of previously deposited material resuspended from the ground (*resuspension*),
- External exposure to material deposited on the ground (*groundshine*), and
- External exposure to material in the air (*immersion* or *cloudshine*).

The factors that DOE used to convert estimates of *radionuclide* intake (by inhalation or ingestion) or exposure (by groundshine or immersion) to a radiation *dose* are called dose coefficients. For this Repository SEIS, DOE used the International Commission on Radiological Protection inhalation and ingestion dose coefficients from *The ICRP Database of Dose Coefficients: Workers and Members of the Public* (DIRS 172935-ICRP 2001, all) and the groundshine and immersion dose coefficients from *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA* (DIRS 175544-EPA 2002, all) to estimate radiation doses. The Department based its use of these dose coefficients on, and incorporated them from, the recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, all; DIRS 152446-ICRP 1996, all; respectively). Some dose coefficients have increased and some have decreased. Therefore, changes in radiation doses as a result of changes in dose coefficients are not uniform.

7.1.2 LATENT CANCER FATALITY CONVERSION FACTORS

Current DOE guidance recommends that the Department base estimates of latent cancer fatalities on received radiation dose and on dose-to-health-effect conversion factors recommended by the Interagency Steering Committee on Radiation Standards. For this Repository SEIS, DOE used the updated guidance for workers and members of the public. The latent cancer fatality conversion factor is 0.0006 fatality per *person-rem* (DIRS 174559-Lawrence 2002, p. 2).

7.2 Summary of No-Action Alternative Impacts

Under the No-Action Alternative, *decommissioning* and reclamation would begin as soon as practicable and could take several years to complete. Decommissioning and reclamation would include removal or shutdown of existing surface and *subsurface facilities* and restoration of disturbed lands. Short-term impacts from site reclamation at Yucca Mountain would be small. Table 7-1 summarizes the estimated local short-term impacts by resource area.

DOE recognizes that the future course Congress, DOE, and the commercial utilities would take if the U.S. Nuclear Regulatory Commission (NRC) did not license the *Yucca Mountain Repository* is uncertain. DOE further recognizes that it and the nuclear utilities could pursue a number of possibilities that include the continued storage of spent nuclear fuel and high-level radioactive waste at each generator site in expanded onsite storage facilities, storage of these materials at one or more centralized locations, study and selection of another location for a deep *geologic repository* (Chapter 1 of the Yucca Mountain FEIS identified the alternative sites DOE previously selected for technical study as potential *geologic* repository locations), development of new technologies, or reconsideration of alternatives to geologic *disposal*. Other documents have analyzed the environmental considerations of these possibilities in other contexts to varying degrees. Table 7-1 of the Yucca Mountain FEIS described studies related to centralized or regionalized interim storage that included alternatives in DOE *National Environmental Policy Act* documents, and summarized the relevant considerations. As mentioned below, some of these documents have been updated.

The proposed Private Fuel Storage facility on the reservation of the Skull Valley Band of Goshute Indians in Tooele County, Utah, is an example of the difficulty in predicting sustainable alternatives to storage and disposal of spent nuclear fuel. The NRC licensed this facility on February 21, 2006 (DIRS 181683-Ruland 2006, all). However, the construction of the facility has not begun due to a failure to lease the site or obtain the necessary right-of-way access across federally managed land. Both the Bureau of Indian

Table 7-1. Potential No-Action Alternative short-term impacts in the Yucca Mountain vicinity.

Resource area	Potential environmental impacts
Land use and ownership	DOE would require no new land to support decommissioning and reclamation; it would restore disturbed land to its approximate preconstruction condition.
Air quality	Dismantling and removal of existing structures, recontouring, and revegetation would generate fugitive dust that would be below the regulatory limits.
Hydrology (surface water)	Recontouring of terrain to restore the natural drainage and manage potential surface-water contaminant sources would minimize surface-water impacts.
Hydrology (groundwater)	DOE would use a small amount of groundwater during decommissioning and reclamation.
Biological resources and soils	Reclamation would result in the restoration of 1.4 square kilometers (350 acres) of habitat. Site reclamation would include soil stabilization and revegetation of disturbed areas. Some animal species could take advantage of abandoned tunnels for shelter. Decommissioning and reclamation could produce adverse impacts to the threatened desert tortoise.
Cultural resources	Leaving roads in place after decommissioning could have an adverse impact on cultural resources by increasing public access to the site. Preserving the integrity of important archeological sites and resources important to American Indians could be difficult.
Socioeconomics	The No-Action Alternative would result in the loss of approximately 4,700 jobs (1,800-person workforce for decommissioning and reclamation, 1,400-person engineering and technical personnel in locations other than the repository site, and 1,500 indirect jobs) in the socioeconomic region of influence. Nye County collects most of the federal monies associated with the repository project. The No-Action Alternative would result in the loss of payments in lieu of taxes to Nye County.
Occupational and public health and safety	During decommissioning and reclamation, workers and members of the public would be exposed to naturally occurring nonradioactive and radioactive materials. Doses to worker population could be as high as 150 person-rem as a result of radioactive radon decay, which would result in an estimated 0.09 latent cancer fatality. Annual radiation dose to the offsite population would be less than 2 person-rem, which would result in an estimated 0.001 latent cancer fatality.
Accidents	Accident impacts would be limited to those from traffic and typical industrial hazards encountered during construction or excavation activities. These were estimated at 94 total recordable cases and 45 lost workday cases.
Noise	Noise levels would be no greater than the current baseline noise environment at the Yucca Mountain site.
Aesthetics	Site decommissioning and reclamation would improve the scenic value of the site, which DOE would return to a state as close as possible to its predisturbance state.
Utilities, energy, materials, and site services	Decommissioning would consume electricity, diesel fuel, and gasoline. The No-Action Alternative would not adversely affect the utility, energy, or material resources of the region.
Waste management	Decommissioning would generate some waste that would require disposal in existing Nevada Test Site landfills. DOE would minimize waste by salvaging most equipment and many materials.

Table 7-1. Potential No-Action Alternative short-term impacts in the Yucca Mountain vicinity (continued).

Resource area	Potential environmental impacts
Traffic and transportation	Less than 0.15 traffic fatality would be likely during decommissioning and reclamation.
Environmental justice	Disproportionately high and adverse impacts to minority or low-income populations would be unlikely because there is no reason to believe they would be any more likely to be affected by job loss.

DOE = U.S. Department of Energy.

Affairs and the Bureau of Land Management have disapproved construction and operation of the facility (DIRS 181684-Cason 2006, p. 29; DIRS 181685-Calvert 2006, p. 1).

In light of these types of uncertainties and DOE's conclusion that no action would not result in predictable actions by others, the Yucca Mountain FEIS considered the range of possibilities by focusing the analysis of the No-Action Alternative on the potential impacts of two scenarios.

In No-Action Scenario 1, DOE would continue to manage its spent nuclear fuel and high-level radioactive waste in above- or below-ground dry-storage facilities at DOE sites around the country. Commercial utilities would continue to manage their spent nuclear fuel at current locations. The commercial and DOE sites would remain under *institutional control*; that is, they would be maintained to ensure the protection of workers and the public in accordance with current federal regulations. The storage facilities would be replaced every 100 years. They would undergo one major repair during the first 100 years because this scenario assumes that the design of the first storage facilities at a site would include a facility life of less than 100 years. The facility replacement period of 100 years represents the assumed useful lifetime of the structures. Replacement facilities would be on land adjacent to the existing facilities.

In No-Action Scenario 2, spent nuclear fuel and high-level radioactive waste would remain in *dry storage* at commercial and DOE sites and would be under institutional control for approximately 100 years (the same as Scenario 1). Beyond that time, the scenario assumed no institutional control. Therefore, after about 100 years and up to 10,000 years, the analysis assumed that the spent nuclear fuel and high-level radioactive waste storage facilities at commercial and DOE sites would begin to deteriorate and would eventually release radioactive materials to the environment.

Table 7-2 summarizes potential No-Action Alternative impacts at commercial and DOE sites for both scenarios from 100 to 10,000 years. From a *qualitative* standpoint, the long-term health impacts of the No-Action Alternative scenarios can be estimated for a longer period (that is, 1 million years). Because the scope of the Scenario 1 impacts (with institutional controls) is related to rebuilding the storage installations every 100 years, the estimate of the Scenario 1 impacts over 1 million years would be a time-step function of the 10,000-year value. In other words, the annual impacts would be the same or less (due to radioactive *decay*), but the integrated impacts over the million-year period would be approximately 100 times those of the 10,000-year impacts in Table 7-2.

The scope of health impacts over 1 million years for Scenario 2 is more speculative. The No-Action Alternative evaluation of the 10,000-year period in the Yucca Mountain FEIS showed that the original storage facility and containment vessels of the spent nuclear fuel and high-level radioactive waste would be compromised and dissolution of these materials would cause radionuclides to enter the accessible

Table 7-2. Potential No-Action Alternative impacts at commercial and DOE sites.

Resource area	Short-term impacts (100 years)	Long-term impacts (100 to 10,000 years)	
		Scenario 1	Scenario 2
Land use and ownership	Small; storage would continue at existing sites.	Small; storage would continue at existing sites.	Large; potential contamination of 0.04 to 0.4 km^2 (10 to 100 acres) surrounding each commercial and DOE site.
Air quality	Small; releases and exposures well below regulatory limits.	Small; releases and exposures well below regulatory limits.	Small; degraded facilities would preclude large atmospheric releases.
Hydrology			
Groundwater	Small; use would be small in comparison with other site use.	Small; use would be small in comparison with other site use.	Large; potential for radiological contamination of groundwater around the commercial and DOE sites.
Surface water	Small; minor changes to runoff and infiltration rates.	Small; minor changes to runoff and infiltration rates.	Large; potential for radiological releases and contamination of drainage basins downstream of commercial and DOE sites (concentrations potentially exceeding current regulatory limits).
Biological resources and soils	Small; storage would continue at existing sites.	Small; storage would continue at existing sites.	Large; potential adverse impacts at each of the sites from subsurface contamination of 0.04 to 0.4 km^2 (10 to 100 acres).
Cultural resources	Small; storage would continue at existing sites; limited potential of disturbing sites.	Small; storage would continue at existing sites; limited potential of disturbing sites.	Small; no construction or operation activities; no impacts.
Socioeconomics	Small; population and employment changes would be small compared with totals in the regions.	Small; population and employment changes would be small compared with totals in the regions.	No workers; therefore, no impacts.
Occupational and public health and safety			
Public – Radiological MEI (probability of an LCF)	0.0000052[a]	0.0000016[a]	(b)
Public – Population (LCFs)	0.49[a]	3.1[a]	1,000[c]
Public – Nonradiological (fatalities due to emissions)	Small; exposures well below regulatory limits or guidelines.	Small; exposures well below regulatory limits or guidelines.	Moderate to large; substantial increases in releases of hazardous substances and exposures to the public.
Workers – Radiological (LCFs)	24[a]	15[a]	No workers; therefore, no impacts.

Table 7-2. Potential No-Action Alternative impacts at commercial and DOE sites (continued).

Resource area	Short-term impacts (100 years)	Long-term impacts (100 to 10,000 years) Scenario 1	Long-term impacts (100 to 10,000 years) Scenario 2
Occupational and public health and safety (continued)			
Workers – Nonradiological fatalities (includes commuting traffic fatalities)	9	1,080	No workers; therefore, no impacts.
Accidents			
Public – Radiological MEI (probability of an LCF)	None.	None.	Not applicable.
Public – Population (LCFs)[d]	None.	None.	4 to 16[e]
Workers	Large; for some unlikely accident scenarios workers probably would be severely injured or killed; however, DOE or NRC would manage facilities safely during continued storage operations.	Large; for some unlikely accident scenarios workers would probably be severely injured or killed.	No workers; therefore, no impacts.
Noise	Small; transient and not excessive, less than 85 dBA.	Small; transient and not excessive, less than 85 dBA.	No activities, therefore, no noise.
Aesthetics	Small; storage would continue at existing sites; expansion as needed.	Small; storage would continue at existing sites; expansion as needed.	Small; aesthetic value would decrease as facilities degraded.
Utilities, energy, materials, and site services	Small; materials and energy use would be small compared with total site use.	Small; materials and energy use would be small compared with total site use.	No use of materials or energy; therefore, no impacts.
Waste management	Small; waste generated and materials used would be small compared with total site generation and use.	Small; waste generated and materials used would be small compared with total site generation and use.	No generation of waste or use of hazardous materials; therefore, no impacts.
Environmental justice	Small; no disproportionately high and adverse impacts to minority or low-income populations.	Small; no disproportionately high and adverse impacts to minority or low-income populations.	Large; potential for disproportionately high and adverse impacts to minority or low-income populations.

Table 7-2. Potential No-Action Alternative impacts at commercial and DOE sites (continued).

Source: DIRS 155970-DOE 2002, pp. 2-79 to 2-82.

a. Updated using a conversion factor of 0.0006 LCF per person-rem; no change to external dose coefficients.

b. With no effective institutional controls, the MEI could receive a fatal dose of radiation within a few weeks to months. Death could be caused by acute direct radiation exposure.

c. Updated using a conversion factor of 0.0006 LCF per person-rem and ingestion dose coefficients that overall are about 25 percent of the coefficients used in the Yucca Mountain FEIS.

d. Downstream exposed population of approximately 3.9 billion over 10,000 years.

e. Updated using a conversion factor of 0.0006 LCF per person-rem and inhalation dose coefficients that are approximately the same as coefficients used in the Yucca Mountain FEIS.

dBA = A-weighted decibel.
DOE = U.S. Department of Energy.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.

environment. The Scenario 2 health impacts in Table 7-2 indicate the catastrophic impacts that this scenario could cause. Beyond 10,000 years, the unchecked deterioration and dissolution of the materials would continue and increase impacts even further. The increasing uncertainty (for example, actual locations of radiological materials, climate changes, and degree of institutional control) over this extended period, however, does not provide a meaningful basis for *quantitative* impact analyses because of the limitless number of scenarios that could occur.

7.3 Cumulative Impacts for the No-Action Alternative

DOE analyzed *cumulative impacts* of the continued storage of all spent nuclear fuel and high-level radioactive waste (Inventory Module 1, as discussed in detail in Chapter 8 of this Repository SEIS) at the commercial and DOE facilities for the No-Action Alternative in the Yucca Mountain FEIS. This section summarizes and incorporates by reference Section 7.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 7-43 to 7-54).

The Yucca Mountain FEIS demonstrated that the impacts of continued storage of spent nuclear fuel and high-level radioactive waste would be directly proportional to the increased amount of *commercial spent nuclear fuel* in Inventory Module 1. In the FEIS, the amount of commercial spent nuclear fuel in Inventory Module 1 was approximately 70 percent higher than that in the Proposed Action. The resultant impacts of continued storage of these materials were approximately 1.7 times the impacts from storage of the *Proposed Action inventory*. By applying this linear relationship to the updated Inventory Module 1, the impacts of continued storage of the 130,000 *metric tons of heavy metal* of commercial spent nuclear fuel would be approximately twice that of the Proposed Action (Chapter 8 of this Repository SEIS contains more details). Table 7-3 lists estimates of the potential health impacts of the continued storage

Table 7-3. Potential No-Action Alternative health impacts from continued storage of Inventory Module 1 at commercial and DOE sites.

Resource area	Short-term impacts (100 years)	Long-term impacts (100 to 10,000 years)	
		Scenario 1	Scenario 2
Occupational and public health and safety			
Public – Radiological MEI (probability of an LCF)	0.00001	0.000003	(a)
Public – Population (LCFs)[b]	1	6	2,000
Public – Nonradiological (fatalities due to emissions)	Small; exposures well below regulatory limits or guidelines.	Small; exposures well below regulatory limits or guidelines.	Moderate to large; substantial increases in releases of hazardous substances in the spent nuclear fuel and high-level radioactive waste and exposures to the public.
Workers – Radiological (LCFs)	48	30	No workers; therefore, no impacts.
Workers – Nonradiological fatalities (includes commuting traffic fatalities)	18	2,200	No workers; therefore, no impacts.

a. With no effective institutional controls, the MEI could receive a fatal dose of radiation within a few weeks to months. Cause of death would be acute direct radiation exposure.
b. Downstream exposed population of approximately 3.9 billion over 10,000 years.
DOE = U.S. Department of Energy. MEI = Maximally exposed individual.
LCF = Latent cancer fatality.

of Inventory Module 1 based on this linear relationship. The long-term impacts in Table 7-3 are estimates of the impacts that could occur within 10,000 years. As discussed in Section 7.2, the impacts of continued storage for 1 million years would be higher.

Chapter 8 of this Repository SEIS also evaluates the effects that the Global Nuclear Energy Partnership (GNEP) Program could have on the inventories evaluated for Module 1 (Section 8.1.2.4.1). The premise of the analysis is that approximately half of the commercial spent nuclear fuel in Module 1 could be recycled using one of the available technologies addressed in the upcoming GNEP Programmatic EIS. The effect that this potential recycling would have on the No-Action Alternative of Module 1 would be to lessen the overall impacts as compared to the continued storage of all of the commercial spent nuclear fuel. This would be due to the smaller volume of commercial high-level radioactive waste resulting from the recycling of the spent nuclear fuel. The impacts presented in Table 7-3 would be representative of the impacts of storage of Module 1 regardless of whether recycling technologies were implemented in the future.

REFERENCES

181685	Calvert 2006	Calvert, C. 2006. *Record of Decision Addressing Right-of-Way Applications U 76985 and U 76986 to Transport Spent Nuclear Fuel to the Reservation of the Skull Valley Band of Goshute Indians.* Washington, D.C.: U.S. Department of Interior, Bureau of Land Management. ACC: MOL.20070712.0055.
181684	Cason 2006	Cason, J.E. 2006. *Record of Decision for the Construction and Operation of an Independent Spent Fuel Storage Installation (ISFSI) on the Reservation of the Skull Valley Band of Goshute Indians (Band) in Tooele County, Utah.* Washington, D.C.: U.S. Department of Interior, Bureau of Indian Affairs. ACC: MOL.20070712.0053.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
175544	EPA 2002	EPA (U.S. Environmental Protection Agency) 2002. *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA*. EPA-402-C-99-001, Rev. 1. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20051013.0016.

101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, *No. 1-3 of Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
152446	ICRP 1996	ICRP (International Commission on Radiological Protection) 1996. "Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients." Volume 26, *No. 1 of Annals of the ICRP*. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press. TIC: 235870.
172935	ICRP 2001	ICRP (International Commission on Radiological Protection) 2001. "The ICRP Database of Dose Coefficients: Workers and Members of the Public." *ICRP Publication 72*. New York, New York: Elsevier. TIC: 255638.
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution. August 9, 2002, with attachments. ACC: MOL.20050815.0190.
181683	Ruland 2006	Ruland, W. H. 2006. "Issuance of Materials License No. SNM-2513 for the Private Fuel Storage Facility (TAC No. L23821)." Letter from W.H. Ruland, NRC, to J.D. Parkyn, Private Fuel Storage, L.L.C., February 21, 1006, with attachments. ACC: MOL.20070712.0078.

8

Cumulative Impacts

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8. CUMULATIVE IMPACTS

This chapter describes potential *cumulative impacts* for the *Proposed Action* of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (*Repository* SEIS). An evaluation of cumulative impacts is necessary to understand the environmental implications of implementing the Proposed Action and is essential to the development of appropriate *mitigation* measures and the monitoring of their effectiveness.

In preparing this chapter, the U.S. Department of Energy (DOE or the Department) followed the Council on Environmental Quality regulations handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (DIRS 103162-CEQ 1997, all) that implements the procedural provisions of the *National Environmental Policy Act of 1969* (NEPA; 42 U.S.C. 4321 et seq.). The Council on Environmental Quality regulations define a cumulative impact as "the *impact* on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). The term "reasonably foreseeable" refers to future actions for which there is a reasonable expectation that the action could occur, such as a proposed action under analysis, a project that has already started, or a future action that has obligated funding. Thus, DOE identified actions that could have effects that coincided in time and space with the effects from the proposed repository and associated transportation activities. The Department based its identification of the relevant actions on reviews of resource, policy, development, and land use plans from agencies at all levels of government and from private organizations; other *environmental impact statements*; and environmental assessments. In addition to the assessment of potential cumulative impacts and consistent with Council on Environmental Quality regulations [40 CFR 1502.16(c) and 1506.2], this cumulative impacts analysis considered potential conflicts with plans issued by various government entities to the extent practicable and to the extent they provided relevant information. Past, present, and reasonably foreseeable future actions could contribute incrementally to the overall cumulative impacts.

This chapter summarizes, incorporates by reference, and updates the information in Chapter 8 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS). DOE has organized this chapter as follows:

- Section 8.1 presents past, present, and reasonably foreseeable future federal, non-federal, and private actions. This includes a detailed analysis of nuclear materials that need to be disposed of in addition to those evaluated for the Proposed Action. It describes and evaluates these waste quantities, referred to as Inventory Modules 1 and 2, for which DOE acknowledges the need for legislative action by Congress before these wastes could be disposed of at Yucca Mountain.

- Section 8.2 presents cumulative *preclosure* impacts in the proposed *Yucca Mountain Repository* region that could occur during the *construction*, *operations, monitoring*, and *closure* of the repository. DOE organized this section by resource area, which corresponds to Chapter 4 of this Repository SEIS. The analysis included only the resource areas with potential cumulative impacts.

- Section 8.3 discusses the results from the postclosure cumulative impact analysis DOE conducted for Inventory Modules 1 and 2, the Nevada Test Site, and the Beatty low-level radioactive waste *disposal* and hazardous waste treatment, storage, and disposal facilities.

- Section 8.4 presents cumulative transportation impacts for national and Nevada transportation.

- Section 8.5 describes potential cumulative impacts from the manufacturing of the repository components that would be necessary to emplace Inventory Module 1 or 2.

- Section 8.6 presents a summary table of cumulative impacts. In addition, this section presents a perspective on the cumulative impacts of these actions from the viewpoint of Nye County, Nevada, which is a cooperating agency on this Repository SEIS.

8.1 Past, Present, and Reasonably Foreseeable Future Actions

This section identifies past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action for this Repository SEIS.

8.1.1 PAST AND PRESENT ACTIONS

The description of existing environmental conditions in Chapter 3 includes the impacts of most past and present actions on the environment that the Proposed Action would affect. This includes *site characterization* activities at Yucca Mountain. Therefore, the Chapter 4, 5, and 6 analyses of potential environmental impacts of the Proposed Action generally encompass the impacts of past and present actions because the baseline for these analyses is the *affected environment* described in Chapter 3. Table 8-1 lists two past actions that the Chapter 3 environmental baseline does not address but that DOE identified for inclusion in the cumulative impact analysis. The table also lists information on the potential areas with cumulative impact from these two actions.

Table 8-1. Past and present actions that could result in potential cumulative impacts with the Proposed Action.

Past and present action and description	Potential cumulative impact areas			
	Preclosure	Postclosure	Transportation	Manufacturing
Nevada Test Site				
Nuclear weapons testing, waste management	Air quality and public health and safety	Air quality, groundwater, and public health and safety	Occupational and public radiological health and safety	None
Beatty Waste Disposal Area				
Low-level radioactive and hazardous waste disposal	None	Groundwater and public health and safety	Occupational and public radiological health and safety	None

In addition to the specific actions in Table 8-1, the cumulative impacts for national transportation consider the occupational and public radiological health impacts of other past, present, and reasonably foreseeable future *shipments* of *radioactive* material.

8.1.2 REASONABLY FORESEEABLE FUTURE ACTIONS

This section describes the reasonably foreseeable future actions that the cumulative impacts analysis considered. These actions could result in impacts in the repository *region of influence*. Section 8.4 discusses potential effects to national and Nevada transportation. Table 8-2 summarizes the reasonably foreseeable future actions that could result in potential cumulative impacts with the Proposed Action.

Table 8-2. Reasonably foreseeable future actions that could result in potential cumulative impacts.

Name/description	Change from the Yucca Mountain FEIS to the Repository SEIS
Inventory Module 1 Disposal of all SNF and HLW	Increase in projected inventory
Inventory Module 2 Disposal of Inventory Module 1, as well as GTCC and SPAR wastes	Increase in projected inventory
Nevada Test and Training Range	Additional actions.
Nevada Test Site	Additional actions.
DOE	
Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership	New action.
Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste	New action.
Draft Complex Transformation Supplemental Programmatic EIS (DIRS 185273 -DOE 2007, all) – analyzes potential environmental impacts from the continued transformation of the U.S. nuclear weapons complex.	New action.
DOE and BLM have issued the Draft *Programmatic Environmental Impact Statement Designation of Energy Corridors on Federal Land in 11 Western States* (DIRS 185274-DOE 2007, all), which analyzes the potential designation of energy corridors on federal land in western states.	New action.
DOE and BLM have issued a notice of intent to Prepare a Programmatic Environmental Impact Statement to Evaluate Solar Energy Development, Develop and Implement Agency-Specific Programs, Conduct Public Scoping Meetings, Amend relevant Agency Land Use Plans, and Provide Notice of Proposed Planning Criteria (73 FR 30908, May 29, 2008)	New action.
Nye County	
Yucca Mountain Project Gateway Area Concept Plan for the Yucca Mountain Project entrance (DIRS 182345-Giampaoli 2007, all)	New action.
Desert Space and Science Museum Construction of a science museum (DIRS 182345-Giampaoli 2007, all)	Nye County has decreased acreage for the project since completion of the Yucca Mountain FEIS.
BLM has received 11 right-of-way permit applications for solar energy facilities in Nye County. The applications are in varying stages of review (DIRS 185368-BLM 2008, all)	New action.
BLM has received applications for eight wind energy projects in Nye County. The applications are in varying stages of review.(DIRS 185367-BLM 2008, all)	New action.

Table 8-2. Reasonably foreseeable future actions that could result in potential cumulative impacts (continued).

Name/description	Change from the Yucca Mountain FEIS to the Repository SEIS
U.S. Department of Justice published *Final Environmental Impact Statement for the Proposed Contractor Detention Facility, Las Vegas, Nevada Area* (DIRS 185475-DOJ 2008, all)	New action.

BLM = Bureau of Land Management.
DOE = U.S. Department of Energy.
EIS = Environmental impact statement.
GTCC = Greater-Than-Class-C
HLW = High-level radioactive waste.
NRC = U.S. Nuclear Regulatory Commission.
SNF = Spent nuclear fuel.
SPAR = Special-Performance-Assessment-Required.

8.1.2.1 Inventory Modules 1 and 2

Under the Proposed Action, DOE would emplace as much as 70,000 *metric tons of heavy metal* (MTHM) of *spent nuclear fuel* and *high-level radioactive waste* in the proposed repository. Of the 70,000 MTHM, approximately 63,000 MTHM would be *commercial spent nuclear fuel* and commercial high-level radioactive waste. The remaining 7,000 MTHM would consist of DOE materials (spent nuclear fuel and high-level radioactive waste).

As in the Yucca Mountain FEIS, DOE analyzed the *emplacement* of Inventory Modules 1 and 2 as a reasonably foreseeable action. Under Module 1, DOE would emplace all of the projected spent nuclear fuel and high-level radioactive waste. Under Module 2, DOE would emplace all of Inventory Module 1 plus other radioactive materials that could require disposal in a monitored *geologic repository* (commercial *Greater-Than-Class-C waste* and DOE *Special-Performance-Assessment-Required waste*). This Repository SEIS updates, as necessary, the estimated inventories of these modules. As stated in the Yucca Mountain FEIS, DOE acknowledges the need for legislative action by Congress before these actions could occur. DOE also acknowledges that prior to disposal of spent nuclear fuel and high-level radioactive waste in excess of 70,000 MTHM, appropriate regulatory authorizations would be obtained from the NRC, including any necessary amendments to DOE's license for the operation of the Yucca Mountain Repository.

As a result of developments involving the *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership* (GNEP Programmatic EIS), which DOE is preparing, the Department has modified the analysis of Inventory Modules 1 and 2 from the evaluated in the Draft Repository SEIS. Section 8.2.4.1 contains details about the GNEP Draft Programmatic EIS.

Some of the GNEP programmatic alternatives involve the recycling of commercial spent nuclear fuel. Rather than disposing of the Module 1 or Module 2 inventory of commercial spent nuclear fuel at Yucca Mountain (as was analyzed in the Draft Repository SEIS), the commercial spent nuclear fuel in excess of the Proposed Action could be recycled using one of the technologies DOE is analyzing in the upcoming GNEP Programmatic EIS. In this case, the high-level radioactive waste that resulted from this recycling activity would require geologic disposal rather than the spent nuclear fuel.

In this Repository SEIS, Inventory Module 1 would include all commercial spent nuclear fuel (about 130,000 MTHM) projected to be generated by existing U.S. reactors (assuming a 60-year operating life) (DIRS 182343-BSC 2006, all), all *DOE spent nuclear fuel* (about 2,500 MTHM) (DIRS 155970-DOE

2002, all), and all high-level radioactive waste (approximately 36,000 *canisters*) (DIRS 182702-Koutsandreas 2007, all). This inventory has not changed from the Draft Repository SEIS.

Inventory Module 2 has changed from the Draft Repository SEIS and would include the Module 1 inventory plus about 36,000 cubic meters of Greater-Than-Class-C or Greater-Than-Class-C-like low-level radioactive wastes (DIRS 185296-Joyce 2008, all). This increase (from about 6,000 cubic meters) results primarily from a revised estimate of Greater-Than-Class-C-like wastes that could be generated as a result of the project-specific alternative of the Advanced Fuel Cycle Facility proposed to be analyzed in the GNEP Programmatic EIS. The Department is proposing the Advanced Fuel Cycle Facility as a project-specific alternative, rather than programmatic alternative, that could be pursed by the Department independent of its decision on the programmatic alternatives. DOE assumes that if the Greater-Than-Class-C wastes were packaged in *transportation, aging, and disposal (TAD) canisters* prior to disposal, it would require approximately 12,000 TAD canisters.

To evaluate the potential effects of GNEP on the impacts of the repository, this Repository SEIS evaluates two disposal cases (A and B) for Inventory Modules 1 and 2. Case A represents the inventory modules without recycle. This is what DOE evaluated in the Draft Repository SEIS. Case B represents the inventory modules assuming the use of one of the recycling technologies through the implementation of one of the GNEP programmatic alternatives (that is, a thermal reactor recycle alternative) that assumes commercial spent nuclear fuel recycling. As such, under Case B the Department would dispose of 63,000 MTHM of commercial spent nuclear fuel as spent nuclear fuel, as in the Proposed Action for this SEIS; the balance of the commercial spent nuclear fuel inventory (67,000 MTHM) would be recycled and the resultant commercial high-level radioactive waste form would be transported to Yucca Mountain and disposed of in engineered waste packages. DOE presents a quantitative evaluation of the environmental impacts of this inventory scenario in Module 1 Case B.

The inventory for Module 1 Case B includes the commercial high-level radioactive waste potentially resulting from the recycling of approximately 67,000 MTHM of commercial spent nuclear fuel. The resultant volume of these commercial wastes would depend on the treatment technology. For instance, the West Valley Demonstration Project vitrified the high-level radioactive waste resulting from the reprocessing of commercial spent nuclear fuel from 1966 to 1972. The canisters of high-level radioactive waste resulting from this reprocessing contain an equivalent of 2.3 MTHM per canister (DIRS 155970-DOE 2002, Appendix A, p. A-36). Under the thermal reactor recycle programmatic GNEP alternative, the processes could generate high-level radioactive waste that had the volumetric characteristics of approximately 5.0 MTHM per canister. Assuming these two surrogate processes would define the range of canisters requiring disposal, the expected number of canisters would range from 13,400 to 29,000. This analysis assumed these commercial high-level radioactive waste canisters would have the same radiological characteristics as the existing commercial high-level radioactive waste canisters from West Valley, which are described in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix A, Section A.2.3).

The recycling of commercial spent nuclear fuel through implementation of the thermal reactor recycle alternative could also generate an additional Greater-Than-Class-C waste stream (DIRS 185502-Schwartz 2008, all). The preliminary estimate of the volume of the Greater-Than-Class-C waste generated as a result of recycling 67,000 MTHM of commercial spent nuclear fuel could be approximately 140,000 cubic meters. If the same packaging configuration assumptions from the preliminary estimate for Case A were applied to Greater-Than-Class-C wastes in Case B (that is, if DOE assumed that all of the Greater-

Than-Class-C wastes would be placed in TAD canisters prior to shipment to and disposal at the repository), then the Greater-Than-Class-C waste in Case B of Module 2 would require more than 55,000 additional waste packages. This increase in waste packages would be high enough to make it highly uncertain that DOE would dispose of these materials in the Yucca Mountain Repository in this configuration. Rather, DOE would investigate other alternatives such as volume reduction, alternative waste package designs, or additional pretreatment considerations before making any decisions on disposal of this material. Because the disposal of this volume of Greater-Than-Class-C wastes in the Yucca Mountain Repository in the assumed configurations would be highly uncertain, DOE does not provide a quantitative evaluation of the environmental impacts of Module 2 Case B.

Table 8-2a lists the projected inventories of each waste type for each of the inventory modules.

Table 8-2a. Waste types and amounts considered for the inventory modules.

Inventory Module/Case	CSNF (MTHM)	DHLW (canisters)	DSNF (MTHM)	CHLW (canisters)	GTCC-EIS (cubic meters)	GTCC-GNEP (cubic meters)
Module 1A	130,000	36,000	2,500	0	0	0
Module 1B	63,000	36,000	2,500	13,400 – 29,000	0	0
Module 2A	130,000	36,000	2,500	0	36,000	0
Module 2B	63,000	36,000	2,500	13,400–29,000	36,000	140,000

Number of DHLW canisters includes about 280 canisters of commercial HLW canisters from West Valley Demonstration Project.
CHLW = Commercial high-level radioactive waste
CSNF = Commercial spent nuclear fuel.
DHLW = Defense high-level radioactive waste.
DSNF = DOE spent nuclear fuel.
GTCC-EIS = Greater-Than-Class-C Environmental Impact Statement.
GTCC-GNEP = Greater-Than-Class-C resulting from the Global Nuclear Energy Partnership programmatic alternatives.
MTHM = Metric tons of heavy metal.

This Repository SEIS examines the potential impacts of disposal of Case A of the inventory modules by evaluating the following factors:

- The commercial spent nuclear fuel inventory in Case A of the inventory modules (130,000 MTHM) is approximately twice that of the Repository SEIS Proposed Action amount (63,000 MTHM).
- The Yucca Mountain FEIS established an analytical relationship between the impacts in each environmental resource area for the Proposed Action and those of Inventory Module 1. This relationship, which was based on detailed analyses, did not always result in a linear increase in relation to the higher amount of materials.
- The Yucca Mountain FEIS Module 1 commercial spent nuclear fuel inventory (105,000 MTHM) is about 67 percent higher than that of the FEIS Proposed Action amount (63,000 MTHM).
- The Greater-than-Class-C or Greater-than-Class-C-like low-level radioactive wastes that DOE plans to analyze in the Greater-than-Class-C EIS, which are included in Module 2, would require an estimated 12,000 TAD canisters for transportation and disposal (DIRS 185296-Joyce 2008, all).

This Repository SEIS considers the following factors for the evaluation of Module 1, Case B:

- The disposal of 67,000 MTHM of commercial spent nuclear fuel would require approximately 7,000 waste packages. A range of 2,700 to 5,800 waste packages would be required to dispose of the commercial high-level radioactive waste resulting from recycling 67,000 MTHM of commercial spent nuclear fuel, a reduction of 17 to 61 percent of the required number of waste packages. This analysis assumed there would be five canisters of commercial high-level radioactive waste per waste package.

- With the reduction in the number of waste packages, the number of rail shipments would decrease proportionately. Consistent with DOE's other transportation analyses there would be five canisters of commercial high-level radioactive waste per rail transportation cask.

Chapters 4, 5, and 6 of this Repository SEIS present the environmental impacts for the Proposed Action.

8.1.2.2 Nevada Test and Training Range

The U.S. Air Force operates the Nevada Test and Training Range (formerly known as the Nellis Air Force Range) in south-central Nevada (Figure 8-1), a national test and training facility for military equipment and personnel that consists of approximately 12,000 square kilometers (3 million acres). In *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999, all), the Air Force addressed potential environmental impacts of extending the land withdrawal to continue use of the Nevada Test and Training Range lands for military use. In 2005, the Air Force designated the Indian Springs Air Force Auxiliary Airfield as Creech Air Force Base and expanded its mission and *infrastructure* to play a major role in the war on terrorism. The base is home to two key military operations: the MQ-1 unmanned aerial vehicle and the Unmanned Aerial Vehicle Battle laboratory. The 1,590-square-kilometer (390,000-acre) Bureau of Land Management-administered National Wild Horse Range is within the boundary of the Nevada Test and Training Range. More than 3,200 square kilometers (800,000 acres) of the Test and Training Range comprise the Desert National Wildlife Refuge. The Air Force and the U.S. Fish and Wildlife Service jointly manage this area. In 2004, the Bureau of Land Management prepared a resource management plan for about 8,900 square kilometers (2.2 million acres) of withdrawn public lands on the Test and Training Range (DIRS 178102-BLM 2004, all). The plan guides the management of the affected Range natural resources 20 years into the future (2024). The decisions, directions, allocations, and guidelines in the plan are based on the primary use of the withdrawn area for military training and testing purposes. Environmental assessments are periodically completed for new or changing activities at the Range. Table 8-3 is a summary of Nevada Test and Training Range environmental assessments identified since the completion of the Yucca Mountain FEIS.

8.1.2.3 Nevada Test Site

The Nevada Test Site was established in 1951 as the nation's proving ground for developing and testing nuclear weapons (Figure 8-1). The site is on land administratively held by the Bureau of Land Management, but the Test Site land was withdrawn for use by the U.S. Atomic Energy Commission and its successors (including DOE). At present, the National Nuclear Security Administration manages the site, which consists of about 3,200 square kilometers (800,000 acres) of land.

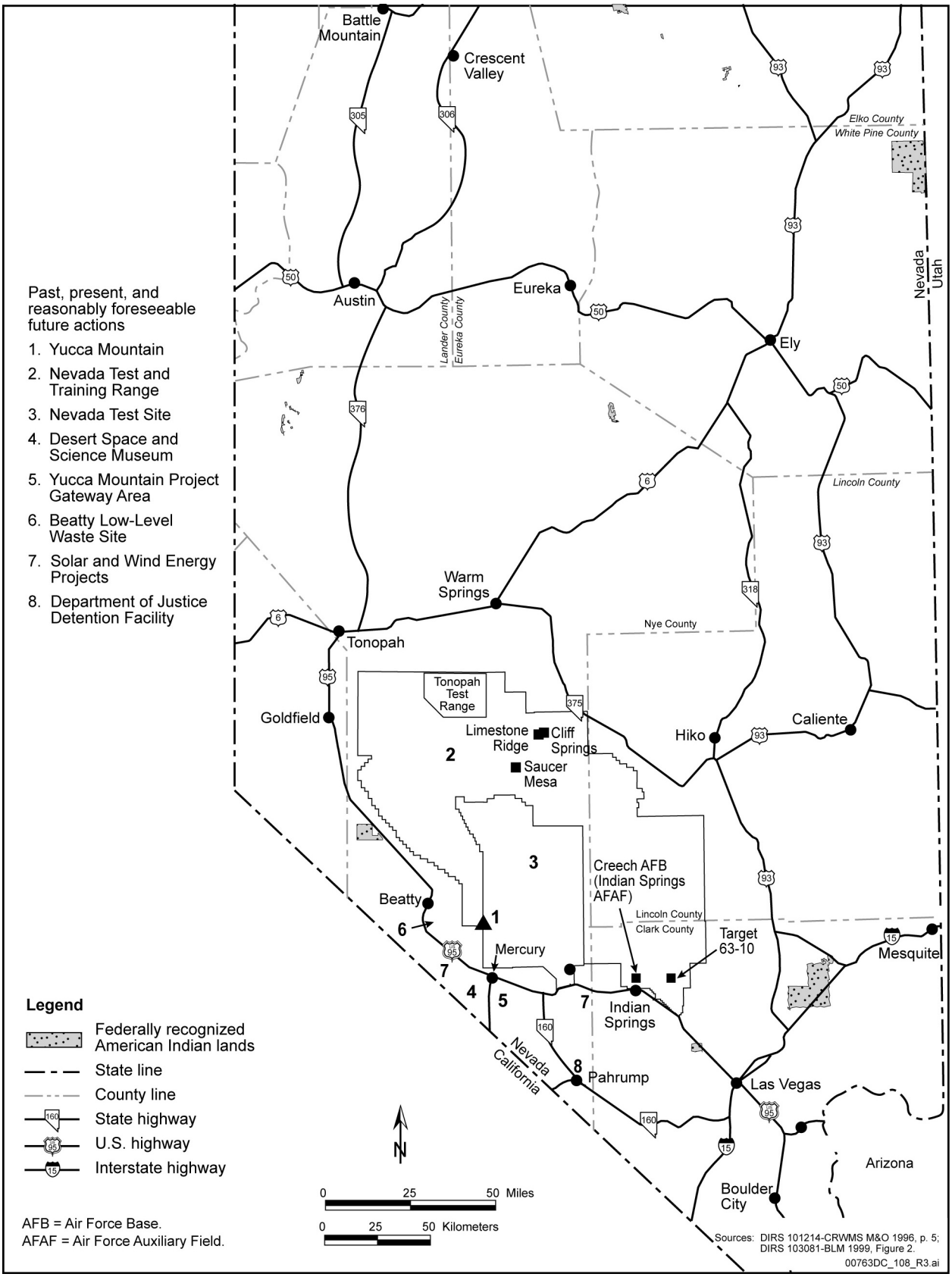

Figure 8-1. Locations of past, present, and reasonably foreseeable future actions.

Table 8-3. Environmental assessments identified since completion of the Yucca Mountain FEIS for the Nevada Test and Training Range.

Title	Description
Final Environmental Assessment for Increased Depleted Uranium Use on Target 63-10, Nevada Test and Training Range (DIRS 181607-USAF 2006, all)	The proposed action was to increase the use of depleted uranium ammunition at the Nevada Test and Training Range to meet ongoing test and training requirements for A-10 aircraft. The Air Force was to increase the number of depleted uranium rounds authorized to be fired on Target 63-10 from 7,900 to 19,000 annually. The environmental assessment evaluated five resource areas—air quality, soil and water resources, health and safety, hazardous and radioactive materials and waste, and biological resources—in detail to identify potential environmental impacts. The Air Force issued a Finding of No Significant Impact.
Final Environmental Assessment for Predator Force Structure Changes at Indian Springs Air Force Auxiliary Field, Nevada (DIRS 172314-USAF 2003, all)	The proposed action included changes to personnel assignments, upgrades to existing facilities, construction of new facilities, and extension of a runway by 120 meters (400 feet). The Air Force completed facilities for the Predator unmanned aerial vehicles in 2006. The Air Force issued a Finding of No Significant Impact.
Expeditionary Readiness Training Course Expansion, Final Environmental Assessment, Creech AFB (DIRS 182838-USAF 2006, all)	Environmental assessment to increase the number of Security Forces personnel trained at the Regional Training Center at Silver Flag Alpha and Creech AFB, Nevada, from an existing 2,520 to 6,000 students per year. The Air Force issued a Finding of No Significant Impact.
Wing Infrastructure Development Outlook, Final Environmental Assessment, Nellis AFB (DIRS 182839-USAF 2005, all)	The proposed action consists of 630 Wing Infrastructure and Development Outlook projects in 11 categories as classified under 32 CFR Part 989, *Air Force EIAP*. A total of 18 new construction and demolition projects are proposed for Creech Air Force Base. On the Nevada Test and Training Range, the proposed action would implement four new construction projects at four locations. At Tonopah Test Range, three new construction projects are planned along with the demolition of 10 buildings. The Air Force issued a Finding of No Significant Impact.
Draft Range 74 Target Complexes Environmental Assessment Nevada Test and Training Range, Nevada (DIRS 185372-USAF 2007, all)	The proposed action is to construct and operate three target complexes in mountainous terrain in Range 74 of the Nevada Test and Training Range at Saucer Mesa, Limestone Ridge, and Cliff Springs. The Saucer Mesa target array would employ both large-scale live and inert munitions; the Limestone Ridge sites would employ large-scale inert munitions; both target sites would employ small-scale live munitions. The Cliff Springs target complex would be laser and simulated attack targets and no munitions would be used. The Air Force issued a Finding of No Significant Impact.
A Final Base Realignment and Closure Environmental Assessment for Realignment of Nellis Air Force Base (DIRS 181492-USAF 2007, all)	The proposed action would affect the Nevada Test and Training Range by adding 1,400 F-16 sorties flown from Nellis Air Force Base. Although they would not cause total annual sortie operations to exceed the current maximum of 300,000 at the Nevada Test and Training Range, the environmental assessment evaluated noise, air quality, socioeconomics and infrastructure, water and soil resources, biological resources, cultural resources, and hazardous materials and waste. The Air Force issued a Finding of No Significant Impact.

AFB = Air Force Base.

A number of defense-related material and management activities, waste management, environmental restoration, and non-defense research and development are conducted at the site. DOE activities at the Nevada Test Site include stockpile stewardship and management (helping ensure the U.S. nuclear weapon stockpile is safe, secure, and reliable), materials disposition (removal of nuclear materials in a safe and

timely manner), and nuclear emergency response. Between 1951 and 1992, the Federal Government conducted just over 900 nuclear tests at the site. The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all) described existing and projected future actions at the Test Site. That EIS was followed by *Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 162638-DOE 2002, all). Table 8-4 is a summary of the Nevada Test Site environmental assessments identified since the issuance of the Yucca Mountain FEIS. A new *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 185437-DOE 2008, all) has been developed and, based on this analysis, the National Nuclear Security Administration presents a preliminary conclusion that no additional NEPA documentation is required including:

- No substantial changes have occurred with respect to the proposals included in the Nevada Test Site EIS and selected for implementation in DOE Records of Decision.

- Screening analyses for the following resource areas showed no significant new circumstances or information relevant to environmental concerns: land use, infrastructure, socioeconomics, geology and soils, hydrology, biological resources, air quality, noise, visual resources, cultural resources, public radiological impacts from normal operations, worker radiological and occupational health and safety, waste management (portions), transportation (portions), and environmental justice.

Table 8-4. Environmental assessments identified since completion of the Yucca Mountain FEIS for the Nevada Test Site.

Title	Description
Environmental Assessment for Relocation of Technical Area 18 capabilities and materials from the Los Alamos National Laboratory to the Nevada Test Site (DIRS 162639-DOE 2002, all)	DOE completed relocation of Technical Area 18 operational capabilities and materials from the Los Alamos National Laboratory to the Nevada Test Site in November 2005. Relocation included the transport of about 2.4 metric tons (2.6 tons) of special nuclear material and approximately 10 metric tons (11 tons) of natural and depleted uranium and thorium, as well as support equipment, some of which would have radioactive contamination, associated with the operations. A Finding of No Significant Impact was issued.
Environmental Assessment for Defense Logistics Agency transfer of waste to DOE and Finding of No Significant Impact (DIRS 172280-DLA 2003, all) (DIRS 172281-DOD 2003, all)	The Defense Logistics Agency of the U.S. Department of Defense issued an environmental assessment of its proposal to transfer thorium nitrate from the Defense National Stockpile Center to DOE for disposal as a low-level radioactive waste at the Nevada Test Site. The Agency issued a Finding of No Significant Impact in November 2003 (DIRS 172281-DOD 2003, all). The Defense Logistics Agency made eight shipments of low-level thorium waste [about 310 cubic meters (10,900 cubic feet)] in 2004 (DIRS 182346-DOE 2005, all).

DOE = U.S. Department of Energy.

More detailed analyses were performed and identified no significant new circumstances or information relevant to environmental concerns for the following resource areas: public worker impacts from radiological and chemical accidents, low-level and mixed low-level radioactive waste management, and transportation (portions).

8.1.2.4 U.S. Department of Energy

DOE is completing several environment impact statements for proposals that can be considered reasonably foreseeable future actions.

8.1.2.4.1 *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership*

DOE is preparing a GNEP Programmatic EIS. GNEP is a domestic and international program designed to support expansion of nuclear energy production while advancing nonproliferation goals and reducing the impacts of spent nuclear fuel disposal.

The GNEP Programmatic PEIS will evaluate the impacts of domestic programmatic alternatives that would reduce the volume, thermal output, and radiotoxicity of spent nuclear fuel and wastes requiring geologic disposal in the future. Within these programmatic alternatives, the Programmatic EIS will evaluate a range of potential growth scenarios for nuclear power generation through approximately 2060 to 2070 that range from the status quo of the current generation capability (approximately 100 gigawatts) to an annual growth of approximately 2.5 percent (400 gigawatts after a period of approximately 55 to 60 years). It also will evaluate a project-specific alternative to pursue the potential implementation of an Advanced Fuel Cycle Facility to conduct research, development, and demonstration at one or more of five DOE sites in the continental United States (DIRS 185502-Schwartz 2008, all).

The programmatic alternatives in the GNEP Programmatic EIS vary by reactor type, fuel type, and whether they would incorporate recycling of commercial spent nuclear fuel to recover usable materials for reuse in other reactor fuels. The alternatives include a no-action alternative that assumes continued use of light-water reactors without recycling spent nuclear fuel. All of the programmatic alternatives assume that the current licensed reactors would be replaced by similar or different reactor types, depending on the alternative.

Depending on the specific programmatic alternative analyzed, the resultant radiological materials that required geologic disposal could range from only high-level radioactive waste from recycling spent nuclear fuel, to only spent nuclear fuel (at varying mass projections depending on the reactor type alternative and the nuclear power growth scenario). The estimates of spent nuclear fuel vary widely among the alternatives. For the alternatives with repeated recycle of usable materials, no spent nuclear fuel would require geologic disposal (DIRS 185502-Schwartz 2008, all).

There are many uncertainties associated with the implementation of any programmatic alternative and many factors (such as market forces, research and development, regulatory issues, and public policy) could impact the successful implementation of any alternative. Because of these factors, it is not possible to predict with confidence when, and to what extent, any of the programmatic action alternatives would be implemented. In any event, transition to any new fuel cycle could take many decades to complete.

The United States presently uses a “once-through” fuel cycle in which a nuclear utility uses nuclear fuel in a reactor only once, and then utility places the spent nuclear fuel in storage while awaiting disposal. GNEP would not diminish in any way the need for the nuclear waste disposal program at Yucca Mountain, because any fuel-recycling scenario would produce high-level radioactive waste and/or spent

nuclear fuel that would require disposal, and none of the spent nuclear fuel recycling scenarios would treat existing inventories of DOE high-level radioactive waste that require disposal at the Repository.

DOE anticipates that by about 2020 the commercial utilities will have produced about 86,000 MTHM of spent nuclear fuel, which exceeds DOE's disposal limit of 63,000 MTHM of commercial spent nuclear fuel for the Yucca Mountain Repository. If DOE decided in a GNEP Record of Decision to proceed with its proposal to recycle spent nuclear fuel, the necessary facilities would not begin operations until 2020 or later. Given the current uncertainties associated with the timelines, potential capacities, technological developments, need of, and the private industry support for, the facilities evaluated in the GNEP programmatic alternatives, the Department believes there would be no change in the spent nuclear fuel and high-level radioactive waste inventory analyzed under the Proposed Action of this Repository SEIS [that is, 63,000 MTHM of commercial spent nuclear fuel, which could include about 280 canisters of commercial high-level radioactive waste from the West Valley Demonstration Project, and 7,000 MTHM of DOE spent nuclear fuel (about 3,200 canisters) and high-level radioactive waste (about 9,300 canisters)].

As discussed in Section 8.1.2.1, in light of the developments in the preparation of the GNEP Programmatic EIS DOE has modified its analysis of the inventory modules in this Repository SEIS.

8.1.2.4.2 *Disposal of Greater-Than-Class-C Low-Level Radioactive Waste Environmental Impact Statement*

DOE is preparing the *Disposal of Greater-Than-Class-C Low-Level Radioactive Waste Environmental Impact Statement* (DOE/EIS-0375) (72 FR 40135, July 23, 2007). This EIS will address the disposal of wastes with concentrations greater than Class C, as defined in U.S. Nuclear Regulatory Commission (NRC) regulations at 10 CFR Part 61, and DOE low-level radioactive waste and *transuranic waste* having characteristics similar to Greater-Than-Class-C waste and that otherwise do not have a path to disposal. DOE proposes to evaluate alternatives for Greater-Than-Class-C low-level waste and Greater-Than-Class-C-like waste (also referred to as Special-Performance-Assessment-Required waste; Section 8.1.2.1) disposal in a geologic repository, in intermediate depth *boreholes*, and in enhanced near-surface facilities. Candidate locations for these disposal facilities are the Idaho National Laboratory, the Los Alamos National Laboratory and Waste Isolation Pilot Plant in New Mexico, the Nevada Test Site and the proposed Yucca Mountain Repository, the Savannah River Site in South Carolina, the Oak Ridge Reservation in Tennessee, and the Hanford Site in Washington. DOE will also evaluate disposal at generic commercial facilities in *arid* and humid locations. This Repository SEIS evaluates the potential cumulative impacts of disposal of these wastes at Yucca Mountain as a reasonably foreseeable action, which is referred to as Inventory Module 2.

8.1.2.4.3 *Complex Transformation Supplemental Programmatic EIS*

In December 2007, the National Nuclear Security Administration and DOE published *Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement* (formerly known as the Complex 2030 Supplemental Programmatic EIS) (DIRS 185273-DOE 2007, all). This supplemental programmatic EIS analyzes the potential environmental impacts of reasonable alternatives to continue transformation of the U.S. nuclear weapons complex under the National Nuclear Security Administration's vision of a smaller, more responsive, efficient, and secure complex. As part of the proposed action, activities could take place at Los Alamos National Laboratory in New Mexico, the

Nevada Test Site, the Pantex Plant in Texas, the Y-12 National Security Complex in Tennessee, the Savannah River Site in South Carolina, White Sands Missile Range, and Lawrence Livermore National Laboratory.

8.1.2.4.4 *Programmatic EIS To Designate Energy Corridors on Federal Land*

To identify appropriate right-of-way *corridors* throughout the western United States, including Nevada, DOE and the Bureau of Land Management are co-lead agencies and have issued *Draft Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States*, which analyzes the potential designation of energy corridors on federal land in western states (DIRS 185274-DOE 2007, all). The proposed action is to designate corridors for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities. The states are Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Based on information and analyses developed, DOE and the Bureau of Land Management, as well as the federal cooperating agencies (U.S. Forest Service and U.S. Department of Defense), might amend their relevant land use plans. The energy corridors in the Draft Programmatic EIS near the Nevada Test Site and Yucca Mountain Repository follow existing, designated energy corridors.

8.1.2.4.5 *Notice of Intent To Prepare an EIS To Evaluate Solar Energy Development*

DOE and the Bureau of Land Management have issued a Notice of Intent in response to the following mandates: Executive Order 13212, *Actions to Expedite Energy-Related Projects* and Title II, Section 211 of the *Energy Policy Act of 2005* (73 FR 30908, May 29. 2008). DOE and the Bureau have identified utility-scale solar energy development as a potentially critical component in meeting these mandates. DOE and the Bureau are considering the development and implementation of agency-specific programs related to solar energy development in six western states (Arizona, California, Colorado, New Mexico, Nevada, and Utah). DOE proposes to develop a solar energy program of environmental policies and mitigation strategies that would apply to the deployment of DOE-supported solar energy projects on Bureau-administered lands or other federal, state, tribal, or private lands. The Bureau would establish its own environmental policies and mitigation strategies to use when making decisions on whether to issue rights-of-way for utility-scale solar energy development projects on public lands administered by the Bureau. Until details for specific utility-scale solar energy development projects are available, the possibility of cumulative impacts, if any, with the Yucca Mountain Project is unknown.

8.1.2.5 Nye County

Nye County is proposing several projects that can be considered as reasonably foreseeable future actions.

8.1.2.5.1 *Yucca Mountain Project Gateway Area Concept Plan*

Nye County has completed a Yucca Mountain Project Gateway Area Concept Plan with proposed land use designations for the area around the entrance to the proposed repository site (DIRS 182345-Giampaoli 2007, all). This report presents Nye County's proposed multiphase land use plan for the portion of the town of Amargosa Valley that is adjacent to and near the site entrance area. Nye County proposed this plan to ensure that land development occurs in an orderly manner and to increase opportunities for industrial and commercial development consistent with the repository program. Nye County views this plan as a starting point for development of the infrastructure, institutional capacity, and facilities to offset the potential impacts associated with the repository while also benefiting the repository program. The

county developed the plan to use and manage existing initiatives while expanding and improving the area. It states the purposes of the plan as follows:

- Describe key objectives and methods to manage the expected impacts of repository-related activities, which would include growth in neighboring towns,
- Review existing conditions and identify necessary planning and infrastructure improvements,
- Review financial options for land and utility development, and
- Present a land use concept to ensure orderly and compatible development for the area around the repository site entrance.

Nye County plans to nominate Crater Flat lands for disposal of the land (transfer of land) in the Bureau of Land Management Resource Management Plan amendment process.

8.1.2.5.2 *Desert Space and Science Museum*

The Yucca Mountain FEIS evaluated the proposed museum that the Nevada Science and Technology Center, LLC, would construct and operate under lease from Nye County. Nye County would construct infrastructure and oversee development of industrial, commercial, recreational, and public purpose facilities on the adjacent 1.4 square kilometers (350 acres). The U.S. Fish and Wildlife Service issued a notice of availability for the "Nye County Habitat Conservation Plan for Lands Conveyed at Lathrop Wells, NV" (67 FR 39737, June 10, 2002), which includes the proposed museum and the adjacent development. In total, 3.3 square kilometers (820 acres) of land would transfer from the Bureau of Land Management to Nye County, of which the county would develop 0.4 square kilometer (99 acres) for the proposed facilities and manage the remaining area for natural resource values and desert tortoise *habitat* (DIRS 182804-Maher 2006, all). The U.S. Fish and Wildlife Service has made a preliminary determination that approval of the Habitat Conservation Plan qualifies as a categorical exclusion under NEPA.

8.1.2.5.3 *U.S. Highway 95 Technology Corridor*

Nye County has outlined a strategy for a Technology Corridor along U.S. Highway 95 (DIRS 182841-Gamble 2007, all). The corridor extends from Indian Springs in Clark County in the south to Tonopah in the north, passing through the Pahrump Valley, Mercury (entrance to the Nevada Test Site), Amargosa Valley, Beatty, and Goldfield. Nye County would like to increase industrial space to accommodate new high-technology businesses by completing the Amargosa Valley Science and Technology Park at Lathrop Wells, assisting Beatty to adaptively reuse the Barrick Bullfrog site for new industry, and encouraging Pahrump to facilitate a business park for the Pahrump Valley. Nye County's goals for the Technology Corridor are to change economic diversity of the region's industries, transform the regional economy to one more closely associated with national trends, and increase the presence of green energy industry in the region.

As part of its Technology Corridor, a major goal of Nye County is to pursue development of renewable energy along the U.S. Highway 95 corridor (DIRS 182841-Gamble 2007, Goal 1-7, p. C-1). Wide expanses and sunny climate offer abundant opportunity to employ solar energy options to spread energy

demand and lower operating costs for households and businesses. Nevada has created an incentive for power utilities to invest in alternative energy. To increase renewable energy research and development activities, Nye County plans to work cooperatively with (1) the DOE National Laboratory for Renewable Energy to provide contracts to regional providers, (2) private industry to attract investment to promote renewable energy projects, and (3) installation providers to recruit and provide skill training through Great Basin College to local workers (DIRS 182841-Gamble 2007, Section 3.3.10, p. 31).

The Bureau of Land Management has received right-of-way permit applications for solar energy facilities in Nye County. The applications are in varying stages of review by the Bureau. The following are descriptions of the eight solar energy applications the Bureau's Las Vegas Field Office is evaluating:

- Solar Millennium LLC applied in November 2007 for a right-of-way permit for about 3.4 square kilometers (840 acres) of Bureau of Land Management land in Amargosa Valley in the Anvil Farm Road area. The applicant is proposing to build and operate a 150- to 350-megawatt solar parabolic trough electric power plant (DIRS 185368-Seley 2008, all).

- Solar Millennium LLC applied in November 2007 for a right-of-way permit for about 17 square kilometers (4,100 acres) of Bureau of Land Management land in Amargosa Valley in the Amargosa Farm Road area. The applicant is proposing to build and operate a 150- to 350-megawatt solar parabolic trough electric power plant (DIRS 185368-Seley 2008, all).

- Solar Investments LLC applied in March 2007 for a right-of-way permit for about 89 square kilometers (22,000 acres) of Bureau of Land Management land northwest of the Big Dune Area of Critical Environmental Concern and abutting U.S. Highway 95. The applicant is proposing to construct and operate a 1,000-megawatt solar thermal energy facility in the Big Dune area of Nye County (DIRS 185368-Seley 2008, all).

- Solar Investments LLC applied in February 2007 for a right-of-way permit for about 53 square kilometers (13,000 acres) of Bureau of Land Management land east of the Big Dune Area of Critical Environmental Concern and abutting U.S. Highway 95. The applicant is proposing to construct and operate a 1,000-megawatt solar thermal energy facility in Amargosa (DIRS 185368-Seley 2008, all).

- Solar Investments LLC applied in March 2007 for a right-of-way permit for about 53 square kilometers (13,000 acres) of Bureau of Land Management land south of the Beatty Airfield, near the Town of Beatty. The applicant is proposing to construct and operate a 1,000-megawatt solar thermal energy facility (DIRS 185368-Seley 2008, all).

- Pacific Solar Investments, Inc., applied in December 2007 for two right-of-way permits, one for about 30 square kilometers (7,500 acres), and one for about 31 square kilometers (7,700 acres), for Bureau of Land Management land in the Amargosa Desert adjacent to the Big Dune Area of Critical Environmental Concern and south of U.S. Highway 95. The applicant is proposing to construct and operate 500-megawatt parabolic trough plants, known as the proposed Amargosa South and North Plants (DIRS 185368-Seley 2008).

- Ausra NV 1 LLC applied in March 2008 for a right-of-way permit for about 28 square kilometers (7,000 acres) of Bureau of Land Management land near the Ash Meadows Wildlife Refuge in the Johnnie Amargosa area. The applicant is proposing to construct and operate a compact linear Fresno

reflector power plant, where the first phase would be 400-megawatts and the second phase would be 200 megawatts (DIRS 185368-Seley 2008, all).

The Bureau of Land Management Battle Mountain Field Office is evaluating:

- Solar Millennium LLC applied in November 2007 for a right-of-way permit for about 10 square kilometers (2,500 acres) of Bureau of Land Management land just west of the Beatty Airport, near the Town of Beatty. The applicant is proposing to build and operate a 150- to 350-megawatt solar parabolic trough electric power plant (DIRS 185368-Seley 2008, all).

The Bureau of Land Management has also received an application for a wind energy site testing a project area in Nye County.

- Greenwing Pacific Energy Corporation applied in August 2007 for a right-of-way permit for about 30 square kilometers (7,400 acres) of Bureau of Land Management land west of the Town of Beatty and abutting Nevada State Route 374 (DIRS 185367- BLM 2008, all).

8.1.2.5.4 *U.S. Department of Justice Detention Facility*

The U.S. Department of Justice Office of the Federal Detention Trustee and the U.S. Marshals Service determined that there is a need to house federal detainees at a facility near Las Vegas. In March 2008, the Department of Justice published the *Final Environmental Impact Statement for the Proposed Contractor Detention Facility, Las Vegas, Nevada Area* (DIRS 185475-DOJ 2008, all). The EIS preferred alternative identified is a 120-acre site in Pahrump, about 80 kilometers (50 miles) from the repository site. Development of the proposed facility would take about 12 to 15 months and would employ 200 to 250 people upon operation. Operation of the proposed detention facility is anticipated to result in approximately 40 to 50 contractor employees relocating to Nye County, and the remainder of the new contractor employees are expected to be current residents of Clark County who would continue to reside in Clark County within commuting distance of the selected site.

8.2 Cumulative Preclosure Impacts in the Proposed Yucca Mountain Repository Region

This section describes preclosure cumulative impacts during the construction, operations, monitoring, and closure analytical periods of the proposed repository in the regions of influence for the resources the repository could affect and updates information from Chapter 8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-1 to 8-116).

DOE has organized the analysis of cumulative impacts by resource area. As necessary, the discussion of each resource area includes cumulative impacts: from Inventory Module 1 or 2; from other federal, non-federal, and private actions; and from the combination of Inventory Modules 1 and 2 and other federal, non-federal, and private actions.

8.2.1 LAND USE AND OWNERSHIP

Impacts to the ownership, management, and use of the *analyzed land withdrawal area* described in Chapter 4, Section 4.1.1 of this Repository SEIS would not change due to Inventory Module 1 or 2. The

amount of land necessary for surface facilities would increase somewhat for Module 1 or 2 because of the larger area for excavated rock storage and additional ventilation *shafts* for the larger repository. Table 8-4a lists the estimated increases in excavation above that estimated for the Proposed Action. The differences in excavation for the various inventory modules and cases are based primarily on the number of waste packages, but take into account the shorter length of the waste packages that would contain high-level radioactive waste in comparison with those that would contain TAD canisters. This increased land disturbance would have no substantial cumulative land use or ownership impact.

Table 8-4a. Increased excavated rock storage area for the inventory modules

Inventory Module/Case	Increase in waste packages[a]	Increased length of excavation [km (miles)]	Excavated rock storage area increase (percentage)	Total excavated rock storage [km^2 (acres)]
Module 1A	14,700	73 (45)	110	1.7 (420)
Module 1B	10,400 – 13,500	41 – 54 (26 – 33)	61 – 79	1.3 – 1.5 (320 – 360)
Module 2A	26,700	150 (91)	220	2.6 (630)

a. Estimated number of waste packages in the Proposed Action would be 11,200.
km = kilometers.
km^2 = square kilometers.

To identify and quantify cumulative impacts for land use, DOE evaluated actions that had occurred or could occur within an 84-kilometer (52-mile) radius of the repository. The only *quantitative* change in land use impacts from other federal, non-federal, and private actions from the Yucca Mountain FEIS would be a decrease in land disturbance for the Desert Space and Science Museum from 1.8 square kilometers (440 acres) to 0.40 square kilometer (100 acres). Changes in impacts from the continued use of the Nevada Test Site and the Nevada Test and Training Range would be unlikely. The Bureau of Land Management has designated land in the town of Amargosa Valley adjacent to the repository site entrance for disposal, indicating that the land has limited public use. The Nye County Yucca Mountain Project Gateway Area Concept Plan presents a land use concept to ensure orderly and compatible development of an approximately 23-square-kilometer (9-square-mile)-area around the repository site entrance (DIRS 182345-Giampaoli 2007, all). The county proposed this plan to ensure that land development would occur in an orderly manner and increase the opportunities for industrial and commercial development consistent with the repository program. Nye County views this plan as a starting point for development of the infrastructure, institutional capacity, and facilities to support the Yucca Mountain Repository.

The Bureau of Land Management has received several permit applications for solar and wind energy projects in Nye County near the repository. Locations and amount of proposed acreage are discussed in Section 8.1.2.5.3. A major goal of Nye County is to pursue development of renewable energy and these uses would permit orderly development of the area. No additional land use or ownership impacts are available at this time.

The U.S. Department of Justice proposes a 120-acre site in Pahrump, about 80 kilometers (50 miles) from the repository site. Because of the compact, self-contained nature of the proposed facility, it would not have a significant effect on local land use patterns or land uses in the area of the selected site and is not expected to contribute to cumulative impacts.

8.2.2 AIR QUALITY

The cumulative preclosure nonradiological impacts to *air quality* would essentially be the same as those for the Proposed Action in Chapter 4, Section 4.1.2 of this Repository SEIS. In summary, construction,

operations, monitoring, and closure of the proposed repository would have small impacts on regional air quality for Inventory Module 1 or 2.

The activities that produced releases of *criteria pollutants* (*nitrogen dioxide*, *sulfur dioxide*, *carbon monoxide*, and *particulate matter*) and carbon dioxide would be roughly the same for Inventory Module 1 or 2 as those described for the Proposed Action (Section 4.1.2). One change would be the increased land disturbance and particulate matter generated for the larger area for the excavated rock storage pile and additional ventilation shafts from the larger *subsurface* repository. DOE would monitor the excavated rock storage pile, ventilation shafts, and other areas to ensure compliance with applicable air quality standards throughout the construction, operations, monitoring, and closure periods. Carbon dioxide output would be related to fossil-fuel demand, which would be the same annually for Inventory Modules 1 or 2 as that for the Proposed Action but would last for a longer period.

8.2.2.1 Construction

The repository construction period for Inventory Module 1 or 2 would produce the same levels of all pollutants and cristobalite because the amount of surface or subsurface construction during this 5-year period would be constant. The additional excavation necessary for Module 1 or 2 would occur during the operations period. The land disturbance outside the analyzed land withdrawal area and near the boundary of the *land withdrawal area* would not change. The air concentrations would still be less than the applicable regulatory limits, as reported in Chapter 4, Section 4.1.2.1.

8.2.2.2 Operations and Monitoring

The operations period for Inventory Module 1 or 2 would produce the same levels of gaseous pollutants but slightly higher concentrations of particulate matter and cristobalite. During the operations period, the excavated rock storage pile for Inventory Module 1 or 2 would contain between two and three times the amount of excavated rock as that for the Proposed Action. This could increase the amount of particulate matter with an aerodynamic diameter of 10 micrometers or less (PM_{10}) released to the air and increase the PM_{10} concentration. However, due to the distance between the excavated rock storage pile and the boundary of the analyzed land withdrawal area, the PM_{10} concentration from the rock pile would still be significantly less than the regulatory limit. The cristobalite concentration would be less than 0.05 percent of the regulatory limit. The amount of land disturbed by ventilation shafts would increase.

As shown in Chapter 4, Section 4.1.2.2, all pollutant concentrations would be less than the applicable regulatory limits for the Proposed Action during the operations period. Because the development of the emplacement *drifts* for Module 1 or 2 would take additional time in comparison with that for the Proposed Action, these releases of criteria pollutants would occur over a longer period than those for the Proposed Action.

During the subsequent monitoring and maintenance activities, the concentrations would decrease considerably and would be the same as those reported in Chapter 4, Section 4.1.2.3.

8.2.2.3 Closure

Closure of the proposed repository for Inventory Module 1 or 2 could produce comparable, but slightly higher, concentrations of gaseous pollutants, particulate matter, and cristobalite than those estimated for

the Proposed Action. The concentrations would be much less than the applicable regulatory limits. With Inventory Module 1 or 2, the amount of backfill necessary would be larger than that for the Proposed Action, and the size of the excavated rock storage pile to reclaim would be larger. The duration of the closure period for Inventory Module 1 or 2 would be longer than that of the Proposed Action, which could result in minor changes in the air concentrations between the Proposed Action and Inventory Module 1 or 2.

As in the Yucca Mountain FEIS, other reasonably foreseeable actions would be unlikely to have cumulative impacts with the repository or Modules 1 or 2 because they would be sufficiently far away that plumes would have limited potential for overlap. Further, the responsible agencies would take measures for each action to minimize regional air quality impacts. Repository activities would have no effect on air quality in the Las Vegas Valley air basin, which is a *nonattainment area* for carbon monoxide and PM_{10}, because the basin is approximately 120 kilometers (75 miles) southeast of the proposed repository site. Section 8.2.7.2 evaluates radiological air quality cumulative impacts.

8.2.3 HYDROLOGY

The cumulative preclosure potential impacts to surface waters and *groundwater* from Inventory Module 1 or 2 and other federal, non-federal, or private actions would be similar to those described in Section 8.2.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-39 to 8-43), which this section incorporates by reference and summarizes.

8.2.3.1 Inventory Module 1 or 2

8.2.3.1.1 *Surface Water*

Potential surface-water impacts from Inventory Module 1 or 2 would be relatively minor and would include the following:

- Introduction and movement of *contaminants*,
- Changes to runoff or infiltration rates, and
- Alterations of natural drainage.

Introduction and Movement of Contaminants

Inventory Module 1 or 2 would result in essentially no change in the potential for soil *contamination* during the construction, operations, monitoring, and closure periods. Neither the types of contaminants nor the operations that could involve spills or releases would change, but the operations would last longer. Similarly, there would be no change in the threat of flooding to cause contaminant releases.

Changes to Runoff or Infiltration Rates

Inventory Module 1 or 2 would require the disturbance of additional land, primarily as a result of the need for more area for the excavated rock storage pile and the need to construct additional ventilation shafts for the subsurface area. The additional land disturbance would be small (less than 20 percent) in comparison with the total 9 square kilometers (2,200 acres) that the Proposed Action without Inventory Module 1 or 2 would disturb. This increase in disturbed land would be a relatively small portion of the natural drainage areas and would make little difference in the amount of water that soaked into the ground or reached the intermittently flowing drainage channels, particularly because most of the additional land disturbance (for the excavated rock storage pile) would be in areas where stormwater *detention ponds* would control

runoff. Disturbed areas not covered by structures would slowly return to conditions similar to those of the surrounding undisturbed ground.

Alterations of Natural Drainage

No additional actions or land disturbances from Inventory Module 1 or 2 would involve a potential to alter noteworthy natural drainage channels in the area beyond those the Proposed Action alters. The excavated rock storage pile and its increased size for Module 1 or 2 would be in an area already altered and controlled through the installation of collection ditches and stormwater detention ponds. Potential impacts to *floodplains* would be the same as those described for the Proposed Action (Chapter 4, Section 4.1.3.1.4). Construction could involve the placement of structures, facilities, or roadways in or over drainage channels or their associated floodplains (or flood zones) and could affect the 100- and 500-year floodplains of *Fortymile Wash*, Busted Butte Wash (also known as Dune Wash), Drill Hole Wash, and Midway Valley Wash (also known as Sever Wash) at Yucca Mountain.

8.2.3.1.2 *Groundwater*

Potential groundwater impacts from Inventory Module 1 or 2 would relate to the following:

- The potential for a change in infiltration rates that could increase the amount of water in the *unsaturated zone* and adversely affect the performance of waste containment in the repository or decrease the amount of recharge to the *aquifer*,
- The potential for contaminants to migrate to the unsaturated or saturated groundwater zones during the active life of the repository, and
- The potential for water demands for the repository to deplete groundwater resources to an extent that could affect downgradient groundwater use or users.

Changes to Infiltration and Aquifer Recharge

Under Inventory Module 1 or 2, DOE anticipates changes due to infiltration and recharge rates in three areas—an increase in the size of the excavated rock storage pile, an increase in the number of ventilation shaft operations areas, and an extended scope for subsurface activities. The following paragraphs discuss these items.

Additional land disturbance would result from the continued growth of the excavated rock storage pile. Although the rock pile could have different infiltration rates than undisturbed ground, it probably would not be a recharge location because of the extended depth of unconsolidated material, and it probably would not cause a large change in the amount of water that would otherwise reach recharge areas such as drainage channels.

Increased land disturbance would result from the additional ventilation shaft operation areas and the access roads that DOE would need for the increased size of the repository footprint. These areas of disturbance would be primarily on steeper terrain, uphill from the *portal* areas, where unconsolidated material is probably thin and where disturbances could expose *fractured* bedrock and increase infiltration rates. However, road material or equipment pads would cap much of the disturbed area, and the amount of disturbed land would be small in comparison to the surrounding undisturbed area.

Underground activities and their associated potential to increase recharge due to their use of water would be basically the same as those described for the Proposed Action, except that emplacement drift construction could take up to twice as long to complete in comparison to the Proposed Action. As described for the Proposed Action, the quantities of water in the subsurface that ventilation or pumping did not remove to the surface, and thus were available for recharge, would be small.

Potential for Contaminant Migration to Groundwater Zones

Neither Inventory Module 1 nor 2 would involve additional actions likely to increase the potential for contaminant releases to the environment, although actions, in general, would last longer.

Potential to Deplete Groundwater Resources

Anticipated annual water demand for Inventory Module 1 or 2 would be the same as or very similar to that for the Proposed Action, but the operations period, when both emplacement and subsurface development were occurring, could last two to three times as long. DOE based the repository water demand estimates described in Chapter 4, Section 4.1.3.2 on a maximum design throughput of the surface facilities of about 3,000 MTHM per year of spent nuclear fuel and high-level radioactive waste. Because Inventory Module 1 or 2 would roughly double the amount of materials the facilities handled, it would take about twice as long and the associated water demand, already based on a maximum operational rate, would stay the same. The extended duration of this period (when subsurface development and emplacement were both ongoing) would result in a significant increase in the total water demand for the action, but the annual demand would be unlikely to change in any appreciable amount. As described in Section 4.1.3.2, water demand during this period would probably range from 270,000 to 300,000 cubic meters (220 to 240 acre-feet) per year. A notable change in water demand would be unlikely during the construction period or during the 5 years immediately after the construction period when some building on the surface would still be under way, the subsurface area would still be under construction, and emplacement would be ongoing.

As noted in Chapter 4, Section 4.1.3.2 for the repository portion of the Proposed Action, water demand for the monitoring and closure periods would probably remain unchanged from those identified in the Yucca Mountain FEIS. As in the operations period, closure would take longer with the Module 1 or 2 inventory, but annual demand rates during closure would probably be the same or very similar.

Potential impacts to water resources under Inventory Module 1 or 2 would be very similar to those under the Proposed Action because the annual water demand would change little, and the best understanding of the groundwater resource is that it replenishes on an annual basis as gauged by the perennial yield of the groundwater basin. Under Module 1 or 2, the highest annual water demand would be below estimates of perennial yield for the Jackass Flats *hydrographic area*; this would include the lowest estimated value of perennial yield [720,000 cubic meters (580 acre-feet)] for the western two-thirds of this hydrographic area (Chapter 3, Section 3.1.4.2.2). Chapter 2, Section 2.3 contains more information on regional groundwater use and demand for the combined repository and rail actions.

8.2.3.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

As in the Yucca Mountain FEIS, other reasonably foreseeable actions would be unlikely to have cumulative impacts for the repository or Modules 1 or 2. Potential impacts to groundwater from the Proposed Action, including both repository and rail actions as described in Chapter 2, Section 2.3, and

from Inventory Module 1 or 2 would be small and limited to the immediate vicinity of land disturbances from the action. The exceptions to this could be the potential impact from water demands on groundwater resources and potential impacts from contaminants in groundwater. With these exceptions, other federal, non-federal, or private action effects would have to occur in the same region of influence to be cumulative with those from the Proposed Action or Inventory Module 1 or 2; no currently identified actions meet this criterion. With respect to impacts from groundwater contamination, there would be very limited potential for the Proposed Action to cause such impacts during the preclosure period. Rather, this is considered a postclosure concern and is addressed in Section 8.3.

The remainder of this discussion addresses potential impacts to groundwater resources from water demand. The discussion of impacts to groundwater resources in Chapter 4, Section 4.1.3.2 includes ongoing water demands from Area 25 of the Nevada Test Site. Area 25 is the proposed location of the primary repository surface facilities. It is also the location of wells J-12, J-13, and the C-wells complex, which would provide water for the Proposed Action and for ongoing Nevada Test Site activities in this area. During the 7-year period from 2000 to 2006, the average Test Site water withdrawal from the *Jackass Flats* hydrographic area for the Area 25 activities has been about 83,000 cubic meters (67 acre-feet) per year (DIRS 181232-Fitzpatrick-Maul 2007, all). In a 2002 analysis, DOE indicated there were no planned expansions of existing operations on the Test Site that would affect water use, but that future programs could involve additional water use (DIRS 162638-DOE 2002, pp. 4-18 and 4-19). DOE assumed that this recent use represents a reasonable estimate of Nevada Test Site water demand, at least in the near term (5 to 10 years). However, it is recognized that the Test Site demand could increase at some time in the more distant future, but water demand for the Proposed Action would decrease over time.

Water demand from rail and repository actions in the Jackass Flats hydrographic area, as described in Chapter 2, Section 2.3, is based on the assumption that rail construction actions, as well as infrastructure improvements, primarily would be scheduled for the 2 years before the start of repository construction. Under this same scenario, and for the combined construction period, water demand for rail and repository activities under Inventory Module 1 or 2 combined with the baseline demands from Nevada Test Site activities would remain below the lowest value of perennial yield estimated for the western two-thirds of the hydrographic area. Estimated water demand for the peak year (which includes the demand for Nevada Test Site activities in Area 25 and for the remaining rail activities that would occur in the Jackass Flat hydrographic area) would be approximately 670,000 cubic meters (540 acre-feet) in comparison with the lowest estimate of perennial yield of 720,000 cubic meters (580 acre-feet) for the western two-thirds of the hydrographic area. Several other years during this combined construction period would have water demands quite similar to the peak year, ranging from 620,000 to 650,000 cubic meters (500 to 530 acre-feet). None of the water demand estimates would approach the high estimate of perennial yield for the entire Jackass Flats hydrographic basin, which is 4.9 million cubic meters (4,000 acre-feet) (Chapter 3, Section 3.1.4.2.2). Potential impacts to groundwater resources from this combined demand would be no different than those described in Chapter 2, Section 2.3 and in more detail in Chapter 4, Section 4.1.3.2; that is, some decline in the water level could be likely near the production wells, and water elevation decreases at the town of Amargosa Valley would probably be no more than 0.4 to 1.1 meter (1.2 to 3.6 feet) (Section 4.1.3.2.6). The reduction in underflow from the Jackass Flats hydrographic area to the *Amargosa Desert* hydrographic area would be less than the quantity of water actually withdrawn from the upgradient area because there would probably be minor changes in groundwater flow patterns as the water level adjusted to the withdrawals. Groundwater flow models predict that the reduction in underflow

to the Amargosa Desert would be no higher than 160,000 to 180,000 cubic meters (130 to 150 acre-feet) per year, even with the assumption of a long-term groundwater withdrawal rate of 530,000 cubic meters (430 acre-feet) per year (Section 4.1.3.2).

A new *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 185437–DOE 2008, all) has a preliminary description of water demand estimates as being lower than those estimated in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all). A conservative approach would be to look at the estimates in the *Supplement Analysis for the Nevada Test Site FEIS* (DIRS 162638-DOE 2002, pp. 4-18 and 4-19), which identified potential future projects that, if implemented, could involve additional Nevada Test Site water use. The Atlas Facility in Area 6 of the Nevada Test Site could require water primarily for dust suppression during construction. Its operating use of 400 cubic meters (0.32 acre-foot) per year would be minor and would not present a cumulative effect. The Advanced Accelerator applications project would use the most water of the potential projects and would be in either Area 22 or Area 25 of the Nevada Test Site (DIRS 162638-DOE 2002, p. 3-8). This project could require an estimated 4.9 million cubic meters (4,000 acre-feet) for construction and system initialization and about 490,000 to 980,000 cubic meters (400 to 790 acre-feet) per year thereafter. If DOE implemented this project, particularly in Area 25, its water demand could be significant and cumulative with the Proposed Action, although the Supplement Analysis indicated that its water demand would be sustainable by existing groundwater resources (DIRS 162638-DOE 2002, p. 4-19).

Tables 8-3 and 8-4 list documents generated since completion of the Yucca Mountain FEIS that address other proposed actions at the Nevada Test and Training Range and the Nevada Test Site. DOE considered the actions described in these documents as reasonably foreseeable future actions and used the information therein to determine if there would be cumulative impacts when considered with those of the repository action. None of these documents addressed water demand estimates or associated concerns. Based on the document reviews, DOE judged the proposed actions to either have little potential to involve significant water demands or they were proposed for areas outside the Alkali Flat-Furnace Creek groundwater basin, or both. Groundwater moves between the various basins in the Death Valley regional groundwater flow system, but how much the outside basins contribute to the Alkali Flat-Furnace Creek basin is a matter of speculation. Similarly, DOE believes it would be speculative to attempt to gauge the degree to which outside groundwater withdrawals would be cumulative with those inside.

Cumulative demands on the Jackass Flats hydrographic area could have long-term impacts on water availability in the downgradient aquifers beneath the Amargosa Desert. The groundwaters in these areas are hydraulically linked, but even in these adjacent areas the exact nature and extent of the link is a matter of study and some speculation. However, the amount of water being withdrawn in the Amargosa Desert [averaging about 16 million cubic meters (13,000 acre-feet) per year between 2000 and 2004 (Chapter 3, Section 3.1.4.2.1)] is much greater than the quantities being considered for withdrawal from Jackass Flats. If water pumped from Jackass Flats affected levels in the Amargosa Desert, the impacts would be small in comparison with those caused by local pumping in that area (both are in the Alkali Flat-Furnace Creek groundwater basin).

The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository site entrance (DIRS 182345-

Giampaoli 2007, all). Development could affect available water; Nye County proposed this plan to ensure that development occurred in an orderly manner consistent with the proposed repository land use.

8.2.4 BIOLOGICAL RESOURCES

The cumulative preclosure impacts to biological resources would be similar to those for the Proposed Action in Chapter 4, Section 4.1.4, of this Repository SEIS. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock storage pile, habitat loss, and loss of individuals of some animal species during site clearing and from vehicle traffic. Inventory Module 1 or 2 would require disturbance of biological resources in a larger area [as shown in Table 8-4a: 1.3 to 2.6 square kilometers (310 to 630 acres)] than that disturbed under the Proposed Action, primarily because the excavated rock storage pile would be larger.

The Nye County Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) anticipates potential effects on some species of plants, fish, and wildlife resources. Because this is only a plan, specific impacts cannot be determined.

8.2.5 CULTURAL RESOURCES

The cumulative preclosure impacts to cultural resources could increase slightly from those reported for the Proposed Action (Chapter 4, Section 4.1.5) due to the increase in land disturbance associated with Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas surveyed during site characterization activities and an increase in the time of operation. Because repository construction, operations, monitoring, and closure would be federal actions, DOE would identify and evaluate cultural resources, as required by Section 106 of the *National Historic Preservation Act*, and would take appropriate measures to avoid or mitigate adverse impacts to such resources. As a consequence, archaeological information from artifact retrieval during land disturbance would contribute additional cultural resources information to the regional database for understanding past human occupation and use of the land.

The Nye County Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) is for managing development of the area south of the analyzed land withdrawal area. If implemented, this plan could have impacts on cultural resources; however, there are no currently identified specific actions that would have a noticeable cumulative impact on these resources. To the extent the development involves federal actions, it could be subject to compliance with Section 106 of the *National Historic Preservation Act.*

8.2.6 SOCIOECONOMICS

The cumulative preclosure impacts to socioeconomics would be similar to those in Chapter 4, Section 4.1.6 for the Proposed Action. The increased inventory associated with the modules would not result in a larger number of employees, but would result in a longer duration of the operations period. The annual socioeconomic impacts would occur for a longer period.

Additional cumulative impacts from other reasonably foreseeable federal, non-federal, or private actions could probably be from actions at the Nevada Test Site, as discussed in the Yucca Mountain FEIS. Nye County acknowledges there could be potential impacts to the socioeconomics of the region in the Yucca

Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all). This plan, as stipulated earlier, is for management of the development of the area south of the analyzed land withdrawal area and it has no currently identified specific actions that would have a noticeable cumulative impact on socioeconomics. Also, the Department of Justice has proposed a detention facility in *Final Environmental Impact Statement for the Proposed Contractor Detention Facility, Las Vegas, Nevada Area* (DIRS 185475-DOJ 2008, all), with a preferred alternative site in Pahrump, Nevada, employing 200 to 250 personnel upon completion. Operation of the proposed detention facility is anticipated to result in approximately 40 to 50 contractor employees relocating to Nye County, and the remainder of the new contractor employees are expected to be current residents of Clark County who would continue to reside in Clark County within commuting distance of the selected site.

Information on jobs associated with the construction or operation of proposed solar and wind energy facilities are not available.

8.2.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

8.2.7.1 Industrial Hazards

The preclosure cumulative impacts to nonradiological occupational health and safety would increase proportionately (from that presented for the Proposed Action in Chapter 4, Section 4.1.7.1) with the number of full-time equivalent worker years on the project. This effect on impacts during the operations period is attributable to a linear relationship to the total number of processed waste packages. Table 8-4b lists the total numbers of waste packages DOE would handle during the operations period for each inventory module and disposal case. As presented in Section 4.1.7.1, half of the estimated impacts for the Proposed Action would occur during the operations period. Therefore, the total estimated impacts from industrial hazards could increase by the percentage shown in Table 8-4b over the impacts in Section 4.1.7.1. The estimated values are shown in the last three columns of Table 8-4b.

Table 8-4b. Estimated industrial hazard impacts for the inventory modules.

Inventory Module/Case	Total number of waste packages[a]	Percentage increase waste package handling operations over Proposed Action	Total project period increase of industrial hazard impacts (percent)[b]	Total recordable cases	Lost workday cases	Fatalities
Module 1A	25,900	130	65	2,970	1,320	1.52
Module 1B	21,600 – 24,700	93 – 120	60	2,880	1,280	1.47
Module 2A	37,900	240	120	3,960	1,760	2.02

a. Estimated number of waste packages in the Proposed Action would be 11,200.
b. Percent increase from the values in Table 4-22.

Nye County Public Safety Report (DIRS 182710-NWRPO 2007, all) addresses Nye County's concerns and provides recommendations on public safety issues. Nye County recommends a comprehensive and integrated approach for public safety services with DOE, including fire, emergency, medical, and law enforcement services.

8.2.7.2 Radiological Impacts

This section discusses preclosure radiological health and safety impacts to workers and members of the public from construction, operations, monitoring, and closure activities at the *Yucca Mountain site* for Inventory Module 1A, 1B, or 2A. Appendix D, Section D.3 contains the approach and methods DOE used to estimate radiological health and safety impacts and detailed radiological impact results for the Proposed Action, which are presented in Chapter 4, Section 4.1.7.

The radiological characteristics of the spent nuclear fuel and defense high-level radioactive waste for Inventory Module 1 or 2 would be the same as those for the Proposed Action. However, there would be more material to emplace, as listed in Table 8-2a. DOE assumed the commercial high-level radioactive waste in Module 1B would exhibit the same radiological characteristics as the commercial high-level radioactive waste from the West Valley Demonstration Project, which is defined in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Appendix A, Section A.2.3)

The estimated volume of Greater-than-Class-C and Greater-than-Class-C-like low-level radioactive wastes in Module 2A has increased from that analyzed in the Draft Repository SEIS for Module 2. The estimated volume of 36,000 cubic meters includes projected Greater-than-Class-C-like wastes that could be generated as a result of the proposed Advanced Fuel Cycle Facility, which is a project-specific alternative in the GNEP Draft Programmatic EIS (DIRS 185296-Joyce 2008, all). For this analysis, the radiological constituents of the Greater-than-Class-C or Greater-than-Class-C-like wastes would be similar to those described in Appendix A of the Yucca Mountain FEIS.

The primary parameters that would affect the magnitude of worker health and safety impacts between the Proposed Action and the inventory module would be the number of waste package handling operations, which would also affect the size of the excavated repository. For the public, the principal changes in parameters that would affect the magnitude of the health impact estimates would be the length of the various periods and the rate at which air containing radon-222 would exhaust from the repository. The exhaust rate of the repository ventilation system would affect the worker exposures from manmade radionuclides and radon-222 concentrations and the quantity of *radionuclides* released to the environment. Appendix D, Section D.3.1, discusses potential releases of radon-222 and manmade radionuclides during the project periods for the Proposed Action. The amount of radon released from the larger repository required for the inventory modules would increase linearly with the ratio of excavated volume to that required for the Proposed Action. This ratio is roughly linear to the increased number of waste packages. Therefore, doses to workers and the public as a result of radon release to the atmosphere would increase by the factors presented in the third column of Table 8-4b.

For comparison, Table 8-5 lists the radiological impacts to workers for each repository analytical period and for the entire project duration for the Proposed Action. Tables 8-5a, 8-5b, and 8-5c list the radiological impacts to workers for each repository analytical period and for the entire project duration for Inventory Modules 1A, 1B, and 2A, respectively.

The estimated radiological impacts would include potential *doses* and radiological health impacts to *involved workers*, *noninvolved workers*, and the total for all workers. Radiological health impacts for maximally exposed individuals would be the increase in the *probability* of a *latent cancer fatality* from the *radiation* dose received. Radiological health impacts for populations would be the estimated number of latent cancer fatalities that resulted from the collective radiation dose received. The estimated number

Table 8-5. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Proposed Action.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Proposed Action					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	4,200	890	400	5,500
Noninvolved	4.7	190	26	18	240
Nevada Test Site noninvolved	0.12	9.2	8.9	1.2	19
Total	38	4,400	930	420	5,800
Number of latent cancer fatalities					
Involved	0.02	2.5	0.54	0.24	3.3
Noninvolved	0.0028	0.12	0.016	0.011	0.14
Nevada Test Site noninvolved	0.000074	0.0055	0.0053	0.00073	0.012
Total	0.023	2.6	0.56	0.25	3.5

Table 8-5a. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Module 1A.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1A					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	9,700	2,100	920	13,000
Noninvolved	4.7	440	60	42	550
Nevada Test Site noninvolved	0.12	21	21	2.8	44
Total	38	10,000	2,200	970	13,000
Number of latent cancer fatalities					
Involved	0.020	5.8	1.2	0.55	7.6
Noninvolved	0.0028	0.28	0.037	0.025	0.34
Nevada Test Site noninvolved	0.000074	0.013	0.012	0.0017	0.027
Total	0.023	6.0	1.3	0.58	7.9

of latent cancer fatalities for repository workers during the construction, operations, monitoring, and closure periods for Module 1A could be about 7.9 fatalities. Impacts for Module 1B would be lower due to the decrease in the number of waste packages. The estimated number of latent cancer fatalities for repository workers during the construction, operations, monitoring, and closure periods for Module 2A

Table 8-5b. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Module 1B.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1B					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	9,300	2,000	880	12,000
Noninvolved	4.7	420	58	40	520
Nevada Test Site noninvolved	0.12	20	20	2.7	43
Total	38	9700	2,100	930	13,000
Number of latent cancer fatalities					
Involved	0.020	5.5	1.2	0.53	7.3
Noninvolved	0.0028	0.27	0.035	0.024	0.33
Nevada Test Site noninvolved	0.000074	0.012	0.012	0.0016	0.026
Total	0.023	5.8	1.2	0.55	7.6

Table 8-5c. Estimated radiation doses and radiological health impacts to workers for each analytical period and the entire project duration—Module 2A.

Worker group and impact category	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 2A					
Maximally exposed worker					
Dose (rem)					
Involved	0.49	30	13	1.6	30
Noninvolved	0.052	0.25	0.21	0.028	0.25
Probability of latent cancer fatality					
Involved	0.00029	0.018	0.0078	0.00097	0.018
Noninvolved	0.000031	0.00015	0.00012	0.000017	0.00015
Worker population					
Collective dose (person-rem)					
Involved	33	14,000	3,000	1,400	19,000
Noninvolved	4.7	640	88	61	800
Nevada Test Site noninvolved	0.12	31	30	4.1	65
Total	38	15,000	3,100	1,400	20,000
Number of latent cancer fatalities					
Involved	0.020	8.50	1.8	0.81	11
Noninvolved	0.0028	0.41	0.054	0.037	0.50
Nevada Test Site noninvolved	0.000074	0.019	0.018	0.0025	0.039
Total	0.023	8.8	1.9	0.85	12

would be about 12 fatalities. Most of the total worker radiation dose would be from the receipt and handling of spent nuclear fuel during the operations period. Radiation *exposure* from inhalation of radon-222 and its *decay* products from radiation that emanated from the subsurface would be contributors to the

total dose. DOE identified no other activities in the area that could cause cumulative radiological impacts to repository workers.

For comparison, Table 8-6 lists the estimates of radiological impacts to the public for each repository activity period and the entire project duration for the Proposed Action. Tables 8-6a, 8-6b, and 8-6c list the radiological impacts to the public for each repository analytical period and for the entire project duration for Inventory Modules 1A, 1B, and 2A, respectively. They list estimated radiation doses and health effects for the offsite maximally exposed individual and the potentially exposed population.

Table 8-6. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Proposed Action.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Proposed Action					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	7.6	7.5	7.5	7.6
Total	4.2	310	300	41	530
Probability of LCF	0.0000025	0.00019	0.00018	0.000025	0.00032
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	6,400	6,100	840	13,000
Number of LCFs	0.051	3.8	3.7	0.51	8

LCF = Latent cancer fatality.

Table 8-6a. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Module 1A.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1A					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	18	17	17	18
Total	4.2	720	690	95	1,200
Probability of LCF	0.0000025	0.00044	0.00042	0.000058	0.00074
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	15,000	14,000	1,900	31,000
Number of LCFs	0.051	8.8	8.6	1.2	19

LCF = Latent cancer fatality.

The radiological doses and health impacts would result primarily from exposure of the public to naturally occurring radon-222 and its decay products released from the subsurface facilities in ventilation exhaust air. The calculated increase in probability that the maximally exposed individual would experience a latent cancer fatality would be less than 0.00074 for Module 1A. Module 1B would be slightly lower due to the decrease in the number of waste packages. The calculated increase in probability that the maximally exposed individual would experience a latent cancer fatality would be less than 0.0011 for Module 2A. The estimated increase in the number of latent cancer fatalities could be 19 or 27 for the exposed population within 84 kilometers (52 miles) over the entire project duration for Modules 1A or 2A, respectively.

Table 8-6b. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Module 1B.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 1B					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	17	17	17	17
Total	4.2	690	660	90	1,200
Probability of LCF	0.0000025	0.00042	0.00040	0.000055	0.00071
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	14,000	13,000	1,900	30,000
Number of LCFs	0.051	8.4	8.2	1.1	18

LCF = Latent cancer fatality.

Table 8-6c. Estimated radiation doses and radiological health impacts to the public for each analytical period and entire project—Module 2A.

Dose and health impact	Construction	Operations	Monitoring	Closure	Entire project
Inventory Module 2A					
Maximally exposed individual					
Dose (millirem)					
Maximum annual	1.4	26	25	25	26
Total	4.2	1,100	1,000	140	1,800
Probability of LCF	0.0000025	0.00064	0.00061	0.000085	0.0011
Exposed 84-kilometer (52-mile) population					
Collective dose (person-rem)	85	22,000	21,000	2,800	45,000
Number of LCFs	0.051	13	13	1.7	27

LCF = Latent cancer fatality.

Statistics published by the Centers for Disease Control and Prevention indicate that during 1998, 24 percent of all deaths in the State of Nevada were attributable to *cancer* of some type (DIRS 153066-Murphy 2000, p. 8). Assuming this rate would remain unchanged for the projected population in 2067 of about 117,000 within 84 kilometers (52 miles) of the Yucca Mountain site, about 28,000 members of this population would be likely to die from cancer-related causes. During the project duration, the corresponding number of cancer deaths unrelated to the project in the general population would be 42,000.

A *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 185437-DOE 2008, all) has a preliminary report that the maximum combined individual dose from current and projected Nevada Test Site operations would be approximately 0.6 millirem per year. Because the calculated population dose has been less than 0.6 person-rem for over a decade, the population dose to residents within 80 km (50 miles) is no longer estimated (DIRS 185437-DOE 2008, all, Section 5.4.4).

With one exception, DOE identified no other federal, non-federal, or private actions with spatially or temporally coincident short-term impacts in the region of influence that would result in cumulative health and safety impacts with those of the proposed repository. Chapter 3 discusses potential radiological doses from past weapons testing at the Nevada Test Site. Residents who were present during the periods when

weapons testing occurred (in particular, atmospheric weapons testing from the 1950s to the early 1960s) could have received as much as 5 *rem* to the thyroid from iodine-131 releases. Using a tissue-weighting factor of 0.05 as specified in Publication 60 of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, all), this would equate to an effective *dose equivalent* of about 250 millirem. DOE has not added this dose to the dose to the hypothetical maximally exposed individual, but has included this information so long-term residents in the region of influence can evaluate their potential for impacts from past nuclear weapons testing. Potential radiological doses from past weapons testing at the Nevada Test Site could result in additional impacts to residents who were present during that period. Assuming the maximally exposed individual was present during the entire period in which weapons testing occurred, the maximally exposed individual doses listed in Tables 8-6 through 8-6c could increase by as much as 250 millirem.

8.2.8 ACCIDENTS

The cumulative preclosure impacts of *accidents* related to Inventory Modules 1 and 2 would be the same as those for the Proposed Action. In summary, disposal in the proposed repository of Inventory Module 1 or 2 could result in a very small increase in the estimated risk from accidents described in Chapter 4, Section 4.1.8 for the Proposed Action. Workers would handle the same types of materials, but the repository operations period would be longer.

Additional cumulative impacts from other federal, non-federal, or private actions have decreased from those in the Yucca Mountain FEIS due to the likely elimination of an action—the proposed VentureStar®/ Kistler project—because Kistler filed to reorganize under Chapter 11 of the U.S. Bankruptcy Code (DIRS 169260-Kistler Aerospace 2003, all). DOE does not expect other federal, non-federal, or private actions in the region to have cumulative accident impacts.

8.2.9 NOISE

The cumulative preclosure impacts on noise would be the same as those in Chapter 4, Section 4.1.9 for the Proposed Action. In summary, the emplacement of Inventory Module 1 or 2 would have noise levels from the construction and operation of the repository similar to those for the Proposed Action. An increase in noise impacts from Module 1 or 2 would result only from the increased number of shipments to the site. The expected rate of receipt would be about the same as that for the Proposed Action; therefore, the impact would be an extended period that shipping would continue beyond the Proposed Action.

DOE does not expect other federal, non-federal, or private actions in the region to add measurable noise impacts to those of the Proposed Action or Inventory Module 1 or 2 because the other activities would be some distance from the proposed repository, and overall increased noise would be unlikely.

8.2.10 AESTHETICS

The cumulative preclosure impacts to aesthetics for Inventory Modules 1 and 2 would be the same as those for the Proposed Action. In summary, there would be no impacts for Inventory Module 1 or 2 beyond those described in Chapter 4, Section 4.1.10 because the profile of the repository facility would not be different as a result of implementation of these modules. There would be no difference in the appearance of the access road or facilities built outside the analyzed land withdrawal area.

Additional cumulative impacts from other reasonably foreseeable federal, non-federal, or private actions would most likely be from anticipated growth adjacent to the repository. Nye County has written the Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) to assist in managing the development of the area outside the analyzed land withdrawal area. Future development along U.S. Highway 95 would change the landscape from its current undeveloped state; however, the plan would manage this development to minimize aesthetic impacts.

8.2.11 UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

Preclosure cumulative impacts for utilities, energy, materials, and site services for the disposal of Inventory Modules 1 or 2 would have only minor differences from those in Chapter 4, Section 4.1.11 for the Proposed Action. Because the surface facilities and the annual throughput would be the same for the inventory modules, annual impacts to electricity use, fossil-fuel demand, and residential water and sewer services would be the same as those for the Proposed Action, but would last for a longer operations period.

The emplacement of the larger inventories of Module 1 or 2 would require two to three times the subsurface excavation and underground construction materials, as listed in Table 8-6a.

Additional cumulative impacts from other reasonably foreseeable federal, non-federal, or private actions would most likely be from anticipated growth adjacent to the repository. Nye County has written the Yucca Mountain Project Gateway Area Concept Plan (DIRS 182345-Giampaoli 2007, all) to assist in managing the development of the area outside the analyzed land withdrawal area. This anticipated growth could result in future use of utilities, energy, and materials. DOE does not anticipate that this additional use would result in measurable strain on the regional supplies of energy or materials.

8.2.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

Preclosure cumulative impacts from the management of repository-generated waste and hazardous materials for the disposal of Inventory Module 1 or 2 would have only minor differences from those in Chapter 4, Section 4.1.12 for the Proposed Action. Because the surface facilities and the annual throughput would be the same for the inventory modules, the annual production of all waste types would be the same as that for the Proposed Action, but would last for a longer operations period. As described in Chapter 3, Section 3.1.12.4, there are limitations associated with the current availability of licensed commercial capacity for disposal of low-level radioactive waste. However, additional facilities are expected to be developed because the nation will continue to need to dispose of low-level radioactive waste from nuclear power plants and in the form of industrial and medical wastes. It is reasonable to conclude that disposal capacity would be available.

Additional cumulative impacts from other federal, non-federal, or private actions could occur to waste operations at regional facilities or the Nevada Test Site from the disposal of waste for Inventory Modules 1 and 2. The disposal of construction and demolition debris impacts would not change from those in the Yucca Mountain FEIS.

8.2.13 ENVIRONMENTAL JUSTICE

The cumulative preclosure impacts to *environmental justice* would be the same as those in Chapter 4, Section 4.1.13 for the Proposed Action. This Repository SEIS does not identify any high and adverse impacts to members of the general public. Further, DOE has not identified subsections of the population, including minority or low-income populations, that would receive disproportionate impacts, and it has identified no unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. Therefore, this SEIS concludes that no disproportionately high and adverse impacts to minority or *low-income* populations would result from these cumulative activities.

DOE recognizes that American Indian people who live near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on access to the site. Chapter 4, Section 4.1.5.1.2 discusses these views and beliefs.

8.3 Cumulative Postclosure Impacts in the Yucca Mountain Repository Region

This section updates the estimated postclosure human health and safety cumulative impact analysis of the disposal of the larger inventory projected for Inventory Modules 1 and 2 and references Chapter 8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-1 to 8-116), which discusses cumulative impacts from other federal, non-federal, and private actions.

8.3.1 INVENTORY MODULE 1 OR 2 IMPACTS

The analysis of postclosure performance for Inventory Modules 1 and 2 used a scaling approach based on analyses in the Yucca Mountain FEIS, results for the Proposed Action (Chapter 5), and inventories updated since the completion of the FEIS. As discussed in Section 8.1 of the Yucca Mountain FEIS, the Module 1 inventory would contain 105,000 MTHM of commercial spent nuclear fuel and the *Proposed Action inventory* would contain 63,000 MTHM (DIRS 155970-DOE 2002, pp. 8-2 to 8-20). The first-10,000-year and the 1-million-year peak of the mean doses to individuals in the FEIS would be 60 percent higher for Module 1 than those for the Proposed Action (DIRS 155970-DOE 2002, Table I-13). The commercial spent nuclear fuel inventory in the FEIS for Module 1 would be approximately 67 percent higher than that for the Proposed Action, which indicated approximately a linear relationship between the commercial spent nuclear fuel inventory and individual radiological impacts. Module 2 impacts would add a fraction of a percent to the 1-million-year radiological impacts for the Proposed Action in the FEIS.

DOE used a bounding analysis in the Yucca Mountain FEIS to estimate the postclosure impacts from chemically toxic material. As discussed in Appendix I, Section I.6.2 of the FEIS, due to the nature of the analysis the estimated impacts would be directly proportional to the number of *waste packages* in each inventory (DIRS 155970-DOE 2002, pp. I-54 to I-62). DOE performed a similar bounding analysis for this Repository SEIS so such proportionality would also exist.

In addition to postclosure human health impacts from radioactive and chemically toxic material releases, the other potential postclosure impact that DOE identified would involve biological resources. Although the surface area affected by heat rise would be larger for Inventory Module 1 or 2, the amount of heat per

unit area would be constant. Therefore, postclosure biological effects of Module 1 or 2 from heat generated by waste packages that could raise ground surface temperatures would be the same as those described in Chapter 5, Section 5.10 for the Proposed Action.

8.3.1.1 Radioactive and Chemically Toxic Material Scale Factors for Inventory Modules 1 and 2

The Proposed Action contains an inventory that would include 63,000 MTHM of commercial spent nuclear fuel; Case A of the Module 1 inventory would contain 130,000 MTHM (Section 8.1.2.1). The scaling factor for radiological impacts for Module 1 is proportional to the MTHM of commercial spent nuclear fuel. Therefore the scaling factor for Module 1 is 130,000 divided by 63,000 or about 2.1.

Rather than the 130,000 MTHM of commercial spent nuclear fuel, Case B of Module 1 would include 63,000 MTHM of commercial spent nuclear fuel and the 13,400 to 29,000 canisters of commercial high-level radioactive waste from the recycling of the balance of the commercial spent nuclear fuel. From Module 1A to 1B, there would be a reduction of 1,200 to 4,300 waste packages because of the smaller volume of waste to be disposed of. In comparison with Module 1A, Module 1B would reflect a reduction in the total radionuclide content because the uranium and plutonium in the 67,000 MTHM of recycled commercial spent nuclear fuel would have been removed and recycled into new commercial fuel assemblies for use in nuclear reactors. Therefore, DOE expects that the mean annual individual dose for Module 1B would be no greater than that for Module 1A.

The postclosure performance model DOE used for the Proposed Action indicates that waste packages containing high-level radioactive waste could fail earlier than waste packages containing commercial spent nuclear fuel. This would be due primarily to the added strength the TAD canisters would provide to the spent nuclear fuel waste packages. Codisposal waste packages contain DOE spent nuclear fuel and high-level radioactive waste, which would be received at the repository in disposable canisters. Commercial spent nuclear fuel would be placed in TAD canisters prior to insertion in a waste package. DOE has taken no additional containment credit for the TAD canisters after the projected breach of a waste package. Considering this, without further waste package design modifications ,packages containing commercial high-level radioactive waste could fail earlier than their comparable commercial spent nuclear fuel waste packages, resulting in the potential for earlier release. As discussed in Chapter 5, Section 5.1.1.1, the postclosure model predicts that failure of waste packages (including packages containing defense high-level radioactive waste) from stress corrosion cracking would not begin until around 100,000 years. Therefore, disposal of Module 1B would result in little, if any, differences from estimated Module 1A individual doses during the first 10,000 years after repository closure and would affect the timing of the doses only after the first 10,000 years and up to 1 million years after closure.

The estimated Module 2A inventory of Greater-Than-Class C waste has increased since the publication of the Draft Repository SEIS. The postclosure model DOE used for the Yucca Mountain FEIS evaluated the effects of adding approximately 6,000 cubic meters of Greater-Than-Class C waste in Module 2 and found that it increased the results by a fraction of a percent. Based on the analysis in the Yucca Mountain FEIS increasing this projected volume to 36,000 cubic meters would likely have very little effect on the overall annual individual dose beyond that projected for Module 1A.

The scaling factor used to estimate impacts from chemically toxic materials for Module 1 or 2 would be proportional to the number of waste packages. Table 8-4b in Section 8.1.2.1 lists the estimated number of

waste packages for Modules 1A, 1B, and 2A. DOE developed the scaling factors by dividing the number of waste packages for each module by the estimated number for the Proposed Action, 11,200. The resultant scaling factors for Modules 1A, 1B, and 2A are 2.3, 2.2, and 3.4, respectively.

8.3.1.2 Waterborne Radioactive Material Impacts

Chapter 5 and Appendix F discuss the Proposed Action postclosure impacts. Table 8-7 summarizes the impacts for the Proposed Action. The estimated impacts from Module 1 would be about twice these values and those from Module 2 would add an additional fraction of 1 percent to the Module 1 values.

Table 8-7. Impacts to the reasonably maximally exposed individual from groundwater releases of radionuclides—combined scenario classes.

	Mean		Median		95th percentile	
	Annual individual dose (millirem)	Probability of LCF[a] per year	Annual individual dose (millirem)	Probability of LCF[a] per year	Annual individual dose (millirem)	Probability of LCF[a] per year
During the first 10,000 years after repository closure	0.24	1.4×10^{-7}	0.13	7.7×10^{-8}	0.67	4.0×10^{-7}
After the first 10,000 years and up to 1 million years after repository closure	2.0	1.24×10^{-6}	0.96	5.7×10^{-7}	9.1	5.4×10^{-6}

a. LCF = Latent cancer fatality; assuming a risk of 0.0006 latent cancer fatality per rem for members of the public (DIRS 174559-Lawrence 2002, p.2).

8.3.1.3 Waterborne Chemically Toxic Material Impacts

Table 8-8 summarizes the impacts from waterborne chemically toxic materials for the Proposed Action. The Yucca Mountain FEIS addressed chromium, but DOE has eliminated it through a screening analysis discussed in Appendix F, Section F.5.1, so Table 8-8 addresses impacts from molybdenum, nickel, and vanadium. The estimated impacts for Modules 1A, 1B, and 2A would increase from that for the Proposed Action by factors of 2.3, 2.2, and 3.4, respectively. By applying these factors to the bounding impact analysis in Appendix F, Section F.5, molybdenum and vanadium would remain below their respective oral reference doses. The oral reference dose for nickel (0.02 milligram per kilogram of body mass per day) would be slightly exceeded (0.0024). Considering the conservative assumptions described in Section F.5.2.1, this estimated concentration and intake would be unlikely. One example of a conservative assumption is that the impact estimate neglects time delays, mitigation effects by sorption in rocks, and other beneficial effects of transport in the biosphere; the mass of mobilized waterborne chemically toxic materials would be instantly available at the biosphere exposure locations.

8.3.1.4 Atmospheric Radioactive Material Impacts from Other than Volcanic Eruption

Impacts from nonvolcanic atmospheric releases are discussed in Chapter 5, Section 5.5. These releases would be extremely small. As with the Yucca Mountain FEIS it would not be expected that any significant increase of these impacts would result from Modules 1 and 2.

Table 8-8. Impacts and applicable standards for waterborne chemically toxic materials released during 10,000 years after repository closure—Proposed Action.

Material	Estimated concentration (milligram per liter)	Intake[a] (milligram per kilogram of body mass per day)	Intake standard: Oral reference dose (milligram per kilogram of body mass per day)
Molybdenum	0.044	0.0013	0.005[b]
Nickel	0.21	0.0073	0.02[c]
Vanadium	0.0001	0.0000054	0.007[d]

Source: Appendix F, Section F.5.2.5 of this Repository SEIS.
a. Assumes daily intake of 2 liters (0.53 gallons) per day by a 70-kilogram (154-pound) individual.
b. DIRS 148228-EPA 1999, all.
c. DIRS 148229-EPA 1999, all.
d. DIRS 103705-EPA 1997, all.

8.3.2 CUMULATIVE IMPACTS FROM OTHER FEDERAL, NON-FEDERAL, AND PRIVATE ACTIONS

Section 8.3.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-76 to 8-85) discusses the cumulative postclosure impacts from two other sources—Nevada Test Site past, present, and reasonably foreseeable future actions and Beatty low-level radioactive waste disposal and hazardous waste treatment, storage, and disposal facilities. There would be no additional cumulative postclosure impacts beyond those discussed in the FEIS. This section of the Repository SEIS summarizes and updates the information from the FEIS.

8.3.2.1 Nevada Test Site—Past, Present, and Reasonably Foreseeable Future Actions

The primary mission of the Nevada Test Site historically was to conduct nuclear weapons tests. Nuclear weapons testing and other activities have resulted in radioactive contamination at the Test Site. These past activities have continuing potential for radioactive and nonradioactive contamination of some areas of the Test Site, including groundwater under the site. DOE evaluated these areas, the associated contamination, and the potential for contamination for potential cumulative impacts with postclosure impacts from the proposed repository. Deep underground testing and greater confinement disposal categories represent the primary radionuclide inventories that could, combined with the repository inventory, result in increased cumulative impacts. After evaluation, the estimated total potential cumulative impact (Yucca Mountain impact plus Nevada Test Site impact) would be 0.24 millirem per year to the *reasonably maximally exposed individual*. The Test Site impact makes an insignificant contribution to the total.

New actions could also result in additional waste disposal at the Nevada Test Site. This potential new waste, in addition to the waste discussed in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, all) should result in minimal impact for waste management. The total amount of waste DOE expects to dispose of at the Test Site is within the bounds evaluated in the most recent EISs [Nevada Test Site EIS (DIRS 101811-DOE 1996, all) and programmatic waste management EIS (DIRS 101816-DOE 1997, all)] and would not contribute to postclosure impacts beyond those described in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 8-82 to 8-84).

8.3.2.2 Beatty Low-Level Radioactive Waste Disposal and Hazardous Waste Treatment, Storage, and Disposal Facilities

The low-level radioactive waste disposal facility, formerly operated by U.S. Ecology, a subsidiary of American Ecology, is 16 kilometers (10 miles) southeast of Beatty, Nevada, and 180 kilometers (110 miles) northwest of Las Vegas. This site is about 15 kilometers (9.3 miles) west of the proposed repository. The Nevada State Health Division formally accepted permanent custody of the low-level radioactive commercial waste disposal facility in a letter to American Ecology dated December 30, 1997 (DIRS 148088-AEC 1999, all). The U.S. Ecology Hazardous Waste Treatment, Storage, and Disposal Facility is a *Resource Conservation and Recovery Act*-permitted facility, with *engineered barriers* and systems and administrative controls that minimize the potential for offsite migration of hazardous constituents. DOE has determined that cumulative postclosure impacts from the Beatty low-level radioactive waste disposal facility with the repository would be very small.

8.4 Cumulative Transportation Impacts

This section discusses the results of the cumulative impact analysis of transportation under assumed conditions. The information in Section 8.4.1 covers cumulative impacts of the transportation of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the proposed repository. Chapter 6 discusses environmental impacts of national transportation. Section 8.4.2 presents the cumulative impacts from the Rail Alignment EIS.

8.4.1 NATIONAL TRANSPORTATION

This section describes estimated cumulative impacts from national transportation. Section 8.4.1.1 presents potential cumulative impacts from the storage and loading of spent nuclear fuel and high-level radioactive waste at commercial generator sites and DOE facilities. Section 8.4.1.2 presents the potential cumulative impacts from shipment of Inventory Module 1 or 2 from commercial generator sites and DOE facilities to the proposed repository. Section 8.4.1.3 presents potential cumulative national transportation impacts for the Proposed Action and Module 1 or 2 when combined with past, present, and reasonably foreseeable future shipments of radioactive material.

8.4.1.1 Cumulative Impacts of Storage and Loading at Generator Sites

The activities associated with the Proposed Action would include the loading of commercial spent nuclear fuel in TAD canisters at the commercial generator sites, loading of TAD and other canisters in rail *casks*, and loading of the rail casks on railcars. Additional related activities that could result in impacts at the generator sites include the loading of commercial spent nuclear fuel in other canisters, such as *dual-purpose canisters*, and the storage of commercial or DOE spent nuclear fuel or high-level radioactive waste. This section describes the cumulative impacts of these related actions.

The primary cumulative impacts from these actions would be from radiation exposures of workers, fatalities from industrial accidents, and from radiation exposures of members of the public.

Table 8-9 lists the cumulative radiological impacts to workers of storage and loading at the generator sites. DOE based the estimation of impacts of loading of canisters on the same methods and data as those for loading of TAD canisters (see Appendix G). The Department based the estimates of the impacts of

Table 8-9. Estimated cumulative radiological impacts of storage and loading at the generator sites for workers.

Action	Radiation dose (person-rem)	Latent cancer fatalities
Loading of canisters	120	0.074
Storage of canisters[a]	2,400	1.5
Storage of high-level radioactive waste[b]	14,000	8.5
Storage of DOE spent nuclear fuel[c]	3,600	2.2
Proposed Action	10,000	6.0
Total	30,000	18

a. DIRS 175019-Holtec 2002, all.
b. DIRS 101816-DOE 1997, all.
c. DIRS 101802-DOE 1995, all.

canister storage at the commercial generator sites on data for surveillance and maintenance of *dry storage* casks (DIRS 175019-Holtec 2002, all). DOE used a 20-year storage period to estimate impacts for canister storage under the assumptions that the average spent nuclear fuel age would be 25 years and that the spent nuclear fuel would be in a spent nuclear fuel storage pool for 5 years before being moved to dry storage.

DOE based the impacts of the storage of high-level radioactive waste on the impacts in *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DIRS 101816-DOE 1997, all). The Department based impacts of the storage of DOE spent nuclear fuel on the impacts in *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DIRS 101802-DOE 1995, all). There would be an estimated 18 latent cancer fatalities in the exposed population of workers for loading and storage at the generator sites. These activities would take place at 76 facilities across the United States over 50 years, so the probability of a latent cancer fatality for an individual worker at an individual facility would be small.

Table 8-10 lists the cumulative industrial safety impacts of the loading and storage of spent nuclear fuel and high-level radioactive waste at the generator sites. DOE based the estimation of industrial safety impacts on the same methods and data as those for the loading of TAD canisters (Appendix G). DOE based the impacts of canister storage at the commercial generator sites on data from Holtec (DIRS 175019-Holtec 2002, all) for surveillance and maintenance of dry storage casks.

Table 8-10. Cumulative industrial safety impacts of storage and loading at the generator sites for workers.

Action	Industrial safety fatalities
Loading and storage of canisters[a]	0.0079
Storage of high-level radioactive waste[b]	2.5
Storage of DOE spent nuclear fuel[c]	< 1
Proposed Action	0.25
Total	< 3.8

a. DIRS 175019-Holtec 2002, all.
b. DIRS 101816-DOE 1997, all.
c. DIRS 101802-DOE 1995, all.

DOE based the estimates of impacts of canister storage on a 20-year storage time. It based the impacts of storage of high-level radioactive waste on the impacts in *Final Waste Management Programmatic*

Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (DIRS 101816-DOE 1997, all). The Department based the impacts of DOE spent nuclear fuel storage on the impacts in *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DIRS 101802-DOE 1995, all). There would be an estimated 4 fatalities from industrial accidents in the population of workers for loading and storage at the generator sites. These activities would take place at 76 facilities across the United States over 50 years, so the probability of a fatality for an individual worker at an individual facility would be small.

8.4.1.2 Inventory Module 1 or 2 Impacts at Generator Sites

This section describes the potential cumulative impacts of loading operations at the generator sites for Inventory Modules 1 and 2. Chapter 6 presents the transportation impacts for the Proposed Action inventory.

For the Proposed Action, DOE would ship 70,000 MTHM of commercial and DOE spent nuclear fuel and high-level radioactive waste from the generator sites to the repository. For Module 1A, the inventory shipped would be about 130,000 MTHM of commercial spent nuclear fuel, about 2,500 MTHM of DOE spent nuclear fuel, and 36,000 canisters of high-level radioactive waste. As discussed in Section 8.1.2.1 for Module 1B, DOE would recycle 67,000 MTHM of commercial spent nuclear fuel of the 143,300 MTHM from Module 1A, convert it to high-level radioactive waste (about 13,400 to 29,000 canisters), and ship it to the repository. Module 2A includes the Module 1A inventory and 12,000 canisters of Greater-Than-Class C radioactive waste, using the bounding estimate for the number of high-level radioactive waste canisters. Table 8-11 lists the numbers of rail and truck casks for the Proposed Action and each of the Modules using the 29,000-canister estimate for high-level radioactive waste.

Table 8-11. Numbers of rail and truck casks for the Proposed Action, Module 1, and Module 2.

Mode	Proposed Action	Module 1A	Module 1B	Module 2A
Rail	9,500	22,000	21,000	34,000
Truck	2,700	5,000	2,700	5,000
Total	12,000	27,000	23,000	39,000

Note: Totals might differ from sums due to rounding.

In Chapter 6, Section 6.2.1, DOE estimated 1.4 fatalities from exposure to vehicle emissions and from traffic fatalities for shipment of empty TAD canisters and campaign kits to generator sites. Based on the increase in the number of casks for Module 1A—about 120 percent—DOE estimated there could be about 3 fatalities from shipment of TAD canisters and campaign kits to generator sites for Module 1A. For Module 1B, TAD canisters and campaign kits would not be necessary for the 67,000 MTHM of commercial spent nuclear fuel that DOE would recycle. Therefore, DOE estimated that there would be about 1.4 fatalities from shipment of empty TAD canisters and campaign kits to generator sites. For Module 2A, the increase in the number of casks would be about 220 percent, and DOE estimated there could be about 4.5 fatalities from shipment of TAD canisters and campaign kits to generator sites. Table 8-12 summarizes these impacts.

In Chapter 6, Section 6.2.2, DOE estimated the probability of a latent cancer fatality for members of the public who would be exposed to radioactive releases from the generator sites would be 0.0017. Based on

Table 8-12. Summary of estimated cumulative fatality impacts at generator sites.

Activity	Proposed Action	Module 1A	Module 1B	Module 2A
Transportation of canisters to generator sites	1.4[a]	3.1[a]	1.4[a]	4.5[a]
Radiation exposure of public around generator sites	0.0017	0.0038[b]	0.0053[b]	0.0054[b]
Radiation exposure of workers at generator sites	6[b]	13[b]	19[b]	19[b]
Industrial accidents at generator sites	0.41[c]	0.91[c]	1.3[c]	1.3[c]

a. From exposure to vehicle emissions and from traffic fatalities.
b. Latent cancer fatalities
c. From industrial accidents, exposure to vehicle emissions, and traffic fatalities for involved and noninvolved workers.

the increase in the number of casks for Modules 1 and 2, DOE estimated the probability of a latent cancer fatality for the exposed members of the public would be 0.0038 for Module 1A, 0.0053 for Module 1B, and 0.0054 for Module 2A (Table 8-12). For Module 1B, this would include the impacts for members of the public around generator and recycling sites for the 67,000 MTHM of spent nuclear fuel that would be recycled.

In Chapter 6, Section 6.2.3, DOE estimated there would be 6 latent cancer fatalities in the population of workers who were exposed to radiation from loading activities at the generator sites. Based on the increase in the number of casks shipped for Modules 1 and 2, DOE estimated there could be 13 latent cancer fatalities among workers for Module 1A, 19 for Module 1B, and 19 for Module 2A (Table 8-12). For Module 1B, this would include the impacts for workers at generator and recycling sites from loading and unloading the 67,000 MTHM of commercial spent nuclear fuel that would be recycled, and the loading of 29,000 canisters of high-level radioactive waste that would result from the recycling in rail casks.

In Chapter 6, Section 6.2.4, DOE estimated 0.41 fatality from industrial accidents, exposure to vehicle emissions, and traffic fatalities for involved and noninvolved workers at the generator sites. Based on the increase in the number of casks shipped for Modules 1 and 2, DOE estimated 0.91 fatality for Module 1A and 1.3 fatalities for Modules 1B and 2A (Table 8-12). For Module 1B, this would include the impacts for involved and noninvolved workers at generator and recycling sites from loading and unloading the 67,000 MTHM of commercial spent nuclear fuel that would be recycled, and the loading of 29,000 canisters of high-level radioactive waste that would result from the recycling in rail casks.

In Chapter 6, Section 6.2.5, DOE estimated the probability of a latent cancer fatality for the population within 16 kilometers (10 miles) of a generator site would range from 1.5×10^{-12} (1 chance in 700 billion) for an accident that involved the drop of a spent nuclear *fuel assembly* to 3.6×10^{-4} (1 chance in 3,000) for an accident that involved the drop of a transfer cask. Although the probability of these accidents could increase with the handling of more spent nuclear fuel, the consequences of the accidents would not increase and the impacts of loading accidents under Module 1 or 2 would be the same as those for the Proposed Action.

8.4.1.3 Inventory Module 1 and 2 Impacts for National Transportation

Table 8-13 lists the impacts for national transportation of spent nuclear fuel and high-level radioactive waste by rail and some truck shipments for the Proposed Action, Module 1, and Module 2. As with the

Table 8-13. National transportation impacts for the Proposed Action, Module 1, and Module 2.

Rail alignment	No. of casks	Members of the public radiation dose (person-rem)	Involved workers radiation dose (person-rem)	Members of the public (latent cancer fatalities)	Workers (latent cancer fatalities)	Vehicle emission fatalities	Radiological accident dose risk (person-rem)	Radiological accident risk (latent cancer fatalities)	Traffic fatalities	Total fatalities
Proposed Action										
Caliente										
Rail	9,495	800	4,700	0.48	2.8	0.99	4.1	0.0025	2.1	6.4
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.00041	0.57	1.4
Total	12,145	1,200	5,600	0.69	3.4	1.1	4.2	0.0025	2.7	7.8
Mina										
Rail	9,495	700	5,100	0.42	3	0.88	3.7	0.0022	2.2	6.5
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.00041	0.57	1.4
Total	12,145	1,100	5,900	0.63	3.6	1	3.7	0.0022	2.8	8
Module 1A										
Caliente										
Rail	21,909	1,900	11,000	1.1	6.6	2.3	9.5	0.0057	4.8	15
Truck	5,025	660	1,700	0.4	1	0.25	0.13	0.00077	1.1	2.7
Total	26,934	2,500	13,000	1.5	7.6	2.5	9.6	0.0058	5.9	18
Mina										
Rail	21,909	1,600	12,000	0.98	7	2	8.5	0.0051	5	15
Truck	5,025	660	1,700	0.4	1	0.25	0.13	0.00077	1.1	2.7
Total	26,934	2,300	13,000	1.4	8	2.3	8.6	0.0052	6.1	18
Module 1B										
Caliente										
Rail	20,537	2,300	14,000	1.4	8.3	2.9	12	0.0072	6.1	19
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.000041	0.57	1.4
Total	23,187	2,700	15,000	1.6	8.8	3.0	12	0.0072	6.7	20
Mina										
Rail	20,537	2,100	15,000	1.2	8.9	2.6	11	0.0064	6.4	19
Truck	2,650	350	880	0.21	0.53	0.13	0.068	0.000041	0.57	1.4
Total	23,187	2,400	16,000	1.4	9.4	2.7	11	0.0065	6.9	20
Module 2A										
Caliente										
Rail	33,909	2,900	17,000	1.7	10	3.5	15	0.0088	7.4	23
Truck	5,025	660	1,700	0.40	1.0	0.25	0.13	0.000077	1.1	2.7
Total	38,934	3,500	19,000	2.1	11	3.8	15	0.0089	8.5	26
Mina										
Rail	33,909	2,500	18,000	1.5	11	3.1	13	0.0079	7.8	23
Truck	5,025	660	1,700	0.40	1.0	0.25	0.13	0.000077	1.1	2.7
Total	38,934	3,200	20,000	1.9	12	3.4	13	0.0080	8.9	26

Note: Totals might differ from sums due to rounding.

cumulative impacts of loading and storage at the generator sites, DOE based the impacts of Module 1 and Module 2 on the impacts of the Proposed Action and on the increases in the number of rail and truck casks for Modules 1 and 2. For the Proposed Action, DOE estimated there could be a total of about 8 fatalities. The majority of these fatalities (about 80 percent) would be from worker radiation exposures and traffic accidents. The Department estimated there could be about 18 total fatalities for Module 1A, about 20 total fatalities from Module 1B, and about 26 total fatalities for Module 2A. As with the Proposed Action, the majority of these fatalities would be from worker radiation exposures and traffic fatalities. For Module 1B, national transportation impacts would include the impacts from transporting 67,000 MTHM of commercial spent nuclear fuel that would be recycled, and the impacts from transporting 29,000 canisters of high-level radioactive waste that would result from the recycling.

DOE does not expect radiological impacts for maximally exposed workers and members of the public to change from those for the Proposed Action due to the conservative assumptions for the Proposed Action analysis (Chapter 6, Section 6.3). Maximally exposed workers would include a crew member, an inspector, and a railyard crew member; maximally exposed members of the public would be a resident along a route, a person in a traffic jam, a person at a service station, and a resident near a rail stop. The assumptions for estimation of radiological doses include the use of the maximum allowed dose rate and conservative estimates of exposure distance and time. For example, DOE used the U.S. Department of Transportation maximum allowable dose rate of 10 millirem per hour at a distance of 2 meters (6.6 feet) [40 CFR 173.44(b)] to estimate exposures to individuals. In addition, it would be unlikely that the actual exposure distance and time for workers and the public would result in greater exposure than DOE's conservative assumptions for the Proposed Action and for Inventory Module 1 or 2.

8.4.1.4 Inventory Module 1 and 2 Impacts for Transportation Associated with the Repository

Chapter 6, Section 6.4.2 describes the impacts of the transportation of construction materials, repository components, and consumables to the repository; the impacts from workers who would commute to the repository; and the impacts of offsite shipment of nonhazardous *solid waste* and hazardous, mixed, and low-level radioactive waste. DOE estimated less than 1 latent cancer fatality and about 13 fatalities from exposure to vehicle emissions and 44 to 46 traffic fatalities due to these transportation activities.

The implementation of Inventory Module 1A, 1B, or 2A would increase this transportation as a result of additional subsurface development and the longer time necessary for repository development, emplacement, and closure. For example, for Modules 1A, 1B, and 2A, DOE would need additional repository components such as waste packages and drip shields. With the increased transportation of other material, personnel, and repository-generated wastes for Module 1A, 1B, or 2A, these transportation impacts could increase to about 14 to 15 fatalities from exposure to vehicle emissions and 47 to 51 traffic fatalities. Less than an estimated 1 latent cancer fatality would occur due to these increased transportation activities.

8.4.1.5 Cumulative Impacts from the Proposed Action, Inventory Module 1 or 2, and Other Federal, Non-Federal, and Private Actions

The overall assessment of the cumulative national transportation impacts for past, present, and reasonably foreseeable future actions concentrated on the cumulative impacts of offsite transportation, which would yield potential radiation doses to a greater portion of the general population than onsite transportation and

could result in fatalities from traffic accidents. DOE used the collective dose to workers and to the general population to quantify overall cumulative radiological transportation impacts. The Department chose this measure because it relates directly to latent cancer fatalities with the use of a cancer risk coefficient and because of the difficulty in identification of a maximally exposed individual for shipments throughout the United States from 1943 through 2073. Operations at the Hanford Site and the Oak Ridge Reservation began in 1943, and 2073 is when the Repository SEIS analysis assumed radioactive material shipments to the repository for Inventory Module 1 or 2 would end.

The cumulative impacts of the transportation of radioactive material would consist of impacts from:

- Historical DOE shipments of radioactive material to and from the Nevada Test Site, the Idaho National Laboratory, the Savannah River Site, the Hanford Site, the Oak Ridge Reservation, and *naval spent nuclear fuel* and test specimens.

- Reasonably foreseeable actions that include the transportation of radioactive material in various DOE NEPA analyses; for example, the Nevada Test Site EIS (DIRS 101811-DOE 1996, all), the DOE spent nuclear fuel management EIS (DIRS 101802-DOE 1995, all; DIRS 101812-DOE 1996, all), and the DOE waste management EIS (DIRS 101816-DOE 1997, all) (see Table 8-14). In some cases, transportation impacts included impacts that might have been counted twice. For example, Table 8-14 includes the impacts from shipment of 40,000 MTHM of spent nuclear fuel to a potential Private Fuel Storage Facility in Tooele County, Utah (DIRS 157761-NRC 2001, all), but the impacts from the Proposed Action do not account for this 40,000 MTHM. Table 8-14 lists reasonably foreseeable projects that include limited transportation of radioactive material (for example, shipment of submarine reactor compartments from the Puget Sound Naval Shipyard to the Hanford Site for burial and shipments of uranium billets and low-specific-activity nitric acid from the Hanford Site to the United Kingdom). In addition, for reasonably foreseeable future actions for which there was no identified preferred alternative or Record of Decision, the analysis used the alternative that would result in the largest impacts. While this is not an exhaustive list of the projects that could include limited transportation of radioactive material, it indicates that the impacts of such projects would be low in comparison to major projects or general transportation.

- General radioactive materials transportation that would not relate to a particular action; for example, shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities.

- Shipments of spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste under the Proposed Action or Inventory Module 1A, 1B, or 2A.

NRC evaluated these types of shipments based on a survey of radioactive materials transportation published in 1975 (DIRS 101892-NRC 1977, all). Categories of radioactive material evaluated in this NRC document included: (1) limited quantity shipments, (2) medical, (3) industrial, (4) fuel cycle, and (5) waste. NRC estimated that the annual collective worker dose for these shipments was 5,600 person-rem (DIRS 101892-NRC 1977, p. 4-15). The annual collective general population dose for these shipments was estimated to be 4,200 person-rem (DIRS 101892-NRC 1977, p. 5-52). These collective dose estimates were used to estimate transportation collective doses for 1943 through 1982 (40 years). Based on the NRC transportation dose assessments, the cumulative transportation collective doses for

Table 8-14. Cumulative transportation-related health effects.

Category	Worker dose (person-rem)	General population dose (person-rem)	Traffic fatalities
Historical DOE shipments (DIRS 101811-DOE 1996, all)	330	230	NL
Reasonably foreseeable actions			
Private Fuel Storage Facility (DIRS 157761-NRC 2001, all)	24	184	0.78
Sodium-Bonded Spent Nuclear Fuel (DIRS 157167-DOE 2000, all)	0.0044	0.032	0.0001
Idaho High-Level Waste and Facilities (DIRS 179508-DOE 2002 , all)	520	2,900	0.98
Surplus Plutonium Disposition (DIRS 118979-DOE 1999, all)	60	67	0.053
Sandia National Laboratories Site-Wide EIS (DIRS 157155-DOE 1999, all)	94	590	1.3
Depleted Uranium Hexafluoride (DIRS 152493-DOE 1999, all)	--	750	4
Tritium Production in a Commercial Light Water Reactor (DIRS 157166-DOE 1999, all)	16	80	0.06
Parallex Project (DIRS 157153-DOE 1999, all)	0.00001	0.00007	0.00005
Los Alamos National Laboratory Site-Wide EIS (DIRS 185511-DOE 2008, all)	910	290	2.7
Plutonium Residues at Rocky Flats (DIRS 155932-DOE 1998, all)	2.1	1.3	0.0078
Import of Russian Plutonium-238 (DIRS 157156-DOE 1993, all)	1.8	4.4	0.0036
Nevada Test Site Expanded Use (DIRS 101811-DOE 1996, all)	--	150	8
Spent nuclear fuel management (DIRS 101802-DOE 1995, all; DIRS 101812- DOE 1996, all)	360	810	0.77
Waste Management Programmatic EIS (DIRS 101816-DOE 1997, all)	16,000	20,000	36
Waste Isolation Pilot Plant (DIRS 148724-DOE 1997, Appendix E)	790	5,900	5
Molybdenum-99 production (DIRS 101813-DOE 1996, all)	240	520	0.1
Tritium supply and recycling (DIRS 103208-DOE 1995, all)	--	--	0.029
Surplus highly enriched uranium disposition (DIRS 103216-DOE 1996, all)	400	520	1.1
Storage and Disposition of Fissile Materials (DIRS 103215-DOE 1996, all)	--	2,400	5.5
Stockpile Stewardship (DIRS 103217-DOE 1996, all)	--	38	0.064
Pantex (DIRS 103218-DOE 1996, all)	250	490	0.006
West Valley (DIRS 179454-DOE 2003, all)	520	410	0.15
S3G and D1G prototype reactor plant disposal (DIRS 103221-DOE 1997, all)	2.9	2.2	0.010
S1C prototype reactor plant disposal (DIRS 103219-DOE 1996, all)	6.7	1.9	0.0037
Container system for naval spent nuclear fuel (DIRS 101941-USN 1996, all)	11	15	0.045
Cruiser and submarine reactor plant disposal (DIRS 103479-USN 1996, all)	5.8	5.8	0.00095
Submarine reactor compartment disposal (DIRS 103477-USN 1984, all)	--	0.053	NL
Uranium billets (DIRS 103189-DOE 1992, all)	0.5	0.014	0.00056
Nitric acid (DIRS 103212-DOE 1995, all)	0.43	3.1	NL
Los Alamos Relocation of Area 18 FEIS (DIRS 162639-DOE 2002, all)	< 1	< 1	0.00020
Construction, Operation of Depleted DUF_6 Conversion Facility, Portsmouth, Ohio FEIS (DIRS 182373-DOE 2004, all)	520	29	0.45
Enrichment Facility in Lea County, New Mexico (DIRS 182375-NRC 2005, all)	1,500	450	24
Decontamination, Demolition, and Removal of Facilities at West Valley (DIRS 182374-DOE 2006, all)	14	11	0.013
Hanford Site Solid Waste Program FEIS (DIRS 182376-DOE 2004, all)	1,200	11,000	2.4
Moab Uranium Mill Tailings FEIS (DIRS 182377-DOE 2005, all)	0.09	3.4	0.33
Mixed-Oxide Fuel Fabrication at Savannah River Site (DIRS 178816-NRC 2005, all)	530	560	0.056
Complex Transformation Programmatic EIS (DIRS 185273-DOE, 2007, all)	3,700	210	0.20
Subtotal of historical DOE shipments and reasonably foreseeable actions	28,000	49,000	94
General radioactive material transportation (1943 to 2073)	350,000	300,000	28
Subtotal of nonrepository-related transportation impacts	380,000	350,000	120
Proposed Action	5,600 – 5,900	1,100 – 1,200	2.7 – 2.8
Module 1A	13,000	2,300 – 2,500	5.9 – 6.1
Module 1B	15,000 – 16,000	2,400 – 2,700	6.7 – 6.9
Module 2A	19,000 – 20,000	3,200 – 3,500	8.5 – 8.9
Total collective dose (total latent cancer fatalities) and total traffic fatalities			
Proposed Action	390,000 (230)	350,000 (210)	120
Module 1A	390,000 (230)	350,000 (210)	130
Module 1B	400,000 (240)	350,000 (210)	130
Module 2A	400,000 (240)	350,000 (210)	130

Note: Numbers are rounded to 2 significant figures; therefore, totals may differ from sums.
NL = Not listed; information was not listed in the reference.

1943 through 1982 were 220,000 person-rem for workers and 170,000 person-rem for the general population.

In 1983, another survey of radioactive materials transportation in the United States was conducted. This survey included NRC, *Agreement State* licensees, and DOE. Both spent nuclear fuel and radioactive waste shipments were included in the survey. Weiner et al. (DIRS 146270-Weiner et al. 1991, all) used the survey to estimate collective doses from general transportation. These transportation dose assessments were used to estimate transportation doses for 1983 through 2073 (91 years). Weiner et al. evaluated eight categories of radioactive material shipments: (1) industrial, (2) radiography, (3) medical, (4) fuel cycle, (5) research and development, (6) unknown, (7) waste, and (8) other. Based on a median external exposure rate, an annual collective worker dose of 1,400 person-rem and an annual collective general population dose of 1,400 person-rem were estimated (DIRS 146270-Weiner et al. 1991, Table VI). Over the 91-year period from 1983 through 2073, the collective worker and general population doses would be 130,000 person-rem.

For the period from 1943 through 2073, the collective worker dose would be 350,000 person-rem and the collective population dose would be 300,000 person-rem.

NRC evaluated traffic fatalities and estimated that there could be 0.213 traffic fatality per year from radioactive material shipments (DIRS 101892-NRC 1977, p. 5-52). Using this estimate, for the 131-year period between 1943 through 2073, there could be 28 traffic fatalities.

Table 8-14 lists the cumulative doses to workers and the general population from the transportation of radioactive material, and it lists the numbers of traffic fatalities. The estimated cumulative transportation-related collective worker doses would range from 390,000 to 400,000 person-rem (230 to 240 latent cancer fatalities) for the Proposed Action, Modules1A, 1B, and 2A over the period 1943 through 2073. The estimated general population doses would be about 350,000 person-rem (210 latent cancer fatalities) for the Proposed Action, Modules 1A, 1B, and 2A over the period 1943 through 2073. Most of the doses to workers and the general population would result from general transportation of radioactive material. For perspective, about 600,000 people die from cancer in the United States every year.

For transportation accidents that involved radioactive material, the dominant risk would be from accidents that do not relate to the cargo (traffic or vehicular accidents). The radiological accident risk (latent cancer fatalities) from transportation accidents is typically less than 1 percent of the vehicular accident risk. In addition, no acute radiological fatalities from transportation accidents have ever occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

From 1943 through 2073, DOE estimated 5 million motor vehicle fatalities and about 130,000 *railroad* accident fatalities. Based on the estimated number of traffic fatalities for the reasonably foreseeable actions and for the Proposed Action and Inventory Modules 1A, 1B, and 2A in Table 8-14, the transport of radioactive material could contribute a total of about 120 to 130 traffic fatalities over the period 1943 through 2073.

8.4.2 NEVADA RAIL ALIGNMENT TRANSPORTATION

The Rail Alignment EIS, Chapter 5, includes detailed information about the cumulative impacts of each of the technical resource areas evaluated in the Repository SEIS. The Rail Alignment EIS, Chapter 5, is herby incorporated by reference. The cumulative impacts summary Table 8-16 in Section 8.6.1 includes the cumulative impacts from the Rail Alignment EIS.

8.5 Cumulative Manufacturing Impacts

This section describes potential cumulative environmental impacts from the manufacture of repository components DOE would require to emplace Inventory Module 1A, 1B, or 2A in the proposed repository. DOE has identified no adverse cumulative impacts from other federal, non-federal, or private actions because it has identified no actions that, when combined with the Proposed Action or Inventory Module 1A, 1B, or 2A, would exceed the capacity of existing manufacturing facilities.

The overall approach and analytical methods and the baseline data that DOE used for the evaluation of cumulative manufacturing impacts for Inventory Module 1A, 1B, or 2A were the same as those discussed in Chapter 4, Section 4.1.14 for the Proposed Action. The evaluation focused on ways in which the manufacture of repository components could affect environmental resources at a representative manufacturing site and potential impacts to material sources and supplies.

Table 8-15 lists the total number of repository components DOE would require for the Proposed Action and Inventory Modules 1A, 1B, and 2A. The total number would increase by as much as 120 percent for Modules 1A, 1B, and 2A in comparison with the Proposed Action. The highest total number of

Table 8-15. Number of offsite-manufactured components required for the Proposed Action and Inventory Modules 1A, 1B, and 2A.

		Number to be manufactured[a]			
Component	Description	Proposed Action	Module 1A	Module 1B	Module 2A
Rail shipping casks or overpacks	Storage and shipment of SNF and HLW	79	99	99	99
Legal-weight truck shipping casks	Storage and shipment of uncanistered fuel	30	30	30	30
Waste packages	Outside container for SNF and HLW for emplacement in the repository	11,200	25,900	24,800	37,900
TAD canisters	Standardized canisters to hold commercial SNF	7,400	14,300	13,200	26,300
Emplacement pallets	Support for emplaced waste packages	11,200	25,900	24,800	37,900
Drip shields	Titanium covers for waste packages	11,500	26,200	25,100	38,200
Aging overpacks	Metal and concrete storage vaults for aging	2,500	2,500	2,500	2,500
Shielded transfer casks	Casks for transfer of canisters between and in site facilities	6 to 10	10	10	10

a. The number of components is an approximation based on the best available estimates.
HLW = High-level radioactive waste.
SNF = Spent nuclear fuel.
TAD = Transportation, aging, and disposal (canister).

repository components would be for Module 2A, so this was the number that DOE used in the cumulative impact analysis. Section 8.1.2.1 and Table 8-2a present a range of waste canisters for Inventory Module 1B, which would translate to a range of waste packages, TAD canisters, emplacement pallets, and drip shields. For ease of presentation and to be conservative, Table 8-15 presents only the high value of the applicable range.

DOE based the Proposed Action evaluation on a 24-year manufacturing period for all components other than the drip shields. This 24-year period would keep pace with the repository facilities' maximum processing capacity and, therefore, is conservative (a longer manufacturing period would spread the impacts over a longer period). Project timelines have not been established for the inventory modules, but it is reasonable to assume that the additional inventory would require a longer time for handling and emplacement. Similarly, it is reasonable to assume that component manufacturing would occur over an extended period. Because the Module 2A inventory would be more than triple that of the Proposed Action, it would take more than three times as long for repository facilities to handle the inventory at maximum capabilities. This evaluation derived an 80-year manufacturing period for Module 2A components by using the repository's maximum waste package handling rate with the exception of the drip shields, which are not linked to the rate at which the repository facilities would handle waste packages. Because there would be more than triple the number of waste packages under Module 2A than under the Proposed Action, this evaluation made the conservative assumption that drip shields would be needed over a 30-year period, compared with the 10-year period for the Proposed Action evaluation.

Because the increased number of most repository components would be manufactured over a longer period, at a rate very similar to that for the Proposed Action, annual impacts would be very similar. The drip shields, however, would increase in numbers by 230 percent for the Module 2A inventory and the manufacturing period would increase by an estimated 200 percent, going from 10 to 30 years. As a result, the annual Module 2A impacts for air quality, socioeconomics, material use, and waste generation would be as much as 11 percent higher than those for drip shield manufacture in Chapter 4, Section 4.1.14 for the Proposed Action, and these impacts would continue for 30 years rather than the 10 years for the Proposed Action. The total number of worker injuries and illness or fatalities could increase in proportion to the increase in manufactured components, and they would occur over an estimated 110 years considering the assumed 80 years for the manufacture of most components plus the separate 30 years assumed for the drip shields. The potential number of reportable injuries and illnesses over the entire 110-year period for Module 2A could be about 4,600, and the estimated number of fatalities could be 1.7; that is, based on national averages for the type of work involved, a fatality could occur during the manufacture of repository components under Module 2A. As for the Proposed Action, there would be few or no impacts on other resources because existing manufacturing facilities would meet projected manufacturing needs, new construction would not be necessary, and environmental justice impacts (that is, disproportionately high and adverse impacts to minority or low-income populations) would be unlikely.

8.6 Summary of Cumulative Impacts

This section summarizes the cumulative impacts DOE has discussed in this chapter. In addition, it presents the viewpoint of Nye County as a cooperating agency and site of the Proposed Action of this Repository SEIS.

8.6.1 CUMULATIVE IMPACTS FROM ALL SOURCES

Table 8-16 summarizes cumulative impacts from all sources. DOE has included *qualitative* descriptions if they are more meaningful than quantitative values, even though the previous sections might provide quantitative values. In other cases, quantitative values provide a better representation of potential impacts.

Table 8-16. Summary of cumulative impacts.

Resource area	Cumulative impact
Land use and ownership	The ownership, management, and use of the analyzed land withdrawal area would not change for Inventory Module 1 or 2. The amount of land for surface facilities would increase somewhat for Module 1 or 2 because of the larger excavated rock storage area and additional ventilation shafts for the larger repository. This would have no substantial cumulative land use or ownership impact.
	The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository site entrance. Development could affect land use.
	Cumulative impacts to land use and ownership in the Caliente and Mina rail alignment region of influence on local-scale of the proposed railroad and other existing and reasonably foreseeable projects could be moderate to large, particulary in the City of Caliente, the Town of Goldfield, or within the Walker River Paiute Reservation. Cumulative impacts of reasonably foreseeable projects and right-of-way on public land would be small on a regional scale, as they would only affect a small percentage of public land.
Air quality	The activities that produced releases of criteria pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter) and carbon dioxide would be roughly the same for Inventory Module 1 or 2 as those described for the Proposed Action. The changes would be the increased land disturbance and particulate matter for the larger excavated rock storage area and additional ventilation shafts from the larger subsurface repository. Carbon dioxide output for Inventory Module 1 or 2 would be the same annually as that for the Proposed Action, but would last for a longer period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4.
	Potential cumulative impacts to air quality and climate from construction and operation of a Caliente or Mina railroad would be small, but could approach moderate if the potential violations of the *National Ambient Air Quality Standards* occurred from quarry or staging yard construction.
Hydrology	
Surface water	Additional land disturbances for the emplacement of Inventory Module 1 or 2 would be small and in an area already altered for the Proposed Action. Changes to runoff, infiltration rates, natural drainage alteration, and contaminant movement in soil would not increase much from the Proposed Action.
	The cumulative impacts to surface-water resources of the Caliente or Mina proposed railroad and other existing or reasonably foreseeable projects would be small. Project planning and best management practices would help avoid or reduce potential impacts to changes in drainage, infiltration rate, and flood control from the proposed railroad or other ongoing or reasonably foreseeable future actions. DOE and other planned projects would be subject to requirements that ensure impacts to wetlands are minimized, and BLM Resource Management Plans have objectives that protect riparian and wetland areas. Spill-control and management plans would reduce the likelihood of spills and contamination from the proposed railroad and other projects.

Table 8-16. Summary of cumulative impacts (continued).

Resource area	Cumulative impact
Groundwater	Anticipated impacts to groundwater from the emplacement of Inventory Modules 1 and 2 would be the same or very similar to those for the Proposed Action. This would include changes to infiltration, potential for contaminant migration, and potential to deplete groundwater resources.
	Water demand at the start of construction activities for the emplacement of Inventory Module 1 or 2 combined with the baseline demands from the Nevada Test Site would remain below the lowest value of perennial yield, but for only 1 year. The Advanced Accelerator project proposed for the Test Site could increase water use and be cumulative with the Proposed Action. Potential also exists for impacts from the development in the proposed Yucca Mountain Project Gateway Area Concept Plan, which Nye County presented to manage development and minimize impacts.
	Overall, the needs of the proposed railroad would represent a small portion of the current cumulative water usage within the Caliente or Mina region of influence, which in some locations would continue to exceed perennial yield values. The cumulative impacts to groundwater resources of the proposed railroad and other existing and reasonably foreseeable projects, could be moderate to large but impacts of the proposed railroad would be minimized.
Biological resources and soils	Cumulative preclosure nonradiological impacts to biological resources would be similar to those for the Proposed Action. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock storage pile, habitat loss, and the loss of individuals of some animal species during site clearing and from vehicle traffic. Inventory Module 1 or 2 would require disturbance of biological resources in a larger area than the Proposed Action would disturb, primarily because the excavated rock storage pile would be larger.
	Cumulative impacts to biological resources in the Caliente or Mina rail alignment region of influence could be small to moderate.
Cultural resources	Cumulative preclosure impacts to cultural resources could increase slightly from those for the Proposed Action due to a slight increase in land disturbance for Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas DOE surveyed during site characterization activities and an increase in time of operation.
	The cumulative impacts to cultural resources in the Caliente or Mina rail alignment region of influence would be small because intensive field surveys would be conducted and mitigation measures, including avoidance, implemented.
	DOE would identify and evaluate cultural resources, as required by Section 106 of the *National Historic Preservation Act*, and would take appropriate measures to avoid or mitigate adverse impacts to such resources.
Socioeconomics	Cumulative preclosure impacts to socioeconomics would be similar to impacts for the Proposed Action. The increased inventory associated with Module 1 or 2 would not result in a larger number of employees, but would result in a longer operations period. Annual socioeconomic impacts would occur for a longer period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4.
	The cumulative impacts in the Caliente or Mina rail alignment region of influence could be moderate because of the numerous planned development projects.

Table 8-16. Summary of cumulative impacts (continued).

Resource area	Cumulative impact
Occupational and public health and safety	
Nonradiological	The total estimated impacts from industrial hazards for Inventory Module 1 or 2 could increase by 60 to 120 percent over those impacts for the Proposed Action. The impacts from manufacturing for Modules 1 and 2 would increase in proportion to the increase in components manufactured.
	For both the Caliente and Mina railroads, under Module 1, up to 21,909 casks would be transported to the repository by rail; and under Module 2, 33,909 casks would be transported to the repository by rail. To estimate the cumulative health and safety impacts of Modules 1 and 2, the impacts of the Proposed Action were increased by the ratio of the number of casks transported in the Module versus the Proposed Action. For Module 1, the nonradiological health and safety impacts noted above would increase by an additional 65 percent over the impacts under the Proposed Action. For Module 2, nonradiological health and safety impacts would increase by 119 percent over the impacts under the Proposed Action.
Radiological	Calculated values for latent cancer fatalities for repository workers during the construction, operations, monitoring, and closure periods for Module 1A could be about 7.9 fatalities and, for Module 2A, about 12 fatalities. Impacts for Module 1B would be lower than those for Module 1A due to the decrease in the number of waste packages.. The likelihood that the maximally exposed individual could experience a latent cancer fatality would be less than 0.00074 for Module 1A and 0.0011 for Module 2A. Module 1B would be slightly lower than Module 1A due to the decrease in waste packages.
	For workers along the Caliente or Mina rail line, DOE estimated that there could be 1.2 latent cancer fatalities for Module 1, and 1.7 latent cancer fatalities for Module 2.
	For members of the public along the Caliente rail alignment, DOE estimated that 0.00034 latent cancer fatality for Module 1, and 0.00052 latent cancer fatality for Module 2 could occur from transportation of spent nuclear fuel and high-level radioactive waste.
	For members of the public along the Mina rail alignment, DOE estimated that 0.0020 latent cancer fatality for Module 1, and 0.0030 latent cancer facility for Module 2 could occur from transportation of spent nuclear fuel and high-level radioactive waste.
Accidents	Disposal in the proposed repository of Inventory Module 1 or 2 would result in a very small increase in the estimated risk from accidents.
Noise	The emplacement of Inventory Module 1 or 2 would have noise levels associated with the construction and operation of the repository similar to those for the Proposed Action. An increase in potential noise impacts would be from the increased number of shipments and increased shipping time for Inventory Module 1 or 2.
	Cumulative impacts from noise in the Caliente or Mina rail alignment region of influence could be moderate to large. No vibration impacts would result from the proposed railroad because of the localized and short-term nature of the vibration sources and no cumulative vibration impacts are expected.

Table 8-16. Summary of cumulative impacts (continued).

Resource area	Cumulative impact
Aesthetics	Because the profile of the repository facilities and the appearance of access roads would not change as a result of implementation of Inventory Modules 1 or 2, there would be no additional impacts.
	The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository. Development could affect aesthetics.
	There would be no known interactions of the proposed railroad with other reasonably foreseeable activities that would affect a Class I or Class II area in the Caliente or Mina regios of influence. The cumulative impacts to aesthetic resources of the proposed railroad and other existing and reasonably foreseeable projects could be small to moderate in the Caliente and Mina regions of influence because of the potential impacts to the Class III and IV land.
Utilities, energy, materials, and site services	Because the surface facilities and the annual throughput would be the same for Inventory Module 1 or 2 and the Proposed Action, annual impacts to electricity use, fossil-fuel demand, and residential water and sewer services would be the same as those for the Proposed Action. These impacts would last for a longer duration due to the increased operations period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4.
	The Nye County Yucca Mountain Project Gateway Area Concept Plan is a land use concept to ensure orderly and compatible development for the area around the repository. Development could affect utilities, energy, materials, and services.
	The cumulative impacts to utilities, energy, and materials of the proposed Caliente or Mina railroad and other existing and reasonably foreseeable projects would be small..
Waste management	Because the surface facilities and the annual throughput would be the same for Inventory Module 1 or 2 and the Proposed Action, the annual production of waste types would be the same as that for the Proposed Action. These impacts would last for a longer duration due to the increased operations period. In addition, the increase in the manufacturing of drip shields associated with Module 2 could result in 11-percent higher impacts from the drip shield impacts discussed in Chapter 4.
	The cumulative impacts to hazardous materials and waste of the proposed Caliente or Mina railroad and other existing and reasonably foreseeable projects would be small.
Environmental justice	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for Inventory Module 1 or 2 or the Caliente or Mina rail alignment.
	DOE recognizes that American Indian people who live in the region have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on access to the site.

8.6.2 NYE COUNTY VIEWPOINT (AS WRITTEN BY NYE COUNTY)

Nye County would host the repository and associated facilities and would be the funnel through which all waste shipments converged for disposal, regardless of the final mode or method of transportation. The proposed repository is one of many federal and private sector actions that have affected, or have the potential to affect, county resources. About 98 percent of the total land area of Nye County is under the stewardship of federal agencies, which have conducted a wide range of activities, including atomic and conventional weapons testing and training, habitat and wilderness preservation, waste disposal, and resource development. Past, present, and reasonably foreseeable future activities by these agencies have direct and indirect cumulative impacts on the county environment and economy. These impacts are

cumulative with activities in the private sector, including mining and milling, agriculture, and land development, although impacts from such activities could be offset by economic and other benefits to the county.

From the Nye County perspective, impacts from the proposed repository would be cumulative with all past, present, and reasonably foreseeable future actions by the federal and private sectors. Therefore, in accordance with its status as a cooperating agency for this Repository SEIS, Nye County is providing its perspective on the cumulative impacts of the Proposed Action. DOE based the discussion in this section on the technical resource document prepared by the County (DIRS 182884-NWRPO 2007, all). This section provides an objective assessment that reflects the county's unique perspective on cumulative impacts.

8.6.2.1 Nye County's Assessment of Baseline Environment and Baseline Conditions

In Nye County's view, the baseline for the Proposed Action predates all historical repository-related actions, regardless of when the actions occurred. The conditions that currently exist in the regions of influence include impacts of past repository-related actions (for example, the segregation of certain land from mineral entry), and reflect direct or *indirect impacts* related to the repository program, rather than true baseline conditions. Nye County does not believe that the current existing conditions are the baseline against which DOE should measure repository and cumulative impacts.

Where the implementation of historical federal actions has affected Nye County (for example, withdrawal of public land from any form of public entry for the Nevada Test and Training Range and the Nevada Test Site), the existing conditions include the impacts associated with those actions. Those impacts contribute to the cumulative impacts of past federal actions and to the total cumulative impacts of federal and non-federal actions on the county.

8.6.2.2 Nye County's Assessment of Region of Influence

From the Nye County perspective, the region of influence should include Nye County in its entirety as well as the region around the county. The County recognizes that the region of influence that DOE considered for analysis of cumulative impacts will vary depending on the evaluated element of the affected environment, and that DOE should base its analysis on the region in which impacts could reasonably be expected to occur. For geology, cultural resources, noise, and biological resources and soils, the region of influence can be limited to only those areas that would be disturbed, or where activities would occur. The region of influence for air quality includes all topographic basins in which land disturbances or emissions would occur, and where additional urban development would occur as a result of employee in-migration. For socioeconomics and occupational and public health and safety, the region of influence potentially includes all of Nye County, and could include each potentially affected unit of local government and the State of Nevada. The region of influence for surface-water resources includes hydrographic basins in which DOE would take actions and any basins to which they are tributary. For groundwater resources, the region of influence includes the entire Death Valley regional flow system.

8.6.2.3 Nye County's Assessment of Impacts of Past and Present Federal and Private Sector Actions

Past and present actions by federal agencies in Nye County are characterized in four broad areas: (1) land withdrawals and designations; (2) conventional and nuclear weapons testing and training; (3) waste disposal operations; and (4) congressional mandates regarding land and resource uses. The Nye County technical resource document describes adverse and beneficial direct and indirect impacts from these actions (DIRS 182884-NWRPO 2007, all).

Federal agencies have withdrawn more than 10,500 square kilometers (2.6 million acres) in Nye County for missions that include the Nevada Test Site, Nevada Test and Training Range, Death Valley National Park, National Wildlife Refuges, and American Indian reservations. In addition, agencies have designated more than 240 square kilometers (59,000 acres) for conservation, wildlife, or preservation. These land withdrawals and designations have had or will have significant adverse impacts due to the loss of potential revenues to Nye County from restrictions on development of mineral, renewable energy, oil and gas, and water resources; loss of future productivity from the withdrawn lands; and significant alterations of transportation routes through road closures and lack of rights-of-way across withdrawn lands. The designation by the Bureau of Land Management of about 190 square kilometers (46,000 acres) of federal land in Nye County for disposal to the private sector will result in impacts on water availability, infrastructure, and the environment as development occurs. Impacts from private sector development could be offset by economic and other benefits to the County provided that appropriate resources are applied to ensure development occurs in a controlled manner. Nye County is preparing a Yucca Mountain Project Gateway Area Concept Plan to provide a basis for managing development near the gateway to the repository, but might not have adequate resources to implement the plan without support from DOE. The Proposed Action would permanently withdraw about 180 square kilometers (44,000 acres) of additional public land currently within the taxing district for the town of Amargosa Valley. The impacts of that withdrawal would be cumulative with the other land withdrawals and designations.

Above-ground and subsurface nuclear weapons tests, conventional weapons and weapons systems tests, firing ranges, and activities associated with these operations result in significant disturbances over hundreds of square kilometers. Significant adverse impacts have included blast and collapse craters, radioactive contamination of soils and groundwater, safety hazards from unexploded ordnance, fugitive emissions from contaminated soils, annoyance and startle effects from supersonic aircraft, and a remaining radionuclide burden of more than 300 million *curies*. Significant injury to natural resources, especially water resources, has occurred with a corresponding significant loss of long-term productivity.

Waste disposal actions have included disposal of about 9.8 million curies of radioactive wastes in craters, the Greater Confinement Disposal site, and the Area 5 Radioactive Waste Disposal Site on the Nevada Test Site; disposal of ordnance and other waste on U.S. Air Force and DOE lands; disposal of low-level radioactive waste and hazardous waste at a privately operated site near the community of Beatty; and disposal of municipal waste at Amargosa Valley and Pahrump. Impacts associated with the latter two actions are offset by economic and other benefits to the county. The Proposed Action would add a significant new contribution to the radioactive burden in the county, generate an appreciable volume of industrial and construction wastes, and result in an increased demand for municipal waste disposal capacity in employment and housing centers. If DOE transported the high-level radioactive wastes to the repository site without incident, and the repository performed at least as well as estimated by the *Total*

System Performance Assessment (Chapter 5), no significant new impacts to the environment would result from waste disposal at the repository. However, releases of radioactive constituents during transportation and handling or after emplacement could have significant impacts. *Stigma* associated with waste disposal (and disposal of radioactive waste in particular) could be a significant impact, but would vary by demographics. Although Nye County does not perceive any stigma from the Proposed Action at this time, public perception and the stigma associated with nuclear waste and waste management facilities could attach to the county and affect in-migration, adding to cumulative impacts from the Proposed Action.

Congressional mandates for resource management, protection, and preservation have resulted in significant adverse impacts on Nye County through the imposition of severe restrictions on water, mineral, and land development, with a corresponding decrease in long-term productivity from those lands and loss of potential tax revenues. Impacts from the implementation of the *Nuclear Waste Policy Act* are cumulative with those of other congressional mandates.

8.6.2.4 Nye County's Perspective of Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions considered in Nye County planning include both federal and non-federal actions that are likely to occur by 2050. Federal actions would include continued operations at the Nevada Test Site and the Nevada Test and Training Range; implementation of resource management and general management plans for national parks, wildlife refuges, and public lands; and construction, operation, and closure of a high-level nuclear waste repository at Yucca Mountain.

DOE based the identification of reasonably foreseeable actions by local government and the private sector on planning estimates of future population, land development patterns, and the availability of additional natural resources. Reasonably foreseeable actions by local government and the private sector should lead to an increase in population in Amargosa Valley to about 50,000 persons by 2050, with a corresponding population increase in Pahrump to about 150,000 persons. These projections do not include the incremental impacts from construction and operation of the proposed repository. All remaining farmland in Pahrump should be retired from agriculture by 2030 and agriculture in Amargosa Valley should cease by 2050. At least one new precious metal mine is likely to be permitted and opened in the southern part of the county in a rural, generally undeveloped area; it would have an operating life of 40 years or less. Dairy operations should cease in Pahrump by 2012 and in Amargosa Valley by 2040. The waste disposal site at Beatty is likely to continue operations for 20 years, after which state regulatory authorities will permit no hazardous, mixed-waste, or low-level waste disposal operations. All groundwater resources in the southern part of Nye County will be appropriated and placed to a beneficial use by 2050.

8.6.2.5 Nye County's Perspective of Cumulative Adverse Impacts

The cumulative adverse impacts of past, present, and future federal actions and mandates are significant. The most significant adverse impact is from conventional and nuclear weapons testing activities that have contaminated isolated areas on DOE and U.S. Air Force-controlled lands, and massive and widespread soil and groundwater contamination in large areas on the Nevada Test Site. The Nye County Water Resources Plan (August 2004) estimated that the volume of groundwater contaminated from weapons testing is about 6.17 billion cubic meters (5 million acre-feet). This contamination has significantly reduced the water resources available for use in the county. Contamination of the soils and groundwater on DOE-controlled land is cumulative with that on and under Air Force-controlled lands, and

contamination from other sources, which includes waste disposal activities by the federal and private sectors. Soil or groundwater contamination that occurred as a result of the Proposed Action would add to the contamination that has already accumulated, further decreasing the water resources available to the county and the long-term productivity of the contaminated areas.

The second most important adverse impact from past federal actions is the loss of access to lands due to withdrawal by DOE, the Department of Defense, and the Department of the Interior, and the designation of lands for environmental protection through National Parks, National Wildlife Refuges, and Areas of Critical Environmental Concern. More than 8,100 square kilometers (2 million acres) of land in Nye County are not available for the development of mineral and water resources. The withdrawal of additional land for the Proposed Action would add to the cumulative impact of the loss of lands for water and mineral resource development.

The third most important adverse impact from federal actions relates to the inventory of *radioactivity* that weapons testing and past and continuing radioactive waste disposal on the Nevada Test Site, as well as commercial disposal of low-level radioactive waste near Beatty, have deposited in Nye County. In total, more than 300 million curies have been deposited at sites in Nye County, primarily on the Nevada Test Site. The Proposed Action would add an estimated 14 billion or more curies to this cumulative amount.

The last major category of adverse impacts is loss of local control as a result of congressional mandates and federal policies on land and resource use. Early federal policies led to the settlement and development of Nye County and the adverse as well as beneficial impacts from mining, ranching, farming, and urbanization that followed the implementation of these policies. In the mid-1900s, federal policies led to the development of vast weapons testing and military training programs that have resulted in significant adverse environmental impacts as discussed above. Subsequent federal policies aimed at environmental protection led to significant constraints on the development of resources the county needed to sustain its economic viability. Compliance with these more recent federal policies has resulted in reductions in employment in some sectors, increased costs for development of water and land resources, decreased tax revenues, and loss of long-term productivity for large areas in Nye County. DOE based the Proposed Action on a legislative mandate (the *Nuclear Waste Policy Act*) that would impose further constraints on resource utilization and would be cumulative with the significant adverse impacts that have already occurred.

Although Nye County believes that these cumulative adverse impacts have occurred and would increase incrementally as a result of the Proposed Action, it also believes that many of the impacts could be addressed and mitigated through implementation of various, routine measures. Identification and implementation of such measures could be facilitated through consultation and cooperation between the County and DOE. In Chapter 9, Nye County presents its perspective on the types of measures that could be jointly pursued by DOE and Nye County to minimize and mitigate the expected incremental impacts of the Proposed Action. With a memorandum of understanding/consultation and cooperation agreement (NWPA, Section 117), Nye County will assist DOE in the identification of environmental and socioeconomic impacts and their significance, and then cooperatively plan and develop effective mitigation measures. As the situs jurisdiction for the Yucca Mountain Project, Nye County has a tremendous stake in the NEPA process and will continue to participate as a cooperating agency and protect the safety, environmental values, and economic well-being of the residents of Nye County.

REFERENCES

148088	AEC 1999	AEC (American Ecology Corporation) 1999. "AE News, 1998 News Releases." Boise, Idaho: American Ecology Corporation. Accessed April 20, 1999. TIC: 243770. URL: http://www.americanecology.com/page1398.html
103081	BLM 1999	BLM (Bureau of Land Management) 1999. *Cortez Gold Mines, Inc. Pipeline Infiltration Project.* Environmental Assessment NV063-EA98-062. Battle Mountain, Nevada: Bureau of Land Management. ACC: MOL.20010727.0170.
178102	BLM 2004	BLM (Bureau of Land Management) 2004. *Record of Decision for the Approved Nevada Test & Training Range Resource Management Plan and Final Environmental Impact Statement.* Las Vegas, Nevada: U.S. Department of the Interior, Bureau of Land Management. ACC: MOL.20061031.0155.
182343	BSC 2006	BSC (Bechtel SAIC Company) 2006. *2006 Projection of Future Spent Nuclear Fuel Discharges.* 000-00C-CRWW-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061003.0001.
103162	CEQ 1997	CEQ (Council on Environmental Quality) 1997. *Considering Cumulative Effects Under the National Environmental Policy Act.* Washington, D.C.: Council on Environmental Quality. TIC: 243482.
101214	CRWMS M&O 1996	CRWMS M&O 1996. *Nevada Potential Repository Preliminary Transportation Strategy Study 2.* B00000000-01717-4600-00050 REV 01. Two volumes. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960724.0199; MOL.19960724.0200.
172280	DLA 2003	DLA (Defense Logistics Agency) 2003. *Environmental Assessment, Disposition of Thorium Nitrate.* Fort Belvoir, Virginia: Defense Logistic Agency, Defense National Stockpile Center. ACC: MOL.20041122.0200.
172281	DOD 2003	DOD (U.S. Department of Defense) 2003. *Finding of No Significant Impact, Defense National Stockpile Center, Disposition of Thorium Nitrate, Environmental Assessment.* Fort Belvoir, Virginia: U.S. Department of Defense, Defense Logistics Agency. ACC: MOL.20041122.0201.

103189	DOE 1992	DOE (U.S. Department of Energy) 1992. *Environmental Assessment for the Shipment of Low Enriched Uranium Billets to the United Kingdom from the Hanford Site, Richland, Washington.* DOE/EA-0787. Richland, Washington: U.S. Department of Energy. ACC: MOL.20010730.0389.
157156	DOE 1993	DOE (U.S. Department of Energy) 1993. *Environmental Assessment of the Import of Russian Plutonium-238.* DOE/EA-0841. Washington, D.C.: U.S. Department of Energy, Office of Nuclear Energy. TIC: 251416.
101802	DOE 1995	DOE (U.S. Department of Energy) 1995. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement.* DOE/EIS-0203-F. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20010727.0192; MOL.20010727.0193; MOL.20010727.0194.
103208	DOE 1995	DOE (U.S. Department of Energy) 1995. *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling, Executive Summary.* DOE/EIS-0161. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010730.0377.
103212	DOE 1995	DOE (U.S. Department of Energy) 1995. *Environmental Assessment, Disposition and Transportation of Surplus Radioactive Low Specific Activity Nitric Acid, Hanford Site, Richland, Washington.* DOE/EA-1005. Two volumes. Washington, D.C.: U.S. Department of Energy. TIC: 243921.
101811	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243. Las Vegas, Nevada: U.S. Department of Energy, Nevada Operations Office. ACC: MOL.20010727.0190; MOL.20010727.0191.
101812	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.* DOE/EIS-0218F. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010727.0195; MOL.20010727.0196.

101813	DOE 1996	DOE (U.S. Department of Energy) 1996. *Medical Isotopes Production Project: Molybdenum-99 and Related Isotopes, Environmental Impact Statement.* Two volumes. DOE/EIS-0249-F. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010727.0169.
103215	DOE 1996	DOE (U.S. Department of Energy) 1996. *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement.* DOE/EIS-0229. Summary and four volumes. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010724.0328; MOL.20010727.0147; MOL.20010727.0148; MOL.20010727.0149.
103216	DOE 1996	DOE (U.S. Department of Energy) 1996. *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement.* DOE/EIS-0240. Two volumes and summary. Washington, D.C.: U.S. Department of Energy, Office of Fissile Materials Disposition. ACC: MOL.20010727.0179.
103217	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Programmatic Environmental Impact Statement for Stockpile Stewardship and Management.* DOE/EIS-0236. Summary and four volumes. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010802.0028; MOL.20010802.0029.
103218	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapon Components.* DOE/EIS-0225. Three volumes. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010727.0158.
103219	DOE 1996	DOE (U.S. Department of Energy) 1996. *Final Environmental Impact Statement, S1C Prototype Reactor Plant Disposal.* DOE/EIS-0275. Two volumes. Washington, D.C.: U.S. Department of Energy, Office of Naval Reactors. ACC: MOL.20010727.0176.
101816	DOE 1997	DOE (U.S. Department of Energy) 1997. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste.* DOE/EIS-0200-F. Summary and five volumes. Washington, D.C.: U.S. Department of Energy, Office of Environmental Management. ACC: MOL.20010727.0150; MOL.20010727.0151; MOL.20010727.0152.

103221	DOE 1997	DOE (U.S. Department of Energy) 1997. *Final Environmental Impact Statement, Disposal of the S3G and D1G Prototype Reactor Plants.* DOE/EIS-0274. Two volumes. Washington, D.C.: U.S. Department of Energy, Office of Naval Reactors. ACC: MOL.20010730.0388.
148724	DOE 1997	DOE (U.S. Department of Energy) 1997. *Waste Isolation Pilot Plant Disposal Phase, Final Supplemental Environmental Impact Statement, Appendices.* DOE/EIS-0026-S-2. Volume 2. Carlsbad, New Mexico: U.S. Department of Energy, Carlsbad Area Office. TIC: 238195.
155932	DOE 1998	DOE (U.S. Department of Energy) 1998. *Final EIS on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site, Summary.* DOE/EIS-0277F. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20011009.0063.
118979	DOE 1999	DOE (U.S. Department of Energy) 1999. *Surplus Plutonium Disposition Final Environmental Impact Statement.* DOE/EIS-0283. Washington, D.C.: U.S. Department of Energy, Office of Fissile Materials Disposition. TIC: 246385.
152493	DOE 1999	DOE (U.S. Department of Energy) 1999. *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.* DOE/EIS-0269. Germantown, Maryland: U.S. Department of Energy. ACC: MOL.20001010.0216.
157153	DOE 1999	DOE (U.S. Department of Energy) 1999. *Environmental Assessment for the Parallex Project Fuel Manufacture and Shipment.* DOE/EA-1216. Washington, D.C.: U.S. Department of Energy, Office of Fissile Materials Disposition. ACC: MOL.20020327.0438.
157155	DOE 1999	DOE (U.S. Department of Energy) 1999. *Site-Wide Environmental Impact Statement.* DOE/EIS-0281. Two volumes. Albuquerque, New Mexico: U.S. Department of Energy, Albuquerque Operations Office. ACC: MOL.20020222.0027; MOL.20020222.0028.
157166	DOE 1999	DOE (U.S. Department of Energy) 1999. *Final Environmental Impact Statement for the Production of Tritium in a Commercial Light Water Reactor.* DOE/EIS-0288. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20020326.0368.

157167	DOE 2000	DOE (U.S. Department of Energy) 2000. *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel.* DOE/EIS-0306. Washington, D.C.: U.S. Department of Energy, Office of Nuclear Energy, Science and Technology. ACC: MOL.20020225.0097.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
162638	DOE 2002	DOE (U.S. Department of Energy) 2002. *Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada.* DOE/EIS-0243-SA-01. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office. ACC: MOL.20030409.0001.
162639	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for the Proposed Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory.* DOE/EIS-0319. Volume 1. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20030409.0002.
179508	DOE 2002	DOE (U.S. Department of Energy) 2002. *Idaho High-Level Waste and Facilities Disposition, Final Environmental Impact Statement.* DOE/EIS-0287. Idaho Falls, Idaho: U.S. Department of Energy, Idaho Operations Office. ACC: MOL.20070613.0004.
179454	DOE 2003	DOE (U.S. Department of Energy) 2003. *West Valley Demonstration Project Waste Management Environmental Impact Statement, Final Summary.* DOE/EIS-0337F. West Valley, New York: U.S. Department of Energy, West Valley Area Office. ACC: MOL.20070613.0003.
182373	DOE 2004	DOE (U.S. Department of Energy) 2004. *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site.* DOE/EIS-0360. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20071003.0058.

182376	DOE 2004	DOE (U.S. Department of Energy) 2004. *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington.* DOE/EIS-0286F. Volume I. Sections 1 through 7. Richland, Washington: U.S. Department of Energy, Richland Operations Office. ACC: MOL.20070913.0517.
182346	DOE 2005	DOE (U.S. Department of Energy) 2005. *Annual Report - FY 2004, Radioactive Waste Shipments to and from the Nevada Test Site (NTS).* DOE/NV-1032. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20070810.0043.
182377	DOE 2005	DOE (U.S. Department of Energy) 2005. *Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah, Final Environmental Impact Statement*. DOE/EIS-0355. Washington, D.C.: U. S. Department of Energy. ACC: MOL.20071003.0059.
182374	DOE 2006	DOE (U.S. Department of Energy) 2006. *Environmental Assessment for the Decontamination, Demolition, and Removal of Certain Facilities at the West Valley Demonstration Project.* DOE/EIS-1552. West Valley, New York: U.S. Department of Energy, West Valley Demonstration Project. ACC: MOL.20071003.0060.
185273	DOE 2007	DOE (U.S. Department of Energy) 2007. *Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement.* DOE/EIS-0236-S4. Summary and two volumes. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20080304.0037.
185274	DOE 2007	DOE (U.S. Department of Energy) 2007. *Draft Programmatic Environmental Impact Statement of the Designation of Energy Corridors in the 11 Western States.* DOE/EIS-0386. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20080328.0086.
185437	DOE 2008	DOE (U.S. Department of Energy) 2008. *Draft Supplement Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0243-SA-03. Las Vegas, Nevada: U.S. Department of Energy, National Nuclear Security Administration, Nevada Site Office. ACC: MOL.20080513.0176.
185511	DOE 2008	DOE (U.S. Department of Energy) 2008. *Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico*. DOE/EIS-0380. Three volumes. Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration. ACC: MOL.20080529.0125.

185475	DOJ 2008	U.S. Department of Justice 2008. *Final Environmental Impact Statement Proposed Contractor Detention Facility, Las Vegas, Nevada Area*. Arlington, Virginia: U.S. Department of Justice, Office of the Federal Detention Trustee. ACC: MOL.20080529.0055.
103705	EPA 1997	EPA (U.S. Environmental Protection Agency) 1997. *Health Effects Assessment, Summary Tables, FY-1997 Update.* EPA 540/R-97-036. Washington, D.C.: U.S. Environmental Protection Agency. ACC: MOL.20010724.0301.
148228	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Nickel, Soluble Salts; CASRN Various." IRIS (Integrated Risk Information System). Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0364. URL: http://www.epa.gov/iris/subst/0271.htm
148229	EPA 1999	EPA (U.S. Environmental Protection Agency) 1999. "Nickel, Soluble Salts; CASRN Various." *IRIS (Integrated Risk Information System)*. Washington, D.C.: U.S. Environmental Protection Agency. Accessed June 10, 1999. ACC: MOL.20010719.0364. URL: http://www.epa.gov/iris/subst/0271.htm
181232	Fitzpatrick-Maul 2007	Fitzpatrick-Maul, D. 2007. "SEIS Water Balance Revision 4." E-mail from D. Fitzpatrick-Maul to L. Morton, April 16, 2007, with attachment. ACC: MOL.20070816.0027; MOL.20070808.0055.
182841	Gamble 2007	Gamble, R. 2007. "*Nye County Comprehensive Economic Development Strategy*." E-mail from R. Gamble to L. Morton, October 9, 2007, with attachment. ACC: MOL.20071009.0076; MOL.20070913.0316.
182345	Giampaoli 2007	Giampaoli, M.C. 2007. *Yucca Mountain Project Gateway Area Concept Plan.* Pahrump, Nevada: Nuclear Waste Repository Project Office, Nye County, Nevada. ACC: MOL.20070712.0048.
175019	Holtec 2002	Holtec International 2002. *Final Safety Analysis Report for the Holtec International Storage, Transfer, and Repository Storage Cask System (HI-STAR 100 Cask System).* Volume I. Docket No. 72-1008, Rev. 1. Marlton, New Jersey: Holtec International. TIC: 257520.

101836	ICRP 1991	ICRP (International Commission on Radiological Protection) 1991. "1990 Recommendations of the International Commission on Radiological Protection." Volume 21, No. 1-3 of *Annals of the ICRP*. ICRP Publication 60. New York, New York: Pergamon Press. TIC: 235864.
185296	Joyce 2008	Joyce, J. 2008. "Transmittal of Updated GTCC Inventory and TAD Estimates." Email from J. Joyce to J. Summerson, March 13, 2008, with attachment. ACC: MOL.20080328.0084.
169260	Kistler Aerospace 2003	Kistler Aerospace. 2003. "Kistler Aerospace Corporation Restructures its Finances to Achieve the Reusable Launch Vehicle's First Flight." Kirkland, Washington: Kistler Aerospace. Accessed April 21, 2004. TIC: 256006. URL: http://www.kistleraerospace.com/newsinfo/pressreleases/071503print.html
182702	Koutsandreas 2007	Koutsandreas, D. 2007. "Revised HLW Canisters Numbers for the YM EIS." E-mail from D. Koutsandreas to S. Gomberg, March 22, 2007. ACC: MOL.20070913.0503.
174559	Lawrence 2002	Lawrence, A. 2002. "Radiation Risk Estimation from Total Effective Dose Equivalents (TEDEs)." Memorandum from A. Lawrence (DOE) to distribution, August 9, 2002, with attachments. ACC: MOL.20050815.0190.
182804	Maher 2006	Maher, M. 2006. "Nye County, Nevada Request to Initiate Transaction for Acquisition of 292.46 Acres of Land for Commercial Purposes Pursuant to Public Law #106-113." Letter from M. Maher (Nye County) to J. Palma (BLM), March 21, 2006, with enclosure. ACC: MOL.20070913.0510
153066	Murphy 2000	Murphy, S.L. 2000. *Deaths: Final Data for 1998. National Vital Statistics Reports.* Vol. 48, No. 11. Hyattsville, Maryland: National Center for Health Statistics. TIC: 249111.
101892	NRC 1977	NRC (U.S. Nuclear Regulatory Commission) 1977. *Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes.* NUREG-0170. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 221616.

157761	NRC 2001	NRC (U.S. Nuclear Regulatory Commission) 2001. *Final Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah.* NUREG-1714. Two volumes. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 253836.
178816	NRC 2005	NRC (U.S. Nuclear Regulatory Commission) 2005. *Environmental Impact Statement on the Construction and Operation of a Proposed Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina*. NUREG-1767, Volume 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20060111.0289.
182375	NRC 2005	NRC (U.S. Nuclear Regulatory Commission) 2005. *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico.* NUREG-1790. Volume 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20071003.0061.
182710	NWRPO 2007	NWRPO (Nuclear Waste Repository Project Office) 2007. *Nye County Public Safety Report.* NWRPO-2007-06. Las Vegas, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20070913.0315.
182884	NWRPO 2007	NWRPO (Nye County Nuclear Waste Repository Project Office) 2007. *Nye County Perspective: Potential Impacts Associated with the Long-Term Presence of a Nuclear Waste Repository at Yucca Mountain, Ney County, Nevada. Site Count Viewpoint on Cumulative Impacts and Recommended Mitigation Actions.* Pahrump, Nevada: Nye County Nuclear Waste Repository Project Office. ACC: MOL.20071009.0078.
185367	Seley 2008	Seley, W. 2008. "Wind Energy Applications - Nye and Esmeralda County, Nevada." Email from W. Seley (BLM) to H. Woods, April 15, 2008, with attachment. ACC: MOL.20080521.0035.
185368	Seley 2008	Seley, W. 2008. "Solar Energy Chart." Email from W. Seley (BLM) to H. Woods (NV BLM), April 15, 2008, with attachment. ACC: MOL.20080521.0034.
185502	Schwartz 2008	Schwartz, F.G. 2008. "GNEP Spent Fuel and Waste Generation Data." Memorandum from F.G. Schwartz (DOE) to J.R. Summerson (DOE/Nevada Operations Office), May 19, 2008, with attachments. ACC: MOL.20080528.0005.

103472	USAF 1999	USAF (U.S. Air Force) 1999. *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement.* Washington, D.C.: U.S. Air Force. ACC: MOL.20010726.0068.
172314	USAF 2003	USAF (U.S. Air Force) 2003. *Predator Force Structure Change at Indian Springs Air Force Auxiliary Airfield, Nevada.* Washington, D.C.: U.S. Air Force. ACC: MOL.20041206.0122.
182839	USAF 2005	USAF (U.S. Air Force) 2005. *Wing Infrastructure Development Outlook (WINDO) Environmental Assessment.* Las Vegas, Nevada: U.S. Air Force, Nellis Air Force Base. ACC: MOL.20070913.0514.
181607	USAF 2006	USAF (U.S. Air Force) 2006. *Environmental Assessment for Increased Depleted Uranium Use on Target 63-10, Nevada Test and Training Range.* Nellis Air Force Base, Nevada: U.S. Air Force. ACC: MOL.20070712.0025.
182838	USAF 2006	USAF (U.S. Air Force) 2006. *Expeditionary Readiness Training (ExpeRT) Course Expansion, Final Environmental Assessment.* Indian Springs, Nevada: U.S. Air Force, Creech Air Force Base. ACC: MOL.20070913.0516.
181492	USAF 2007	USAF (U.S. Air Force) 2007. *Final Base Realignment and Closure (BRAC) Environmental Assessment for Realignment of Nellis Air Force Base*. Nellis Air Force Base, Nevada: U.S. Air Force. ACC: MOL.20070712.0026.
185372	USAF 2007	USAF (U.S. Air Force) 2007. *Final, Range 74 Target Complexes Environmental Assessment Nevada Test and Training Range, Nevada.* Nellis Air Force Base, Nevada: U.S. Air Force. ACC: MOL.20080501.0029.
103477	USN 1984	USN (U.S. Department of the Navy) 1984. *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants.* Three volumes. Washington, D.C.: U.S. Department of the Navy. ACC: MOL.20010810.0026.
101941	USN 1996	USN (U.S. Department of the Navy) 1996. *Department of the Navy Final Environmental Impact Statement for a Container System for the Management of Naval Spent Nuclear Fuel.* DOE/EIS-0251. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20010724.0299.

103479	USN 1996	USN (U.S. Department of the Navy) 1996. *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants.* Washington, D.C.: U.S. Department of the Navy. ACC: MOL.20010726.0071.
146270	Weiner et al. 1991	Weiner, R.F.; LaPlante, P.A.; and Hageman, J.P. 1991. "An Approach to Assessing the Impacts of Incident-Free Transportation of Radioactive Materials: II. Highway Transportation." *Risk Analysis, 11*, (4), 661-666. New York, New York: Plenum Press. TIC: 236745.

9

Best Management Practices and Management Actions to Mitigate Potential Adverse Environmental Impacts

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9. BEST MANAGEMENT PRACTICES AND MANAGEMENT ACTIONS TO MITIGATE POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS

9.1 Introduction

This chapter describes *mitigation* measures that the U.S. Department of Energy (DOE or the Department) would implement to mitigate adverse *impacts* to the environment that could occur if the Department implemented the *Proposed Action* to construct, operate, monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

The Council on Environmental Quality defines mitigation as (40 CFR 1508.20):

> " (a) Avoiding the impact altogether by not taking a certain action or parts of an action.
>
> (b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
>
> (c) Rectifying the impact by repairing, rehabilitating, or restoring the *affected environment.*
>
> (d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
>
> (e) Compensating for the impact by replacing or providing substitute resources or environments."

The mitigation measures that DOE would implement fall into two categories: a general category called *best management practices* and a specific category called management actions. DOE has defined best management practices for this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (*Repository* SEIS) as the processes, techniques, procedures, or considerations it would employ to avoid or reduce the potential environmental impacts of its Proposed Action in a cost-effective manner while meeting the *Yucca Mountain Repository* project objectives. While best management practices are not regulatory requirements, they can overlap and support such requirements. Use of best management practices would not replace any local, state, or federal requirements. Best management practices are integral to the design, *construction,* and *operation* of the Yucca Mountain Repository, and the repository design incorporates them. Specific management actions DOE would take to mitigate potential adverse impacts of the Proposed Action include compliance with other government agency stipulations or specific guidance, coordination with government agencies or interested parties, implementation of DOE policy decisions, monitoring of relevant ongoing and future activities and, if appropriate, instituting corrective actions. Corrective actions would include, for instance, limiting the degree or magnitude of the action; reducing or eliminating the impact over time by preservation and maintenance operations; and repairing, rehabilitating, or restoring the affected environment.

The impact avoidance and reduction framework DOE has used in this Repository SEIS includes the following:

- As Chapter 2 discusses, the Proposed Action would adhere to U.S. Nuclear Regulatory Commission (NRC) safety requirements in 10 CFR Part 63 for the construction, operations, *monitoring*, and *closure* of a *geologic* repository and follow or exceed the requirements of 10 CFR Part 71 for the transportation of spent nuclear fuel and high-level *radioactive* waste. The incorporation of safety factors and controls in the engineering design and operational procedures would help prevent *accidents* and thereby minimize potential releases to the environment.

- As Chapters 4 and 6 discuss, DOE would implement best management practices to mitigate potential environmental impacts it identified for the Proposed Action.

- In this chapter, DOE summarizes best management practices and presents the management actions it would undertake to mitigate potentially adverse environmental impacts further.

- Chapter 10 presents unavoidable adverse impacts that would remain after DOE implemented best management practices and management actions.

9.2 Yucca Mountain Repository

DOE views the best management practices and management actions discussed in Sections 9.2.1 and 9.2.2, respectively, as representing the initial step in a longer-term, iterative process to further develop, detail, and eventually implement these practices and actions. The Department considers the process to be longer-term, in that the best management practices and management actions identified in this Repository SEIS would be further developed and detailed through (1) the regulatory compliance process, (2) development of the final design and associated specifications, and (3) consultation with directly affected parties. The process is iterative, in that DOE intends to consult with directly affected parties as the practices and actions advance from the conceptual to the more detailed, as engineering of the repository advances from preliminary through final design, and during implementation and monitoring of their effectiveness.

DOE based this process, in part, on the use of an adaptive management approach described herein as: consider the magnitude of potential impacts, mitigate, implement, monitor, and adapt. Using this approach, the Department could respond to unanticipated changes in local conditions or subsequently developed information, for example, and thus make cost-effective adjustments to its best management practices and management actions, as necessary. DOE developed a similar adaptive management approach as part of the *Nevada Test Site Resource Management Plan* (DIRS 103226-DOE 1998, all).

In undertaking this process, DOE would:

1. Consider the magnitude of potential adverse environmental impacts, based on the environmental conditions (affected environment) and analyses of this Repository SEIS;

2. Develop detailed best management practices and management actions in response to these adverse impacts. In this step, DOE would identify the desired outcome of these practices and actions and

identify associated performance measures by which it could determine the effectiveness of such practices and actions during their implementation;

3. Identify monitoring protocols to determine the effectiveness of these best management practices and management actions given the desired outcome. Before developing these protocols, DOE would undertake additional studies to further assess the then-current baseline conditions (affected environment), as appropriate. The protocols would be developed to distinguish between changes in conditions due to DOE's actions and those from other causes;

4. Consider the cost of implementation, as well as monitoring, when developing the final best management practices and management actions;

5. Determine the need to adapt or modify the best management practices and management actions, based on performance (outcome) monitoring, after such practices and actions have been implemented; and

6. Determine the extent to which the regulatory community and other directly affected parties find such mitigation measures and their associated monitoring protocols and performance measures to be acceptable.

DOE would undertake this mitigation process in consultation with federal, state, and local regulatory authorities having jurisdiction over the construction and operation of the proposed repository and *railroad*, and in consultation with directly affected parties. To that end, DOE is proposing to charter one or more Mitigation Advisory Boards, each to be led by the governmental entities through which the *rail line* would pass or in which it would construct and operate the repository. For example, as the situs county of the Proposed Action for this Repository SEIS, the Board for Nye County would provide advice on the development of mitigation measures for the construction, operations, monitoring, and closure of the Yucca Mountain Repository and the construction and operation of the railroad. DOE would determine in the future the exact construction of the Boards and the processes under which they would operate.

9.2.1 BEST MANAGEMENT PRACTICES

Chapter 9 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 9-1 to 9-30) (Yucca Mountain FEIS) presented mitigation measures DOE determined it would implement or identified for consideration to reduce potential impacts from the construction, operations, monitoring, and eventual closure of the proposed repository. This chapter summarizes, reorganizes, and incorporates by reference the mitigation measures presented in the FEIS. For this Repository SEIS, many of those mitigation measures are best management practices. Table 9-1 summarizes best management practices DOE has identified for this SEIS.

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository.

Environmental resource	Best management practice
Land use	• Reclaim lands disturbed during the construction process. • Reclaim lands disturbed by surface facilities as they become no longer necessary. • Restore disturbed areas to their approximate condition before repository construction; follow guidelines in DOE's *Reclamation Implementation Plan* (DIRS 154386-YMP 2001, all).
Air quality	• Reduce fugitive dust emissions using standard dust control measures (such as water spraying, chemical treatment, and wind fences). • Reduce maximum fugitive dust by minimizing activities that were near each other. • Use fossil-fuel vehicles that meet at least the Tier 3 emission standards. • Use air filters to reduce air emissions in waste handling buildings. • Inspect regularly and maintain construction equipment to ensure the proper operation of pollution control devices.
Surface water	• Minimize disturbance of surface areas and vegetation, thereby minimizing changes in surface-water flow and soil porosity that would change infiltration and runoff rates. • Minimize physical changes to drainage channels by building bridges or culverts where roadways would intersect areas of intermittent water flow. Perform hydrologic studies as necessary and design drainage structures to minimize erosion up- and downstream of these structures. • Use erosion and runoff control features such as proper placement of pipe, grading, and use of riprap to enhance the effectiveness of the bridges or culverts and minimize erosion and associated sediment transport. • Maintain natural contours to the maximum extent feasible, stabilize slopes, and avoid unnecessary off-road vehicle travel to minimize erosion. • In and near floodplains, follow reclamation guidelines. • Train employees in the handling, storage, distribution, and use of hazardous materials. • Manage hazardous materials in accordance with an approved Spill Prevention, Control, and Countermeasures Plan. • Conduct fueling operations and store hazardous materials and other chemicals in bermed areas or use other appropriate secondary containment to reduce the likelihood of inadvertent releases. • Store hazardous materials away from floodplains to decrease the probability of an inadvertent spill in these areas. • Maintain and move hazardous and mixed wastes in closed containers. • Select herbicide products (used for weed control) that would minimize impacts to water bodies and wildlife. • Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills. • Use sediment-trapping devices such as hay or straw bales, fabric fences, and devices to control water flow and discharge to trap sediments moved by runoff. • Prepare and submit a Storm Water Pollution Prevention Plan consistent with state and federal standards for construction activities. • Use measures to prevent runoff or floodwaters from reaching areas where they could contact contaminated surfaces or cause release of hazardous materials (such as constructing structures above specified flood elevations, designing facilities to withstand a specific flood event, or constructing stormwater ponds or diversion structures).

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository (continued).

Environmental resource	Best management practice
Surface water (continued)	• Remove structures and impermeable surfaces when no longer necessary and reclaim disturbed areas to help restore infiltration and runoff rates to near preconstruction conditions.
Groundwater	• Recycle water collected in subsurface areas for use in dust suppression and other activities. • Implement measures to minimize the potential for water use during operations that could interfere with waste isolation in the repository. • Minimize surface disturbance, thereby minimizing changes in surface-water flow and soil porosity that could change infiltration and runoff rates. • Monitor to detect and define unanticipated spills, releases, or similar events. • Construct evaporation ponds with synthetic liners and/or leak detection systems to prevent infiltration and potential groundwater contamination.
Biological resources and soils	• Develop and implement methods to control invasive species and noxious weeds on disturbed sites (including long-term topsoil stockpiles) during repository construction and operation. • Develop and implement a worker education program that would include training to prevent the intentional or unintentional take of sensitive or protected plant and animal species. • Conduct preconstruction surveys to ensure that work would not affect important biological resources and to determine the reclamation potential of sites. • Implement measures to relocate or avoid sensitive species. • Minimize groundbreaking or land-clearing activities in nesting habitat during the critical nesting period for migratory birds. If activities must occur during the nesting season, conduct surveys for migratory bird nests before initiating those activities. Prohibit activities that would harm nesting migratory birds or result in nest abandonment. • Before ground-disturbing activities, collect data to plan for the restoration of disturbed areas and minimize impacts to sensitive habitats. • Phase construction to the extent practicable. Limit grading activities to the phase immediately under construction and limit ground disturbance to areas necessary for project-related construction activities. • Reduce side slopes of evaporation and stormwater ponds or construct a ramp in the ponds to minimize loss of animals that could become trapped due to depth of water or steep slopes. • Cover sanitary waste in landfills frequently to minimize use by scavenger species. • Stockpile topsoil removed during construction activities for use during reclamation efforts. • Stabilize stockpiled topsoil to prevent erosion by reestablishing vegetation. • Conduct measures to reclaim disturbed areas that could include backfilling and grading to restore natural drainage patterns and create a stable landform; spreading and contouring stockpiled topsoil; creating erosion-control structures; ripping, seeding, spreading, and anchoring mulch; and fencing to reduce loss of new vegetation to herbivores.

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository (continued).

Environmental resource	Best management practice
Cultural resources	• Ensure that onsite employees complete cultural resource sensitivity and protection training to reduce the potential for intentional or accidental harm to sites or artifacts. Work with American Indian tribes to involve tribal representatives in the training. • Conduct preconstruction surveys to ensure that work would not affect important archaeological resources and to determine the research potential of sites. Work with American Indian tribes to involve tribal monitors in survey activities. • If construction could threaten important archaeological resources, and modification or relocation of roads or structures would not be reasonable, develop appropriate mitigation measures.
Occupational and public health and safety	• Use ventilation to keep radon levels low in subsurface areas. • Design and operate the ventilation system to control ambient air velocities to minimize dust resuspension. • Use engineering controls during subsurface work to control exposures of workers to silica dust, including the use of dust shields and air curtains on tunnel boring machines, water sprays and atomizing nozzles, isolated work areas, air stream scrubbing, and provision of fresh air to work areas through duct lines. • Use administrative controls such as access restrictions or respiratory protection if dust concentrations exceeded applicable limits for cristobalite until engineering controls could establish acceptable conditions. • Avoid erionite-bearing strata where practicable during repository construction and drift development. • If drilling encountered erionite, close operations in potentially affected areas until proper engineering controls were in place; controls for exposure to silica dust would apply to potential exposure to erionite. • Use monitoring devices and respirators with high-efficiency particulate air filters as appropriate. • Design task procedures to reduce the potential for accidents. • Implement health and safety procedures and administrative controls to minimize risks to construction and operations workers. • Develop and implement emergency response plans for use during construction and operations. • Develop and implement an Ordnance and Explosives Safety Construction Support Program applicable to construction activities. Include ordnance and explosives training for all construction personnel working in the areas designated by the U.S. Department of Defense as being at risk of containing unexploded ordnance. • Employ unexploded ordnance technicians to screen areas identified as having a potential for unexploded ordnance before allowing workers to conduct field surveys or construction work in such areas.
Noise	• Use noise suppressors on ventilation fans to maintain noise levels below recommended exposure limits. • Use engineering controls to control noise levels during construction. • Regularly inspect and maintain construction equipment to ensure that noise-control devices were in good working condition. • Use personal hearing protection as necessary to supplement engineering controls.
Aesthetics	• Use exterior lighting only where necessary to accomplish facility tasks. • Limit the height of exterior lighting units. • Use shielded or directional lighting to limit the effects of the lighting to areas where it is necessary.

Table 9-1. Summary of best management practices for potential environmental impacts of the proposed repository (continued).

Environmental resource	Best management practice
Utilities, energy, and materials	• Implement procedures and equipment that would minimize the use of utility services, energy, and materials. • Incorporate high-performance and sustainable building criteria into the design and construction of nonnuclear facilities.
Waste and hazardous materials	• Implement a Pollution Prevention/Waste Minimization Program (and include it in DOE's Environmental Management System) that would evaluate methods to eliminate, reduce, or minimize the amounts of hazardous materials used and hazardous wastes generated. • Recycle wastewater to reduce the amount of water necessary for repository facilities and the amount of wastewater that could require disposal. • Use decontamination techniques that would reduce waste generation in comparison with other techniques. • Collect and sample wastewater from surface facilities (such as floor and equipment drains) and water from the emplacement side of the subsurface to determine proper management and disposal. • Use evaporation ponds and oil-water separators to reduce wastewater volumes. • Institute preventive maintenance and inventory management programs to minimize waste from breakdowns and overstocking. • When practicable, recycle nonradioactive materials such as paper, plastic, glass, nonferrous metals, steel, fluorescent bulbs, shipping containers, oils, and lubricants rather than dispose of them. • Encourage the reuse of materials and the use of recycled materials. • Avoid use of hazardous materials where feasible. • Update DOE's *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all) to include actions DOE would take during repository construction and operation to prevent, control, and remediate spills of petroleum products and other hazardous materials and reporting requirements for a spill or release. • Ensure that equipment is available to respond to spills and identify the location of such equipment. • Dispose of drill cuttings through land application. • Inspect and replace worn or damaged components. • Salvage extra materials and use for other construction activities or for regrading activities.

DOE = U.S. Department of Energy.

9.2.2 MANAGEMENT ACTIONS

DOE is firmly committed to its implementation of sound stewardship practices that are protective of air, water, land, and cultural and ecological resources that repository activities could affect. DOE would accomplish its commitment through implementation of the Environmental Management System, which is part of its Integrated Safety Management System at the Yucca Mountain Project site. This structured approach to adaptive management through monitoring is currently an active part of DOE's management structure; DOE would continue this practice throughout the Proposed Action.

The Council on Environmental Quality recognizes the benefits of aligning the complementary processes of the *National Environmental Policy Act* (NEPA) and an environmental management system and encourages federal agencies to do so where appropriate (DIRS 185325-CEQ 2007, all). The Council states that an environmental management system can improve the NEPA process by supporting an adaptive management approach for projects that face uncertain or unforeseen conditions during

implementation. Taking advantage of the complementary elements of these two processes can help managers make decisions more effectively, reduce environmental impacts, and further NEPA policy goals and processes.

DOE encourages the integration of NEPA and environmental management systems and would continue to do so as part of the Proposed Action. The structure of the Integrated Safety Management System/ Environmental Management System fully supports mitigation of impacts DOE has identified in this Repository SEIS. For example, as part of the planning process DOE would establish measurable environmental objectives and set measurable goals and targets (such as pollution prevention goals for reductions in waste generation). DOE would then implement programs, procedures, and controls for monitoring and measuring progress; document progress; and, if appropriate, institute corrective actions.

This section identifies management actions that DOE would use upon implementation of the Proposed Action, including actions it currently uses as part of the Yucca Mountain Project Environmental Management System.

To minimize potential impacts from the Proposed Action, DOE would prepare a Mitigation Action Plan that identified specific commitments for mitigation of adverse environmental impacts due to the Proposed Action. The plan would describe specific actions DOE would take to implement mitigation commitments and would reflect available information about the course of action. DOE could revise this plan as more specific and detailed information became available. The Mitigation Action Plan would incorporate all practicable measures to avoid or minimize adverse environmental and human health impacts that could result from the Proposed Action and would include the Environmental Management System. The Mitigation Action Plan would contain:

- An introduction describing the basis, function, and organization of the plan,
- A summary of the impacts DOE would mitigate,
- A description of specific mitigation measures,
- A description of the Mitigation Action Plan monitoring and reporting system DOE would implement to ensure that it met elements of the plan and that those elements were effective, and
- A schedule for actions and identification of the responsible parties.

DOE would develop the Mitigation Action Plan for the repository in consultation with the proposed Mitigation Advisory Board for Nye County.

DOE would conduct monitoring activities during all phases of the project to ensure the appropriate implementation of the Proposed Action and to ensure mitigation of impacts. The following are examples of activities DOE would perform:

- Conduct the Performance Confirmation Program, which would consist of a focused program of tests, experiments, and analyses during all analytical periods of the repository project, to monitor repository conditions, assess the adequacy of the geotechnical and design parameters, and preserve the ability to

perform waste retrieval, if necessary. The Performance Confirmation Program would continue until *permanent closure* of the repository.

- Monitor *groundwater* quality, air emissions, and the repository workplace to ensure worker safety and other aspects of project interaction with the natural and human environment.

- Conduct cultural resource monitoring as appropriate before and during surface disturbance activities to identify and assess the potential for impacts to previously unidentified archaeological resources.

- Monitor reclaimed lands to determine if reclamation efforts were successful following guidance in DOE's *Reclamation Implementation Plan* (DIRS 154386-YMP 2001, all).

- Monitor emplaced waste in the repository starting with the first waste package *emplacement* and continuing through closure.

- After completion of emplacement, continue to monitor and inspect *waste packages* and continue performance activities.

- After sealing the repository openings, conduct *postclosure* monitoring to ensure acceptable repository performance. Define details of this program during processing of the license amendment for repository closure.

DOE currently uses the following measures as part of its Environmental Management System and would continue to use them upon implementation of the Proposed Action:

- Provide assistance to state or local governments to mitigate economic, social, public health and safety, and environmental impacts under Section 116(c) of the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.).

- Observe all terms and conditions, reporting requirements, and conservation recommendations in the U.S. Fish and Wildlife Service Final Biological Opinion (DIRS 155970-DOE 2002, Appendix O), which includes five reasonable and prudent measures to minimize impacts to the desert tortoise and 18 terms and conditions with which DOE must comply to implement the five measures.

- Continue the Yucca Mountain Project Native American Interaction Program, which has been in existence since 1985, to promote a government-to-government relationship with American Indian tribes and to concentrate on the continued protection of important cultural resources.

- Continue to abide by Section 106 of the *National Historic Preservation Act* (16 U.S.C. 470 et seq.) process during negotiation of the draft programmatic agreement among DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Office.

In addition, DOE has identified the following management actions it would implement as part of the Proposed Action:

- The Bureau of Land Management would conduct mineral examinations to assess valid existing rights in all mining claims within the lands subject to permanent legislative withdrawal. DOE would provide just compensation for the acquisition of such valid property rights.

- DOE would continue to work with the U.S. Air Force to accommodate its need to fly through the Nevada Test Site airspace. The Department would authorize specific Air Force activities over the repository consistent with the repository safety analysis. DOE would continue to allow military flights over the repository by fixed-wing aircraft with the following restrictions: (1) a maximum of 1,000 flights per year above 4,300 meters (14,000 feet) above mean sea level altitude; (2) a prohibition of maneuvering of aircraft—flight is to be straight and level; (3) a prohibition of carrying ordnance over the flight-restricted airspace; and (4) a prohibition of electronic jamming activity over the flight restricted airspace.

- Before any ground-disturbing activities, DOE would identify geodetic control monuments in areas that could be disturbed. The Department would notify the Office of the Director of the National Oceanic and Atmospheric Administration, National Geodetic Survey no less than 90 days before planned activities that could disturb or destroy a monument. If a geodetic control monument required relocation, DOE would consult with the Administration to develop a mitigation measure that could include compensation for the cost of monument relocation.

- DOE would conduct a formal delineation of waters of the United States in the vicinity of the proposed repository surface facilities and, if necessary, develop a plan to avoid when practicable and otherwise minimize impacts to those waters. If repository activities would affect waters of the United States, DOE would consult with the U.S. Army Corps of Engineers and obtain permit coverage for those impacts. If the activities were not covered under a nationwide permit, DOE would apply to the Corps of Engineers for a regional or individual permit.

- DOE would work closely with the Nevada Department of Transportation if it was necessary to implement mitigative actions along U.S. Highway 95 near the intersection with Nevada State Route 373 and Gate 510 to the Nevada Test Site. As discussed in Chapter 6, Section 6.4.3 of this Repository SEIS, an increase in traffic due to the Proposed Action could affect traffic conditions in this area, resulting in a decrease in the level of service [from a baseline level of service “B” (almost free flow conditions) to a level of service “D” (high-density but still stable conditions)]. Widening U.S. Highway 95 to four lanes could improve the level of service. While widening of the highway could be an effective mitigation measure, such action would be the responsibility of the Nevada Department of Transportation. Implementation of this type of mitigation action (that is, widening U.S. Highway 95) would require further NEPA review. That NEPA documentation would include an evaluation of environmental impacts from the action and mitigation measures that could be necessary as a result of its implementation.

9.2.3 NYE COUNTY PERSPECTIVE ON MANAGEMENT ACTIONS TO MITIGATE POTENTIAL ADVERSE IMPACTS

This section presents the viewpoint of Nye County as a cooperating agency and the situs county of the Proposed Action of this Repository SEIS.

As discussed in the Nye County Viewpoint in Chapter 8, Section 8.6.2, the County believes that the majority of the direct, indirect, and *cumulative impacts* of past and ongoing federal actions, as well as those incremental impacts that can be reasonably expected to occur if the Proposed Action is implemented, can be effectively mitigated. Even the groundwater *contamination* that resulted from nuclear testing, although not directly remediable, can be addressed through management actions. It is imperative from Nye County's perspective, however, that the Repository SEIS clearly identify the full spectrum of appropriate mitigation measures, whether or not DOE has the jurisdictional authority for implementation of the mitigation measures.

Nye County believes that DOE's evaluation in this Repository SEIS of potential impacts from the Proposed Action has been adequately rigorous. Because of differences in perspective between DOE and Nye County, however, coupled with uncertainty about future conditions, the County believes that the conclusions about potential impacts presented in this SEIS should be continuously assessed and evaluated through an appropriate monitoring program.

Nye County believes that the most prudent course of action, should the Proposed Action be implemented, would be to include an aggressive and comprehensive program of environmental monitoring, including monitoring of socioeconomic factors. As the local jurisdiction affected by the Proposed Action and as a cooperating agency in the preparation of this Repository SEIS, Nye County's view is that there is mutual benefit for the federal and local government in partnering to monitor, assess, and evaluate conditions at and around the repository site as repository-related activities take place. In this way, Nye County can assist DOE in the identification of any potential impacts, whether significant or not, and cooperatively develop effective and efficient mitigations, as appropriate, through ongoing adaptive management.

The Council on Environmental Quality's NEPA Task Force, in *Modernizing NEPA Implementation* (DIRS 185310-CEQ 2003, all), recommended the use of an adaptive management approach (predict, mitigate, implement, monitor, and adapt). DOE can take action with an adaptive management plan in place to account for unanticipated changes in local conditions or subsequent information that might affect the original environmental and socioeconomic conclusions that were presented in this Repository SEIS. Using the recommended adaptive management approach, DOE would be able to make cost-saving adjustments when the Proposed Action and mitigation strategies are implemented. The ability to adjust when necessary, and to have a strategy in place for such adjustments, would provide management flexibility when constraints and opportunities are encountered.

The adaptive management plan would be designed and implemented as part of the Proposed Action. As indicated by its title, the plan is meant to be "adaptive." The plan would be modified, if necessary, to address inefficiencies in approach or changes in environmental and socioeconomic conditions. Monitoring data collected as part of the planned activities would be analyzed and reviewed regularly to ensure early detection of potential issues.

The initial adaptive management plan would be based on the existing environmental conditions described in this Repository SEIS and the current knowledge of resources in the vicinity of the repository. The initial plan would be focused on the establishment of environmental and socioeconomic baseline conditions and management of the monitoring and mitigation activities associated with the Yucca Mountain Repository. It would specifically address the management of monitoring and mitigation activities associated with construction and operation of the repository and related facilities, while

recognizing the need for identification of non-repository-related environmental and socioeconomic stressors that could exacerbate potential repository-related impacts.

Nye County proposes to constructively engage DOE to assist in identifying the resource areas that it believes will be susceptible to further impacts. Such identification would be based on the County's perspective on cumulative impacts as presented in Chapter 8, Section 8.6.2, and on the results of DOE's analyses presented in the body and appendices of this Repository SEIS. Nye County believes that such mutual consultation and cooperation should be documented through formal agreements. Nye County also believes that it would be beneficial to both DOE and the County if the adaptive management approaches for both rail and repository activities in Nye County were integrated.

With a memorandum of understanding/consultation and cooperation agreement (NWPA Section 117), Nye County will assist DOE in the identification of environmental and socioeconomic impacts and their significance, and then cooperatively plan and develop effective mitigation measures. Some mitigation measures need to be started several years before the Yucca Mountain Project starts (for example, road construction and worker training programs). As the situs jurisdiction for the Yucca Mountain Project, Nye County has a tremendous stake in the NEPA process and will continue to participate as a cooperating agency and protect the safety, environmental values, and economic well-being of the residents of Nye County.

9.3 Transportation

Transportation-related mitigation measures that DOE identified in the Yucca Mountain FEIS included measures for national transportation impacts and State of Nevada transportation impacts. Since completion of the FEIS, DOE issued a policy statement for waste *shipments* to Yucca Mountain. Chapter 2, Sections 2.1.7.2 and 2.1.7.3 and Chapter 6 of this Repository SEIS discuss this in detail. Briefly, DOE would use *dedicated trains* for most waste shipments and thereby derive benefits in safety, security, cost, and operations. DOE has updated the mitigation measures with the measures in Chapter 6 of this SEIS and in the Rail Alignment EIS. The following sections discuss the best management practices and mitigation measures for national and Nevada transportation activities.

9.3.1 NATIONAL TRANSPORTATION

As Chapter 6 of this Repository SEIS describes, potential impacts from national transportation activities would occur primarily to occupational and public health and safety. Because the Proposed Action shipments would represent a relatively small incremental increase in national highway or rail traffic, they would have little or no measurable impacts on other resource areas. Therefore, the best management practices DOE implemented during the proposed transportation of spent nuclear fuel and high-level radioactive waste would be those that improved the protection of workers and the public. Appendix H of this SEIS includes detailed descriptions of supplemental information about transportation activities for the Proposed Action. This information includes discussions of transportation regulations, operational practices, *cask* safety and testing programs, emergency response, security, and liability.

As indicated in the Yucca Mountain FEIS, Section 180(c) of the NWPA requires DOE to provide technical assistance and funds to states for training local government and American Indian tribal public safety officials through whose jurisdictions DOE could plan to transport spent nuclear fuel or high-level radioactive waste. As a specific management action to mitigate impacts, DOE would provide such

training. The training would cover procedures for safe, routine transportation and for emergency response situations.

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows the U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any future rules that Congress, the Department of Transportation, or the NRC might establish. For example, as discussed in Section 6.3.4 of this Repository SEIS, the NRC has promulgated rules (10 CFR 73.37) and interim compensatory measures (67 FR 63167, October 10, 2002) specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. The purposes of these security measures are to minimize the possibility of sabotage and to facilitate recovery of spent nuclear fuel shipments that could come under the control of unauthorized persons. These measures include the use of armed escorts to accompany all shipments, safeguarding of the detailed shipping schedule information, monitoring of shipments through satellite tracking and a communication center with 24-hour staffing, and coordination of logistics with state and local law enforcement agencies, all of which would contribute to shipment security. The Department has committed to follow these rules and measures (see 69 FR 18557, April 8, 2004).

9.3.2 NEVADA TRANSPORTATION

Chapter 7 of the Rail Alignment EIS presents information about best management practices and mitigation in relation to the construction and operation of a railroad in Nevada. It presents information from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental consequence and mitigation analyses. DOE incorporates by reference the best management practices and mitigation measures in Chapter 7 for the construction and operation of a railroad in Nevada.

DOE would use an adaptive management approach, similar to the approach described in Section 9.2 of this Repository SEIS, to further develop and detail the best management practices and mitigation measures identified in Chapter 7 of the Rail Alignment EIS. In addition, the Department proposes to charter Mitigation Advisory Boards to assist in these efforts.

The Rail Alignment EIS discusses best management practices and mitigation measures related to transportation along the proposed rail line in the Caliente or Mina rail corridor. The EIS does not include practices or measures for transportation along other rail lines in Nevada (that is, along rail lines from the Nevada border to the beginning of the Caliente or Mina rail corridors). Rather, the transportation-related best management practices and management actions that DOE discusses in Section 9.3.1 of this Repository SEIS for national transportation would apply to the transport of spent nuclear fuel and high-level radioactive waste along other rail lines or highways in Nevada.

REFERENCES

185310 CEQ 2003 — CEQ (Council on Environmental Quality) 2003. *The NEPA Task Force Report to the Council on Environmental Quality, Modernizing NEPA Implementation*. Washington, D.C.: Council on Environmental Quality. ACC: MOL.20080414.0051.

185325	CEQ 2007	CEQ (Council on Environmental Quality) 2007. *Aligning National Environmental Policy Act Processes with Environmental Management Systems: A Guide for NEPA and EMS Practitioners.* Washington, D.C.: Council on Environmental Quality. ACC: MOL.20080429.0002.
103226	DOE 1998	DOE (U.S. Department of Energy) 1998. *Nevada Test Site Resource Management Plan.* DOE/NV-518. Las Vegas, Nevada: U.S. Department of Energy. ACC: MOL.20010731.0305.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
172055	DOE 2004	DOE (U.S. Department of Energy) 2004. *Spill Prevention, Control, and Countermeasures Plan for Site Activities.* BAB000000-01717-4600-00009 Rev 02. Las Vegas, Nevada: U.S. Department of Energy, Office or Repository Development. ACC: DOC.20040329.0003.
154386	YMP 2001	YMP (Yucca Mountain Site Characterization Project) 2001. *Reclamation Implementation Plan.* YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

10

Unavoidable Adverse Impacts; Short-Term Uses and Long-Term Productivity; and Irreversible or Irretrievable Commitment of Resources

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10. UNAVOIDABLE ADVERSE IMPACTS; SHORT-TERM USES AND LONG-TERM PRODUCTIVITY; AND IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

The *construction*, *operations, monitoring*, and eventual *closure* of the proposed *Yucca Mountain Repository* and the associated transportation of *spent nuclear fuel* and *high-level radioactive waste* could produce some environmental *impacts* that the U.S. Department of Energy (DOE or the Department) could not mitigate. Similarly, some aspects of the *Proposed Action* could affect the long-term productivity of the environment or would require the permanent use of some resources. This chapter discusses unavoidable adverse impacts, the relationship between short-term uses and long-term productivity, and irreversible or irretrievable commitment of resources.

In keeping with previous chapters of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS), this chapter contains discussions of the *repository*, national transportation, and transportation in the State of Nevada. This chapter summarizes, incorporates by reference, and updates Chapter 10 of the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, pp. 10-1 to 10-14) (Yucca Mountain FEIS). This chapter also incorporates by reference the information presented in Chapter 8 of the Rail Alignment EIS.

10.1 Unavoidable Adverse Impacts

This section summarizes potential impacts due to the Proposed Action that would be unavoidable and adverse and that would remain after DOE implemented *best management practices* and *mitigation* measures, which are discussed in Chapters 4, 6, and 9 of this Repository SEIS, and references Chapter 8 of the Rail Alignment EIS.

10.1.1 YUCCA MOUNTAIN REPOSITORY

This section summarizes unavoidable adverse impacts from the construction, operations, monitoring, and closure of the proposed repository. This Repository SEIS provides estimated potential environmental impacts in Chapter 4, Section 4.1. Adverse impacts that would remain after implementation of best management practices and the institution of management action mitigation measures are unavoidable adverse impacts.

10.1.1.1 Land Use

To develop a repository at Yucca Mountain, DOE would have to obtain permanent control of the geologic repository operations area, currently under the control of DOE (National Nuclear Security Administration), the U.S. Department of Defense (U.S. Air Force), and the U.S. Department of the Interior (Bureau of Land Management). This would require congressional action. The geologic repository operations area would occupy a small portion of a larger area [600 square kilometers (230 square miles or approximately 150,000 acres)], which would include a buffer zone.

As Chapter 4, Section 4.1.1 discusses, DOE would disturb or clear land for *subsurface* and surface facility activities during the construction and operations analytical periods. The total land disturbance for the proposed repository would be approximately 9 square kilometers (2,200 acres), which would include land inside and outside the *analyzed land withdrawal area*.

10.1.1.2 Air Quality

Construction, operations, monitoring, and closure of a repository at Yucca Mountain would produce small impacts to regional *air quality*. During the construction analytical period, land disturbance and rock excavation would produce *fugitive dust* emissions, as would the operation of concrete batch plants (Chapter 4, Section 4.1.2). DOE would control most of these emissions with dust suppression methods. During the construction and operations analytical periods, construction equipment and other machinery would emit *nitrogen dioxide*, *sulfur dioxide*, and carbon monoxide. Exposures of maximally exposed individuals of the public to these *criteria pollutants* would be a small fraction of applicable regulatory limits. Other impacts would come from materials such as cristobalite. Chapter 4, Section 4.1.2 discusses emission of cristobalite particles from the subsurface exhaust ventilation system during excavation operations and as fugitive dust from the excavated rock storage pile.

10.1.1.3 Hydrology

As Chapter 4, Section 4.1.3 notes, repository construction and operation would result in minor changes to runoff and infiltration rates and minimal alteration of natural surface-water drainage channels. Repository activity would result in the unavoidable crossing of washes and their associated *floodplains*. The potential for flooding that could cause damage would be small.

Potential *contaminants* that could spill during construction would consist mostly of fuels (diesel, propane, and gasoline) and lubricants (oils and grease) for equipment. DOE would construct and install fuel storage tanks early in the construction analytical period with appropriate secondary containment. Other potential contaminants such as paints, solvents, strippers, and concrete additives would be present in small quantities. DOE would minimize the potential for spills to occur and, if they occurred, would minimize *contamination* by following its *Spill Prevention, Control, and Countermeasures Plan for Site Activities* (DIRS 172055-DOE 2004, all), which would be updated for repository construction.

DOE would withdraw *groundwater* during the construction and operations analytical periods. The highest annual water demand for the Proposed Action would be below the Nevada State Engineer's ruling of perennial yield (the amount that can be withdrawn annually without depleting reserves) for the *Jackass Flats hydrographic area* (DIRS 105034-Turnipseed 1992, pp. 9 and 12). The Proposed Action would withdraw groundwater that would otherwise move into *aquifers* of the *Amargosa Desert*, but the combined water demand for the repository and Nevada Test Site activities in Jackass Flats would, at most, have small impacts on the availability of groundwater in the Amargosa Desert area in comparison with the quantities of water already being withdrawn there.

10.1.1.4 Biological Resources and Soils

As Chapter 4, Section 4.1.4 notes, the construction of surface facilities and the disposition of excavated rock from subsurface construction would remove or alter vegetation in the analyzed land withdrawal area and within the 37-square-kilometer (9,100-acre) offsite area directly to the south. Removal of vegetation

would result in impacts to small amounts of widely distributed land cover types that are not under-represented in the affected area. The largest losses would be to the Sonora-Mojave Creosotebush-White Bursage Desert Scrub and Sonora-Mojave Mixed Salt Desert Scrub, with disturbance of approximately 0.25 percent and 0.15 percent of these land cover types in the affected areas, respectively. The removal of vegetation could result in colonization by invasive plant species, which could suppress *native species*. DOE would use reclamation methods that would reduce the likelihood that *invasive species* would overtake species on reclaimed lands.

Direct impacts to biological resources would occur through: (1) loss of *habitat* from construction of facilities and infrastructure; (2) localized deaths of individuals of some species, particularly burrowing species of small mammals and reptiles during land disturbances, and deaths of individual animals from vehicle collisions; (3) fragmentation of undisturbed habitat that could create a *barrier* to the movement of individual species; and (4) displacement of wildlife because of an aversion to the noise and activity of construction, operations, monitoring, and closure of the repository. DOE anticipates that the effect of the impacts to biological resources would be small because habitats similar to those at Yucca Mountain are widespread locally and regionally. The species that occur at the site are generally widespread throughout the Mojave or *Great Basin* deserts, and the deaths of some individuals due to proposed repository activities would have a small impact on the regional populations of those species or on the overall biodiversity of the region. Large areas of undisturbed and unfragmented habitat would be available away from disturbed areas and impacts to wildlife from noise and vibration would occur only near the source of the noise.

The desert tortoise is the only species in the analyzed land withdrawal area listed as threatened under the *Endangered Species Act*, as amended (16 U.S.C. 1531 et seq.). There are no endangered or *candidate species* and no species that are proposed for listing. Repository construction would result in the loss of a small portion of the desert tortoise habitat at the northern edge of its range in an area where the abundance of desert tortoises is low.

Several species that are classified as sensitive by the Bureau of Land Management occur in the *region of influence*. Impacts to bat species would be small because of their low abundance on the site and broad distribution. Impacts to the common chuckwalla and Western burrowing owl from disturbance and loss of individuals would be small because they are widespread regionally and are not abundant in the land withdrawal area. Impacts to the Western red-tailed skink would be small because it is widespread regionally and occupies small pockets of isolated habitat that would not be overly affected by any proposed disturbances. One species of insect, Giuliani's dune scarab beetle, has been reported only in the southern portion of the analyzed land withdrawal area away from any proposed disturbances, and therefore would not be affected.

Construction and operation activities at the proposed repository would disturb land and expose bare soil to wind and water erosion. Studies during Yucca Mountain *site characterization* work and experience at the Nevada Test Site indicate that natural succession on disturbed, semiarid land would be a very slow process (Chapter 4, Section 4.1.4.3.2). Soil recovery would be unlikely without reclamation. DOE is committed to reclamation of disturbed areas.

10.1.1.5 Cultural Resources

In the Yucca Mountain FEIS, DOE provided a summary of the American Indian view of cultural resource management and preservation. In the view of American Indians, the implementation of the Proposed Action would further degrade the environmental setting. Even after closure and reclamation, the presence of the repository would, from the perspective of American Indians, represent an irreversible impact to traditional lands. That perspective in the context of this section would therefore indicate that any action would result in unavoidable adverse impacts.

Some unavoidable adverse impacts could occur to archaeological sites and other cultural resources. There could be a loss of archaeological information due to illicit artifact collection. In addition, excavation activities could cause a loss of archaeological information. Chapter 4, Section 4.1.5 discusses impacts to cultural resources in the region of influence.

10.1.1.6 Socioeconomics

The construction and operation of a repository at Yucca Mountain would result in increased employment and population, which would place increased demands on housing and public services such as public safety and schools (Chapter 4, Section 4.1.6), particularly in Nye County and other locations in the region of influence where the populations are smaller and existing infrastructure is less developed. However, the increases, in southern Nevada as a whole and the metropolitan Las Vegas area in particular, would be small in comparison with *total employment*, population, *real disposable personal income*, *Gross Regional Product*, and state and local government spending in the region of influence.

For the five socioeconomic parameters DOE evaluated for this Repository SEIS, the changes in economic parameters would increase by less than 1 percent over the projected baseline values (Chapter 3, Section 3.1.7). The less-than-1-percent estimate assumes historical residential patterns. The potential impacts could be greater than a 1-percent change over baseline for communities in Nye County and elsewhere in the region of influence if more of the onsite workers and their families chose to live outside the Las Vegas/Clark County area.

Chapter 9, Section 9.2.3 provides Nye County's perspective on management actions to mitigate potential adverse impacts. This section presents the County's viewpoint as a cooperating agency and the situs county of the Proposed Action for this Repository SEIS.

10.1.1.7 Occupational and Public Health and Safety

There would be a potential for injuries or fatalities to workers from the construction, operations, monitoring, and closure of the proposed repository due to common industrial *accidents* and inhalation of cristobalite and *erionite*. In addition, during the construction analytical period, workers could encounter unexploded ordnance at some surface locations. Engineering controls, administrative controls, and training and safety programs would reduce but not eliminate the potential for worker injuries or fatalities. Chapter 4, Section 4.1.7.1 discusses nonradiological occupational and public health and safety issues.

Chapter 4, Section 4.1.7.2 discusses potential radiological impacts to workers and the public. The types of potential health and safety impacts to workers during the construction analytical period would include those from exposure to naturally occurring radionuclides (primarily radon-222 and its decay products).

Engineering controls and training and safety programs would reduce but not eliminate the potential. During the operations analytical period, radiological impacts to workers could occur during the receipt, handling, aging, and *emplacement* of spent nuclear fuel and high-level *radioactive* waste and continued development of the subsurface facility. Monitoring of emplaced *waste packages* and closure activities would also result in some exposures.

Members of the public could be exposed to airborne releases of radon-222 and its decay products from the subsurface exhaust ventilation air throughout the construction, operations, monitoring, and closure analytical periods. Table 4-24 lists the estimated individual *risk* of contracting a latent *cancer* for the maximally exposed member of the public and the exposed population within 84 kilometers (52 miles) of the repository for all analytical periods of the project (construction, operations, monitoring, and closure).

10.1.1.8 Utilities, Energy, Materials, and Site Services

The construction, operations, monitoring, and closure of a repository at Yucca Mountain would result in the unavoidable use of energy (mostly electricity and petroleum products) and material (mostly cement, steel, and copper). In addition, DOE would consume nickel, palladium, and titanium in the manufacture of repository components. The consumption of energy and construction material (cement, steel, and copper) would not be large enough to affect national or regional supplies. The consumption of nickel, palladium, and titanium would have a moderate affect on supply but could be supported by U.S. and world markets. Chapter 4, Section 4.1.11 lists the amounts of resources the Proposed Action would consume. Chapter 4, Section 4.1.14 presents information on the quantities of materials required for the manufacture of repository components, such as the palladium and titanium required for *drip shields*.

In relation to site services, DOE would respond to and mitigate most onsite incidents, which would include underground incidents, without outside support (Chapter 4, Section 4.1.11.6). The Fire, Rescue and Medical Facility would provide space for fire protection, firefighting services, underground rescue services, emergency and occupational medical services, and *radiation* protection. A helicopter pad would enable emergency medical evacuations. DOE would coordinate the operation of this facility with facilities in Nye County and at the Nevada Test Site to increase response capabilities.

Traffic volumes along U.S. Highway 95 would increase as a result of repository construction and operation. Increased traffic could result in more accidents, which could affect Nye County law enforcement and emergency services.

10.1.2 NATIONAL TRANSPORTATION

Chapter 6 identifies the following unavoidable impacts from the transport of spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to a siding for the Caliente or Mina *rail corridor*.

10.1.2.1 Occupational and Public Health and Safety

Certain adverse impacts to workers and the public from the transportation of spent nuclear fuel and high-level radioactive waste would be unavoidable. The loading and transportation of these materials would have the potential to affect workers and the public through industrial accidents, exposure to radiation and vehicle emissions, and traffic accidents.

10.1.2.1.1 *Impacts from Loading Canisters at Generator Sites*

DOE estimated the following impacts could occur from loading activities at the generator sites:

- About 1.2 traffic fatalities and about 0.23 fatality from vehicle emissions would result from shipping about 6,500 empty *transportation, aging, and disposal* (TAD) *canisters* and 4,900 campaign kits to generator sites. Chapter 6, Section 6.2.1 presents a discussion of the transportation of canisters to generator sites.

- The *population dose* to members of the public within 16 kilometers (10 miles) of the generator sites would be 2.9 *person-rem* over the duration of loading operations. In the exposed population, the estimated *probability* of a *latent cancer fatality* would be 0.0017 or about 1 chance in 600. The estimated radiation *dose* to the maximally exposed member of the public 800 meters (0.5 mile) from a generator site would be 7.7×10^{-6} *rem*. The estimated probability of a latent cancer fatality for this individual would be 4.6×10^{-9} or about 1 chance in 200 million.

- The collective radiation dose for workers who performed loading activities would be 10,000 person-rem. In the exposed population of workers, this radiation dose would result in 6.0 latent cancer fatalities.

10.1.2.1.2 *Incident-Free Transportation*

DOE estimated the following impacts could occur from *incident-free* transportation of spent nuclear fuel and high-level radioactive waste to Nevada:

- About 4 latent cancer fatalities could occur in the population of transportation workers who would be exposed to radiation from the *shipments*. Because many workers would be involved, the risk for an individual worker would be small.

- There would be about 1 (0.7) latent cancer fatality among members of the public who would be exposed to radiation. Because this estimate is for the entire population of individuals who would be exposed along the transportation routes over the course of shipments to the repository, the risk for a single individual would be small.

- The number of vehicles bound for Yucca Mountain would be small in relation to normal traffic volume, which would result in a small impact on air quality.

10.1.3 NEVADA TRANSPORTATION

Chapter 8 of the Rail Alignment EIS and Chapter 10, Section 10.1.3 of the Yucca Mountain FEIS present information about unavoidable adverse impacts related to the construction and operation of a *railroad* in Nevada. Chapter 8 presents information drawn from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental impacts and mitigation analyses. The chapter addresses all environmental resource categories with an emphasis on those that could experience unavoidable adverse impacts.

10.2 Relationship Between Short-Term Uses and Long-Term Productivity

The Proposed Action would require short-term uses of the environment that would affect long-term environmental productivity. This section describes possible impacts to long-term productivity from those short-term uses.

This Repository SEIS identified two distinct periods for the evaluation of the use of the environment by the Proposed Action:

- A 105-year period for surface activities that would consist of construction, operations, monitoring, and closure of the proposed repository. DOE activities during this period would include construction of facilities, receipt and emplacement of spent nuclear fuel and high-level radioactive waste, recovery of recyclable materials, ventilation of subsurface emplacement areas, decontamination, closure of surface and subsurface facilities, reclamation of land, and monitoring. This period would be the only time during which DOE would involve the surface of the land used for the repository.

- The balance of a 1-million-year period that would consist of an evaluation of impacts from the disposal of spent nuclear fuel and high-level radioactive waste for the first 10,000 years and an evaluation of impacts for up to 1 million years.

In general, transportation and disposal activities associated with the proposed repository would benefit long-term productivity by the removal of spent nuclear fuel and high-level radioactive waste from commercial and DOE sites around the country. In addition, removing these materials from existing sites would free people and resources committed—now and in the future—to the monitoring and safeguarding of these materials for other potentially more productive activities. Removal could create conditions that would enable the initiation of other productive uses at the commercial and DOE sites. Finally, disposing of spent nuclear fuel and high-level radioactive waste in the proposed repository would provide a long-term global benefit by isolating the materials from concentrations of human population and human activity, thereby reducing the potential for sabotage.

10.2.1 YUCCA MOUNTAIN REPOSITORY

In the Yucca Mountain FEIS, DOE described “short-term” as the time from start of construction to the end of relevant surface and subsurface human activity and “long-term” as the time from the end of the short-term period to the time environmental resources had recovered from the potential for impacts and were again productive, or a maximum of 1 million years. “Productivity” refers to the ability of an element of the environment to generate crops, provide habitat, or otherwise serve as a medium for the creation of value. For transportation purposes, short-term refers to the time of construction or actual transportation, and long-term refers to the time from the end of the short-term period to the time of environmental recovery.

10.2.1.1 Land Use

The withdrawal of land for the repository would total about 600 square kilometers (150,000 acres), which would include about 180 square kilometers (44,000 acres) in the town of Amargosa Valley taxing district, resulting in loss of productivity. The repository, however, would enable consideration of other uses for

sites where spent nuclear fuel and high-level radioactive waste are being stored and the land buffering those sites. Many present storage sites are in locations that would permit a wider range of *alternative* uses than would Yucca Mountain.

10.2.1.2 Hydrology

As noted in Chapter 3, Section 3.1.4 of this Repository SEIS, the proposed repository is in the Alkali Flat-Furnace Creek groundwater basin, which discharges mainly at Alkali Flat and potentially to the Furnace Creek area of Death Valley, and is part of the Death Valley regional groundwater flow system. Death Valley is hydrologically isolated and separated from other surface and subsurface water. Once water enters Death Valley it can leave only by *evapotranspiration*. There would, however, be the potential for materials disposed of at the proposed repository to reach groundwater at some time between several thousand and 1 million years. If such contamination reached groundwater, and if the water exceeded applicable regulatory requirements, there could be an attendant loss of productivity for the affected groundwater and for surface waters in the basin. Conversely, the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain would free a wide range of major and minor water bodies throughout the United States from the potential threat of radioactive contamination from the materials at the present storage sites.

10.2.1.3 Biological Resources and Soils

As described in Chapter 4, Section 4.1.4 of this Repository SEIS, biological resources would be affected directly by land disturbances. The overall impact to populations of species would be limited because the area disturbed and the number of individual animals lost would be small in relation to the regional availability.

Long-term productivity loss for soils would be limited to areas affected by land disturbances. DOE would revegetate these areas after the completion of closure activities. The disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain would remove these materials from proximity to biota near the present storage sites across the United States.

10.2.2 TRANSPORTATION ACTIONS

Chapter 8 of the Rail Alignment EIS presents information on short-term uses and long-term productivity related to the construction and operation of a railroad in Nevada. The chapter presents information drawn from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental impacts and mitigation analyses.

The major long-term benefit of the transport of spent nuclear fuel and high-level radioactive waste to the repository would be the permanent consolidation of these materials in an isolated location away from concentrations of people, with highly limited long-term *exposure pathways* to such concentrations.

10.3 Irreversible or Irretrievable Commitment of Resources

The Proposed Action would involve the irreversible or irretrievable commitment of land, energy, and materials. The commitment of a resource is irreversible if its primary or secondary impacts limit future options for the resource. An irretrievable commitment refers to the use or consumption of resources that

are neither renewable nor recoverable for later use by future generations. Construction, operations, monitoring, and eventual closure of a repository at Yucca Mountain would result in a permanent commitment of land, groundwater, surface, subsurface, mineral, biological, soil, and air resources; materials such as copper, nickel, palladium, steel, titanium, and cement; and energy in forms such as fossil fuels and electricity. Water use would support construction, operations, monitoring, and closure of the repository and construction of the proposed railroad. Radiological contamination of groundwater beyond safe levels, although not likely (Chapter 5), could limit future groundwater uses. There would be an irreversible and irretrievable commitment of natural resources such as land use and habitat productivity.

10.3.1 YUCCA MOUNTAIN REPOSITORY

Construction, operations, monitoring, and eventual closure of a repository at Yucca Mountain would result in a permanent commitment of the analyzed land withdrawal area, including about 180 square kilometers (44,000 acres) in the town of Amargosa Valley taxing district, which would include surface and subsurface resources. The public could not make use of resources in that area.

Mitigation approaches that would involve the excavation of archaeological sites to prevent degradation by construction activities would destroy the contexts of those sites and reduce the finite number of such resources in the region. DOE expects that its activities at the proposed repository would affect no more than a minimal number of such sites.

Electric power, fossil fuels, and construction materials would be irreversibly committed to the project. Aggregate would be crushed and mixed in concrete for use in the repository. Chromium, molybdenum, nickel, and steel used to manufacture the TAD canisters as well as the palladium and titanium used in drip shields would be an irreversible and irretrievable commitment of resources. Some copper and steel ramps and access mains to subsurface facilities would be recyclable, while some in the emplacement *drifts* would be irreversibly and irretrievably lost. Most of the steel used for the surface facilities would be recyclable and, therefore, not an irreversible or irretrievable commitment. Some steel, such as rebar, would be difficult to recycle. The quantity of resources consumed would be small in comparison with their national consumption or their availability to consumers in southern Nevada.

10.3.2 TRANSPORTATION ACTIONS

The manufacture of *transportation casks* would require commitment of aluminum, chromium, copper, depleted uranium, lead, molybdenum, nickel, and steel. With the exception of nickel, the required amounts of these materials would be low in relation to U.S. production and supply (DIRS 155970-DOE 2002, p. 10-13). The shipment of spent nuclear fuel and high-level radioactive waste to Nevada would involve irreversible commitments of electric power, fossil fuels, and construction materials.

Chapter 8 of the Rail Alignment EIS presents information on irreversible and irretrievable commitment of resources related to the construction and operation of a railroad in Nevada. The chapter presents information drawn from the analysis of the Proposed Action and Shared-Use Option and consolidates information from the environmental impacts and mitigation analyses.

REFERENCES

155970	DOE 2002	DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
172055	DOE 2004	DOE (U.S. Department of Energy) 2004. *Spill Prevention, Control, and Countermeasures Plan for Site Activities.* BAB000000-01717-4600-00009 Rev 02. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: DOC.20040329.0003.
105034	Turnipseed 1992	Turnipseed, R.M. 1992. "Official Ruling in the Matter of Application 52338 Filed to Appropriate the Waters from an Underground Source Within the Forty Mile Canyon-Jackass Flats Groundwater Basin, Nye County, Nevada." Letter from R.M. Turnipseed (State Engineer, State of Nevada) to C. Gertz (YMP), March 2, 1992. ACC: HQX.19930511.0006.

11

Statutory and Other Applicable Requirements

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11. STATUTORY AND OTHER APPLICABLE REQUIREMENTS

This chapter identifies major requirements that could be applicable to the *Proposed Action*, which is to construct, operate, monitor, and close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.

On February 14, 2002, the Secretary of Energy, in accordance with the *Nuclear Waste Policy Act*, as amended (42 U.S.C. 10101 et seq.) (NWPA), transmitted the recommendation, and the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS), to the President for approval of the *Yucca Mountain site* for development of a *geologic* repository. The President considered the site to qualify for application to the U.S. Nuclear Regulatory Commission (NRC) for construction authorization and recommended the site to Congress. On July 23, 2002, the President signed the *Yucca Mountain Development Act of 2002* (Public Law 107-200; 116 Stat. 735), which approved the Yucca Mountain site for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. In referring to acts of Congress, this chapter refers to the law as amended in the United States Code, or it refers to the unamended act by Public Law number.

The U.S. Department of Energy (DOE or the Department) has reviewed and updated this chapter for this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). This chapter summarizes, incorporates by reference, and updates Chapter 11 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-1 to 11-25) and presents new information, as applicable, from statutory and other applicable requirements that have arisen since completion of the FEIS. In this chapter:

- Section 11.1 summarizes statutes and regulations that establish DOE's authority to construct and operate a geologic repository in the State of Nevada. This section also summarizes the license application statutes and authority for the proposed *Yucca Mountain Repository.*

- Section 11.2 summarizes statutes and regulations that set environmental protection requirements that could apply to the *construction* and *operation* of the repository and to transportation of radioactive materials.

- Section 11.3 summarizes potential licenses, permits, and approvals DOE could require to construct and operate the proposed repository.

- Section 11.4 summarizes DOE Orders and describes the mechanism by which these Orders give precedence to NRC rules in relation to the repository.

- Section 11.5 refers to a list of other federal regulations and DOE Orders that are potentially applicable to the construction, operations, *monitoring*, and *closure* of a geologic repository.

- Section 11.6 refers to statutes, regulations, requirements, and orders specific to the proposed Nevada *railroad*.

11.1 Statutes and Regulations that Establish or Affect Authority To Propose, License, and Develop a Geologic Repository

This section describes the DOE analysis of statutes and regulations that establish or affect the Department's authority to construct and operate the proposed Yucca Mountain Repository. It summarizes, incorporates by reference, and updates Section 11.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-1 to 11-7).

11.1.1 NUCLEAR WASTE POLICY ACT OF 1982, AS AMENDED (42 U.S.C. 10101 et seq.)

The NWPA establishes the Federal Government's responsibility for the disposal of spent nuclear fuel and high-level radioactive waste and the generators' responsibilities to bear the costs of disposal. Congress amended the original *Nuclear Waste Policy Act of 1982* in 1987 and identified the Yucca Mountain site in Nye County, Nevada, as the only site for study as a potential location for a geologic repository.

Other than appropriations, no changes have been made to the NWPA since completion of the Yucca Mountain FEIS.

11.1.2 YUCCA MOUNTAIN DEVELOPMENT ACT OF 2002 (42 U.S.C. 10135)

On February 15, 2002, President George W. Bush approved the Secretary of Energy's recommendation of Yucca Mountain as the site for the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste. The House of Representatives approved the Yucca Mountain site on May 8, 2002, as did the Senate on July 9, 2002. The Act is a joint resolution of the House of Representatives and the Senate to approve the site at Yucca Mountain, Nevada, for the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste pursuant to the NWPA. The joint resolution acknowledged that the governor of the State of Nevada submitted a notice of disapproval on April 8, 2002. This approval of the site at Yucca Mountain became known as the *Yucca Mountain Development Act*, which the President signed into law on July 23, 2002.

11.1.3 ENERGY POLICY ACT OF 1992 (42 U.S.C. 13201 et seq.)

Congress passed the *Energy Policy Act of 1992* in part to modify the rulemaking authorities of the U.S. Environmental Protection Agency (EPA) and NRC in relation to the proposed repository at Yucca Mountain. Congress had previously directed EPA to establish standards to protect the general environment from offsite releases of radioactive materials in repositories. Section 801(a) of the Energy Policy Act directs EPA (1) to retain the National Academy of Sciences to make findings and recommendations on reasonable public health and safety standards for Yucca Mountain, and (2) to establish Yucca Mountain-specific standards based on and consistent with the National Academy of Sciences findings and recommendations. Section 801(b) of the Act directs NRC to modify its technical requirements and criteria for geologic repositories to be consistent with the site-specific EPA Yucca

Mountain standard (40 CFR Part 197). Section 801(c) of the Act requires that DOE continue its oversight of the Yucca Mountain site after repository-closure to prevent: (1) unreasonable *risk* of breaching the repository's *barriers*, and (2) increase in the *exposure* of individual members of the public to *radiation* beyond allowable limits.

11.1.4 DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN A PROPOSED GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN (10 CFR PART 63) AND ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR YUCCA MOUNTAIN (40 CFR PART 197)

In 2001, both EPA and NRC adopted public health and safety standards for any radioactive material to be disposed of in a Yucca Mountain Repository. In 2004, in response to legal challenges, the U.S. Court of Appeals for the District of Columbia Circuit struck down the portions of those standards that addressed the period for which compliance must be demonstrated and remanded the provisions to the federal agencies for revision.

In 2005, EPA proposed new standards to address the court's decision. The proposed standards incorporate multiple compliance criteria applicable at different times for protection of individuals and the environment, and in circumstances involving *human intrusion* into the repository. The proposals also identify certain specific processes that must be considered in projecting repository performance. When finalized, these standards will be codified in 40 CFR Part 197, Subpart B.

Because Section 801 of the *Energy Policy Act of 1992* requires NRC to modify its technical requirements for licensing of a Yucca Mountain Repository to be consistent with the standards promulgated by EPA, NRC also proposed new standards in 2005 to implement the proposed EPA standards for *doses* that could occur after 10,000 years but within the period of geologic stability. The proposed NRC standards also specify a value to be used to represent climate change after 10,000 years, as required by EPA, and specify that calculations of radiation doses for workers use the same weighting factors that EPA proposed for calculating individual doses to members of the public. When finalized, these standards will be codified in 10 CFR Part 63.

In developing the *Total System Performance Assessment* (TSPA)-LA model for the analysis in this Repository SEIS, DOE took into consideration the regulatory requirements in the proposed EPA and NRC standards to provide a perspective on potential radiological *impacts* during the *postclosure* period. The TSPA-LA model for the analyses in this Repository SEIS was finalized for purposes of the compliance assessment included in the application DOE submitted to the NRC for construction authorization for the Yucca Mountain Repository.

11.1.5 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 (42 U.S.C. 4321 et seq.)

DOE has prepared this Repository SEIS in accordance with the provisions of the *National Environmental Policy Act* (NEPA) as implemented by Council on Environmental Quality regulations (40 CFR Parts 1500 through 1508) and DOE NEPA regulations (10 CFR Part 1021), and in conformance with the NWPA.

11.1.6 ATOMIC ENERGY ACT OF 1954, AS AMENDED (42 U.S.C. 2011 et seq.)

The *Atomic Energy Act of 1954*, as amended, provides fundamental jurisdictional authority to DOE and NRC over governmental and commercial use of nuclear materials. This Act ensures proper management, production, possession, and use of radioactive materials. To comply with the Act, DOE established a system of requirements it issued as DOE Orders. (Section 11.4 discusses DOE Orders.)

The Act gives NRC authority to regulate the possession, transfer, storage, and disposal of nuclear materials, as well as aspects of transportation packaging design for radioactive materials that include testing for packaging certification. The Act gives EPA the authority to develop standards for the protection of the environment and public health from radioactive material.

11.1.7 FEDERAL LAND POLICY AND MANAGEMENT ACT OF 1976 (43 U.S.C. 1701 et seq.)

The *Federal Land Policy and Management Act of 1976* governs the use of federal lands under the administration of the U.S. Department of the Interior. The *analyzed land withdrawal area* for the proposed repository encompasses public lands under the administration of the Bureau of Land Management, which is an agency of the Department of the Interior. The Bureau governs public lands primarily through the regulations on the establishment of rights-of-way (43 CFR Part 2800) and administrative withdrawals of public domain land from public use (43 CFR Part 2300). The Act, by which the government accomplishes most federal land withdrawals, contains a detailed procedure for application, review, and study by the Bureau of Land Management, as well as decisions by the Secretary of the Interior on withdrawal and on the terms and conditions of withdrawal. Only Congress has the power to withdraw federal lands permanently for the exclusive purposes of specific agencies. Through legislative action, Congress can authorize and direct a permanent withdrawal of lands such as those proposed for the Yucca Mountain Repository.

11.2 Statutes, Regulations, and Executive Orders for Environmental Protection

This section describes the environmental protection statutes, regulations, and Executive Orders relevant to the proposed Yucca Mountain Repository. It summarizes, incorporates by reference, and updates Section 11.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-7 to 11-20).

11.2.1 PROTECTION AND ENHANCEMENT OF ENVIRONMENTAL QUALITY (EXECUTIVE ORDER 11514, AS AMENDED)

Executive Order 11514 directs federal agencies to continuously monitor and control their activities continually to protect and enhance the quality of the environment. The Order also requires the development of procedures both to ensure the fullest practical provision of timely public information and understanding of federal plans and programs with potential environmental impacts, and to obtain the views of interested parties. DOE has promulgated regulations to ensure compliance with NEPA.

11.2.1a Strengthening Federal Environmental, Energy, and Transportation Management (Executive Order 13423)

Executive Order 13423 directs federal agencies to conduct their environmental-, transportation-, and energy-related activities in support of their respective missions in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

11.2.2 AIR QUALITY

11.2.2.1 Clean Air Act of 1963, as Amended (42 U.S.C. 7401 et seq.)

The purpose of the *Clean Air Act of 1963* is to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Pursuant to the Act, EPA has established National Ambient Air Quality Standards at 40 CFR Parts 50 through 99 to protect the public health and the environment. More specifically, the Act regulates emissions of hazardous air pollutants, including *radionuclides*, through the National Emissions Standards for Hazardous Air Pollutants Program (40 CFR Parts 61 and 63).

11.2.2.2 Nevada Revised Statutes: Air Emission Controls, Chapter 445B

Nevada Revised Statutes, Air Emission Controls, and regulations in the Nevada Administrative Code implement state and federal clean air provisions. DOE would need operating permits from the Nevada Division of Environmental Protection, Bureau of Air Pollution Control, for the control of gaseous and particulate emissions from construction and operation of the proposed repository.

As part of Yucca Mountain *site characterization*, DOE has obtained an *air quality* operating permit from the State of Nevada. The permit placed specific operating conditions on systems that DOE used during site characterization activities. These conditions included limiting the emission of *criteria pollutants*, defining the number of hours per day and per year a system may operate, and determining the testing, monitoring, and recordkeeping required for the system. This operating air quality permit was updated and renewed in 2006 (DIRS 179968-DeBurle 2006, all).

11.2.3 WATER QUALITY

11.2.3.1 Safe Drinking Water Act of 1974, as Amended [42 U.S.C. 300(f) et seq.]

The primary objective of the *Safe Drinking Water Act* is to protect the quality of public water supplies. This includes any drinking water system at the proposed repository. The Act gives EPA the responsibility and authority to regulate public drinking water supplies by establishing drinking water standards, delegating authority for the enforcement of drinking water standards to the states, and protecting *aquifers* from pollution hazards. The Nevada Division of Environmental Protection, Bureau of Safe Drinking Water, is the state agency responsible for the enforcement of drinking water standards. EPA regulations for this program are codified at 40 CFR Part 141, and Nevada rules for this program are codified at Nevada Administrative Code Chapter 445A. Nevada primary drinking water standards are identical to the national standards. The proposed repository would include a drinking water system that would obtain water from a source outside the geologic repository operating area, and DOE would operate the system in accordance with Nevada permitting requirements.

Since completion of the Yucca Mountain FEIS, a standard for natural uranium has gone into effect, but a proposed standard for radon is still pending. EPA implemented the standard for uranium at 0.03 milligrams per liter [40 CFR 141.66(e)]. In addition, EPA lowered the primary drinking water standard for arsenic from 0.05 milligram per liter to 0.01 milligram per liter (40 CFR 141.23).

11.2.3.2 Clean Water Act of 1977 (33 U.S.C. 1251 et seq.)

The purpose of the *Clean Water Act of 1977*, which amended the *Federal Water Pollution Control Act* (Public Law 92-500, Section 2, 86 Stat. 816), is to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." EPA has delegated to the State of Nevada the authority to implement and enforce most programs in the state under the *Clean Water Act of 1977*. An exception is Section 404, which gives the U.S. Army Corps of Engineers permitting authority over activities that discharge dredge or fill material into waters of the United States.

Under the Act, the State of Nevada sets water quality standards, and EPA and the state regulate and issue permits for point-source discharges as part of the National Pollutant Discharge Elimination System permitting program. EPA regulations for this program are in 40 CFR Part 122, and Nevada rules for this program are in Nevada Administrative Code Chapter 445A. If the construction or operation of a Yucca Mountain Repository would result in point-source discharges, DOE would obtain a National Pollutant Discharge Elimination System permit from the state.

Sections 401 and 405 of the *Water Quality Act of 1987* added Section 402(p) to the *Clean Water Act of 1977*. Section 402(p) requires EPA to establish regulations for EPA or individual states to issue permits for stormwater discharges from industrial activity, which includes construction activities that could disturb 0.2 square kilometer (5 acres) or more (40 CFR Part 122). Nevada rules for this program are in Nevada Administrative Code Chapter 445A.

Under Section 404 of the *Clean Water Act of 1987*, DOE would need to obtain a permit from the U.S. Army Corps of Engineers for discharges of dredge or fill materials into any waters of the United States, which include *wetlands*. For example, DOE has obtained a Section 404 permit for construction activities it might conduct in Coyote Wash and its tributaries. However, in 2006, the Supreme Court (*Rapanos v. U.S.* and *Carabell v. U.S.)* addressed the jurisdictional scope of Section 404 of the *Clean Water Act*, specifically the term "the waters of the U.S." This ruling could affect whether the U.S. Army Corps of Engineers could determine that any dry wash at the Yucca Mountain site is a water of the United States. Appendix C provides further discussion of specific washes at the proposed repository.

Since completion of the Yucca Mountain FEIS, DOE has conducted additional analyses of Section 404 provisions and their impact in relation to the repository and to the Caliente and Mina *rail corridors*. Chapter 4 and Appendix C of this Repository SEIS discuss these analyses.

11.2.3.3 Nevada Revised Statutes: Water Controls, Chapter 445A

Nevada Revised Statutes, Water Controls, classifies the waters of the state, establishes standards for the quality of waters in the state, and specifies permit and notification provisions for stormwater discharges and for other discharges to the waters of the state in accordance with provisions of the *Clean Water Act of 1977* (33 U.S.C. 1251 et seq.) and the *Safe Drinking Water Act of 1974* (42 U.S.C. 300 et seq.). These statutes and the regulations in the Nevada Administrative Code set drinking water standards,

specifications for certification, and conditions for issuance of variances and exemptions; set standards and requirements for the construction of wells and other water supply systems; establish the different classes of wells and aquifer exemptions; and establish requirements for well operation, monitoring, plugging, and abandonment activities.

The Yucca Mountain FEIS reported that DOE obtained Underground Injection Control and Public Water System permits for site characterization activities at Yucca Mountain. Actually, only one Underground Injection Control Permit was obtained and it covers tracers, pump tests, surface discharges, and similar activities. A Public Water System Permit establishes the terms for the provision of potable water.

Since completion of the Yucca Mountain FEIS, DOE has determined that the Nevada Division of Environmental Protection, Bureau of Water Pollution Control, requires a temporary permit for work in waterways of the state. DOE would apply for a temporary permit before using equipment in waters of the state, including dry washes, that could directly discharge pollutants into waterways.

11.2.3.4 Nevada Revised Statutes: Adjudication of Vested Water Rights, Appropriation of Public Waters, Underground Water and Wells, Chapter 534

These Nevada Revised Statutes prescribe requirements for establishing state water rights for use of public waters of the state, which includes underground waters. These statutes provide procedures for the drilling, construction, and plugging of wells for the extraction of underground water.

DOE filed a water appropriation request with the Office of the Nevada State Engineer on July 22, 1997, for permanent rights to withdraw 530,000 cubic meters (430 acre-feet) of water annually. These applications were for the five well sites at J-12, J-13, and the C-Wells complex. The use is considered industrial and includes but is not limited to road construction, facility construction, drilling, dust suppression, tunnel and pad construction, testing, culinary and domestic uses, and other uses that relate to the site. These water appropriation permit applications have been denied by the Nevada State Engineer. The U.S. Department of Justice, on behalf of DOE, has appealed this decision in U.S. District Court.

11.2.3.5 Executive Order 11988, Floodplain Management

Executive Order 11988 directs federal agencies to establish procedures to ensure that agencies, for any federal action in a *floodplain*, consider the potential effects of flood hazards and floodplain management, and to avoid floodplain impacts where possible. DOE implementing regulations are in 10 CFR Part 1022.

11.2.3.6 Compliance with Floodplain/Wetlands Review Requirements (10 CFR Part 1022)

The Yucca Mountain FEIS discussed compliance with floodplain and wetland review requirements. These federal regulations establish DOE procedures for identification of proposed actions in floodplains and provide for early public review of the proposed actions. If DOE determines that an action it proposes would take place wholly or partly in a floodplain or wetland, the regulation requires preparation of a floodplain or wetland assessment with a project description and a discussion of project impacts, *alternatives*, and *mitigations*. If there is no practicable alternative to impacts to and within a floodplain or wetland, DOE must design or modify its action to minimize potential harm.

Appendix C of this Repository SEIS contains a floodplain and wetlands assessment that examines the effects of proposed repository construction and operations.

11.2.4 HAZARDOUS MATERIALS PACKAGING, TRANSPORTATION, AND STORAGE

11.2.4.1 Roles of the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission in Regulation of the Transportation of Radioactive Materials

As the Yucca Mountain FEIS described, NRC and the U.S. Department of Transportation share primary responsibility for regulation of the safe transportation of radioactive materials in the United States. The Department of Transportation has the responsibility to develop and implement transportation safety standards for hazardous materials, including radioactive materials. Title 49 CFR establishes Department of Transportation standards and requirements for packaging, transporting, and handling radioactive materials for all modes of transportation. These standards address labeling, shipping papers, placarding, loading and unloading, allowable radiation levels, and limits for *contamination* of packages and vehicles, among other requirements. The regulations specify safety requirements for vehicles and transportation operations, training for personnel who perform handling and transportation of hazardous materials, and liability insurance requirements for carriers.

NRC sets performance standards for transportation packaging (*shipping casks*) for materials with higher levels of *radioactivity*. The U.S. Department of Transportation, by agreement with NRC, accepts the standards of 10 CFR Part 71 for packaging. NRC also establishes safeguards and security regulations to minimize the possibility of theft, diversion, or attack on shipments of radioactive materials (10 CFR Part 73). NRC revised Class 7 (radioactive materials) requirements on October 1, 2004, to align with the International Atomic Energy Agency regulations for the safe transport of radioactive materials. NRC coordinated the final rule with the Department of Transportation to ensure consistency between NRC and Department of Transportation regulations (69 FR 58841, October 1, 2004).

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any others that might be established in the future, whether by Congress, the Department of Transportation, or NRC.

11.2.4.2 Hazardous Materials Transportation Act (49 U.S.C. 1801 et seq.)

The *Hazardous Materials Transportation Act* gives the U.S. Department of Transportation the authority to regulate the transport of hazardous materials, including the radioactive materials that DOE would transport to the proposed Yucca Mountain Repository from 72 commercial and 4 DOE sites. Department of Transportation regulations (49 CFR Parts 171 through 180) require the identification of hazardous materials that DOE would transport to Yucca Mountain. The rules for selection of routes that carriers must use to transport such materials, and guidance to states in the designation of preferred routes, are in 49 CFR Part 397.

11.2.4.3 Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 1001 et seq.)

The Yucca Mountain FEIS described Subtitle A of the *Emergency Planning and Community Right-to-Know Act of 1986* (also known as "SARA Title III"). Federal facilities, which would include a repository at Yucca Mountain, must provide information on hazardous and toxic chemicals to state emergency response commissions, local emergency planning committees, and EPA. The goal of providing this information is to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. The required information includes inventories of specific chemicals used or stored and descriptions of releases that occur from sites.

11.2.4.4 Nevada Revised Statutes: State Fire Marshal, Chapter 477 and Hazardous Materials, Chapter 459

The State of Nevada could require a Hazardous Materials Storage Permit for DOE to store hazardous materials in quantities above those the Uniform Fire Code specifies (Nevada Revised Statutes, Chapter 477). To receive such a permit, if necessary, DOE would submit an application to the Nevada State Fire Marshal that described its plans for the storage of hazardous materials in excess of specified quantities. DOE obtained a permit from the State Fire Marshal for the storage of flammable materials during site characterization activities. This permit is still active. In addition, DOE would be required to manage and dispose of hazardous waste pursuant to Nevada Revised Statutes Chapter 459 – Hazardous Materials.

11.2.4.5 U.S. Nuclear Regulatory Commission Radioactive Materials Packaging and Transportation Regulations (10 CFR Parts 71 and 73)

Under 10 CFR Part 71, NRC regulates the packaging and transport of spent nuclear fuel for its licensees, which include commercial shippers of radioactive material. In addition, under an agreement with the U.S. Department of Transportation, NRC sets the standards for packages containing Type B quantities of radioactive materials, which include spent nuclear fuel and high-level radioactive waste. An applicant provides the results of its analyses and tests to NRC in a Safety Analysis Report for Packaging. On approving the report, NRC issues a Certificate of Compliance. Under the NWPA, DOE is required to use NRC-certified *casks* for shipment of spent nuclear fuel or high-level radioactive waste to the repository.

The regulations at 10 CFR Part 73 govern safeguards and physical security during the shipment of spent nuclear fuel. These regulations specify requirements for vehicles, carrier personnel, communications, notification of state governors, escorts, and route planning for such shipments.

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any others that might be established in the future, whether by Congress, the Department of Transportation, or NRC.

11.2.4.6 U.S. Department of Transportation Hazardous Materials Packaging and Transportation Regulations (49 CFR Subchapter C – Hazardous Materials Regulations, Parts 171 Through 180)

The U.S. Department of Transportation regulates the shipment of hazardous materials, which include spent nuclear fuel and high-level radioactive waste, by land, air, and navigable water. As outlined in a 1979 memorandum of understanding with NRC (44 FR 38690, July 2, 1979), the Department of Transportation specifically regulates carriers of spent nuclear fuel and the conditions of transport, such as routing for highway shipments, handling and storage, and vehicle and driver requirements. The Department of Transportation does not regulate the routing of rail shipments of radioactive materials.

The purposes of the public highway routing regulations of the U.S. Department of Transportation are to reduce the impacts of the transportation of *Highway Route Controlled Quantities of Radioactive Materials* [49 CFR 173.403(1)], to establish consistent and uniform requirements for route selection, and to identify the roles of state and local governments in the routing.

U.S. Department of Transportation regulations include requirements for carriers, drivers, vehicles, routing, packaging, labeling, marking, placarding, shipping papers, training, and emergency response. The requirements specify the maximum dose rate external to the packaging and the maximum allowable levels of radioactive surface contamination on packages and vehicles.

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated and subject to the utmost scrutiny. DOE carefully follows U.S. Department of Transportation and NRC transportation rules now and will follow or exceed any others that might be established in the future, whether by Congress, the Department of Transportation, or NRC.

11.2.5 CONTROL OF POLLUTION

11.2.5.1 Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.)

The *Pollution Prevention Act of 1990* establishes a national policy for waste management and pollution control that focuses first on source reduction, then on environmentally safe recycling, treatment, and disposal. DOE requires each of its sites to establish specific goals to reduce the generation of waste.

11.2.5.2 Standards for Protection Against Radiation (10 CFR Part 20)

The purpose of these standards is to provide standards and procedures for protection against radiation from NRC-licensed activities. Provisions of 10 CFR Part 20 address repository occupational dose limits, public dose limits, survey and monitoring procedures, exposure control in *restricted areas*, respiratory protection and controls, precautionary procedures, and related topics.

11.2.5.3 DOE Worker Safety and Health Program (10 CFR Part 851)

The purpose of these regulations, which became effective on May 25, 2007, is to ensure that DOE contractor workplaces are free from recognized hazards that can cause death or serious physical harm. To accomplish this objective, 10 CFR Part 851 establishes management responsibilities, worker rights, safety and health standards, and required training. Contractors include parent corporations and subcontractors that have responsibilities for work at a DOE site in furtherance of a DOE mission. The contractor must

provide DOE with a worker and safety health program that describes the methods it will use to implement the requirements. DOE must review and approve these programs. For example, this regulation prohibits a DOE contractor from performing work at a covered workplace unless an approved worker and safety health program is in place.

11.2.5.4 Low-Level Radioactive Waste Policy Amendments Act of 1985 (42 U.S.C. 2021b Through 2021j)

Under the *Low-Level Radioactive Waste Policy Amendments Act of 1985*, DOE is responsible for the disposal of any *low-level radioactive waste* that operations at the proposed Yucca Mountain Repository could generate. DOE would control and dispose of site-generated low-level radioactive waste in a DOE low-level waste disposal site, a site in an *Agreement State*, or in an NRC-licensed site. In addition, this Act assigns responsibility for disposal of greater-than-class-C low-level radioactive waste to the Federal Government.

11.2.5.5 Resource Conservation and Recovery Act, as Amended (42 U.S.C. 6901 et seq.)

EPA regulates the treatment, storage, and disposal of hazardous and nonhazardous waste in accordance with the provisions of the *Solid Waste Disposal Act*, as amended by the *Resource Conservation and Recovery Act* and the *Hazardous and Solid Waste Amendments Act of 1984*, and applicable state laws.

EPA regulations that implement the *hazardous waste* portions of the *Resource Conservation and Recovery Act* define hazardous wastes and specify requirements for their transportation, handling, treatment, storage, and disposal (40 CFR Parts 260 through 272).

Subtitle C of the Act requires characterization and management of covered hazardous wastes. DOE could generate hazardous waste during repository operations. It would track the amount of hazardous wastes each month (to determine generator status) during construction and operations. Sections 444.850 to 444.8746 of the Nevada Administrative Code are the corresponding requirements for wastes that EPA regulates under Subtitle C.

11.2.5.6 Noise Control Act of 1972 (42 U.S.C. 4901 et seq.)

Section 4 of the *Noise Control Act of 1972* directs federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare. This law provides requirements for control of noise from construction, operations, or closure activities at Yucca Mountain.

11.2.5.7 Nevada Revised Statutes: Sanitation, Chapter 444

These statutes and their matching regulations in the Nevada Administrative Code establish the standards, permits, and requirements for septic tanks and other sewage disposal systems for single-family dwellings, communities, and commercial buildings. The construction and operation of a *sanitary sewage* collection system at Yucca Mountain requires a permit from the Nevada Division of Environmental Protection. Since completion of the Yucca Mountain FEIS, Nevada has clarified that applicants must submit plans and specifications to the Division for approval.

These statutes and regulations set forth the definitions, methods of disposal, and special requirements for *solid waste* collection and transportation standards, as well as classification of landfills. DOE operates a permitted large-capacity septic system at the Yucca Mountain site under these provisions. This general permit to operate and discharge from a large-capacity septic system expires on July 22, 2009.

EPA has authorized the State of Nevada to regulate the management and disposal of solid, hazardous, and *mixed wastes* in the state. The Nevada Division of Environmental Protection or an equivalent solid waste management authority would regulate the on- and offsite disposal of nonhazardous solid wastes from the proposed repository.

11.2.5.8 Executive Order 12088, Federal Compliance with Pollution Control Standards

Executive Order 12088, as amended by Executive Order 12580, *Superfund Implementation Control Standards*, generally directs federal agencies to comply with applicable administrative and procedural pollution control standards of, but not limited to, the *Clean Air Act*, the *Noise Control Act*, the *Clean Water Act*, the *Safe Drinking Water Act*, the *Toxic Substances Control Act*, and the *Resource Conservation and Recovery Act*. DOE must comply with this Order for a range of activities for the proposed repository.

11.2.5.9 Executive Order 12856, Right-To-Know Law and Pollution Prevention Requirements

Executive Order 12856 directs federal agencies to reduce and report toxic chemicals that enter any waste stream; improve emergency planning, response, and *accident* notification; and encourage the use of clean technologies and testing of innovative prevention technologies. In addition, the Executive Order states that federal agencies are persons for purposes of the *Emergency Planning and Community Right-to-Know Act* (SARA Title III), which requires agencies to meet the requirements of the Act. DOE must comply with these orders, as applicable, for a range of DOE activities for the proposed repository.

11.2.6 CULTURAL RESOURCES

11.2.6.1 National Historic Preservation Act, as Amended (16 U.S.C. 470 et seq.)

The *National Historic Preservation Act* provides for the placement of sites with significant national historic value on the *National Register of Historic Places*. The Act requires no permits or certifications.

11.2.6.2 Archaeological Resources Protection Act, as Amended (16 U.S.C. 470aa et seq.)

The *Archaeological Resources Protection Act* requires a permit for the excavation or removal of archaeological resources from publicly held or American Indian lands. Excavations must further archaeological knowledge in the public interest, and the removed resources are to remain the property of the United States. If a resource is discovered on land that an American Indian tribe owns, the tribe must give its consent before a permit is issued, and the permit must contain terms or conditions the tribe requests.

11.2.6.3 American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996)

The *American Indian Religious Freedom Act of 1978* reaffirms American Indian religious freedom under the First Amendment and establishes the policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. This law ensures the protection of sacred locations and access of American Indians to those sacred locations and traditional resources that are integral to the practice of their religions.

11.2.6.4 Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001)

The *Native American Graves Protection and Repatriation Act of 1990* directs the Secretary of the Interior to guide the repatriation of federal archaeological collections and collections that are culturally affiliated with American Indian tribes and held by museums that receive federal funding. Major provisions of this law include (1) the establishment of a review committee with monitoring and policymaking responsibilities, (2) the development of regulations for repatriation that include procedures for the identification of lineal descent or cultural affiliation needed for claims, (3) the oversight of museum programs for meeting the inventoryrequirements and deadlines of this law, and (4) the development of procedures to handle unexpected discoveries of graves or grave artifacts during activities on federal or tribal land. Certain provisions of this Act would govern DOE if any surveys or excavations under the Proposed Action led to discoveries of American Indian graves or grave artifacts.

11.2.6.5 Antiquities Act (16 U.S.C. 431 et seq.)

The *Antiquities Act* protects historic and prehistoric ruins, monuments, and objects of antiquity (including paleontological resources) on federally owned or controlled lands. If DOE found historic or prehistoric ruins or objects during the construction or operation of proposed repository facilities, it would have to determine if adverse effects to these ruins or objects would occur. If adverse effects would occur, the Secretary of the Interior would have to grant permission to proceed with the activity (36 CFR Part 296 and 43 CFR Parts 3 and 7).

11.2.6.6 Executive Order 13007, Indian Sacred Sites

Executive Order 13007 directs federal agencies, to the extent permitted by law and not inconsistent with agency missions, to avoid adverse effects to sacred sites and to provide access to those sites to American Indians for religious practices. The Executive Order directs agencies to plan projects to provide protection of and access to sacred sites to the extent compatible with the project.

11.2.6.7 Executive Order 13175, Consultation and Coordination with Indian Tribal Governments

Executive Order 13175 directs federal agencies to establish regular and meaningful consultation and collaboration with American Indian tribal governments in the development of federal policies that have tribal implications, to strengthen United States government-to-government relationships with tribes, and to reduce the imposition of unfunded mandates on tribal governments.

11.2.7 ENVIRONMENTAL JUSTICE

11.2.7.1 Executive Order 12898, Environmental Justice

Executive Order 12898 directs federal agencies, to the extent practicable, to make the achievement of *environmental justice* part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on *minority* and *low-income populations* in the United States and its territories and possessions. The Order provides that the federal agency responsibilities it establishes are to apply equally to American Indian programs.

11.2.8 ECOLOGY AND HABITAT

11.2.8.1 Endangered Species Act, as Amended (16 U.S.C. 1531 et seq.)

The *Endangered Species Act* provides a program for the conservation of threatened and *endangered species* and the *ecosystems* on which those species rely. If a proposed action of a federal agency could affect threatened or endangered species or their *habitat*, the federal agency must assess the potential impacts and develop measures to minimize those impacts. The agency then must consult formally with the U.S. Fish and Wildlife Service (part of the Department of the Interior) and the National Marine Fisheries Service (part of the Department of Commerce), as required under Section 7 of the Act. The regulations that implement the Act are in 50 CFR Parts 15 and 402.

11.2.8.2 Fish and Wildlife Coordination Act, as Amended (16 U.S.C. 661, 48 Stat. 401)

The *Fish and Wildlife Coordination Act* promotes more effectual planning and cooperation among federal, state, public, and private agencies for the conservation and rehabilitation of the nation's fish and wildlife and authorizes the Department of the Interior to provide assistance.

11.2.8.3 Migratory Bird Treaty Act, as Amended (16 U.S.C. 703 et seq.)

The purpose of the *Migratory Bird Treaty Act* is to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. The Act regulates the take and harvest of migratory birds.

11.2.8.4 Bald and Golden Eagle Protection Act, as Amended (16 U.S.C. 668 Through 668d)

The *Bald and Golden Eagle Protection Act* makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Sections 668 and 668c). The Department of the Interior regulates activities that might adversely affect bald and golden eagles.

11.2.8.5 Nevada Revised Statutes: Protection and Preservation of Timbered Lands, Trees, and Flora, Chapter 527

These provisions of the Nevada Revised Statutes broadly protect the indigenous flora of the State of Nevada. On determination that a species or subspecies of native flora is threatened with extinction, the state places that species or subspecies on its list of fully protected species. In general, no member of the species or subspecies may be taken or destroyed unless an authorized state official issues a special permit.

11.2.8.6 Nevada Revised Statutes: Hunting, Fishing, and Trapping; Miscellaneous Protective Measures, Chapter 503

These statutes and the provisions in Nevada Administrative Code, Chapter 503, Sections 010 through 104, specify procedures for the classification and protection of wildlife. On determination that an animal species is threatened with extinction, the state places the species on its list of fully protected species. In general, no member of the species may be taken or destroyed unless the Nevada Division of Wildlife issues a special permit.

11.2.8.7 Executive Order 11990, Protection of Wetlands

Executive Order 11990 directs federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. DOE requirements for compliance with wetlands activity review procedures are in 10 CFR Part 1022 (Section 11.2.3.6).

11.2.8.8 Executive Order 13112, Invasive Species

Executive Order 13112 directs federal agencies to act to prevent the introduction of or to monitor and control invasive (nonnative) species, provide for restoration of *native species*, conduct research, promote educational activities, and exercise care in taking actions that could promote the introduction or spread of *invasive species*.

11.2.8.9 Executive Order 13186, Responsibilities of Federal Agencies To Protect Migratory Birds

Executive Order 13186 requires federal agencies to avoid or minimize the negative impacts of their actions on migratory birds and to take active steps to protect birds and their habitats. The Order directs each federal agency that takes actions that have or are likely to have a negative impact on migratory bird populations to work with the Fish and Wildlife Service to develop an agreement to conserve those birds. The Order requires environmental analyses of federal actions to evaluate effects of those actions on migratory birds, to control the spread and establishment in the wild of exotic animals and plants that could harm migratory birds and their habitats, and either to provide advance notice of actions that could result in the take of migratory birds or report annually to the Fish and Wildlife Service on the numbers of each species taken during the conduct of agency actions.

11.2.9 USE OF LAND AND WATER BODIES

11.2.9.1 Coastal Zone Management Act (16 U.S.C. 1451 et seq.)

The purpose of the *Coastal Zone Management Act* is to preserve, protect, develop, restore, and enhance the resources of the nation's coastal zones. Resources include wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat. This law provides for (1) management to minimize the loss of life and property from improper development and destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands; and (2) improvement, safeguarding, and restoration of the quality of coastal waters, and for protection of existing uses of those waters. The Act requires priority consideration to coastal-dependent uses and orderly processes for siting major facilities in relation to national defense, energy, fisheries development, recreation, ports and transportation, and the location of new commercial and industrial developments in or adjacent to areas where such development already exists.

Transport of spent nuclear fuel to a repository at Yucca Mountain could require the use of barges for transportation along portions of routes from some storage facilities. In addition, rail *corridors*, roads, and bridges from some storage facilities could require repair or enhancement before they could support shipment of spent nuclear fuel. The regulations that implement the Act are in 15 CFR Part 930.

11.2.9.2 Rivers and Harbors Act (33 U.S.C. 401 et seq.)

The transport of spent nuclear fuel and high-level radioactive waste could require the construction or modification of road or rail bridges that span navigable waters. The *Rivers and Harbors Act* prevents the alteration or modification of the course, location, condition, or capacity of any channel of any navigable water of the United States without a permit from the Army Corps of Engineers. If DOE required construction of a road or rail bridge that would span navigable waters, it would need to obtain a permit from the Corps. Regulations that implement this Act are in 33 CFR Part 323.

11.2.9.3 Materials Act of 1947 (30 U.S.C. 601 Through 603)

The *Materials Act of 1947* authorizes land management agencies, such as the Bureau of Land Management, to make common varieties of sand, stone, and gravel from public lands available to federal and state agencies under free-use permits. The Bureau of Land Management regulations that implement the Act are in 43 CFR Part 3604.

11.2.9.4 Farmland Protection Policy Act (7 U.S.C. 4201 et seq.)

The *Farmland Protection Policy Act* seeks to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmlands to nonagricultural uses. Compliance with this law requires concurrence from the Natural Resources Conservation Service of the Department of Agriculture that proposed activities would not affect farmlands. Regulations that implement the Act are in 7 CFR Part 658.

11.2.10 HOMELAND SECURITY

11.2.10.1 Energy Policy Act of 2005 (42 U.S.C. 15801)

Subtitle D (Nuclear Security) of the *Energy Policy Act of 2005* requires that NRC establish a system to secure the transfer of nuclear materials, which include spent nuclear fuel and high-level radioactive waste. Subtitle E (Nuclear Energy) directs DOE to conduct research on cost-effective technologies for increasing (1) the safety of nuclear facilities from natural phenomena and (2) the security of nuclear facilities from deliberate attacks.

11.2.10.2 Homeland Security Act of 2002 (6 U.S.C. 101 et seq.)

The *Homeland Security Act of 2002* contains requirements for safekeeping of radioactive materials. Specifically, the Act provides for measures to secure the people, *infrastructures*, property, resources, and systems in the United States from acts of terrorism that involve chemical, biological, radiological, or nuclear weapons or other emerging threats.

11.3 Potential Permits, Licenses, and Approvals

Table 11-1 lists potential permits, licenses, and approvals that DOE could need for construction, operations, monitoring, and closure of a Yucca Mountain Repository.

Table 11-1. Permits, licenses, and approvals for the proposed Yucca Mountain Repository in Nevada.

Activity	Regulatory action	Statute or regulation	Agency(ies)
Disposal of spent nuclear fuel and high-level radioactive waste	Final public health and environmental protection standards	40 CFR Part 197	EPA
Repository construction, operations, and closure	Construction authorization; license to receive and possess source, special nuclear, and byproduct material	10 CFR Part 63	NRC
Repository construction, operations, and closure	Withdrawal of geologic repository operations area from public use	Congressional action needed to authorize withdrawal	Congress, BLM
Air emissions	Approvals for new sources of toxic air pollutants	40 CFR Parts 61 and 63, NAC 445B	NDEP
Air emissions	Air quality operating permit	40 CFR Parts 61 and 63, NAC 445B	NDEP
Air emissions	National Emissions Standards for Hazardous Air Pollutants Subpart H (radionuclides)	40 CFR Part 61	EPA
Air emissions	Standards for protection against radiation	10 CFR Part 20	NRC
Drinking water	Public water system permit	NAC 445A	NDEP
Effluents	Stormwater discharge	40 CFR Part 122, NAC 445A	NDEP

Table 11-1. Permits, licenses, and approvals for the proposed Yucca Mountain Repository in Nevada (continued).

Activity	Regulatory action	Statute or regulation	Agency(ies)
Effluents	National Pollutant Discharge Elimination System	40 CFR Part 122, NAC 445A	NDEP
Effluents	Septic system permit	NAC 444 and 445A	NDEP
Effluents	Underground injection control permit	40 CFR Part 144, NAC 445A	NDEP
Excavation; facility construction	Cultural resources review clearance, Section 106	36 CFR Part 800	Advisory Council on Historic Preservation, State Historic Preservation Office
Excavation; facility construction	Permit to proceed (Objects of Antiquity)	36 CFR Part 296, 43 CFR Parts 3 and 7	DOI
Excavation; facility construction	Permit for excavation or removal of archaeological resources	16 U.S.C. 470 et seq.	DOI, affected American Indian tribes
Facility construction	Free use of mineral materials	43 CFR Part 3604	BLM
Facility construction	Permit for discharge of dredged or fill materials to waters of the United States	*Clean Water Act*, Section 404	U.S. Army Corps of Engineers
TAD canister certification	Requirements for TAD canisters	10 CFR Parts 63, 71, 72	NRC
Transportation casks	Certification of transportation casks	10 CFR Part 71	NRC
Facility construction and operations	Threatened and endangered species consultation	50 CFR Part 402	Fish and Wildlife Service
Materials storage	Hazardous materials storage permit	NAC 459 and 477	Nevada State Fire Marshal
Water appropriations	Water appropriation permit	Nevada Revised Statutes 532, 533, and 534	Nevada State Engineer

Source: DIRS 155970-DOE 2002, p. 11-2.
BLM = Bureau of Land Management.
CFR = Code of Federal Regulations.
DOI = U.S. Department of the Interior.
EPA = U.S. Environmental Protection Agency.
NAC = Nevada Administrative Code.
NDEP = Nevada Division of Environmental Protection.
NRC = U.S. Nuclear Regulatory Commission.
TAD = transportation, aging, and disposal (canister).
U.S.C. = United States Code.

11.4 Department of Energy Orders

This section summarizes, incorporates by reference, and updates Section 11.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-20 to 11-22).

In the Yucca Mountain FEIS, Table 11-3 listed DOE Orders potentially relevant to the construction, operations, monitoring, and closure of a geologic repository at Yucca Mountain (DIRS 155970-DOE 2002, pp. 11-21 and 11-22). Some DOE Orders overlap or duplicate NRC repository licensing regulations in whole or in part. Recognizing this, DOE issued DOE HQ Order 250.1, *Civilian*

Radioactive Waste Management Facilities - Exemption from Departmental Directives. This Order exempts geologic repository design, construction, operations, and *decommissioning* from compliance with the provisions of DOE Orders that overlap or duplicate NRC requirements in relation to radiation protection, nuclear safety (including quality assurance), and the safeguards and security of nuclear material. The exemption would apply only to the portions of the Proposed Action for which DOE sought an NRC license. DOE Orders would continue to establish requirements for other repository activities that would fall outside the scope of this exemption, such as computer security (DOE Order 205.1A). The mechanism by which DOE Orders give precedence to NRC rules has not changed since completion of the Yucca Mountain FEIS.

Table 11-2 lists DOE Orders potentially relevant to the construction, operations, monitoring, and closure of the proposed Yucca Mountain Repository that have been issued since the completion of the Yucca Mountain FEIS. Table 11-3 updates the revised numbering of relevant DOE Orders in Table 11-3 of the Yucca Mountain FEIS.

Table 11-2. Relevant DOE Orders issued since completion of the Yucca Mountain FEIS.

New DOE Order, date issued, and title	Description
414.1-2A (6/17/2005) *Quality Assurance Management System Guide*	Provides information on principles and practices to establish and implement an effective quality assurance program or quality management system according to the requirements of 10 CFR Part 830.
414.1-5 (3/2/2006) *Corrective Action Program Guide*	Provides guidance to DOE organizations and contractors in the development, implementation, and follow-up of corrective action programs using the feedback and improvement core safety function in DOE's Integrated Safety Management System.
420.1B (12/22/2005) *Facility Safety*	Establishes facility and programmatic safety requirements for DOE facilities, which include nuclear and explosives safety design criteria, fire protection, criticality safety, natural phenomena hazards mitigation, and the System Engineer Program.
426.1-1A (5/18/2004) *Federal Technical Capability Manual*	Provides requirements and responsibilities to ensure recruitment and hiring of technically capable personnel to retain critical technical capabilities within DOE at all times.
440.1B (5/17/2007) *DOE Worker Protection Program*	Establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE workers with a safe and healthful workplace.
231.1A Chg 1 (6/30/2004) *Environment, Safety and Health Reporting*	Ensures timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, and the environment.
414.C (6/17/2005) *Quality Assurance*	To ensure that DOE products and services meet or exceed customer expectations. The Order requires each DOE organization to develop and implement a quality assurance program.
433.1A (2/13/2007) *Maintenance Management Program for DOE Nuclear Facilities*	Defines the safety management program required by 10 CFR 830.204(b)(5) for maintenance and the reliable performance of structures, systems, and components that are part of the safety basis required by 10 CFR 830.202.1 at hazard category 1, 2, and 3 DOE nuclear facilities.

Table 11-2. Relevant DOE Orders issued since completion of the Yucca Mountain FEIS (continued).

New DOE Order, date issued, and title	Description
450.1 Admin Chg 1 (1/3/2007) *Environmental Protection Program*	Implements sound stewardship practices that are protective of air, water, land, and other natural and cultural resources that DOE operations affect and by which DOE cost-effectively complies with applicable environmental, public health, and resource-protection laws, regulations, and Departmental requirements.
451.1 (10/6/2006) *National Environmental Policy Act Compliance Program*	Establishes DOE internal requirements and responsibilities for implementing the *National Environmental Policy Act*. Describes procedures to ensure timely public information and the understanding of federal plans and programs with potential environmental impacts, and to obtain the views of interested parties. DOE updated Order 451.1B, to reflect departmental reorganization.
452.2C (6/12/2006) *Nuclear Explosive Safety*	Establishes specific nuclear explosive safety program requirements to implement the DOE standards and other nuclear explosive safety criteria for routine and planned nuclear explosive operations.
460.2A (12/22/2004) *Departmental Materials Transportation and Packaging Management*	Establishes requirements and responsibilities for management of DOE, including the National Nuclear Security Administration, materials transportation, and packaging to ensure the safe, secure, and efficient packaging and transportation of materials, both hazardous and nonhazardous.
226.1A (7/31/2007) *Implementation of Department of Energy Oversight Policy*	Provides direction for implementing DOE Policy 226.1, Department of Energy Oversight Policy (06-10-2005), which establishes DOE policy for assurance systems and processes established by DOE contractors and oversight programs performed by DOE line management and independent oversight organizations.
460.1B (4/4/2003) *Packaging and Transportation Safety*	Establishes safety requirements for the proper packaging and transportation of DOE/National Nuclear Security Administration offsite shipments and onsite transfers of hazardous materials, and for modal transport.
461.1A (4/26/2004) *Packaging and Transfer or Transportation of Materials of National Security Interest*	Establishes requirements and responsibilities for offsite shipments of naval nuclear fuel elements, Category I and Category II special nuclear material, nuclear explosives, nuclear components, special assemblies, and other materials of national security interest.
470.2B (10/31/2002) *Independent Oversight And Performance Assurance Program*	The Independent Oversight Program is designed to enhance the DOE safeguards and security; cyber security; emergency management; and environment, safety, and health programs by providing DOE with an independent evaluation of the adequacy of DOE policy and the effectiveness of line management performance in safeguards and security; cyber security; emergency management; environment, safety, and health.

CFR = Code of Federal Regulations.
DOE = U.S. Department of Energy.

Table 11-3. Revised DOE Orders since completion of the Yucca Mountain FEIS.

Previous number and title		Revised number and title	
1300.2A	Department of Energy Technical Standards Program	252.1	Technical Standards Program
425.1	Facility Startup and Restart	425.1C	Startup and Restart of Nuclear Facilities
151.1	Comprehensive Emergency Management System	151.C	Comprehensive Emergency Management System
1360.2B	Unclassified Computer Security Program	205.1A	Department of Energy Cyber Security Management

Table 11-3. Revised DOE Orders since completion of the Yucca Mountain FEIS (continued).

Previous number and title		Revised number and title	
3790.1B	Federal Employee Occupational Safety and Health Program	440.1B	Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees
5400.1	General Environmental Protection Program	231.1A Chg. 1	Environment, Safety and Health Reporting
5400.5	Radiation Protection of the Public and the Environment	231.1A Chg. 1	Environment, Safety and Health Reporting
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements	231.1A Chg. 1	Environment, Safety and Health Reporting
5610.14	Transportation Safeguards System Program Operations	461.1A	Packaging and Transfer or Transportation of Nuclear Materials of National Security Interest
5632.1C	Protection and Control of Safeguards and Security Interests	470.4A	Safeguards and Security Program

Chg = Change.
DOE = U.S. Department of Energy.

11.5 Other Potentially Applicable Federal Regulations

This section incorporates by reference Table 11-4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 11-23 to 11-25). That table listed federal regulations and DOE Orders potentially applicable to the construction, operations, monitoring, and closure of a geologic repository.

11.6 Statutes, Regulations, Requirements, and Orders Specific to the Proposed Nevada Railroad

Based on its obligations under the NWPA and its decision to select the mostly rail scenario for the transportation of spent nuclear fuel and high-level radioactive waste (69 FR 18557; April 8, 2004), DOE would ship spent nuclear fuel and high-level radioactive waste by rail in Nevada. To meet this need, DOE is proposing to construct and operate a railroad to connect the repository to an existing rail line in Nevada. Many of the statutes and regulations in the preceding sections of Chapter 11 are applicable to both the repository and the railroad. Chapter 6 of the Rail Alignment EIS discusses the potentially requirements relevant to the proposed Nevada railroad.

11.7 Interagency and Intergovernmental Interactions

In the course of preparing this Repository SEIS, DOE has interacted with a number of government agencies and other organizations. Nye County requested cooperating agency status, which DOE granted. No other agency or government requested cooperating agency status during preparation of this Repository SEIS.

The purposes of DOE interactions with government agencies and other organizations are as follows:

- To discuss issues of concern with organizations having an interest in or authority over land that the Proposed Action (to construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain) would directly affect, or organizations having other interests that some aspect of the Proposed Action could affect;
- To obtain information pertinent to the environmental impacts analysis of the Proposed Action;
- To initiate consultations or permitting processes, including providing data to agencies with oversight, review, or approval authority over some aspect of the Proposed Action;
- To provide information relevant to the development of responses to public comments on the Draft documents.

Table 11-4 presents the ongoing consultations with agencies and Indian tribes that have relevant expertise or organizational interests that the Proposed Action may affect.

Table 11-4. Ongoing consultations with agencies and American Indian tribes.

Agency	Summary of interaction
National Nuclear Security Administration/Nevada Site Office	DOE continues to work closely with the National Nuclear Security Administration/Nevada Site Office regarding site maintenance, security, use of resources, air space and future actions.
U.S. Department of the Navy	DOE continues to consult closely with the Navy regarding inventory and transportation.
U.S. Department of the Air Force	DOE continues to consult closely with the Air Force regarding air space and overflights.
Bureau of Land Management	DOE met routinely with the BLM to discuss project direction and coordination. DOE has held numerous briefings and working meetings with the BLM, regarding the status of the NEPA analyses. In addition, a BLM staff member occupied DOE offices during the development of this Repository SEIS, the Nevada Rail Corridor SEIS, and the Rail Alignment EIS to facilitate communications and interactions between DOE and the BLM.
U.S. Fish and Wildlife Service	DOE met with staff from the U.S. Fish and Wildlife Service on January 27, 2005, March 2, 2006, and December 13, 2006, to discuss how changes in the repository design could affect compliance with the Endangered Species Act for construction and operation of the proposed repository.
U.S. Army Corps of Engineers	Between November 4, 2004 and October 25, 2007, DOE met with the U.S. Army Corps of Engineers to provide an overview of the plans for constructing a railroad to Yucca Mountain and to obtain initial information from the U.S. Army Corps of Engineers on the permitting process for Section 404 of the *Clean Water Act*. These meetings included discussions on jurisdictional determinations for the repository.

Table 11-4. Ongoing consultations with agencies and Indian tribes (continued).

Agency	Summary of interaction
U.S. Environmental Protection Agency	On February 20, 2008, DOE met with staff of the U.S. Environmental Protection Agency to discuss that agency's comments on the NEPA analyses.
State of Nevada	DOE met with personnel from the Nevada Department of Wildlife, the Nevada Division of Forestry, the Nevada Department of Transportation, the Nevada Bureau of Air Quality, and the Nevada Division of Water Resources. Discussions with the U.S. Department of Transportation included the mitigation of potential traffic congestion by widening U.S. Highway 95 as presented in this Repository SEIS.
	DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Office, continue to work together to develop the programmatic agreement for the repository.
Local agencies	Nye County has established cooperating agency status and has been actively involved in the preparation of this Repository SEIS.
American Indian tribes	DOE has met several times in 2005 and 2006 with the Consolidated Group of Tribes and Organizations.
	After each meeting between DOE and the Consolidated Group of Tribes and Organizations or the designated American Indian Writers Subgroup, the tribal representatives prepared a series of recommendations for DOE consideration.
Nuclear Waste Technical Review Board	The Technical Review Board's primary responsibility is to evaluate (1) the site characterization phase of the Yucca Mountain Project and the activities associated with determining whether the Yucca Mountain site is suitable for further development as a geologic repository, and (2) the packaging and transportation of spent nuclear fuel and high-level radioactive waste. DOE has ongoing interactions with the Board.
U.S. Nuclear Regulatory Commission	DOE has met periodically with the U.S. Nuclear Regulatory Commission for technical exchanges.
	DOE submitted the application for construction authorization to NRC in June 2008.

BLM = Bureau of Land Management.
DOE = U.S. Department of Energy.
NEPA = National Environmental Policy Act.
STB = Surface Transportation Board.

REFERENCES

179968 DeBurle 2006 DeBurle, M.A. 2006. "Re: Class II General Air Quality Operation Permit Renewal, #AP9199-0573.02, FIN #A0023." Letter from M.A. DeBurle (NDEP) to W.J. Arthur, III (DOE/OCRWM), August 8, 2006, 0814065554, MAD/tu, with enclosure. ACC: MOL.20070316.0087.

155970 DOE 2002 DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*. DOE/EIS-0250F. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.

12

Glossary

12. GLOSSARY

The U.S. Department of Energy (DOE or the Department) has provided this glossary to assist readers in the interpretation of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). The Glossary includes definitions of technical and regulatory terms common to DOE *National Environmental Policy Act* (NEPA) documents and explains these terms with their most likely meanings in the context of DOE NEPA documents, and in particular this Repository SEIS. To better aid the reader, a number of terms in this glossary emphasize their project-specific relationship to the Yucca Mountain Repository (*italicized* words are defined in the glossary). DOE derived the definitions in this glossary from the most authoritative sources available (for example, a statute, regulation, DOE directive, dictionary, or technical reference book) and checked each definition against other authorities.

100-year flood	A flood *event* of such magnitude that it occurs, on average, every 100 years; this equates to a 1-percent chance of its occurring in a given year. A base flood may also be referred to as a 100-year storm. The area inundated during the base flood is sometimes called the 100-year *floodplain*.
accessible environment	For this Repository SEIS, all points on Earth outside the surface and *subsurface* area controlled over the long term for the proposed *repository*, including the atmosphere above the *controlled area*.
accident	An unplanned sequence of events that results in undesirable consequences. Examples in this Repository SEIS include an inadvertent release of *radioactive* or hazardous materials from their containers or confinement to the environment, vehicular accidents during the transportation of highly radioactive materials, and industrial accidents that could affect workers in the facilities.
actinide	Any one of a series of chemically similar elements of *atomic numbers* 89 (actinium) through 103 (lawrencium). All actinides are *radioactive*.
affected environment	The physical, biological, and human-related environment that is sensitive to changes resulting from the *Proposed Action*. The extent of the affected environment may not be the same for all potentially affected resource areas. For example, traffic may increase within 4 miles of a hypothetical site from which waste would be removed to a nearby landfill (the extent of the affected environment with respect to transportation impacts). In contrast, *groundwater* extending 2 miles from the hypothetical site may be affected (the extent of the affected environment with respect to groundwater impacts).
aging	The retention of *commercial spent nuclear fuel* on the surface in *dry storage* for the purpose of reducing its thermal output as necessary to meet *repository* thermal management goals.

Aging Facility	Facility that provides the capability to age *commercial spent nuclear fuel* as necessary to meet *waste package* thermal limits.
aging overpack	A *cask* specifically designed for aging *spent nuclear fuel*. *Transportation, aging, and disposal* (*TAD) canisters* and *dual-purpose canisters* would be placed in aging overpacks for *aging* on the aging pad.
Agreement State	A state that reaches an agreement with the U.S. Nuclear Regulatory Commission (NRC) to assume regulatory authority to license and regulate *radioactive* materials.
air quality	A measure of the concentrations of pollutants, measured individually, in the air.
alcove	A small excavation (room) off the main tunnel of a *repository* used for scientific study or for the installation of equipment.
aleatory	An inherent variation associated with the physical system or environment. Also referred to as variability, irreducible uncertainty, stochastic uncertainty, and random uncertainty.
alien species	With respect to a particular *ecosystem*, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.
alignment	As used in the transportation analysis in this Repository SEIS, an engineered refinement of a rail corridor in which DOE would identify the location of a rail line.
Alloy 22	A corrosion-resistant, high-nickel alloy DOE would use for the outer shell of the *waste package*, for rails that support the *drip shields*, and for the parts of the *emplacement* pallet that would contact the *waste package*.
alluvium	A general term for the sedimentary material deposited by flowing water.
alpha particle	A positively charged particle ejected spontaneously from the *nuclei* of some *radioactive* elements. It is identical to a helium *nucleus* and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). See *ionizing radiation.*

alternative

One of two or more actions, processes, or propositions from which a *decisionmaker* will determine the course to be followed. The *National Environmental Policy Act* states that in the preparation of an *environmental impact statement*, an agency "shall ... study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" [42 U.S.C. 4321, Title I, Section 102 (E)]. The regulations of the Council on Environmental Quality that implement the National Environmental Policy Act indicate that the alternatives section is "the heart of the environmental impact statement" (40 CFR 1502.14), and include rules for presentation of the alternatives, including no action, and their estimated *impacts*.

This Repository SEIS has two alternatives: the *Proposed Action*, under which DOE would construct, operate and monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain, and the *No-Action Alternative* under which DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate significant adverse environmental impacts and commercial utilities The *Nuclear Waste Policy Act, as amended* states that this Repository SEIS does not have to discuss alternatives to *geologic* disposal or alternative sites to Yucca Mountain; DOE included the analysis of the No-Action Alternative to provide a basis for comparison with the Proposed Action.

alternative segments

Within a *rail alignment*, alternative segments are multiple routes DOE has selected for consideration. DOE would select one of them for the final *rail line*.

Amargosa Desert

The basin area south of Beatty, Nevada, and extending southeast about 80 kilometers (50 miles) to the area of Alkali Flat in California. The unincorporated town of Amargosa Valley, Nevada, is in the central portion of the Amargosa Desert. Amargosa Desert is also the name of *hydrographic area* number 230, which is part of the Death Valley Groundwater Region; both are designations used by the State of Nevada in its water planning and appropriations efforts. The boundaries of the Amargosa Desert hydrographic area closely resemble those of the geographic area.

Amargosa River

The main drainage system of the *Amargosa Desert*. The Amargosa River drainage basin originates in the Pahute Mesa-Timber Mountain area north of Yucca Mountain and includes the main tributary systems of *Beatty Wash* and *Fortymile Wash*. The river, which is frequently dry along much of its length, flows southeast through the Amargosa Desert and ends in the internal drainage system of Death Valley.

ambient	• Undisturbed natural conditions such as ambient temperature caused by climate or natural *subsurface* thermal gradients. • Surrounding conditions.
ambient air	The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in the immediate proximity to emission sources.
ambient air quality standards	Standards established on a federal or state level that define the limits for airborne concentrations of designated *criteria pollutants* to protect public health with an adequate margin of safety (primary standards) and to protect public welfare, including plant and animal life, visibility, and materials (secondary standards). National Ambient Air Quality Standards have been established for *nitrogen dioxide*, *sulfur dioxide*, *carbon monoxide*, *particulate matter* with aerodynamic diameters less than 10 microns (PM_{10}), particulate matter with aerodynamic diameters less than 2.5 microns ($PM_{2.5}$), *ozone*, and lead. See *criteria pollutants*.
analytical periods	See *Repository SEIS analytical periods.*
analyzed land withdrawal area	An area of approximately 600 square kilometers (230 square miles or 150,000 acres) at Yucca Mountain. Because the land has not yet been withdrawn, in this Repository SEIS it is referred to as the analyzed land withdrawal area. DOE uses the same analyzed land withdrawal area for the analyses in this Repository SEIS it used in the Yucca Mountain FEIS.
aquifer	A *subsurface* saturated rock unit (formation, group of formations, or part of a formation) of sufficient *permeability* to transmit *groundwater* and yield usable quantities of water to wells and springs.
atomic mass	The mass of a neutral atom, based on a relative scale, usually expressed in atomic mass units. See *atomic weight.*
atomic number	The number of *protons* in an atom's *nucleus*.
atomic weight	The relative mass of an atom based on a scale in which a specific carbon atom (carbon-12) has a mass value of 12. Also known as relative *atomic mass*.
A-weighted decibel	See *decibel, A-weighted.*
backfill	The general fill that would be placed in the excavated areas of an *underground facility*. Backfill for the proposed *repository* could be *tuff* or other material.
background radiation	*Radiation* from cosmic and cosmogenic sources, external terrestrial sources, radon in homes, and internally deposited radionuclides..

barrier	Any material, structure, or condition (as a thermal barrier) that prevents or substantially delays the movement of water or *radionuclides*. See *natural barrier*.
Beatty Wash	A tributary drainage to the *Amargosa River*; drains the west and north sides of the Yucca Mountain area.
best management practices	The processes, techniques, procedures, or considerations that DOE would employ to avoid or reduce the potential environmental *impacts* of its *Proposed Action* in a cost-effective manner while meeting the *Yucca Mountain Repository* project objectives.
beta particle	A negatively charged *electron* or positively charged positron emitted from a *nucleus* during *decay*. Beta decay usually refers to a *radioactive* transformation of a *nuclide* by electron emission in which the *atomic number* increases by 1 and the mass number remains unchanged. In positron emission, the atomic number decreases by 1 and the mass number remains unchanged. See *ionizing radiation.*
biosphere	The *ecosystem* of the Earth and the living *organisms* that inhabit it.
boiling-water reactor	A *nuclear reactor* that uses boiling water to produce steam to drive a turbine.
borehole	For this Repository SEIS, a hole drilled to collect *site characterization* data or to supply water.
borosilicate glass	*High-level radioactive waste matrix* material in which boron takes the place of the lime used in ordinary glass mixtures. See *vitrification*.
buffer area	Area where railcars or trucks with *transportation casks* would wait until DOE moved them to a waste handling facility or shipped them off the site, and where the Department would store empty *waste packages* on site rail transfer carts until needed.
buffer car	A railcar that DOE would place at the front of a *cask* train between the locomotive and the first cask car and at the back of the train between the last cask car and the *escort car*. Federal regulations require the separation of a railcar that carries *spent nuclear fuel* and *high-level radioactive waste* from a locomotive, occupied caboose, carload of undeveloped film, or a railcar that carries another class of hazardous material by at least one buffer car. These could be DOE railcars or, in the case of general freight service, commercial railcars.
cancer	A group of diseases that are characterized by uncontrolled growth and spread of abnormal cells.

candidate species — Species for which the U.S. Fish and Wildlife Service has enough substantive information on biological status and threats to support proposals to list them as threatened or endangered under the Endangered Species Act. Listing is anticipated but has been precluded temporarily by other listing activities.

canister — An unshielded metal container used as:

- A pour mold in which molten vitrified *high-level radioactive waste* could solidify and cool.
- A container in which DOE and electric utilities would place intact *spent nuclear fuel*, loose rods, or nonfuel components for shipping or storage.
- In general, a container that provides *radionuclide* confinement. Canisters would be used in combination with specialized overpacks that provide structural support, *shielding*, or confinement for storage, transportation, and *emplacement*. Overpacks used for transportation are usually referred to as *transportation casks*; those used for emplacement in a *repository* are referred to as *waste packages*.

Canister Receipt and Closure Facility — Facility that would receive DOE *disposable canisters* and *TAD canisters*, load canisters into *waste packages*, and close the waste packages.

carbon monoxide — A colorless, odorless, poisonous gas produced by incomplete fossil-fuel combustion; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*.

carcinogen — An agent capable of producing or inducing *cancer*.

cask

- A heavily shielded container that meets applicable regulatory requirements used to ship *spent nuclear fuel* or *high-level radioactive waste*;
- A heavily shielded container used by DOE and utilities for the *dry storage* of spent nuclear fuel; usable only for storage, not for transport to or *emplacement* in a *repository*; or
- A heavily shielded container that would be used by DOE to transfer *canisters* among waste handling facilities at the repository.

Cask Receipt Security Station — Facility that would perform initial waste receipt and inspection.

central operations area — The central operations area is an area approximately 0.8 kilometer (0.5 mile) southwest of the *geologic repository operations area* that DOE would develop for all operations, to include support and replacement of *subsurface infrastructure* in the *Exploratory Studies Facility*.

chain reaction	A process in which some *neutrons* released in one *fission* event cause other fission events that in turn release neutrons.
cladding	The metallic outer sheath of a fuel element generally made of stainless steel or a *zirconium alloy*. Its purpose is to isolate the fuel element from the *accessible environment.*
clastic	Describing a rock or sediment that consists mainly of broken fragments of preexisting minerals or rocks that have been transported from their places of origin.
closure	See *closure analytical period*.
closure analytical period	10 years – Overlaps the last 10 years of the *monitoring analytical period* and includes activities that would begin upon receipt of a license amendment to close the repository. Activities would include *decommissioning* and demolishing surface facilities, emplacing *drip shields*, *backfilling*, restoring the surface to its approximate condition before *repository* construction, and constructing monuments to mark the site. See *Repository SEIS analytical periods*.
cloudshine	*Irradiation* of the human body by *neutrons* and *gamma rays* emitted by the passing plume of *radioactive* material.
commercial spent nuclear fuel	Commercial nuclear fuel rods that have been removed from *reactor* use at commercial nuclear power plants. See *spent nuclear fuel* and *DOE spent nuclear fuel.*
common segment	Portions of the *rail alignment* for which DOE has selected a single route for the *rail line*.
composite employment	Sum of *direct* and *indirect employment*.
construction	See *construction analytical period.*
construction analytical period	5 years – Begins upon receipt of *construction* authorization from NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and *subsurface* development. See *Repository SEIS analytical period.*
construction right-of-way	As used in the analysis for the Rail Alignment EIS, nominally 150 meters (500 feet) on either side of the centerline of the *rail alignment*, with some variability. The right-of-way is generally linear but includes areas for support facilities such as quarries, water wells, and access roads.

contaminant	A substance that contaminates (pollutes) air, soil, or water. Also a hazardous substance that does not occur naturally or that occurs at levels greater than those that occur naturally in the surrounding *environment*.
contamination	The intrusion of undesirable elements (unwanted physical, chemical, biological, or radiological substances, or matter that has an adverse effect) to air, water, or land.
controlled area	The area restricted for the long term for the proposed *repository*, as identified by passive *institutional controls* DOE would install at *closure*. The controlled area would be 300 square kilometers (about 120 square miles) maximum surface and *subsurface* area that extended in the predominant direction of *groundwater* flow no farther south than 36 degrees, 40 minutes, 13.6661 seconds north latitude (the present southwest corner of the Nevada Test Site), and no more than 5 kilometers (3 miles) from the repository footprint in any other direction (see 40 CFR 197.12).
corridor	As used in the transportation analysis in this Repository SEIS, a strip of land, approximately 400 meters (0.25 mile) wide, that encompasses one of several possible routes through which DOE could build a *rail line* to transport *spent nuclear fuel*, *high-level radioactive waste*, and other materials to and from the proposed *Yucca Mountain Repository*.
corrosion	The process of dissolving or wearing away gradually, especially by chemical action.
corrosion products	Materials produced by corrosion process.
corrosion-resistant material	Outer *waste package* material, such as *Alloy 22*, that corrodes slowly in a corrosive environment.
criteria pollutants	Six common pollutants (*ozone*, *carbon monoxide*, *particulate matter, sulfur dioxide*, lead, *and nitrogen dioxide*) known to be hazardous to human health and the environment and for which the U.S. Environmental Protection Agency (EPA) sets National *Ambient Air Quality Standards* under the Clean Air Act. See *toxic air pollutants*.
crud	A colloquial term for corrosion and wear products (rust particles, etc.) that become radioactive (i.e., neutron activated) when exposed to radiation.
cumulative impact	An *impact* on the environment that results from the incremental impact(s) of an action added to impacts from other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions that take place over a period of time.

curie	A unit of *radioactivity* equal to 37 billion disintegrations per second; also a quantity of any *nuclide* or mixture of nuclides having 1 curie of radioactivity.
day-night average sound level	The energy average of the *A-weighted decibel* sound levels over a 24-hour period. It includes an adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to noise during the night.
decay (radioactive)	The process in which one *radionuclide* spontaneously transforms into one or more different radionuclides called decay products.
decibel	A standard unit for measuring sound pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is the smallest sound a human can hear.
decibel, A-weighted (dBA)	A measurement of sound that approximates the sensitivity of the human ear, which is used to characterize the intensity or loudness of sound.
decisionmaker	The group or individual who would be responsible for making a decision on the *construction* and *operation* of a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain.
decommissioning	The process of removal from service a facility in which the handling of nuclear materials occurs. If nuclear materials have been handled at the facility, decommissioning includes decontamination of the facility so it can be dismantled or dedicated to other purposes.
dedicated train	A train that handles only one commodity. For the proposed *railroad*, this separate train with its own crew would limit switching between trains of the railcars carrying *spent nuclear fuel* and *high-level radioactive waste*.
detention pond	A low-lying area that is designed to temporarily hold a set amount of water while slowly draining to another location. Detention ponds exist for flood control when large amounts of rain could cause flash flooding if not dealt with properly. The pond acts to reduce the peak runoff downstream by spreading the discharge over a longer period.
direct employment	Jobs that are expressly associated with project activity.
direct impact	An effect that would result solely from the *Proposed Action* without intermediate steps or processes. Examples include *habitat* destruction, soil disturbance, air emissions, and water use.
disintegration	Any transformation of a *nucleus*, whether spontaneous or induced by *irradiation*, in which the nucleus emits one or more particles or *photons*.

disposable canister	A metal vessel for *DOE spent nuclear fuel* assemblies (including *naval spent nuclear fuel*) or solidified *high-level radioactive waste* suitable for storage, shipping, and *disposal*. At the *repository*, DOE would remove the disposable canister from the *transportation cask* and place it directly in a *waste package*. There are a number of types of disposable canisters, including standard canisters, multicanister overpacks, and *TAD canisters*.
disposal	For this Repository SEIS, the *emplacement* in a *repository* of *high-level radioactive waste*, *spent nuclear fuel*, or other highly *radioactive* material with no foreseeable intent of recovery, whether or not such emplacement would permit the recovery of such waste, and the *isolation* of such waste from the *accessible environment*.
distribution	As used in analyses of long-term performance, a range of values and probabilities associated with each value (or subrange of values) within the range. This can be in the form of a mathematical function or a table of values. See *normal distribution.*
DOE spent nuclear fuel	Nuclear fuel that has been withdrawn from a *nuclear reactor*, provided the constituent elements of the fuel have not been separated by reprocessing, that DOE manages from its defense production reactors, U.S. naval reactors, and DOE test and experimental reactors, as well as from university and other research reactors, commercial reactor fuel acquired by DOE for research and development, and from foreign research reactors.
dose (radioactive)	The amount of *radioactive* energy taken into (absorbed by) living tissues.
dose equivalent	The product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. It is expressed numerically in *rem*. The dose equivalent quantity is used to compare the biological effectiveness of different kinds of *radiation* (based on the quality of radiation and its spatial distribution in the body) on a common scale.
drift	From mining terminology, a horizontal underground passage. In relation to the proposed *repository*, this includes excavations for *emplacement* (emplacement drifts), ventilation exhaust mains, access (access mains), and *performance confirmation* (observation drift).
drip shield	A corrosion-resistant *engineered barrier* that DOE would place above a *waste package* to prevent seepage water from direct contact with the waste package for thousands of years. The drip shield would also protect the waste package from rock fall.

dry storage	Storage of *spent nuclear fuel* without *immersion* of the fuel in water for cooling or *shielding*; it involves the encapsulation of spent nuclear fuel in a steel cylinder that might be in a concrete or massive steel *cask* or structure.
dual-purpose canister	A metal vessel suitable for storing (in a storage facility) and shipping (in a *transportation cask*) *commercial spent nuclear fuel* assemblies. At the *repository,* DOE would remove dual-purpose canisters from the transportation cask and open them. DOE would remove the spent nuclear *fuel assemblies* from the dual-purpose canister and place them in a *TAD canister* before placement in a *waste package*. The opened canister would be recycled or disposed of off the site as *low-level radioactive waste.*
duripan	A *subsurface* layer held together (cemented) by silica, usually containing other accessory cements.
earthquake	A series of elastic waves in the crust of the Earth caused by abrupt movement that eases strains built up along *geologic faults* or by volcanic action and that results in movement of the Earth's surface.
ecoregion	A relatively discrete set of *ecosystems* characterized by certain plant communities or assemblages.
ecosystem	A community of *organisms* and their physical environment interacting as an ecological unit.
electron	A stable elementary particle that is the negatively charged constituent of ordinary matter.
emplacement	The placement and positioning of *waste packages* in the proposed *repository*.
emplacement panels	Isolated areas in the proposed *repository* that DOE would set aside for waste *disposal.*
endangered species	An animal or plant species that is in danger of extinction throughout all or a significant part of its range.
engineered barrier	The designed, or engineered, components of the proposed *underground facility* at Yucca Mountain, which would include the *waste packages* and other *barriers*.

environmental impact statement (EIS)

A detailed written statement that describes:

> ...the environmental impact of the proposed action; any adverse environmental effects which cannot be avoided should the proposal be implemented; alternatives to the proposed action (although the Nuclear Waste Policy Act, as amended, precludes consideration of certain alternatives); the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Preparation of an environmental impact statement requires a public process that includes public meetings, reviews, and comments, as well as agency responses to the public comments.

environmental justice

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental *impacts* that result from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898, Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations, directs federal agencies to make the achievement of environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on *minority populations* and *low-income populations*.

epistemic

Lack of knowledge of quantities or processes of the system or the environment. Also referred to as subjective uncertainty, reducible uncertainty, and model form uncertainty.

erionite

Erionite is an uncommon zeolite mineral that forms wool-like fibrous masses and is listed as a known human *carcinogen* by recognized international agencies such as the International Agency for Research on Cancer. Based on geologic studies to characterize the repository horizon, erionite appears to be absent or rare at the proposed repository depth and location.

escort car

Railcar in which escort personnel would travel on a train that carried *spent nuclear fuel* or *high-level radioactive waste*.

evaporation pond

A containment pond with impermeable bottom and sides designed to hold liquid wastes and to concentrate the waste through evaporation.

evapotranspiration	The combined processes of evaporation and plant *transpiration* that remove water from the soil and return it to the air.
event	Any thing that happens discretely at a particular time; for example, an *earthquake* is an event.
Exploratory Studies Facility	An underground laboratory at Yucca Mountain that comprises an 8-kilometer (5-mile) main loop (tunnel), a 3-kilometer (2-mile) cross *drift*, and a research *alcove* system for the performance of underground studies. The proposed *repository* could incorporate some or all of the Exploratory Studies Facility.
exposed	See *exposure (to radiation)*.
exposure (to radiation)	The incidence of *radiation* on living or inanimate material by *accident* or intent. Background exposure is the exposure to natural *ionizing radiation*. Occupational exposure is the exposure to ionizing radiation that occurs during a person's working hours. Population exposure is the exposure to a number of persons who inhabit an area.
exposure pathway	The course a chemical or physical agent takes from the source to the exposed *organism*; it describes a unique mechanism by which an individual or population can become *exposed* to chemical or physical agents at or originating from a release site. Each exposure pathway includes a source or a release from a source, an exposure point, and an exposure route.
fault	A *fracture* or a fracture zone in crustal rocks along which there has been movement of the fracture's two sides in relation to one another, so what were once parts of one continuous rock *stratum* or vein are now separated.
fault-gouge material	Crushed and ground-up rock produced by friction between two sides of a *fault* when there is movement along the fault.
fission	The splitting of a *nucleus* into at least two other nuclei, which results in the release of two or three *neutrons* and a relatively large amount of energy.
floodplain	The lowlands adjoining inland and coastal waters and relatively flat areas and flood-prone areas of offshore islands. Executive Order 11988 requires federal facilities to assess, at a minimum, actions in areas inundated by a 1-percent or greater chance of flood in any given year. By DOE regulation (40 CFR Part 1022), the base floodplain is defined as the 100-year (1.0-percent) floodplain, and the critical action floodplain is defined as the 500-year (0.2-percent) floodplain (see *100-year flood*).
Fortymile Wash	A major tributary to the *Amargosa River*; drains the east side of Yucca Mountain, *Jackass Flats* to the east of Yucca Mountain, and the Fortymile Canyon area to the north. Fortymile Wash is usually dry along most of its length.

fracture	A general term for any break in a rock, whether or not it causes displacement, caused by mechanical failure from stress. Fractures include cracks, joints, and *faults*. Fractures can act as *pathways* for rapid *groundwater* movement.
fuel assembly	A number of fuel elements held together by structural materials for use in a *nuclear reactor*.
fugitive dust	*Particulate matter* composed of soil; can include emissions from haul roads, wind erosion of exposed soil surfaces, and other activities in which soil is removed or redistributed.
full-time equivalent worker years	The number of employees who would be involved in an activity calculated from work hours. Each full-time equivalent worker year consists of 2,000 work hours (the number of hours DOE assumed for one worker in a normal work year).
gamma ray	High-energy, short wavelength, electromagnetic *radiation* emitted from the *nucleus*. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium.
geologic	Of or related to a natural process that acts as a dynamic physical force on the Earth (such as, faulting, erosion, and mountain-building resulting in rock formations).
geologic repository	A system for disposing of *radioactive* waste in excavated *geologic* media, which includes surface and *subsurface* areas of operation and the adjacent part of the geologic setting that provides *isolation* of radioactive waste in a *controlled area*.
geologic repository operations area	As defined at 10 CFR 63.2, the geologic repository operations area is "a *high-level radioactive waste* facility that is part of a *geologic repository,* including both surface and *subsurface* areas, where waste handling activities are conducted."
Great Basin	A subprovince of the Basin and Range Province, generally characterized by north-trending mountain ranges and intervening basins, that stretches north to south from eastern Oregon to southern California, includes most of Nevada, and extends into western Utah.
Greater-Than-Class-C waste	*Low-level radioactive waste* generated by the commercial sector that exceeds NRC concentration limits for Class-C *low-level radioactive waste*, as specified in 10 CFR Part 61. DOE is responsible for disposing of this type of waste pursuant to the Low-Level Radioactive Waste Policy Amendments Act of 1985.
Gross Regional Product	The value of all final goods and services produced in the *region of influence.*

groundshine — The *radiation dose* received from an area on the ground where a *radioactive* plume or cloud has deposited *radioactivity*.

groundwater — Water in pores or fractures in either the *unsaturated zone* or *saturated zone* below ground level.

habitat — Area in which a plant or animal lives and reproduces.

hazardous pollutant — Hazardous chemical that can cause serious health and environmental hazards, and that is listed on the federal list of hazardous air pollutants (42 U.S.C. Part 7412). See *toxic air pollutants.*

hazardous waste — Waste is designated as hazardous if it appears on the list of hazardous materials prepared by the EPA or a state or local regulatory agency, or if it has characteristics defined as hazardous by such agency. If the EPA does not list a material as hazardous, it still may be considered a hazardous waste if it exhibits one of the four characteristics defined in 40 CFR 261 Subpart C: ignitability, corrosivity, reactivity, or toxicity.

heavy-haul truck — An *overweight, overdimension truck* that must have permits from state highway authorities to use public highways; a vehicle DOE would use on public highways to move *spent nuclear fuel* or *high-level radioactive waste shipping casks* designed for a railcar.

heavy metal — In the context of this Repository SEIS, all uranium, plutonium, and thorium used or generated in a manmade *nuclear reactor*.

high-level radioactive waste —

1. The highly *radioactive* material that resulted from the reprocessing of *spent nuclear fuel*, which includes liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains *fission* products in sufficient concentrations. (Note: DOE would vitrify liquid high-level radioactive waste before shipping it to the proposed *repository*.)
2. Other highly radioactive material that the NRC, consistent with existing law, determines by rule requires permanent *isolation*.

human intrusion — The inadvertent penetration into the *repository* by people.

hydric — Describes soils that are characterized by the presence of considerable moisture.

hydrographic area — In reference to Nevada *groundwater*, divisions of the state into groundwater basins and subbasins based primarily on topographic features such as mountains and valleys. The state uses the map of hydrographic areas as the basis for water planning, management, and administration. (Because they are based heavily on topographic features, hydrographic area boundaries sometimes differ from groundwater basin designations developed from studies of inferred or measured groundwater flow patterns.)

hydrology	1. The study of water characteristics, especially the movement of water. 2. The study of water, involving aspects of geology, oceanography, and meteorology.
immersion	See *cloudshine*.
impact	The positive or negative effect of an action (past, present, or future) on the natural environment (land use, *air quality*, water resources, geological resources, ecological resources, aesthetic and scenic resources) and the human environment *(infrastructure*, economics, social, and cultural).
in situ	In its natural position or place. The phrase distinguishes in-place experiments, that is, conducted in the field or *underground facility*, from those conducted in the laboratory.
incident-free	Routine transportation in which cargo travels from origin to destination without being involved in an *accident*.
indirect employment	Jobs that are created as a result of expenditures by directly employed project workers (for example, restaurant workers or childcare providers) or jobs that are created by project-related purchases of goods and services (for example, sales manager of a concrete supply store).
indirect impact	An effect that is related to but removed from a *proposed action* by an intermediate step or process. Examples include surface-water quality changes resulting from soil erosion at construction sites, and reductions in productivity resulting from changes in soil temperature.
indurated	Hardened, as in a *subsurface* layer that has become hardened.
industrial waste	*Solid waste* that is neither hazardous nor *radioactive* such as construction and demolition debris, rubber, and miscellaneous plastic products. Examples of construction and demolition debris include soil, rock, masonry materials, and lumber.
industrial wastewater	Liquid wastes from industrial processes that do not include *sanitary sewage*. *Repository* industrial wastewater would include water for dust suppression, rinse water from concrete production and transport, and process water from building heating, ventilation, and air conditioning systems.
infrastructure	Basic facilities, services, and installations for the functioning of a community or society, such as transportation and communication systems. For the proposed *repository*, these would include surface and *subsurface facilities* (for example, service *drifts*, transporters, electric power supplies, waste handling buildings, and administrative facilities).

Initial Handling Facility — A facility that would receive *high-level radioactive waste* and *naval spent nuclear fuel* canisters, load *canisters* into *waste packages*, and close the waste packages.

institutional control — *Monitoring* and maintenance of storage facilities to ensure that radiological releases to the environment and *radiation doses* to workers and the public remain within federal limits and DOE Order requirements, as applicable. For the proposed *repository*, active institutional control would require the presence of humans to safeguard and maintain the site; passive institutional control would include such devices as permanent markers and land records to warn future generations of dangers.

invasive species — An *alien species* whose introduction does or is likely to cause economic or environmental harm or harm to human health.

invert — The structure constructed in a *drift* to provide the floor of that drift. Drifts are made by boring machines and have a round bottom. The invert makes the bottom of the drift flat.

involved worker — Nonradiological impacts: A worker who would be doing the physical work involved with constructing, operating, monitoring, and closing the *repository*.

Radiological impacts: A worker who would be directly engaged in the activities related to *subsurface* construction and *operations* at the proposed repository, which would include subsurface excavation activities; receipt, handling, packaging, and *emplacement* of waste materials; and *monitoring* of the condition and performance of the *waste packages*. See *noninvolved worker*.

ion —
1. An atom that contains excess *electrons* or is deficient in electrons, which causes it to be chemically active.
2. An electron not associated with a *nucleus*.

ionizing radiation —
1. *Alpha particles*, *beta particles*, *gamma rays*, *x-rays*, *neutrons*, high-speed *electrons*, high-speed *protons*, and other particles capable of producing *ions*.
2. Any *radiation* capable of the displacement of electrons from an atom or molecule, thereby producing ions.

irradiation — *Exposure* to *radiation.*

isolation — Inhibition of the transport of *radioactive* material so the amounts and concentrations of the material that enters the *accessible environment* stay within prescribed limits.

Jackass Flats	A broad asymmetric basin 8 to 10 kilometers (5 to 6 miles) wide and 20 kilometers (12 miles) long that is east of Yucca Mountain and is drained by *Fortymile Wash*. Also the name of the *hydrographic area* (Area 227A) overlapping the same general land area and from which DOE would withdraw *groundwater* to support the *Proposed Action.*
latent cancer fatality	A death that results from *cancer* that *exposure* to *ionizing radiation* caused. There typically is a latent, or dormant, period between the time of the *radiation* exposure and the time the cancer cells become active.
lost workday case	A case that involves days away from work or days of restricted work activity, or both. Equivalent to Days Away, Restricted, or On Job Transfer case in the CAIRS database.
low-income	Below the poverty level, as defined by the Bureau of the Census.
low-income population	A population in which 20 percent or more of the persons live in poverty, as reported by the Bureau of the Census in accordance with Office of Management and Budget requirements.
low-level radioactive waste	*Radioactive* waste that is not classified as *high-level radioactive waste*, *transuranic waste*, byproduct material containing uranium or thorium from processed ore, or naturally occurring *radioactive* material. The *repository* low-level radioactive waste would include personal-protective clothing, air filters, solids from the liquid low-level waste treatment process, radiological control and survey waste, and used *dual-purpose canisters*.
mapping zone	Biogeographically unique areas the Southwest Regional Gap Analysis Project derived from existing ecoregion maps using a combination of topographic and soil information, which it then truncated at state boundaries. Mapping zones are subunits of *ecoregions*.
matrix	The solid, but porous, portion of the rock.
maximally exposed offsite individual	For public health and safety impact analysis, a hypothetical individual who would reside continuously for 70 years at the unrestricted public access area in the prevailing downwind direction from the repository that would receive the highest radiation exposure. For accident analysis, a hypothetical member of the public at a point on the site boundary who would be likely to receive the maximum radiation dose.
maximum contaminant level	Under the Safe Drinking Water Act, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people; the standards established as maximum contaminant levels consider the feasibility and cost of attaining the standard.

mesosphere	Belt of atmosphere, just above the *stratosphere*, from 50 to 80 kilometers (30 to 50 miles) above the Earth's surface.
metric tons of heavy metal (MTHM)	Quantities of *spent nuclear fuel* are traditionally expressed in terms of MTHM (typically uranium, but including plutonium and thorium), without the inclusion of other materials such as *cladding* and structural materials. A metric ton is 1,000 kilograms (1.1 short tons or 2,200 pounds). Uranium and other metals in spent nuclear fuel are called *heavy metals* because they are extremely dense; that is, they have high weights per unit volume. One MTHM disposed of as spent nuclear fuel would fill a space approximately the size of the refrigerated storage area in a typical household refrigerator.
midpillar	The rock section between adjacent *emplacement drifts*.
millirem	One one-thousandth (0.001) of a *rem*.
minority	Hispanic, Black, Asian/Pacific Islander, American Indian/Eskimo, Aleut, and other nonwhite person.
minority population	A community in which the percent of the population of a racial or ethnic minority is 10 points higher than the percent found in the population as a whole.
mitigation	Actions and decisions that: • Avoid *impacts* altogether by not taking a certain action or parts of an action; • Minimize impacts by limiting the degree or magnitude of an action; • Rectify the impact by repairing, rehabilitating, or restoring the *affected environment*; • Reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action; or • Compensate for an impact by replacing or providing substitute resources or environments.
mixed-oxide fuel	A mixture of uranium oxide and plutonium oxide that could be used to power commercial *nuclear reactors*.
mixed waste	Waste that exhibits the characteristics of both *hazardous* and *low-level radioactive wastes*.
monitoring	Activities during the *repository operations* and *monitoring analytical periods* that would include the surveillance and testing of *waste packages* and the repository for *performance confirmation*. See *monitoring analytical period.*

monitoring analytical period	50 years – Begins upon *emplacement* of the final *waste package*. Activities would include maintaining active ventilation of the *repository* for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to *postclosure* performance. See *Repository SEIS analytical periods.*
Monte Carlo sampling technique	Technique for the random generation of inputs from *probability distributions* to simulate the process of sampling from the actual population.
native species	With respect to a particular *ecosystem*, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.
natural barrier	The physical components of the *geologic* environment that individually and collectively act to limit the movement of water or, in relation to this Repository SEIS, *radionuclides*. See *barrier*.
naval spent nuclear fuel	*Spent nuclear fuel* discharged from *reactors* in surface ships, submarines, and training reactors operated by the U.S. Navy.
neutron	An atomic particle with no charge and an *atomic mass* of 1; a component of all atoms except hydrogen; frequently released as *radiation*.
nitrogen dioxide	See *nitrogen oxides:* one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*.
nitrogen oxides	Gases formed in great part from atmospheric nitrogen and oxygen when combustion occurs under conditions of high temperature and high pressure; a major air pollutant. Two primary nitrogen oxides, nitric oxide and *nitrogen dioxide*, are important airborne *contaminants*. Nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide. Both nitric oxide and nitrogen dioxide can, in high concentration, cause lung *cancer*. Nitrogen dioxide is a *criteria pollutant*.
noise-sensitive receptors	As used in this Repository SEIS, any specific resource (population or facility) that would be more susceptible to the effects of the noise impact of implementing the Proposed Action than would otherwise be.
No-Action Alternative	DOE included the analysis of the No-Action Alternative to provide a basis for comparison with the *Proposed Action*. For this SEIS, under the No-Action Alternative DOE would terminate activities at Yucca Mountain and undertake site reclamation to mitigate significant adverse environmental *impacts*. Commercial utilities and DOE would continue to store and manage *spent nuclear fuel* and *high-level radioactive waste* at 76 sites in the United States in a manner that protected public health and safety and the environment. See *alternative*.

nonattainment area	An area that does not meet the National *Ambient Air Quality Standard* for one or more *criteria pollutants*. Further designations (for example, serious, moderate) describe the magnitude of the nonattainment.
noninvolved worker	A worker who would perform managerial, technical, supervisory, or administrative activities but would not be directly involved in *construction*, excavation, or *operations* activities. Noninvolved workers include DOE Nevada Test Site workers. See *involved worker*.
nonnative species	A species found in an area where it has not historically been found.
normal distribution	As used in analyses of long-term performance, a special type of symmetrical distribution known in the science of statistics as the Gaussian distribution and commonly known as the "bell-shaped curve." See *distribution.*
North Construction Portal	*Portal* that would be used for construction of the *subsurface* facility.
North Portal	An existing *portal (*current northern access to the *Exploratory Studies Facility*) that DOE would use initially for *subsurface* construction and to emplace *waste packages* in the *subsurface facility*.
North Ramp	An existing, gently sloping incline that begins at the *North Portal* on the surface and extends through the *subsurface* to the edge of the *subsurface facility*. It would support *waste package emplacement* operations.
noxious weed	Any species of plant which is, or is likely to be, detrimental or destructive and difficult to control or eradicate.
nuclear reactor	A device in which a nuclear *fission chain reaction* can be initiated, sustained, and controlled to generate heat or to produce useful *radiation*.
Nuclear Waste Technical Review Board	An independent body in the executive branch created by the *Nuclear Waste Policy Amendments Act of 1987* to provide independent scientific and technical oversight of DOE's program for managing and disposing of *high-level radioactive waste* and *spent nuclear fuel*. The President appoints Board members from a list prepared by the National Academy of Sciences.
nucleus (nuclei)	The central, positively charged, dense portion of an atom. Also known as atomic nucleus.
nuclide	An atomic *nucleus* specified by its *atomic weight*, *atomic number*, and energy state; a *radionuclide* is a *radioactive* nuclide.
operations	See *operations analytical period.*

operational phases	Four stages used in the license application to indicate when specific facilities are expected to be operational under the planned phased construction. Operational phases are Phase 1, Phase 2, Phase 3, and Phase 4.
operations analytical period	50 years – Begins upon receipt of a license to receive and possess radiological materials and ends upon *emplacement* of the final *waste package*. Activities would include receipt, handling, *aging*, emplacement, and *monitoring* of waste, as well as continued construction of surface and *subsurface facilities*. See *Repository SEIS analytical periods.*
organism	An individual living system, such as animal, plant or micro-organism, that is capable of reproduction, growth and maintenance.
overweight, overdimension truck	Semi- and tandem tractor-trailer trucks with gross weights over 80,000 pounds that must obtain permits from state highway authorities to use public highways.
ozone	The triatomic form of oxygen; in the *stratosphere*, ozone protects the Earth from the Sun's *ultraviolet radiation*, but in lower levels of the atmosphere, it is an air pollutant; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*.
particulate matter	Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*. See $PM_{2.5}$ and PM_{10}.
pathway	A potential route by which *radionuclides* might reach the *accessible environment* and pose a threat to humans.
perceived risk	How an individual perceives, or senses, the amount of risk from a certain activity.
perched water	A *saturated zone* condition that is not continuous with the *water table* because an impervious or semipervious layer underlies the perched zone or a *fault* zone and creates a *barrier* to water movement and perches water. See *permeable.*
performance confirmation	The program of tests, experiments, and analyses DOE conducted to evaluate the accuracy and adequacy of the information it used to determine with reasonable assurance that the *repository* would meet the performance objectives for the period after *permanent closure*.
permanent closure	Final sealing of *shafts* and *boreholes* of the *underground facility*, which would include the installation of permanent monuments to mark the location and boundaries of the *repository*.

permeability	In general terms, the capacity of such mediums as rock, sediment, and soil to transmit liquid or gas. Permeability depends on the substance transmitted (such as oil, air, and water) and on the size and shape of the pores, joints, and *fractures* in the medium and the manner in which they interconnect. "Hydraulic conductivity" is equivalent to "permeability" in technical discussions of *groundwater*.
permeable	Pervious; a permeable rock is one that is either porous or cracked and that allows water to soak into and pass through freely.
person-rem	A unit to measure the *radiation exposure* to an entire group for comparison of the effects of different amounts of radiation on groups of people; it is the product of the average *dose equivalent* (in rem) to a given organ or tissue multiplied by the number of persons in the population of interest.
petrocalcic	A *subsurface* layer in which calcium carbonate or other carbonates have accumulated to the extent that the layer is cemented or *indurated*.
photon	A massless particle; the quantum of an electromagnetic field that carries energy, momentum, and angular momentum.
picocurie per liter (or gram)	A unit of concentration measure that describes the amount of *radioactivity* (in picocuries) in volume (or mass) of a given substance [typically, air or water (by volume) or soil (by mass)]. A picocurie is one-trillionth of a *curie*.
$PM_{2.5}$	*Particulate matter* with an aerodynamic diameter of 2.5 micrometers or less (about 0.0001 inch). This fine particulate matter is able to penetrate to the deepest part of the lungs and poses a risk to human health.
PM_{10}	*Particulate matter* with an aerodynamic diameter less than or equal to a nominal 10 micrometers (about 0.0004 inch). Particles smaller than this diameter are small enough to be breathable and could be deposited in lungs.
population dose	A summation of the *radiation doses* received by individuals in an exposed population; equivalent to collective dose. Expressed in *person-rem*.
portal	A portal is the opening to the *subsurface facility* that would provide access for construction, equipment, rock removal, and waste *emplacement.*
postclosure	The timeframe after *repository-closure* of the *repository* through the 1 million years analyzed in this Repository SEIS.
preclosure	The timeframe from construction authorization to *repository-closure*.
pressurized-water reactor	A nuclear power *reactor* that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.

primarily canistered approach — The packaging of most (a goal of 90 percent) *commercial spent nuclear fuel* at the commercial sites in multipurpose *TAD canisters*. The remaining commercial spent nuclear fuel (about 10 percent) would arrive at the *repository* as *uncanistered spent nuclear fuel* or in *dual-purpose canisters*.

prime farmland — Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is available for these uses (urban areas are not eligible). It has the soil quality, growing season, and moisture supply necessary for the economic production of sustained high yields of crops when treated and managed (including water management) in accordance with acceptable farming methods.

probabilistic —

1. Based on or subject to *probability*.
2. Involving a variable factor, such as temperature or porosity. At each instance of time, the factor can take on any of the values of a specified set with a certain probability. Data from a probabilistic *process* are an ordered set of observations, each of which is one item in a probability *distribution*.

probability — The relative frequency at which an *event* can occur during a defined period. Statistical probability is about what happens in the real world and is verifiable by observation or sampling. Knowledge of the exact probability of an event is usually limited by the inability to know, or compile the complete set of, all possible outcomes over time or space. Probability is measured on a scale of 0 (event will not occur) to 1 (event will occur).

process — Any phenomenon that occurs over a relatively long period, as opposed to an *event*, which occurs relatively instantaneously. An example of a process is general corrosion of metal.

proposed action — The activity proposed to accomplish a federal agency's purpose and need. An *environmental impact statement* analyzes the environmental *impacts* of the proposed action. A proposed action includes the project and its related support activities (preconstruction, construction, and operation, along with postoperational requirements). The Proposed Action for this Repository SEIS is the *construction*, *operation* and *monitoring,* and eventual *closure* of a *geologic repository* for *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain in Nevada.

Proposed Action inventory — Materials planned for *disposal* at the *Yucca Mountain Repository.*

proton — An elementary particle that is the positively charged component of ordinary matter and, together with the *neutron*, is a building block of all atomic *nuclei*.

pyroclastic	Of or related to individual particles or fragments of *clastic* rock material of any size formed by volcanic explosion or ejected from a volcanic vent.
qualitative	In relation to a variable, a parameter, or data, an expression or description of an aspect in terms of nonnumeric qualities or attributes. See *quantitative*.
quantitative	A numeric expression of a variable. See *qualitative.*
rad	A unit of absorbed *radiation dose* in terms of energy. One rad equals 100 ergs of energy absorbed per gram of tissue. (The word derives from radiation absorbed dose.)
radiation	The emitted particles or *photons* from the *nuclei* of *radioactive* atoms. Some elements are naturally radioactive; others are induced to become radioactive by *irradiation* in a *reactor*. Naturally occurring radiation is indistinguishable from induced radiation.
radioactive	Emitting *radioactivity*.
radioactivity	The property possessed by some elements (for example, uranium) of spontaneously emitting alpha, beta, or *gamma rays* by the *disintegration* of atomic *nuclei*.
radionuclide	An unstable *nuclide* capable of spontaneous transformation into an other nuclide by emitting photons or particles, thus changing its nuclear configuration or energy level.
rail alignment	A strip of land less than 400 meters (0.25 mile) wide within a corridor within which DOE would specify the location of a *rail line*.
rail corridor	A strip of land 400 meters (0.25 mile) wide through which DOE would identify an *alignment* for the construction of a *rail line*.
rail line	An engineered feature that consists of the track, ties, ballast, and subballast at a specific location.
railroad	A transportation system that incorporates the *rail line*, rail line operations support facilities, railcars, locomotives, and other related property and *infrastructure*.
reactor	See *nuclear reactor*.
real disposable personal income	The dollar income, including the value of transfer payments, available to individuals after taxes have been paid.

reasonably maximally exposed individual	A hypothetical person who is exposed to environmental *contaminants* (in this case *radionuclides*) in such a way (that is, by a combination of factors that include location, lifestyle, and dietary habits) that this individual is representative of the *exposure* of the general population. DOE used this hypothetical individual to evaluate long-term *repository* performance. The receptor represents the *reasonably maximally exposed individual* defined in 40 CFR Part 197. See *maximally exposed individual.*
Receipt Facility	A facility for the transfer of *TAD canisters* and *dual-purpose canisters*, as appropriate, to the *Wet Handling Facility*, a *Canister Receipt and Closure Facility*, and the *aging pads*.
Record of Decision	A document that provides a concise public record of a decision made by a government agency.
recordable cases	Occupational injuries or occupation-related illnesses that result in: 1. A fatality, regardless of the time between the injury or the onset of the illness and death, 2. *Lost workday cases* (nonfatal), or 3. The transfer of a worker to another job, termination of employment, medical treatment, loss of consciousness, or restriction of motion during work activities.
region of influence	A specialized term that indicates a specific area of study for each of the resource areas that this Repository SEIS analysis addresses.
release fraction	The fraction of each *radionuclide* in *spent nuclear fuel* or *high-level radioactive waste* that could be released from a containment in an *accident*.
rem	The unit of effective *dose equivalent* from *ionizing radiation* to the human body. It is an expression of the amount of *radiation* to which a person has been exposed. The effective dose equivalent in rem is equal to the absorbed *dose* in *rad* multiplied by quality and weighting factors that are necessary because biological effects can vary both by the type of radiation (even of the same deposited energy) and by the specific tissue exposed. (The word derives from roentgen equivalent in man).
repository	A burial vault. See *Yucca Mountain Repository.*
repository-closure	The point in time when activities associated with the closure analytical period, such as decommissioning and demolishing surface facilities and backfilling subsurface-to-surface openings, have been completed. Permanent closure of the repository would be complete; postclosure timeframe would begin.

Repository SEIS analytical periods

Four timeframes DOE defined for use in this Repository SEIS to best evaluate potential preclosure environmental impacts:

- *Construction analytical period*: 5 years – Begins upon receipt of the *construction* authorization from the NRC and ends prior to receipt of a license to receive and possess radiological materials. Activities would include site preparation, surface construction, and *subsurface* development.

- *Operations analytical period*: 50 years – Begins upon receipt of a license to receive and possess radiological materials and ends upon *emplacement* of the final waste package. Activities would include receipt, handling, *aging*, emplacement, and *monitoring* of waste, as well as continued construction of surface and *subsurface facilities*.

- *Monitoring analytical period*: 50 years – Begins upon emplacement of the final waste package. Activities would include maintaining active ventilation of the repository for as long as 50 years, remotely inspecting waste packages, and continuing investigations in support of predictions related to *postclosure* performance.

- *Closure analytical period*: 10 years – Overlaps the last 10 years of the monitoring analytical period and includes activities that would begin upon receipt of a license amendment to close the repository. Activities would include *decommissioning* and demolishing surface facilities, emplacing *drip shields*, *backfilling*, sealing subsurface-to-surface openings, restoring the surface to its approximate condition before repository construction, and constructing monuments to mark the site.

Resource area

For this Repository SEIS, a resource area, also known as a subject area, is one of the 13 areas evaluated to determine potential impacts to human health and welfare and the environment if the *Proposed Action* was implemented.

restricted area

As defined at 10 CFR 20.1003 and 10 CFR 63.2, an area in which DOE would separate waste handling operations from other activities in the *geologic repository operations area.* During phased *construction*, the restricted area would separate operational waste handling facilities from waste handling facilities under construction. DOE would monitor the restricted area to ensure adequate safeguards and security for *radioactive* materials.

resuspension

The renewed suspension into the atmosphere of material that had once settled to the ground.

retention pond

A pond designed to hold up to a specific amount of water indefinitely.

retrieval	The act of removing *radioactive* waste from the underground location at which the waste had been previously emplaced for *disposal*. Retrieval would be a contingency action, performed only if the waste needed to be retrieved in order to protect the public health and safety or the environment or to recover resources from *spent nuclear fuel*.
riprap	Broken stones or chunks of concrete used as foundation material or in embankments to control water flow or prevent erosion.
risk	The product of the *probability* that an undesirable *event* will occur multiplied by the consequences of the undesirable event.
sanitary sewage	Domestic wastewater from, sinks, showers, kitchens, floor drains, restrooms, change rooms, and food preparation and storage areas.
sanitary waste	*Solid waste* that is neither hazardous nor *radioactive*. Sanitary waste streams include paper, glass, and discarded office material. (State of Nevada waste regulations define this waste stream as household waste.)
saturated zone	The region below the *water table* where water completely fills all spaces (*fractures* and rock pores).
sedimentary rock	Rock formed by the accumulation and consolidation of sediment in water or land, usually in layered deposits. Sandstone, limestone, dolomite, and shale are types of sedimentary rocks DOE has identified in this Repository SEIS. They are differentiated by chemistry, deposition, and texture.
seismic	Pertaining to, characteristic of, or produced by *earthquakes* or earth vibrations.
sensitive species	As designated by the Bureau of Land Management, *native species* other than federally listed, proposed, or *candidate species* that the State Director deems to be in need of protection to ensure that actions authorized, funded, or carried out do not contribute to the need for the species to become listed under the Endangered Species Act. Bureau of Land Management Manual 6840.06 E provides the factors by which a native species may be listed as sensitive.
shaft	For the *Yucca Mountain Repository*, an excavation or vertical passage of limited area, in comparison with its depth, DOE would use to ventilate underground facilities.
shielding	Any material that provides *radiation* protection.
shielded transfer cask	A metal vessel used to transfer *canisters* among waste handling facilities.
shipment	The movement of a properly prepared (loaded, unloaded, or empty) *cask* from one site to another and associated activities to ensure compliance with applicable regulations.

shipping cask — A massive container with heavy *shielding* that would meet regulatory requirements for the shipment of *spent nuclear fuel* or *high-level radioactive waste*. See *cask*.

site characterization — Activities associated with the determination of the suitability of the *Yucca Mountain site* as a *geologic repository*. DOE constructed the *Exploratory Studies Facility*, which included surface facilities and *subsurface* ramps and *drifts*, to support the following activities related to the determination of site suitability:

- Gather and evaluate surface and subsurface site data,
- Predict the performance of the *repository,*
- Prepare the repository design, and
- Assess the performance of the system against the required regulations and program performance criteria.

soil map unit — A conceptual group of one or more map delineations identified by the same name in a soil survey that represent similar landscape areas that consist of either:

1. The same kind of component soils, with inclusions of minor or erratically dispersed soils; or
2. Two or more kinds of component soils that might or might not occur together in various delineations but that have similar special use and management properties.

soil order — The broadest category of soil classification, identified by the presence or absence of diagnostic layers, or horizons, which have specific physical, chemical, and biological properties.

soil series — The lowest category of soil taxonomy with the most restrictive classification of soil properties.

solid cancer — Solid *cancers* include all neoplasms other than those of the lymphatic and hematopoietic tissue.

solid waste — For this Repository SEIS analysis, non-liquid, nonsoluble materials ranging from municipal garbage to industrial wastes that contain complex, and sometimes hazardous, substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, and mining residues.

source term — Types and amounts of *radionuclides* that are the source of a potential release of *radioactivity*.

South Portal development area — An existing *portal* and ramp (current southern access to the *Exploratory Studies Facility*) that DOE would use for construction of the *subsurface facility*.

Southwest Regional Gap Analysis Project — This 2004 project was a multi-institutional effort to map and assess biodiversity for approximately 1.45 million square kilometers (560,000 square miles) in the southwestern United States. One task of this project was the development of a land cover map for the region.

Special-Performance-Assessment-Required wastes — *Low-level radioactive wastes* generated in DOE production *reactors*, research reactors, reprocessing facilities, and research and development activities that exceed the NRC Class C shallow-land burial *disposal* limits.

spent nuclear fuel

1. *Nuclear reactor* fuel that has been used to the extent that it can no longer effectively sustain a *chain reaction*.
2. Fuel that has been withdrawn from a nuclear reactor after *irradiation*, the component elements of which have not been separated by reprocessing. For this Repository SEIS, this refers to:
    a. Intact, nondefective *fuel assemblies*,
    b. Failed fuel assemblies in *canisters*,
    c. Fuel assemblies in canisters,
    d. Consolidated fuel rods in canisters,
    e. Nonfuel assembly hardware inserted in *pressurized-water reactor* fuel assemblies,
    f. Fuel channels attached to *boiling-water reactor* fuel assemblies, and
    g. Nonfuel assembly hardware and structural parts of assemblies resulting from consolidation in canisters.

stigma — An undesirable attribute that blemishes or taints an area or locale.

stratigraphic units — A layer or body of rock, distinct from that above or below, based on a specific property or characteristic of the rock. (A stratigraphic unit based on one rock property may not coincide with the unit designation based on another property.)

stratigraphy — The branch of geology that deals with the definition and interpretation of rock strata, the conditions of their formation, character, arrangement, sequence, age, distribution, and especially their correlation by the use of fossils and other means of identification. See *stratum*.

stratosphere	The atmospheric shell above the *troposphere* and below the *mesosphere*. It extends from 10 to 20 kilometers (6 to 12 miles) to about 53 kilometers (33 miles) above the surface.
stratum	A sheet-like mass of *sedimentary rock* or earth of one kind between beds of other kinds.
subsurface	A zone below the surface of the Earth, the *geologic* features of which are principally layers of rock that have been tilted or faulted and are interpreted on the bases of drill hole records and geophysical (*seismic* or rock vibration) evidence. In general, it is all rock and solid materials lying beneath the Earth's surface.
subsurface facility (subsurface geologic repository operations area)	The structure, equipment and systems (such as ventilation), *backfill* materials if any, and openings that penetrate underground (for example, ramps, *shafts*, and *boreholes*, including their seals).
sulfur dioxide	A pungent, colorless gas produced during the burning of sulfur-containing fossil fuels; one of the six *criteria pollutants* for which there is a National *Ambient Air Quality Standard*. It is the main pollutant involved in the formation of acid rain. Coal- and oil-burning electric utilities are the major source of sulfur dioxide in the United States. Inhaled sulfur dioxide can damage the human respiratory tract and severely damage vegetation. See *criteria pollutants, ambient air quality standards*.
TAD canister	See *transportation, aging, and disposal (TAD) canister*.
threatened species	A species that is likely to become endangered in the foreseeable future throughout all or a significant part of its range.
threshold limit values	The airborne concentration of a material to which nearly all persons can be exposed day after day, for a normal 8-hour workday or 40-hour workweek, without adverse effects; term used by the American Conference of Governmental Industrial Hygienists.
total employment	The sum of *direct* and *indirect employment* resulting from initiation of an activity. Direct employment consists of jobs performing the activity. Indirect employment consists of jobs in other activities supporting the direct employees. Also defined as *composite employment*.
total recordable cases	The total number of work-related deaths, illnesses, or injuries that resulted in the loss of consciousness, restriction of work or motion, transfer to another job, or that required medical treatment beyond first aid.

total effective dose equivalent	An expression of the *radiation* dose received by an individual from external radiation and from *radionuclides* internally deposited in the body; often generically referred to as *dose*. All doses presented in this Repository SEIS are in terms of total effective dose.
Total System Performance Assessment	A *risk* assessment that *quantitatively* estimates how the proposed *Yucca Mountain Repository* system could perform under the influence of specific features, *events*, and processes, incorporating uncertainty in the models and data.
toxic air pollutant	A hazardous air pollutant not listed as a *criteria pollutant* or a hazardous pollutant.
transpiration	The process by which water enters a plant through its root system, passes through its vascular system, and releases into the atmosphere through openings in its outer covering. It is an important process for removal of water that has infiltrated below the zone where it could be removed by evaporation.
transportation, aging, and disposal (TAD) canister	A *canister* suitable for storage, shipping, and *disposal* of *commercial spent nuclear fuel*. Commercial spent nuclear fuel would be placed directly into a TAD canister at the commercial *reactor*. At the *repository*, DOE would remove the TAD canister from the *transportation cask* and place it directly into a *waste package* or an *aging overpack*. The TAD canister is one of a number of types of *disposable canisters*.
transportation cask	A vessel that meets applicable regulatory requirements for the transport of *spent nuclear fuel* or *high-level radioactive waste* via public transportation routes.
transuranic waste	Waste materials (excluding *high-level radioactive waste* and certain other waste types) contaminated with alpha-emitting *radionuclides* that are heavier than uranium with half-lives greater than 20 years and that occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from treatment and fabrication of plutonium and from research activities at DOE defense installations.
troposphere	The lowest layer of the atmosphere; it contains about 95 percent of the mass of air in the Earth's atmosphere. The troposphere extends from the Earth's surface up to about 10 to 15 kilometers (6 to 9 miles).
tuff	Igneous rock formed from compacted volcanic fragments from *pyroclastic* (explosively ejected) flows with particles generally smaller than 4 millimeters (about 0.16 inch) in diameter; the most abundant type of rock at the *Yucca Mountain site*. Nonwelded tuff results when volcanic ash cools in the air sufficiently so it does not melt together, yet later becomes rock through compression. See *welded tuff*.

ultraviolet radiation — Electromagnetic *radiation* with wavelengths from 4 to 400 nanometers. This range begins at the short wavelength limit of visible light and overlaps the wavelengths of long *x-rays* (some scientists place the lower limit at higher values, up to 40 nanometers). Also known as ultraviolet light.

uncanistered spent nuclear fuel — *Commercial spent nuclear fuel* placed directly into *transportation casks*. At the *repository*, DOE would remove spent nuclear fuel assemblies from the transportation cask and place them in a *TAD canister* before placement in a *waste package* or site *aging overpack.*

underground facility — In relation to the proposed *repository*, the underground structure, backfill materials, if any, and openings that penetrate the underground structure (for example, ramps, *shafts*, and *boreholes*).

unsaturated zone — The region between the surface and the *water table* where water fills only some of the spaces (*fractures* and rock pores).

vibration velocity decibels (VdB) — Vibration velocity in decibels with respect to 1 microinch per second. A measurement of root-mean-square velocity for the evaluation of ground vibration as an average or smoothed vibration amplitude on a logarithmic scale.

visual resource management class — The Bureau of Land Management classification of visual resource values.

Class I	Preserve the existing character of the landscape.	Provides for natural ecological changes but does not preclude limited management activity. Changes to the land must be small and must not attract attention.
Class II	Retain the existing character of the landscape.	Management activities may be seen but should not attract the attention of the casual observer. Changes must repeat the basic elements of form, line, color, and texture of the predominant natural features of the characteristic landscape.
Class III	Partially retain the existing character of the landscape.	Management activities may attract attention but may not dominate the view of the casual observer. Changes should repeat the basic elements in the predominant natural features of the characteristic landscape.
Class IV	Provide for management activities that require major modifications of the existing character of the landscape.	Management activities may dominate the view and be the major focus of viewer attention. An attempt should be made to minimize the impact of activities through location, minimal disturbance, and repeating the basic elements.

vitrification — A waste treatment process that uses glass (for example, *borosilicate glass)* to encapsulate or immobilize *radioactive* wastes.

waste package — Consists of the corrosion-resistant outer container, the waste form and any internal containers (such as the *TAD canister*), spacing structure or baskets, and *shielding* integral to the container. The waste package would be ready for *emplacement* in the *repository* when the outer lid welds were completed and accepted.

water table —
1. The upper limit of the *saturated zone* (the portion of the ground wholly saturated with water).
2. The upper surface of a zone of saturation above which the majority of pore spaces and *fractures* are less than 100 percent saturated with water most of the time (*unsaturated zone*) and below which the opposite is true (saturated zone).

welded tuff — A *tuff* deposited under conditions where the particles that make up the rock were heated sufficiently to cohere. In contrast to nonwelded tuff, welded tuff is denser, less porous, and more likely to be fractured (which increases *permeability*).

Wet Handling Facility — A facility designed to handle uncanistered *commercial spent nuclear fuel* and to open and unload *dual-purpose canisters*; its essential purpose is to load *TAD canisters.*

wetland —
- A shoreline or other area, such as a marsh or swamp, that is saturated with moisture, especially when it is the natural *habitat* of wildlife.
- An area that is inundated or saturated by surface or *groundwater* at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

x-rays — Penetrating electromagnetic *radiation* with a wavelength much shorter than that of visible light. X-rays are identical to *gamma rays* but originate outside the *nucleus*, either when the inner orbital *electrons* of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons.

Yucca Mountain Repository (repository) — Inclusive term for all areas in the *Yucca Mountain site* where DOE would construct the proposed facilities to support the proposed *repository*, including roads.

Yucca Mountain site — The area inside the site boundary over which DOE has control.

Yucca Mountain site boundary	That line beyond which DOE does not own, lease, or otherwise control the land or property for the purposes of the *repository*.
zirconium alloy	An alloy material that contains the element zirconium and that can have several compositions. For this Repository SEIS, it is a *cladding* material.

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Preparers, Contributors, and Reviewer

13. PREPARERS, CONTRIBUTORS, AND REVIEWERS

13.1 Preparers and Contributors

This chapter lists the individuals who filled primary roles in the preparation of this *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DOE/EIS-0250F-S1) (Repository SEIS). Jane R. Summerson, Ph.D., of the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management directed the preparation of the Repository SEIS. The Repository SEIS Team, led by Joseph W. Rivers, Jr., of Jason Associates Corporation provided primary support and assistance to DOE; other members of the team include AGEISS Environmental, Inc., Dade Moeller & Associates, Inc., Tetra Tech NUS Inc., HRA Inc., and Battelle Memorial Institute.

DOE provided direction to the Repository SEIS Team, which was responsible for developing the analytical methodology and alternatives, coordinating the work tasks, performing the impact analyses, and producing the document. DOE was responsible for data quality, the scope and content of the Repository SEIS, and issue resolution and direction. The DOE Office of Civilian Radioactive Waste Management Technical Support Services contractor, Booz Allen Hamilton, assisted DOE in managing information flow and work priorities.

In addition, the Management and Operating contractor to the Office of Civilian Radioactive Waste Management (Bechtel SAIC Corporation and its subcontractors) assisted in the preparation of supporting documentation and information for this Repository SEIS, as did Sandia National Laboratories and the Nye County Nuclear Waste Project Office. These organizations, along with Potomac-Hudson Engineering, worked with the Repository SEIS Team to coordinate data and technologies for the simultaneous preparation of this Repository SEIS, the Rail Alignment EIS, and the application for an authorization to construct a repository.

DOE independently evaluated all supporting information and documentation prepared by these organizations. Further, DOE retained the responsibility for determining the appropriateness and adequacy of incorporating any data, analyses, and results of other work performed by these organizations in this Repository SEIS. The Repository SEIS Team was responsible for integrating such work in this Repository SEIS document.

As required by federal regulations [40 CFR 1506.5(c)], Jason Associates Corporation and its subcontractors have signed *National Environmental Policy Act* (NEPA) disclosure statements in relation to the work they performed on this Repository SEIS. These statements appear at the end of this chapter.

Name	Education	Experience	Responsibility
U.S. Department of Energy			
Jane R. Summerson	Ph.D., Geology, 1991 M.S., Geobiology, 1985 M.A., Anthropology, 1978 B.A., Anthropology, 1977	16 years – waste management projects with the DOE office of Civilian Radioactive Waste Management	DOE Document Manager
Repository SEIS Team			
Joseph W. Rivers, Jr. Jason Associates Corporation	B.S., Mechanical Engineering, 1982	25 years – commercial and DOE nuclear projects, NEPA and regulatory compliance, systems engineering, and safety analysis.	Project Manager
James "Pat" Barker HRA Inc., Conservation Archaeology	Ph.D., Anthropology, 1982	20 years – Bureau of Land Management Cultural Resources Management Program archaeologist, 18 in Nevada	Lead Analyst: Cultural Resources
Tonya Bartels AGEISS Environmental, Inc.	M.S., Analytical Chemistry, 1994 B.S., Chemistry, 1991	8 years – NEPA project support.	Lead Analyst: Land Use, Noise and Vibration, Aesthetics
Pixie Baxter Tetra Tech NUS Inc.	M.B.A., Economics, 1981 B.A., Art History	20 years – multidisciplinary economic and business experience including 15 years as economics college faculty member.	Lead Analyst: Socioeconomics
William J. Craig Dade Moeller & Associates	M.S., Planning, 1977 B.S., Forestry, 1972	27 years – power plant siting, nuclear fuel management, NEPA, project management, and public participation.	Comment Response Team; Lead Analyst: Similar Actions, Unavoidable Impacts, Appendix A
David Crowl Dade Moeller & Associates	B.A., Computer Science, 1985	23 years – NEPA documentation, technical writing and editing, publications management.	Production Team: technical editor

Name	Education	Experience	Responsibility
Keith D. Davis, PE Jason Associates Corporation	M.S., Civil/Environmental Engineering, 1976 B.S., Civil Engineering, 1973	30 years – civil and environmental engineering; waste management; facility permitting and closure; site investigations, feasibility studies, and remedial action planning; 13 years – NEPA documentation.	Lead Analyst: Geology, Hydrology, Manufacturing Repository Components, and Floodplain/Wetlands Assessment (Appendix C)
Peter R. Davis Jason Associates Corporation	Oak Ridge School of Reactor Technology 1962 B.S., Physics, 1961	45 years – nuclear reactor and nuclear facility safety analysis and risk assessment.	Lead Analyst: Accident Scenarios
Med Durel AGEISS Environmental, Inc.	M.S., Chemistry B.S., Chemistry Graduate, US Army War College	35 years – hazardous materials, environmental protection, occupational health and safety and education.	Lead Analyst: Mitigation
Mark Gonzalez Jason Associates Corporation	B.S., Forestry 2002	5 years – preparation of NEPA and CEQA documents and environmental compliance.	Lead Analyst: Waste and Hazardous Materials, Retrieval.
Ernest C. Harr, Jr. Jason Associates Corporation	B.S., Zoology/Chemistry 1977	30 years – DOE and commercial programs and projects, radiological programs, environmental monitoring, and radioactive materials and waste management.	Deputy Project Manager; Comment Response Document Lead
Dennis Heyer AGEISS Environmental, Inc.	1 ½ years of college courses	18 years – environmental investigations, regulatory compliance, and health and safety compliance.	Quality Control Team: Change Control Database check

Name	Education	Experience	Responsibility
Rich Huenefeld AGEISS Environmental, Inc.	M.S., Natural Resource Sciences, 2002 B.S., Natural Resource Sciences, 1996	11 years – wildlife and habitat research and assessment; 3 years – NEPA documentation.	Lead Analyst: Biological Resources and Soils; Integration team lead for Repository SEIS
Laurie Johnson Jason Associates Corporation	A.A., Graphic Design	25 years – graphics design.	Production Team: graphics designer
Aaron Klug AGEISS Environmental, Inc.	B.S., Reclamation, 1996	10 years – regulatory compliance, waste management projects, NEPA documentation.	Quality Control Team: Final Repository SEIS data consistency check
Dave Lechel	M.S., Fisheries Biology, 1974 B.S., Fisheries Biology, 1972	28 years – preparing and managing preparation of NEPA documents (25 years on DOE NEPA work).	DOE consultant: assisted DOE develop the construct of the Repository SEIS; performed independent review of preliminary sections of the Draft SEIS.
Scott Kinderwater Jason Associates Corporation	B.S., Soil Science, 1979	19 years – regulatory compliance, hazardous waste management and water quality enforcement.	Lead Analyst: No-Action Alternative, Statutory Requirements
Robin Klein Dade Moeller & Associates	1 year of college courses	30 years – word processing, advanced formatting, graphic design. Lead word processor on Final Yucca Mountain EIS.	Production Team: word processor

Name	Education	Experience	Responsibility
David H. Lester Jason Associates Corporation	Ph.D., Chemical Engineering, 1969 M.S., Chemical Engineering, 1966 B. Che., Chemical Engineering, 1964	32 years – hazardous and nuclear waste management; nuclear safety analysis reports, hazards analysis, risk assessment, groundwater contamination transport modeling, performance, design of treatment systems, design and analysis of high-level waste packages, and soil remediation studies.	Lead Analyst: Postclosure Consequences
Steven Maheras Battelle Memorial Institute	Ph.D., Health Physics, 1988 M.S., Health Physics, 1985 B.S., Zoology, 1982 Certified Health Physicist, 1992	19 years – transportation risk assessment and radiological assessment, environmental and occupational radiation protection.	Lead Analyst: Transportation
Sanjay Mawalkar Battelle Memorial Institute	MBA, Decision Sciences/MIS, 1993 B.E., Chemical Engineering, 1986	14 years – software design and implementation	Analyst: Transportation
Thomas I. McSweeney Battelle Memorial Institute	Ph.D., Chemical Engineering, 1967 M.A., Mathematics, 1964 M.S., Chemical Engineering, 1961 B.S., Chemical Engineering, 1960	40 years – transportation risk assessment and safety analysis	Analyst: Transportation
Julie Moniot Jason Associates Corporation	B.S., Nursing, 2000	12 years – general office, network administration	Production Team: word processor, comment distribution
Christijo Plemons Jason Associates Corporation	1 ½ years of college courses	18 years – marketing and general office.	Production Team: glossary, references, graphics production
Heidi Roberts HRA Inc., Conservation Archaeology	M.A., Anthropology, 1991	25 years – contract archaeology.	Lead Analyst: Cultural Resources

Name	Education	Experience	Responsibility
Christine Ross Battelle Memorial Institute	AD, Microcomputer Management Specialist/Multimedia Specialist, 1999	8 years – GIS and computer mapping	Analyst: Transportation
Melissa H. Russ, PG AGEISS Environmental, Inc.	M.S., Geology, 1986	25 years – environmental remedial investigations and feasibility studies; emergency response and cleanup; permitting and regulatory compliance; 10 years – NEPA documentation.	Lead Analyst: Proposed Action and Alternatives
Leroy Shaser AGEISS Environmental, Inc.	M.S., Geology 1978 B.S., Geology 1976	15 years – environmental compliance: NEPA, CERCLA, RCRA; 26 years – GIS and computer mapping.	Lead Analyst: Air Quality-nonradiological; Occupational and Public Health and Safety-nonradiological; Utilities, Energy, Materials, and Site Services; and the nonradiological air quality Appendix B; GIS graphics
Erika Shelton Battelle Memorial Institute	B.S., Engineering Physics and Astronomy, 2007	1 year – Transportation risk assessment.	Analyst: Transportation
John O. Shipman Dade Moeller & Associates	B.A., English Literature, 1966	41 years – NEPA documentation, technical writing and editing, publications management; 10 years – public participation.	Comment Response Team; Production Team: lead technical editor
Susan Sobczak-Bryan, PG AGEISS Environmental, Inc.	M.E., Geological Engineer, 1992; B.S., Geological Engineering, 1986	19 years – quality assurance and quality control management and auditing; NEPA water resource analyses; CERCLA hazardous waste site investigations and feasibility studies.	Lead Analyst: Mitigation, Best Management Practices and Unavoidable Adverse Impacts; Document Quality Assurance Manager

Name	Education	Experience	Responsibility
Alisa "Kathryn" Stapelman Jason Associates Corporation	A.A., Event Planning	10 years – office administration.	Word Team: word processor, document coding
Joanne Stover Jason Associates Corporation	B.S., Business Administration, 1996	20 years – technical editing, marketing, NEPA document development, and project management.	Production Team: document production manager, technical editor, document control, Administrative Record, references
Julianne Turko AGEISS Environmental, Inc.	M.A., Geology, 1989 B.S., Geological Sciences, 1981	16 years – environmental compliance experience, NEPA, CERCLA, RCRA, CWA, CAA.	Lead Analyst: Cumulative Impacts
Christine Van Lenten Jason Associates Corporation	B.A., English, 1965	15 years – support to OCRWM/YMP and other DOE programs including WIPP and EM, principally as writer, editor, and policy analyst, handling broad range of subjects.	Summary
Susan Walker AGEISS Environmental, Inc.	Ph.D., Pathology, 1982 B.S., Zoology, 1975	32 years – toxicology, risk assessment, environmental studies including NEPA and regulatory compliance.	Deputy Project Manager; Document Manager; Lead Analyst: Environmental Justice
YuChien Yuan Jason Associates Corporation	Ph.D., Nuclear Engineering, 1976 M.S., Chemical Engineering, 1970 B.S., Chemical Engineering, 1967	31 years – radiological and health risk assessment, radionuclide transport and pathway analysis, occupational radiation protection.	Lead Analyst: Occupational and Public Health and Safety-radiological

13.2 Reviewers

The DOE Office of Civilian Radioactive Waste Management incorporated input to the preparation of this Repository SEIS from a number of other DOE offices that reviewed the document while it was under development. These include the offices of Environmental Management, Naval Reactors, Nuclear Energy, Materials Disposition, the National Spent Nuclear Fuel Program, the National High-Level Waste Program, and General Counsel.

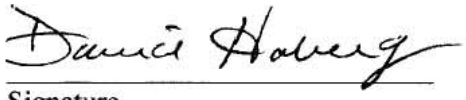
NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, JASON ASSOCIATES CORPORATION hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:



Signature

David Hoberg

Name (printed)

Vice-President/CFO

Title

Jason Associates Corporation

Company

September 5, 2007

Date

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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In accordance with these requirements, LECHEL, Inc. hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

David Lechel
Signature

DAVID LECHEL
Name (printed)

VICE PRESIDENT
Title

LECHEL, INC
Company

8-21-07
Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, AGEISS Environmental, Inc. hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Donna Lawrence

Signature

Donna Lawrence

Name (printed)

President

Title

AGEISS Environmental, Inc.

Company

September 4, 2007

Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

Prime Contract No. DE-AM04-02AL67953
Task Order No. DE-AT28-06RW12374
Subcontract No. 1102S-0301

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purpose of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," (46 FR 18026-18038 at Question 17a and b).

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In accordance with these requirements, Battelle Memorial Institute hereby certifies to the best of its knowledge and belief, it has no financial or other interest in the outcome of the project.

Certified By:

Signature

Scott G. Williams
Name (printed)

Sr. Contract Administrator
Title

Battelle Memorial Institute – Columbus Operations
Company

September 6, 2007
Date

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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In accordance with these requirements, Dade Moeller & Associates hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Signature

Glenn S. Caprio

Name (printed)

Chief Operating Officer

Title

Dade Moeller & Associates

Company

9/4/07

Date

NEPA DISCLOSURE STATEMENT FOR
PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, Tetra Tech NUS, Inc., hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Signature

James L. Oliver
Name (printed)

Aiken Operations Manager
Title

Tetra Tech NUS, Inc.
Company

September 4, 2007
Date

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR A GEOLOGIC REPOSITORY FOR THE DISPOSAL OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE AT YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" (see 46 FR 18026-18031).

In accordance with these requirements, AGEISS Environmental, Inc. hereby certifies it has no financial or other interest in the outcome of the project.

Certified By:

Heidi Roberts

Signature

Heidi Roberts
Name (printed)

_____
Title

HRA Archaeology
Company

9-15-2007
Date

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CONVERSION FACTORS

Metric to English			English to Metric		
Multiply	by	To get	Multiply	by	To get
Area					
Square kilometers	247.1	Acres	Acres	0.0040469	Square kilometers
Square kilometers	0.3861	Square miles	Square miles	2.59	Square kilometers
Square meters	10.764	Square feet	Square feet	0.092903	Square meters
Concentration					
Kilograms/sq. meter	0.16667	Tons/acre	Tons/acre	0.5999	Kilograms/sq. meter
Milligrams/liter	1[a]	Parts/million	Parts/million	1[a]	Milligrams/liter
Micrograms/liter	1[a]	Parts/billion	Parts/billion	1[a]	Micrograms/liter
Micrograms/cu. meter	1[a]	Parts/trillion	Parts/trillion	1[a]	Micrograms/cu. meter
Density					
Grams/cu. centimeter	62.428	Pounds/cu. ft.	Pounds/cu. ft.	0.016018	Grams/cu. centimeter
Grams/cu. meter	0.0000624	Pounds/cu. ft.	Pounds/cu. ft.	16,025.6	Grams/cu. meter
Length					
Centimeters	0.3937	Inches	Inches	2.54	Centimeters
Meters	3.2808	Feet	Feet	0.3048	Meters
Micrometers	0.00003937	Inches	Inches	25,400	Micrometers
Millimeters	0.03937	Inches	Inches	25.40	Millimeters
Kilometers	0.62137	Miles	Miles	1.6093	Kilometers
Temperature					
Absolute					
Degrees C + 17.78	1.8	Degrees F	Degrees F – 32	0.55556	Degrees C
Relative					
Degrees C	1.8	Degrees F	Degrees F	0.55556	Degrees C
Velocity/Rate					
Cu. meters/second	2,118.9	Cu. feet/minute	Cu. feet/minute	0.00047195	Cu. meters/second
Meters/second	2.237	Miles/hours	Miles/hour	0.44704	Meters/second
Volume					
Cubic meters	264.17	Gallons	Gallons	0.0037854	Cubic meters
Cubic meters	35.314	Cubic feet	Cubic feet	0.028317	Cubic meters
Cubic meters	1.3079	Cubic yards	Cubic yards	0.76456	Cubic meters
Cubic meters	0.0008107	Acre-feet	Acre-feet	1,233.49	Cubic meters
Liters	0.26418	Gallons	Gallons	3.78533	Liters
Liters	0.035316	Cubic feet	Cubic feet	28.316	Liters
Liters	0.001308	Cubic yards	Cubic yards	764.54	Liters
Weight/Mass					
Grams	0.035274	Ounces	Ounces	28.35	Grams
Kilograms	2.2046	Pounds	Pounds	0.45359	Kilograms
Kilograms	0.0011023	Tons (short)	Tons (short)	907.18	Kilograms
Metric tons	1.1023	Tons (short)	Tons (short)	0.90718	Metric tons
English to English					
Acre-feet	325,850.7	Gallons	Gallons	0.000003046	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

a. This conversion factor is only valid for concentrations of contaminants (or other materials) in water.

METRIC PREFIXES

Prefix	Symbol	Multiplication factor		
exa-	E	1,000,000,000,000,000,000	=	10^{18}
peta-	P	1,000,000,000,000,000	=	10^{15}
tera-	T	1,000,000,000,000	=	10^{12}
giga-	G	1,000,000,000	=	10^{9}
mega-	M	1,000,000	=	10^{6}
kilo-	K	1,000	=	10^{3}
deca-	D	10	=	10^{1}
deci-	D	0.1	=	10^{-1}
centi-	C	0.01	=	10^{-2}
milli-	M	0.0 001	=	10^{-3}
micro-	μ	0.000 001	=	10^{-6}
nano-	N	0.000 000 001	=	10^{-9}
pico-	P	0.000 000 000 001	=	10^{-12}