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

Volume I – Impact Analyses
Chapters 1 through 14

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

DOE/EIS-0250F-S1

June 2008

ACRONYMS AND ABBREVIATIONS

To ensure a more reader-friendly document, the U.S. Department of Energy (DOE) limited the use of acronyms and abbreviations in this Repository supplemental environmental impact statement. In addition, acronyms and abbreviations are defined the first time they are used in each chapter or appendix. The acronyms and abbreviations used in the text of this document are listed below. Acronyms and abbreviations used in tables and figures because of space limitations are listed in footnotes to the tables and figures.

°C	degrees Celsius
CFR	Code of Federal Regulations
dBA	A-weighted decibels
DOE	U.S. Department of Energy (also called *the Department*)
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FEIS	final environmental impact statement
FR	*Federal Register*
GNEP	Global Nuclear Energy Partnership
MTHM	metric tons of heavy metal
NEPA	*National Environmental Policy Act*
NRC	U.S. Nuclear Regulatory Commission
NWPA	*Nuclear Waste Policy Act*, as amended
PM_{10}	particulate matter with an aerodynamic diameter of 10 micrometers or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 micrometers or less
REMI	Regional Economic Models, Inc.
RMEI	reasonably maximally exposed individual
SEIS	supplemental environmental impact statement
Stat.	United States Statutes
TAD	transportation, aging, and disposal (canister)
TSPA	Total System Performance Assessment
U.S.C.	United States Code
VdB	vibration velocity in decibels with respect to 1 micro-inch per second

TERMS AND DEFINITIONS

In this Repository SEIS, DOE has italicized terms that appear in the Glossary (Chapter 12) the first time they appear in a chapter.

UNDERSTANDING SCIENTIFIC NOTATION

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

Positive Powers of 10	Negative Powers of 10
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	and so on, therefore,
10^6 = 1,000,000 (or 1 million)	10^{-6} = 0.000001 (or 1 in 1 million)

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

Substantive changes in this document are indicated in the margins with change bars.

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COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: *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).

CONTACTS:

For more information about this document, write or call:

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1551 Hillshire Drive M/S 011
Las Vegas, NV 89134
ATTN: Dr. Jane Summerson
Telephone: (800) 967-3477
Fax: (800) 967-0739

For general information on the DOE NEPA process, write or call:

Carol M. Borgstrom, Director
Office of NEPA Policy and Compliance (GC-20)
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585
Telephone: (202) 586-4600
Or leave a message: (800) 472-2756

Information about this document is available on the Internet at the Yucca Mountain Project Web site at http://www.ocrwm.doe.gov and on the DOE *National Environmental Policy Act* (NEPA) Web site at http://www.eh.doe.gov/nepa/.

ABSTRACT: DOE's Proposed Action is to construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain for the disposal of spent nuclear fuel and high-level radioactive waste. Under the Proposed Action, spent nuclear fuel and high-level radioactive waste in storage or projected to be generated at 72 commercial and 4 DOE sites would be shipped to the repository by rail (train), although some shipments would arrive at the repository by truck. The Repository SEIS evaluates (1) the potential environmental impacts from the construction, operations, monitoring, and eventual closure of the repository; (2) potential long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste; (3) potential impacts of transporting these materials nationally and in the State of Nevada; and (4) potential impacts of not proceeding with the Proposed Action (the No-Action Alternative).

COOPERATING AGENCIES: Nye County, Nevada, is a cooperating agency in the preparation of the Repository SEIS.

PUBLIC COMMENTS: In preparing this Repository SEIS, DOE considered written comments received by letter, electronic mail, and facsimile transmission, and oral and written comments given at public hearings at six locations in Nevada, one location in California, and in Washington, DC.

FOREWORD

The U.S. Department of Energy (DOE or Department) has prepared three analyses under the National Environmental Policy Act (NEPA) associated with the proposed disposal of spent nuclear fuel and high-level radioactive waste in a geologic repository at the Yucca Mountain Site in Nye County, Nevada. The first analysis, 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), evaluates the potential environmental impacts of constructing and operating the Yucca Mountain repository under the proposed repository design and operational plans. It supplements 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) (Yucca Mountain FEIS) prepared by the Department in 2002.

The second and third analyses are set forth in 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 – Nevada Rail Transportation Corridor (DOE/EIS-0250F-S2) (Nevada Rail Corridor SEIS) , and the Final Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada (DOE/EIS-0369) (Rail Alignment EIS). These analyses evaluate the potential environmental impacts of constructing and operating a railroad for shipments of spent nuclear fuel and high-level radioactive waste from an existing rail line in Nevada to the repository at Yucca Mountain, in order to help the Department decide whether to construct and operate a railroad, and if so, within which corridor and along which alignment. Because both the Nevada Rail Corridor SEIS and the Rail Alignment EIS address potential environmental impacts associated with the proposed construction and operation of a railroad, they are bound together in one document for the convenience of the reader.

Background and Context

The Nuclear Waste Policy Act, as amended (NWPA, 42 U.S.C. 10101 *et seq.)* directs the Secretary of Energy, if the Secretary decides to recommend approval of the Yucca Mountain site for development of a repository, to submit a final EIS with any recommendation to the President. To fulfill that requirement, the Department prepared the Yucca Mountain FEIS.

On February 14, 2002, the Secretary transmitted to the President the Secretary's recommendation (including the Yucca Mountain FEIS) for approval of the Yucca Mountain site for development of a geologic repository. The President considered the site qualified for application to the NRC for construction authorization and recommended the site to the U.S. Congress. Subsequently, Congress passed a joint resolution of the U.S. House of Representatives and the U.S. Senate designating the Yucca Mountain site for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. On July 23, 2002, the President signed the joint resolution into law (Public Law 107-200). As required by the NWPA [Section 114(b)], the Department has submitted an application to the NRC seeking authorization to construct the repository

Since completion of the Yucca Mountain FEIS in 2002, DOE has continued to develop the repository design and associated construction and operational plans. As now designed, the surface and subsurface facilities would allow DOE to operate the repository following a primarily canistered approach in which most commercial spent nuclear fuel would be packaged at the reactor sites in transportation, aging, and disposal (TAD) canisters. Any commercial spent nuclear fuel arriving at the repository in packages other than TAD canisters would be repackaged by DOE at the repository into TAD canisters. DOE would construct the surface and subsurface facilities over a period of several years (referred to as phased construction) to accommodate an increase in spent nuclear fuel and high-level radioactive waste receipt rates as repository operational capability reaches its design capacity.

To address the modifications to repository design and operational plans, the Department announced its intent to prepare a Supplement to the Yucca Mountain FEIS, consistent with NEPA and the NWPA (Notice of Intent to prepare *Supplement to 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, NV*; 71 FR 60490, October 13, 2006). The Repository SEIS supplements the Yucca Mountain FEIS by considering the potential environmental impacts of the construction, operation and closure of the repository under the modified repository design and operational plans, and by updating the analysis and potential environmental impacts of transporting spent nuclear fuel and high-level radioactive waste to the repository, consistent with transportation-related decisions the Department made following completion of the Yucca Mountain FEIS.

On April 8, 2004, the Department issued a Record of Decision announcing its selection, both nationally and in the State of Nevada, of the mostly rail scenario analyzed in the Yucca Mountain FEIS as the primary means of transporting spent nuclear fuel and high-level radioactive waste to the repository (*Record of Decision on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV*; 69 FR 18557, April 8, 2004). Implementation of the mostly rail scenario ultimately would require the construction of a rail line to connect the repository site at Yucca Mountain to an existing rail line in the State of Nevada. To that end, in the same Record of Decision, the Department also selected the Caliente rail corridor from several corridors considered in the Yucca Mountain FEIS as the corridor in which to study possible alignments for a rail line. On the same day DOE selected the Caliente corridor, it issued a Notice of Intent to prepare an EIS under NEPA to study alternative alignments within the Caliente corridor (the Rail Alignment EIS; DOE/EIS-0369) (*Notice of Intent to Prepare an Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV*; 69 FR 18565, April 8, 2004).

During the subsequent public scoping process, DOE received comments suggesting that other rail corridors be considered, in particular, the Mina route. In the Yucca Mountain FEIS, DOE had considered but eliminated the Mina route from detailed study because a rail line within the Mina route could only connect to an existing rail line in Nevada by crossing the Walker River Paiute Reservation, and the Tribe had informed DOE that it would not allow nuclear waste to be transported across the Reservation.

Following review of the scoping comments, DOE held discussions with the Walker River Paiute Tribe and, in May 2006, the Tribal Council informed DOE that it would allow the Department to consider the potential impacts of transporting spent nuclear fuel and high-level radioactive waste across its reservation. On October 13, 2006, after a preliminary evaluation of the feasibility of the Mina rail corridor, DOE announced its intent to expand the scope of the Rail Alignment EIS to include the Mina corridor (*Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV*; 71 *FR* 60484). Although the expanded NEPA analyses, referred to as the Nevada Rail Corridor SEIS and Rail Alignment EIS, evaluate the potential environmental impacts associated with the Mina corridor, DOE has identified the Mina alternative as non-preferred because the Tribe has withdrawn its support for the EIS process.

Relationships Among the EISs

Although the Yucca Mountain FEIS, the Repository SEIS and the Nevada Rail Corridor SEIS and Rail Alignment EIS are all related to the proposal to construct and operate the Yucca Mountain repository, they consider actions involving the jurisdiction of more than one federal agency. The Repository SEIS supplements the Yucca Mountain FEIS and considers the potential environmental impacts associated with the construction and operation of the Yucca Mountain repository. The responsibility for issuing construction authorization and a license to receive and possess radioactive materials at the repository rests with the Nuclear Regulatory Commission (NRC). Should the NRC authorize development of the repository, DOE would be the federal agency responsible for constructing and operating the repository.

The Nevada Rail Corridor SEIS, which supplements the rail corridor analysis in the Yucca Mountain FEIS, analyzes the potential environmental impacts associated with constructing and operating a railroad within the Mina corridor. The Nevada Rail Corridor SEIS analyzes the Mina corridor at a level of detail commensurate with that of the rail corridor analysis in the Yucca Mountain FEIS, and concludes that the Mina corridor warrants further study in the Rail Alignment EIS to identify an alignment for the construction and operation of a railroad.

The Nevada Rail Corridor SEIS also updates relevant information regarding three other rail corridors previously analyzed in the Yucca Mountain FEIS (Carlin, Jean, and Valley Modified). The update demonstrates that there are no significant new circumstances or information relevant to environmental concerns associated with these three rail corridors, and that they do not warrant further consideration in the Rail Alignment EIS. The Caliente-Chalk Mountain rail corridor, which also was included in the Yucca Mountain FEIS, would intersect the Nevada Test and Training Range, and was eliminated from further consideration because of U.S. Air Force concerns that a rail line within the Caliente-Chalk Mountain corridor would interfere with military readiness testing and training activities.

The Rail Alignment EIS tiers from the broader corridor analysis in both the Yucca Mountain FEIS and the Nevada Rail Corridor SEIS, consistent with the Council on Environmental Quality regulations (see 40 CFR 1508.28). Under the Proposed Action considered in the Rail Alignment EIS, DOE analyzes specific potential impacts of constructing and operating a rail line along common segments and alternative segments within the Caliente and Mina corridors for the purpose of determining an alignment in which to construct and operate a railroad for shipments of spent nuclear fuel and high-level radioactive waste from an existing rail line in Nevada to a geologic repository at Yucca Mountain. If DOE were to decide that a railroad should be constructed, it would be the federal agency charged with responsibility for carrying out the actions necessary to construct and operate the railroad.

The Repository SEIS includes the potential environmental impacts of national transportation, as well as the potential impacts in Nevada from the construction and operation of a rail line along specific alignments in either the Caliente or the Mina corridor, to ensure that the Repository SEIS considers the full scope of potential environmental impacts associated with the proposed construction and operation of the repository. Accordingly, the Repository SEIS incorporates by reference appropriate portions of the Nevada Rail Corridor SEIS and the Rail Alignment EIS. To ensure consistency, the Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS use the same updated inventory of spent nuclear fuel and high-level radioactive waste and the same number of rail shipments for analysis. Thus, the associated occupational and public health and safety impacts within the Nevada rail corridors under consideration are the same in the Repository SEIS, and in the Nevada Rail Corridor SEIS and Rail Alignment EIS. Furthermore, to promote conformity, consistent analytical approaches were used where appropriate to evaluate common resource areas.

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)

Proposed Action:

- DOE would construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain.
- Repository operations would include transporting spent nuclear fuel and high-level radioactive waste to Yucca Mountain nationally and in Nevada by either mostly rail or mostly truck

Record of Decision

- Mostly rail nationally and in Nevada
- Caliente rail corridor to determine alignment

Repository SEIS (DOE/EIS-0250F-S1)

1. Supplements the Yucca Mountain FEIS, as modified by:
   - Record of Decision (mostly rail, Caliente corridor) (69 *FR* 18557)
   - Outcome of the Nevada Rail Corridor SEIS (Mina corridor)
2. Otherwise Proposed Action remains unchanged:
   - DOE would construct, operate, monitor, and eventually close a repository
   - During repository operations, shipments would occur by mostly rail
   - In Nevada, rail shipments would occur on a railroad to be constructed along an alignment within either the Caliente or Mina rail corridor
   - Shipments also would arrive at repository by truck
3. To supplement the Nevada transportation analysis, the Repository SEIS incorporate by reference relevant information from the Rail Alignment EIS:
   - Affected environments of Caliente and Mina rail alignments
   - Environmental impacts from constructing and operating a railroad along Caliente or Mina alignment
   - Cumulative impacts associated with Caliente and Mina rail alignments

Nevada Rail Corridor SEIS (DOE/EIS-0250F-S2)

1. Supplements the Nevada transportation analysis of Yucca Mountain FEIS, as modified by:
   - Record of Decision (mostly rail) (69 *FR* 18557)
   - Proposed consideration of Mina rail corridor
2. Under the Proposed Action, DOE would construct and operate a railroad to connect the Yucca Mountain repository to an existing rail line near Wabuska, Nevada (the Mina rail corridor)
   - Mina rail corridor information and analyses at level of detail commensurate with that of the other corridors in the Yucca Mountain FEIS
3. Consider other corridors in Yucca Mountain FEIS for significant new circumstances or information bearing on environmental concerns
   - Review environmental information available since Yucca Mountain FEIS.
4. Conclusion:
   - The Mina corridor warrants further detailed study to determine an alignment based on impact analysis.
   - There are no significant changes or new information bearing on environmental concerns for the other corridors that would warrant further detailed study determine at the alignment level.

Rail Alignment EIS (DOE/EIS-0369)

1. The Rail Alignment EIS tiers from the Yucca Mountain FEIS and Nevada Rail Corridor SEIS
2. Proposed Action based on Record of Decision (69 *FR* 18557)
   - Under the Proposed Action, DOE would determine an alignment for the construction and operation of a railroad
     - ⇒ Caliente Implementing Alternative (preferred)
     - ⇒ Mina Implementing Alternative (nonpreferred)

Foreword Figure 1. Relationship among the Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS.

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Volume III

1

Purpose and Need for Agency Action

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1. PURPOSE AND NEED FOR AGENCY ACTION

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* (DOE/EIS-0250F; DIRS 155970-DOE 2002, all) (Yucca Mountain FEIS) in February 2002. Since the completion of the FEIS, DOE has continued to develop the *repository* design and associated plans. 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 address the modifications to repository design and operational plans. This Repository SEIS also updates the analysis and potential impacts of transporting *spent nuclear fuel* and *high-level radioactive waste* to the repository, consistent with transportation-related decisions the Department made following completion of the Yucca Mountain FEIS.

Spent nuclear fuel and high-level radioactive waste are long-lived, highly *radioactive* materials that result from certain nuclear activities. For more than 60 years, these materials have accumulated at commercial power plants and DOE facilities and continue to accumulate across the United States. Because of their nature, spent nuclear fuel and high-level radioactive waste must be isolated from the human environment, and monitored for long periods. The United States has focused a national effort on the siting and development of a *geologic repository* for *disposal* of these materials and on the development of systems for transportation of the materials safely from their present storage locations to the repository.

Through the passage of the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.), Congress found that:

- The Federal Government has the responsibility to provide for the permanent disposal of high-level radioactive waste and spent nuclear fuel to protect the public health and safety and the environment.

- Appropriate precautions must be taken to ensure that these materials do not adversely affect the public health and safety and the environment for this or future generations.

Pursuant to the NWPA, Congress directed that DOE evaluate the *Yucca Mountain site* in southern Nevada as a potential location for a *geologic* repository. In addition, in 2002, Congress designated the Yucca Mountain site for the development of a repository for the disposal of high-level radioactive waste and spent nuclear fuel (Public Law 107-200; 116 Stat. 735).

A geologic repository for spent nuclear fuel and high-level radioactive waste would permanently isolate radioactive materials in a deep *subsurface* location to limit *risk* to the health and safety of the public. This Repository SEIS addresses actions that DOE proposes to take to construct, operate and monitor, and eventually close a repository at Yucca Mountain, and to transport spent nuclear fuel and high-level radioactive waste from 76 sites to the Yucca Mountain site for disposal.

Figure 1-1 shows the 72 commercial nuclear power sites and 4 DOE sites in 34 states that currently store radioactive materials that DOE would ship to the repository.[1]

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 needs to ship the majority of spent nuclear fuel and high-level radioactive waste by rail to the Yucca Mountain site in Nevada. Because there is no rail access to the Yucca Mountain site, to implement its decision DOE also needs to construct and operate a *railroad* to connect the repository to an existing *rail line* in Nevada.

Section 1.1 provides background information related to this Repository SEIS. Section 1.2 describes important documents and actions related to Yucca Mountain. Section 1.3 provides a brief overview of spent nuclear fuel, high-level radioactive waste, and surplus weapons-usable plutonium. Section 1.4 provides an overview of the Yucca Mountain site and the proposed disposal approach. Section 1.5 presents information on the environmental *impact* analysis process as it applies to the *Proposed Action*.

1.1 Background

DOE completed the Yucca Mountain FEIS in February 2002. The Proposed Action addressed in the FEIS is to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain in southern Nevada for the disposal of spent nuclear fuel and high-level radioactive waste.

The Yucca Mountain FEIS considered the potential environmental impacts of a repository design for surface and subsurface facilities; a range of *canister* packaging scenarios, repository thermal operating modes, and repository sizes; and plans for the *construction*, *operation*, *monitoring*, and eventual *closure* of the repository. In addition, the FEIS examined various national transportation scenarios and Nevada transportation *alternatives* for *shipment* of spent nuclear fuel and high-level radioactive waste to the repository. 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, including shipment by legal-weight truck, rail, and *heavy-haul truck*. In the FEIS, DOE identified the mostly rail scenario as its preferred mode of transportation, both nationally and in Nevada, due in part to public preference and somewhat lower potential impacts on the health and safety of workers and the public (DIRS 155970-DOE 2002, p. 1-3).

The Yucca Mountain FEIS acknowledged that these repository design concepts and operational plans would continue to evolve during the design and engineering process and that determination of a specific *rail alignment* in which to construct a rail line would require further analysis under the *National Environmental Policy Act* (NEPA; 42 U.S.C. 6901 et seq.).

1. Spent nuclear fuel and high-level radioactive waste currently are stored at 121 sites in 39 states. However, this Repository SEIS addresses the 76 sites from which DOE would ship radioactive materials to Yucca Mountain. The balance of the sites would ship their materials to one of the DOE sites included in this Repository SEIS in accordance with DOE’s Record of Decision published on June 1, 1995 (60 FR 28680), before the Department shipped them to the repository.

Figure 1-1. Commercial and DOE sites from which DOE would ship radioactive materials to Yucca Mountain.

Since completion of the Yucca Mountain FEIS in 2002, DOE has continued to develop the repository design and associated construction and operational plans. As now proposed, the newly designed surface and subsurface facilities would allow DOE to operate the repository following a *primarily canistered approach* in which most *commercial spent nuclear fuel* would be packaged at the *reactor* sites in *transportation, aging, and disposal (TAD) canisters*. DOE would repackage any commercial spent nuclear fuel that arrived at the repository in packages other than TAD canisters in TAD canisters. The Department would construct the surface and subsurface facilities over a period of several years (referred to as phased construction) to accommodate an increase in spent nuclear fuel and high-level radioactive waste receipt rates as repository operational capability reached its design capacity. This Repository SEIS evaluates potential environmental impacts of the repository design and operational plans as described in the application that DOE has submitted to the U.S. Nuclear Regulatory Commission (NRC) seeking authorization to construct the repository, as required in Section 114(b) of the NWPA (DIRS 185301-DOE 2008, all). The responsibility for issuing construction authorization and a license to receive and possess radioactive materials at the repository rests with the NRC. Should the NRC authorize development of the repository, DOE would be the federal agency responsible for actions related to constructing and operating the repository.

1.2 Site Recommendation and Update of Yucca Mountain Decisions

On February 14, 2002, after more than two decades of scientific investigations, the Secretary of Energy submitted a comprehensive statement to the President of the United States that recommended Yucca Mountain as the site for development of a geologic repository. The Yucca Mountain FEIS accompanied the site recommendation.

On February 15, 2002, in accordance with the NWPA, the President recommended the Yucca Mountain site to Congress. On April 8, 2002, the Governor of Nevada submitted to Congress a notice of disapproval of the Yucca Mountain site designation. On May 8 and July 9, 2002, the House of Representatives and the Senate, respectively, passed a joint resolution that overrode the notice of disapproval and approved the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. On July 23, 2002, the President signed into law the joint resolution of the House of Representatives and the Senate that designated the Yucca Mountain site for development as a geologic repository (*Yucca Mountain Development Act of 2002*, Public Law 107-200; 116 Stat. 735). On October 25, 2002, following DOE's distribution of the Yucca Mountain FEIS, the U.S. Environmental Protection Agency (EPA) published its Notice of Availability of the Yucca Mountain FEIS (67 FR 65564).

On December 29, 2003, DOE published "Notice of Preferred Nevada Rail Corridor" (68 FR 74951) that named the Caliente rail corridor as its preferred *corridor* in which to construct a rail line in Nevada.

On April 8, 2004, DOE published "*Record of Decision* on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (69 FR 18557) that announced the selection of the mostly rail scenario the Department analyzed in the Yucca Mountain FEIS for transportation of spent nuclear fuel and high-level radioactive waste nationally and in Nevada. DOE based its decision to select the mostly rail scenario on analyses in the Yucca Mountain FEIS (specifically those analyses related to impacts on the health and safety of workers and the public), public preferences, consideration of irreversible and irretrievable commitments of resources, and *cumulative impacts* from transportation of other radioactive materials. Also on April 8, 2004, DOE announced it had selected the Caliente rail corridor from several corridors the Department considered in the Yucca Mountain FEIS as the corridor in which to study possible rail alignments for the construction and operation of a rail line in Nevada (69 FR 18565). The Department based this decision primarily on the analyses in the Yucca Mountain FEIS, which included land use conflicts and their potential to affect adversely the timely construction of a proposed rail line.

In 2006, DOE proposed a modified approach to repository design, development, and operation. Central to this proposed approach is the use of a canister concept for commercial spent nuclear fuel that minimizes handling of individual spent fuel assemblies; limits the need for complex surface facilities; and simplifies repository design, licensing, construction, and operation. DOE would use a TAD canister to transport, age, and dispose of commercial spent nuclear fuel without ever reopening the canister, thereby simplifying and reducing the number of handling operations involved in the packaging of spent nuclear fuel for disposal. In addition, the canistered approach offers the advantage of the use of practices that are familiar to the nuclear industry and the NRC, which would make the repository easier to design, license, construct, and operate. Although DOE has a small amount of spent nuclear fuel of commercial origin that it could ship to the repository uncanistered in a *cask*, consistent with the analysis in the Yucca Mountain FEIS, this Repository SEIS assumes that it would transport and receive all *DOE spent nuclear fuel* and high-level radioactive waste in *disposable canisters*. On October 13, 2006, in the Notice of Intent to prepare "Supplement to 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, NV" (71 FR 60490), DOE announced that it would prepare a supplement to the Yucca Mountain FEIS to evaluate potential environmental impacts of the modified repository design and operational plans. In its Notice of Intent, DOE described the primarily canistered approach whereby most commercial sites would package their spent nuclear fuel in TAD canisters, and all DOE materials would be packaged in disposable canisters at DOE sites.

Also on October 13, 2006, DOE published "Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (71 FR 60484). Based on public scoping comments, discussions with the Walker River Paiute Tribe, and a preliminary evaluation of the feasibility of the Mina rail corridor, DOE announced it would expand the scope of the EIS to supplement the *rail corridor* analyses of the Yucca Mountain FEIS and analyze the Mina corridor. Although the Nevada Rail Corridor SEIS analyzes the potential environmental impacts associated with the Mina corridor, it identifies the Mina alternative as nonpreferred because the Mina corridor would cross the Walker River Paiute Reservation, and the Tribe has withdrawn its participation in the EIS process. Table 1-1 lists important documents and actions since DOE published the Yucca Mountain FEIS.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS.

Date	Document/Decision	Description
February 14, 2002	Secretary of Energy made Site Recommendation.	Secretary of Energy submitted a comprehensive statement to the President of the United States that recommended Yucca Mountain as the site for development of a geologic repository for nuclear waste. The Site Recommendation was accompanied by the Yucca Mountain FEIS.
February 15, 2002	President recommended Yucca Mountain.	President G. W. Bush recommended the Yucca Mountain site to Congress.
April 8, 2002	Nevada objected to the President's approval.	Governor of Nevada submitted a notice of disapproval of the Yucca Mountain site designation to Congress.
May 8 and July 9, 2002	House of Representatives and Senate approved Yucca Mountain.	House of Representatives and Senate, respectively, passed a joint resolution that overrode the notice of disapproval and approved the development of a repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain.
July 23, 2002	President signed *Yucca Mountain Development Act* into law.	President G. W. Bush signed the joint resolution into law as Public Law 107-200. This law, known as the *Yucca Mountain Development Act*, was codified as 42 U.S.C. 10135 note (Supp. IV 2004). This action completed the site selection process mandated by the NWPA and allowed DOE to seek licenses from the NRC to build and operate a repository at Yucca Mountain.
October 25, 2002	A Notice of Distribution was published (67 FR 65539) and the EPA published its Notice of Availability of the Yucca Mountain FEIS (67 FR 65564).	DOE distributed the Yucca Mountain FEIS and the EPA notified the public of its availability.
November 18, 2003	DOE published *Strategic Plan for the Safe Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to Yucca Mountain*: *A Guide to Stakeholder Interactions* (DIRS 172433-DOE 2003, all).	This plan laid out the operational approach that DOE would follow in definition and development of the comprehensive transportation system required for the safe and secure shipment of spent nuclear fuel and high-level radioactive waste. The plan presents DOE's strategy and describes the process DOE would use to work cooperatively with states, federally recognized tribes, local governments, utilities, the transportation industry, and other interested parties.
December 29, 2003	DOE published "Notice of Preferred Nevada Rail Corridor" (68 FR 74951).	DOE named the Caliente rail corridor as its preferred corridor in which to construct a rail line in Nevada.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS (continued).

Date	Document/Decision	Description
December 29, 2003	BLM segregated public lands for up to 2 years (68 FR 74965).	BLM announced the receipt of a land withdrawal application from DOE that requested the withdrawal of approximately 1,249 square kilometers (308,600 acres) of public land in Nevada from surface entry and mining for a period of 20 years to evaluate the land for the potential construction, operation, and maintenance of a rail line for transportation of spent nuclear fuel and high-level radioactive waste in the Caliente rail corridor. The notice segregated the land from surface entry and mining for as long as 2 years while DOE conducted studies and analyses to support a final decision on the withdrawal application.
April 8, 2004	DOE published "Record of Decision on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (69 FR 18557).	This Record of Decision selected the mostly rail scenario nationally and in Nevada and selected the Caliente rail corridor to examine potential alignments within which to construct the rail line.
April 8, 2004	DOE published "Notice of Intent to Prepare an Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (69 FR 18565).	DOE announced it would prepare an environmental impact statement for the alignment, construction, and operation of a rail line for shipment of spent nuclear fuel, high-level radioactive waste, and other materials from a site near Caliente, Lincoln County, Nevada, to a geologic repository at Yucca Mountain, Nye County, Nevada.
July 9, 2004	U.S. Court of Appeals upheld *Yucca Mountain Development Act*.	U.S. Court of Appeals issued a decision that rejected the State of Nevada's challenge to the constitutionality of the resolution that approved Yucca Mountain. The Court denied all but one of the challenges to EPA and NRC regulations that govern Yucca Mountain. The agencies have proposed new regulations that would address compliance periods for the first 10,000 years and for post-10,000 years (up to 1 million years). The proposed regulations have not been finalized.
December 6, 2005	DOE published *Environmental Assessment for the Proposed Withdrawal of Public Lands Within and Surrounding the Caliente Rail Corridor*, *Nevada* (DIRS 176452-DOE 2005, all).	This environmental assessment evaluated the potential impacts of the proposed land withdrawal and the land evaluation activities.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS (continued).

Date	Document/Decision	Description
December 28, 2005	BLM issued Public Land Order No. 7653 withdrawing public lands for period of 10 years (70 FR 76854).	BLM withdrew approximately 1,249 square kilometers (308,600 acres) of public lands in the Caliente rail corridor in Nevada from surface entry and the location of new mining claims, subject to valid existing rights, for a period of 10 years to enable DOE to evaluate the lands for potential construction, operation, and maintenance of a rail line, which the Department would use to transport spent nuclear fuel and high-level radioactive waste to the proposed Yucca Mountain repository.
October 13, 2006	DOE published "Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (71 FR 60484).	Based on new information, DOE announced it would expand the scope of the Rail Alignment EIS to consider the potential environmental impacts of a newly proposed Mina rail corridor to supplement the Yucca Mountain FEIS rail corridor analysis and and to analyze alternative alignments in the Mina corridor.
October 13, 2006	DOE published Notice of Intent to prepare "Supplement to 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, NV" (71 FR 60490).	DOE announced it would prepare this supplement to evaluate potential environmental impacts of the modified repository design and operational plans.
January 10, 2007	BLM segregated public lands for as long as 2 years (72 FR 1235).	BLM announced the receipt of a land withdrawal application from DOE requesting the withdrawal of approximately 842 square kilometers (208,037 acres) of public land in Nevada from surface entry and mining until December 27, 2015, to evaluate the land for the potential construction, operation, and maintenance of a rail line for transportation of spent nuclear fuel and high-level radioactive waste in the Caliente or Mina rail corridor. The notice segregated the land from surface entry and mining for as long as 2 years while DOE conducted studies and analyses to support a final decision on the withdrawal application.
October 12, 2007	DOE published Notice of Availability of two draft NEPA documents related to its Yucca Mountain Project (72 FR 58071).	DOE announced the availability of the Draft Repository SEIS and the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS, invited interested parties to comment on the documents during a 90-day public comment period, and announced the schedule for public hearings.
March 8, 2008	DOE applied for a right-of-way from the BLM (DIRS 185486-Larson 2008, all).	DOE submitted a right-of-way application to the BLM that includes public land required to construct and operate the proposed railroad in Nevada.

Table 1-1. Important documents and actions since DOE completed the Yucca Mountain FEIS (continued).

Date	Document/Decision	Description
March 17, 2008	DOE submitted an application to the Surface Transportation Board (DIRS 185339-Vandeberg 2008, all).	DOE submitted an application to the Surface Transportation Board for certification of public convenience and necessity to construct and operate a rail line.
June 2008	DOE submitted an application to the NRC (DIRS 185301-DOE 2008, all).	DOE submitted an application to the NRC seeking authorization to construct the repository, as required by Section 114(b) of the NWPA.

BLM = Bureau of Land Management.
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
NEPA = *National Environmental Policy Act.*
NRC = U.S. Nuclear Regulatory Commission.
NWPA = *Nuclear Waste Policy Act*, as amended.

1.3 Radioactive Materials Considered for Disposal

This section summarizes and incorporates by reference Section 1.2 and Appendix A of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 1-4 to 1-8 and A-1 to A-71) and provides updated information on high-level radioactive waste and surplus weapons-usable plutonium.

1.3.1 GENERATION OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

The material used to power commercial *nuclear reactors* typically consists of cylindrical fuel pellets made of a radioactive material, uranium oxide, slightly enriched in uranium-235. Fuel pellets are placed in tubes (called "*cladding*"). The sealed tubes with fuel pellets inside are called "fuel rods." Fuel rods are arranged in bundles called "fuel assemblies," which are placed in a reactor.

After a period of operation in a reactor, the fuel is considered to be "spent." Nuclear reactor operators initially store spent nuclear fuel underwater in pools because of the high levels of *radioactivity* and heat from *decay* of *radionuclides*. When the fuel has cooled and decayed sufficiently, operators can use two storage options: (1) continued in-pool storage or (2) above-ground *dry storage*.

Beginning in 1944, the United States operated reactors to produce materials such as plutonium for nuclear weapons. After discharge of the spent nuclear fuel and other reactor-irradiated nuclear materials, DOE used a chemical *process* called "reprocessing" to extract plutonium and other materials for defense purposes from the reactor-irradiated nuclear materials, which included spent nuclear fuel. One of the chemical byproducts of reprocessing is high-level radioactive waste. In addition, the reprocessing of naval reactor fuels and some commercial reactor fuels, DOE test reactor fuels, and university and other research reactor fuels has produced high-level radioactive waste. As a result of the shutdown of weapons production and some DOE chemical reprocessing plants at the end of the Cold War, DOE did not reprocess all of its spent nuclear fuel. The Department stores some of this fuel at DOE sites, awaiting permanent disposal.

1.3.2 SPENT NUCLEAR FUEL

Spent nuclear fuel consists of nuclear fuel that has been withdrawn from a nuclear reactor, provided the constituent elements of the fuel have not been separated by reprocessing. Spent nuclear fuel is stored at commercial and DOE sites.

1.3.2.1 Commercial Spent Nuclear Fuel

Commercial spent nuclear fuel comes from nuclear reactors that produce electric power. It typically consists of uranium oxide fuel (which contains *actinides*, *fission* products, and other materials), the cladding that contains the fuel, and the assembly hardware. The cladding for commercial spent nuclear fuel assemblies is normally made of a *zirconium alloy*. Commercial spent nuclear fuel is generated and stored at commercial nuclear power plants throughout the United States. Figure 1-1 shows the locations of these sites.

1.3.2.2 DOE Spent Nuclear Fuel

DOE manages spent nuclear fuel from its defense production reactors, U.S. naval reactors, and DOE test and experimental reactors, as well as fuel from university and other research reactors, commercial reactor fuel acquired by DOE for research and development, and fuel from foreign research reactors. DOE stores most of its spent nuclear fuel in pools or dry storage facilities at three primary locations: the Hanford Site in Washington State, the Idaho National Laboratory in Idaho (formerly the Idaho National Engineering and Environmental Laboratory), and the Savannah River Site in South Carolina. Some DOE spent nuclear fuel is stored at the Fort St. Vrain dry storage facility in Colorado. In accordance with DOE's Record of Decision published on June 1, 1995 (60 FR 28680), the Department will transfer the fuel at Fort St. Vrain from Colorado to the Idaho National Laboratory before its shipment to the repository. Also, in accordance with the Record of Decision, spent nuclear fuel from domestic research reactors would be shipped first to Savannah River Site or Idaho National Laboratory before being shipped to the repository. The Department would transport all DOE spent nuclear fuel evaluated in this Repository SEIS to the Yucca Mountain site from the Hanford Site, Idaho National Laboratory, or Savannah River Site.

1.3.3 HIGH-LEVEL RADIOACTIVE WASTE

DOE stores high-level radioactive waste in underground tanks at the Hanford Site, the Savannah River Site, and the Idaho National Laboratory (Figure 1-1). High-level radioactive waste can be in a liquid, sludge, saltcake, solid immobilized glass, or solid granular form (calcine). It can include immobilized plutonium waste and other highly radioactive materials that the NRC has determined by rule to require permanent *isolation*.

The DOE process for preparation of high-level radioactive waste for disposal starts with the transfer of the radioactive waste from storage tanks to a treatment facility. Treatment can include separation of the waste into high- and low-activity fractions, followed by *vitrification* of the high-activity fraction. Vitrification involves the addition of inert materials to the radioactive waste and heating of the mixture until it melts. DOE pours the melted mixture into canisters, where it cools into a solid glass or ceramic form that is very resistant to the leaching of radionuclides. The solidified, immobilized glass and ceramic forms keep the waste stable, confined, and isolated from the environment. DOE will store the solidified high-level radioactive waste onsite in these canisters until eventual shipment to a repository.

DOE has completed solidification and immobilization of high-level radioactive waste at the West Valley Demonstration Project in New York, is continuing to solidify and immobilize waste at the Savannah River Site, and plans to begin solidification and immobilization at the Hanford Site in about 2019. DOE will use the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DIRS 179508-DOE 2002, all) to help determine the method for preparation of high-level radioactive waste at the Idaho National Laboratory for geologic disposal.

1.3.4 SURPLUS WEAPONS-USABLE PLUTONIUM

DOE has identified some weapons-usable plutonium as surplus to national security needs. This material includes purified plutonium, nuclear weapons components, and materials and residues that could be processed to produce purified plutonium. DOE currently stores these plutonium-containing materials at sites throughout the United States.

On March 28, 2007, DOE announced its intent to prepare a supplemental EIS to evaluate the potential environmental impacts of plutonium disposition alternatives (72 FR 14543). In that notice, DOE announced that it intends to analyze alternatives that could result in DOE emplacing surplus weapons-usable plutonium in the repository in two forms. One form could be vitrified plutonium waste that DOE would dispose of as high-level radioactive waste. In the Yucca Mountain FEIS, DOE analyzed the impacts of immobilizing surplus plutonium in a ceramic *matrix* surrounded by vitrified high-level radioactive waste. DOE is still considering this alternative. Another immobilization form DOE is considering is containment of this immobilized plutonium in a lanthanide *borosilicate glass* matrix surrounded by vitrified high-level radioactive waste for which DOE would perform analyses similar to those for immobilized ceramic plutonium it evaluated in the Yucca Mountain FEIS. An alternative would be to fabricate mixed uranium and plutonium oxide fuel (called *mixed-oxide fuel*) assemblies that would be used for power production in commercial nuclear reactors and disposed of in the same manner as other commercial spent nuclear fuel.

1.4 Yucca Mountain Site and the Proposed Disposal Approach

This section summarizes, incorporates by reference, and updates Section 1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 1-13 to 1-22).

1.4.1 YUCCA MOUNTAIN SITE

The Yucca Mountain site is on land that is controlled by the Federal Government in a remote area of the Mojave Desert in Nye County in southern Nevada, approximately 145 kilometers (90 miles) northwest of Las Vegas, Nevada (Figure 1-2). The area surrounding the Yucca Mountain site is sparsely populated and is one of the driest regions in the United States, receiving an average of 199 millimeters (7.9 inches) of precipitation per year (DIRS 185301-DOE 2008, Section 2.3.1.2.1.1). The repository would be above the *water table* in the *unsaturated zone*, the zone of soil or rock between the land surface and the water table. Chapter 3 of this Repository SEIS provides detailed information about the environment at the site.

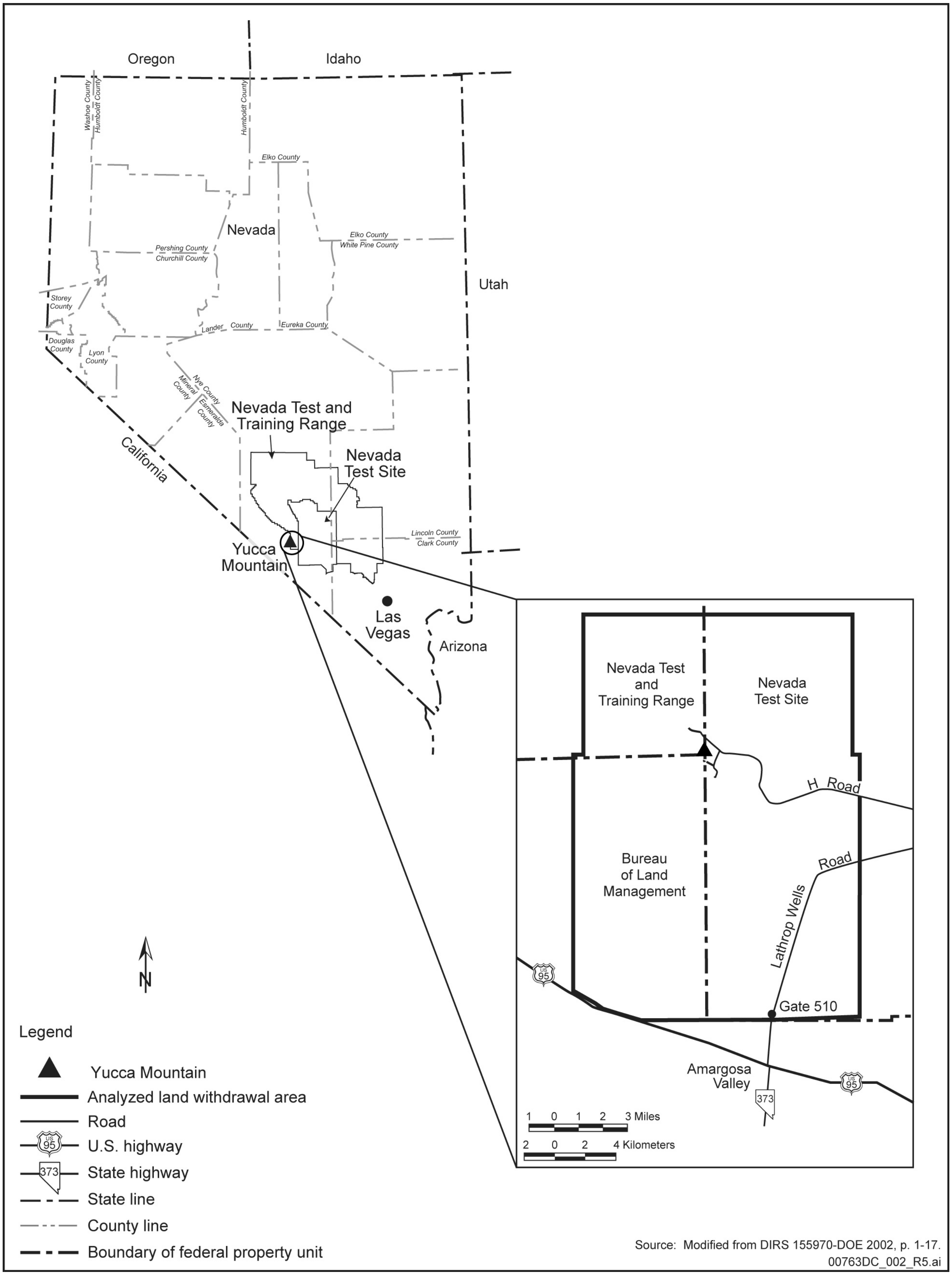

Figure 1-2. Land withdrawal area used for analytical purposes.

The Yucca Mountain site has several characteristics that would limit possible long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste. It is in a remote area on land the Federal Government controls. The dry climate results in a relatively small volume of water that can move through the unsaturated zone. The water table sits substantially below the level at which DOE wouldlocate a repository, which would provide additional separation between water sources and materials in emplaced *waste packages*. Maximizing the separation of water from the repository would minimize *corrosion* and delay any mobilization and transport of radionuclides from the repository. Chapter 5 of this Repository SEIS contains further discussion about long-term impacts.

SITE-RELATED TERMS

Yucca Mountain site:
The area inside the site boundary over which DOE has control. For the purpose of this Repository SEIS, Yucca Mountain site is synonymous with the land withdrawal area.

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.

Analyzed land withdrawal area:
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, an area of approximately 600 square kilometers (230 square miles or 150,000 acres).

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."

Region of influence (the region):
A specialized term that indicates a specific area of study for each of the resource areas that this Repository SEIS analysis addresses.

Groundwater beneath Yucca Mountain flows into a closed, sparsely populated hydrogeologic basin. A closed basin is one in which water introduced into the basin by precipitation cannot flow out of the basin to any river or ocean. This closed basin would make farther transport of radionuclides unlikely if radioactive *contamination* were to reach the groundwater. The land withdrawal area analyzed in this Repository SEIS includes about 600 square kilometers (150,000 acres) of land currently under the control of DOE (Nevada Test Site), the U.S. Air Force (Nevada Test and Training Range), and the U.S. Department of the Interior (Bureau of Land Management) (Figure 1-2). Chapter 3, Section 3.1.1 of this Repository SEIS provides more detail on the land use and ownership the *analyzed land withdrawal area*.

DOE would disturb approximately 12 square kilometers (3,000 acres) inside the analyzed land withdrawal area to develop surface repository and rail facilities, with the remainder serving as a buffer zone. Before receipt of construction authorization, 10 CFR 63.121 provides that the *geologic repository operations area* must be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. In addition, outside the analyzed land withdrawal area, the Proposed Action would disturb approximately 0.57 square kilometer (140 acres) of land in Nevada for an access road and offsite *infrastructure*, and approximately 37 to 58 square kilometers (9,100 to 14,000 acres) for the railroad dependent on the corridor and the alignment within the corridor.

1.4.2 PROPOSED APPROACH TO DISPOSAL

Since completion of the Yucca Mountain FEIS in 2002, DOE has continued to develop the repository design and associated construction and operational plans. As now proposed, DOE would use a primarily canistered approach to operate the repository; under this approach, most commercial spent nuclear fuel would be packaged at the reactor sites in TAD canisters. DOE would repackage commercial spent nuclear fuel that arrived in packages other than TAD canisters into these canisters in newly designed surface facilities at the repository. The Department would package essentially all DOE material in disposable canisters at the DOE sites. Most spent nuclear fuel and high-level radioactive waste would arrive at the repository by rail. Some shipments would arrive by truck. At the repository, DOE would place the TAD and other disposable canisters in waste packages that were manufactured from corrosion-resistant materials. DOE would array the waste packages in the *subsurface facility* in tunnels (*emplacement drifts*). Chapter 2 of this Repository SEIS further describes the disposal approach, which includes the transportation activities necessary to move the spent nuclear fuel and high-level radioactive waste to the Yucca Mountain site.

The NWPA limits the amount of spent nuclear fuel and high-level radioactive waste that DOE can emplace in the first geologic repository to 70,000 *metric tons of heavy metal* (MTHM) until a second repository is in operation [NWPA, Section 114(d)]. The materials DOE would dispose of under the Proposed Action include about 63,000 MTHM of commercial spent nuclear fuel and high-level radioactive waste, about 2,333 MTHM of DOE spent nuclear fuel, and about 4,667 MTHM of high-level radioactive waste. Although the NWPA limits the repository size to 70,000 MTHM, DOE presents the potential impacts associated with a larger repository in the cumulative impacts section of this Repository SEIS.

1.5 National Environmental Policy Act Process

The following information supplements the activities described in Section 1.5 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 1-25 to 1-31).

1.5.1 YUCCA MOUNTAIN FEIS

DOE completed the Yucca Mountain FEIS in February 2002 and submitted the document to the President as part of the Department's comprehensive statement that recommended Yucca Mountain as the site for development of a geologic repository. A Notice of Distribution was published in the *Federal Register* on October 25, 2002 (67 FR 65539) after DOE distributed the Yucca Mountain FEIS to the public and filed it with EPA. EPA published its Notice of Availability of the Yucca Mountain FEIS on the same day (67 FR 65564). DOE made the document available in reading rooms throughout the country and made an electronic copy available on the Internet. The Department distributed paper copies of the Readers Guide, Summary, and an errata sheet, as well as an electronic version on compact disk of the Yucca Mountain FEIS (Volumes I, II, and III) to members of Congress; federal, state, and American Indian tribal governments; local officials, persons, agencies, and organizations that commented on the Draft EIS and Supplement to the Draft EIS (issued on May 11, 2001, and incorporated into the Yucca Mountain FEIS to present the latest design information and the expected environmental impacts that could result from the evolved design); and others who had indicated an interest in the EIS process.

1.5.2 NOTICES OF INTENT AND SCOPING MEETINGS

NEPA regulations do not require public scoping for the preparation of a supplemental EIS. However, on October 13, 2006, DOE published a Notice of Intent to prepare this Repository SEIS (71 FR 60490) and invited comments on the scope of the document to ensure that the document addressed all relevant environmental issues. DOE announced a 45-day public comment period that ended on November 27, 2006, and public scoping meetings in Washington, D.C., and the town of Amargosa Valley and Las Vegas, Nevada. On November 9, 2006, based on input from the public, DOE extended the public comment period to December 12, 2006, and announced an additional public scoping meeting in Reno, Nevada (71 FR 65786). During the scoping period, DOE also conducted scoping on the Rail Alignment EIS. Because public scoping occurred during the same period for both EISs, DOE received many comment documents that contained comments on both EISs. As a consequence, DOE reviewed all scoping documents, regardless of whether the document addressed the Rail Alignment EIS or this Repository SEIS, for applicability to both EISs. This ensured a full and complete consideration of all public input to the scoping process. Section 1.5.3 addresses the relationship between the two documents.

1.5.2.1 Repository SEIS

DOE considered all comments it received as a result of the scoping process and grouped them into categories, as it reported in the *Summary of Public Scoping Comments Related to the Supplement to 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 179543-DOE 2007, all). The Department received 263 comment documents that resulted in 723 comments applicable to this Repository SEIS.

DOE evaluated and considered all comments. Most of the comments were not applicable to the scope of this Repository SEIS. These nonapplicable comments fell into four general categories:

1. Comments complimentary or critical of the process;

2. Comments in favor of or opposed to the repository or nuclear power;

3. Comments on items outside the scope of this Repository SEIS, such as alternatives to the repository (for example, reprocessing or interim storage), alternative locations, and need for a citizens' advisory board; and

4. Comments that were general in nature or already were part of the planned scope, analyses, and technical approaches, such as evaluation of impacts to workers and members of the public from any *exposure* to radiological or hazardous substances and consideration of groundwater impacts.

Some comments that DOE received during scoping resulted in changes to the scope or analyses. The following items summarize comments that resulted in modifications to the scope and analyses originally planned for this Repository SEIS and DOE's responses to these comments:

- DOE should present a range of TAD canister implementation scenarios and not rely solely on the 90-percent program goal (90 percent of commercial spent nuclear fuel would be placed in TAD canisters before shipment to the repository for disposal) because of uncertainties associated with implementation at each reactor site and because more than 10 percent of the spent nuclear fuel might already be packaged in *dual-purpose canisters*.

  Response: This Repository SEIS addresses potential impacts of the goal of a 90-percent TAD canister scenario. To provide a perspective of any implementation differences, Appendix A discusses the impacts associated with a variation of the TAD canister implementation ratio of 75 percent.

- Uncertainties associated with worker residency warrant new analytical assumptions for the socioeconomics analyses.

  Response: The socioeconomics analysis for this Repository SEIS used the same relative workforce residence location that DOE used in the Yucca Mountain FEIS, which was 80 percent in Clark County and 20 percent in Nye County. This approach is based on historical data on the residency of workers on the Nevada Test Site or the Yucca Mountain site. To provide a perspective of potential differences in impacts if a larger percentage of the workforce chose to reside in Nye County, Appendix A discusses the impacts associated with a sensitivity case that assumed 20 percent of the workforce would reside in Clark County and 80 percent would reside in Nye County.

1.5.2.2 Rail Alignment EIS

DOE held two public scoping periods for the Rail Alignment EIS between April 8 and June 1, 2004, and October 13 and December 12, 2006. On April 8, 2004, DOE published a Notice of Intent (69 FR 18565) that announced it would prepare an EIS for the alignment, construction, and operation of a rail line for shipment of spent nuclear fuel, high-level radioactive waste, and other materials from a site near Caliente, Lincoln County, Nevada, to a geologic repository at Yucca Mountain, Nye County, Nevada (Rail Alignment EIS). The Notice of Intent also announced the schedule for public scoping meetings, and invited and encouraged comments on the scope of that EIS to ensure that the document addressed all relevant environmental issues and reasonable alternatives. The scoping comment period began with publication of the Notice of Intent in the *Federal Register*. The schedule called for the period to close on May 24, 2004; however, on April 26, 2004, based on a request from the State of Nevada, DOE extended the comment period to June 1, 2004 (69 FR 22496).

DOE received more than 4,100 comments during the first public scoping period for the Rail Alignment EIS and some comments after the close of the scoping period. DOE summarized all these comments in the *Summary of Public Scoping Comments, Related to the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV* (DIRS 176463-Craig et al. 2004, all) and considered the content of all comments in its determination of the scope of the EIS. The following are the general modifications to the scope and analyses originally planned for the Rail Alignment EIS:

- The elimination, addition, or modification of rail segment alternatives;
- The addition of a Shared-Use Option that considers commercial use of the proposed rail line; and
- Additional fieldwork in Garden Valley for the noise and aesthetics analyses.

On October 13, 2006, DOE published an Amended Notice of Intent (71 FR 60484) that announced the expanded scope of the Rail Alignment EIS to include detailed analysis of construction and operation of a railroad in the Mina rail corridor, should that corridor warrant further consideration based on the analysis of the Nevada Rail Corridor SEIS. The Notice of Intent also announced the schedule for public scoping meetings, and encouraged comments on the scope of the EIS to ensure that the document addressed all relevant environmental issues and reasonable alternatives. The second scoping comment period began with publication of the Amended Notice of Intent in the *Federal Register* and was originally scheduled to close on November 27, 2006. On November 9, 2006, based on requests from the public, DOE extended the comment period to December 12, 2006 (71 FR 65785).

DOE received nearly 800 comments during the second public scoping period for the Rail Alignment EIS, including some comments after the close of the scoping period. DOE summarized all comments received (including those submitted after the close of the scoping period) in *Summary of Public Scoping Comments on the Expanded Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV* (DIRS 181379-DOE 2007, all) and considered the content of all comments in its determination of the scope of the EIS. Most of the comments that DOE received in the second public scoping period were similar to those received in the first period.

Chapter 1 of the Rail Alignment EIS contains additional information on the evaluation and assessment of comments received during both scoping periods about the Caliente and Mina rail alignments. Chapter 1 of the Nevada Rail Corridor SEIS contains additional information on the evaluation and assessment of comments that DOE received during the second scoping period about the Mina rail corridor and the update of information related to the other corridors DOE analyzed in the Yucca Mountain FEIS.

1.5.2a DRAFT REPOSITORY SEIS PUBLIC COMMENT PROCESS AND PUBLIC HEARINGS

On October 12, 2007, EPA announced in the *Federal Register* (72 FR 58081) the availability of the Draft Repository SEIS, and the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS. Also on October 12, 2007, DOE announced in the *Federal Register* (72 FR 58071) the availability of these draft NEPA analyses related to its Yucca Mountain Project. DOE's Notice of Availability invited interested parties to comment on the NEPA documents during a 90-day public comment period that ended on January 10, 2008, and announced the schedule for public hearings. DOE made the NEPA documents available on the Internet on two DOE Web sites; made the documents available in five reading rooms in Nevada and one in Washington, D.C.; and sent the electronic versions on compact disks, as well as paper copies, of either the summaries or the full draft documents to other federal agencies, members of Congress, American Indian tribal governments, state and local governments, and organizations and individuals who are known to have an interest in the EIS. DOE distributed approximately 3,700 copies of the summaries and approximately 400 full copies of the draft documents.

DOE held eight public hearings on the documents at the following locations:

- Hawthorne, Nevada – Hawthorne Convention Center, 932 E. Street, November 13, 2007;
- Caliente, Nevada – Caliente Youth Center, U.S. Highway 93, November 15, 2007;
- Reno/Sparks, Nevada – Reno/Sparks Convention Center, 4590 South Virginia Street, November 19, 2007;

- Amargosa Valley, Nevada – Longstreet Inn and Casino, Nevada State Highway 373, November 26, 2007;
- Goldfield, Nevada – Goldfield School Gymnasium, Hall and Euclid, November 27, 2007;
- Lone Pine, California – Statham Hall, 138 North Jackson Street, November 29, 2007;
- Las Vegas, Nevada – Cashman Center, 850 North Las Vegas Boulevard, December 3, 2007; and
- Washington, D.C. – Marriott at Metro Center, 775 12th Street, NW, December 5, 2007.

DOE reserved the first hour of the public hearings for an open house, where members of the public could engage DOE representatives in discussions, followed by a formal oral statement process. DOE provided public hearing attendees the opportunity to submit comments in writing at the hearing or in person to a court reporter who was available throughout the hearing. Approximately 518 people attended the hearings (the count is approximate because not all attendees registered) and 110 people provided oral comments. In addition, DOE met with the Consolidated Group of Tribes and Organizations in Pahrump on November 27, 2007, to take comments on the NEPA documents.

The public hearings covered the Draft Repository SEIS, and the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS, and DOE considered all comments it received for applicability to the three NEPA analyses. In total, DOE received approximately 4,000 comments on the NEPA analyses from nearly 1,100 commenters. About 2,600 of these comments were on the Repository SEIS. DOE has prepared a Comment-Response Document for the Repository SEIS (Volume III of this Final Repository SEIS) that provides responses to public comments. The Comment-Response Document contains each comment (as an individual comment or summarized with similar comments) and the DOE response to each comment. The Final Repository SIES reflects changes as a result of public comments received on the Draft Repository SEIS. The responses in the Comment-Response Document note changes to sections of the Final Repository SEIS that resulted from comments DOE received on the Draft Repository SEIS.

About 250 of the comments were on the Nevada Rail Corridor SEIS. DOE has prepared a Comment-Response Document for the Nevada Rail Corridor SEIS (Volume V) that provides responses to public comments. The Comment-Response Document contains each comment (as an individual comment or summarized with similar comments) and the DOE response to each comment. The Final Nevada Rail Corridor SEIS reflects changes as a result of public comments received on the Draft Nevada Rail Corridor SEIS. About 1,200 of the comments were on the Rail Alignment EIS. As with the Nevada Rail Corridor SEIS, DOE has prepared a Comment-Response Document for the Rail Alignment EIS (Volume V) that provides responses to public comments. The Comment-Response Document contains each comment (as an individual comment or summarized with similar comments) and the DOE response to each comment. The Final Rail Alignment EIS reflects changes as a result of public comments received on the Draft Rail Alignment EIS. The responses in the Comment-Response Documents note changes to sections of the Final Nevada Rail Corridor SEIS and Final Rail Alignment EIS that resulted from comments DOE received on the Draft Nevada Rail Corridor SEIS and Draft Rail Alignment EIS.

1.5.2b CHANGES MADE TO THE DRAFT REPOSITORY SEIS

This Final Repository SEIS reflects changes made to the Draft Repository SEIS due to public comments and the availability of new and updated information. Substantive changes in this Repository SEIS are indicated in the margins with change bars. Examples of these changes include:

- Update of impact analyses related to occupational and public health and safety and potential accidents to reflect more recent information that is included in the Safety Analysis Report, which was part of the application DOE recently submitted to the NRC for construction authorization.
- Assessment of greenhouse gases potentially released as a result of the Proposed Action, including repository construction and operations, the transportation of spent nuclear fuel and high-level radioactive waste to the repository, transportation of construction and other materials, and commuting workers.
- Discussion of Inyo County, California, research and findings on the behavior and characteristics of the lower carbonate aquifer as it relates to future postclosure repository performance.
- Inclusion of an integrated schedule that provides DOE's analytical basis for consideration of impacts during the construction and operation of the repository in relation to the proposed railroad and site infrastructure.
- Additional explanatory text and graphics that illustrate the differences between overweight, legal-weight, and heavy-haul trucks for transportation of spent nuclear fuel or high-level radioactive waste.
- Assessment of potential impacts to regional traffic as a result of the Proposed Action.
- Discussion of highway routing alternatives that could be used by shippers if the States of Nevada and California exercised their prerogative to designate alternate preferred highway routes for the transportation of spent nuclear fuel or high-level radioactive waste. DOE first presented this analysis in the Yucca Mountain FEIS and has summarized this analysis in this Repository SEIS.
- Discussion of a process (including establishment of mitigation advisory boards) that DOE could implement to address regional impacts associated with the Proposed Action.
- Update of the cumulative impacts analysis of Inventory Modules 1 and 2 to account for potential cumulative effects from the Global Nuclear Energy Partnership (GNEP) program.
- Addition of a list of interagency and intergovernmental interactions related to this Repository SEIS.

1.5.3 RELATIONSHIP TO OTHER ENVIRONMENTAL DOCUMENTS

A number of completed, in preparation, or proposed DOE NEPA documents relate to this Repository SEIS. In addition, other federal agencies have prepared related EISs. Consistent with Council on Environmental Quality regulations that implement NEPA (40 CFR Parts 1500 to 1508), DOE has used information from these documents in its analyses and has incorporated this material by reference as appropriate in this Repository SEIS. Although the Yucca Mountain FEIS, this Repository SEIS, and the Nevada Rail Corridor SEIS and Rail Alignment EIS are all related to the proposal to construct and operate the Yucca Mountain Repository, they consider actions that would involve the jurisdiction of more than one federal agency. The Repository SEIS supplements the Yucca Mountain FEIS and considers the potential environmental impacts from the construction and operation of the Yucca Mountain Repository.

1.5.3.1 Nevada Rail Corridor SEIS and Rail Alignment EIS

DOE prepared the Nevada Rail Corridor SEIS and Rail Alignment EIS, which supplement the Nevada transportation information in the Yucca Mountain FEIS. The Nevada Rail Corridor SEIS, which supplements the rail corridor analysis in the Yucca Mountain FEIS, analyzes potential environmental impacts from constructing and operating a railroad in the Mina rail corridor. The Nevada Rail Corridor SEIS analyzes the Mina corridor at a level of detail commensurate with that of the rail corridor analysis in the Yucca Mountain FEIS, and concludes that the Mina corridor warrants further study in the Rail Alignment EIS to identify an alignment for the construction and operation of a railroad. In addition, the Nevada Rail Corridor SEIS updates relevant information on three other rail corridors analyzed in the Yucca Mountain FEIS (Carlin, Jean, and Valley Modified). The update demonstrates that there are no significant new circumstances or information relevant to environmental concerns associated with these three rail corridors, and that they do not warrant further consideration in the Rail Alignment EIS. The Caliente-Chalk Mountain rail corridor, which also was in the Yucca Mountain FEIS, would intersect the Nevada Test and Training Range, and DOE eliminated it from further consideration because of U.S. Air Force concerns that a rail line in the Caliente-Chalk Mountain corridor would interfere with military readiness testing and training activities.

The Rail Alignment EIS tiers from the broader corridor analysis in both the Yucca Mountain FEIS and the Nevada Rail Corridor SEIS, consistent with the Council on Environmental Quality regulations (40 CFR 1508.28). Under the Proposed Action that DOE considers in the Rail Alignment EIS, the Department would determine a rail alignment in the Caliente or Mina rail corridor and would construct, operate, and potentially abandon a railroad for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials from an existing railroad in Nevada to a geologic repository at Yucca Mountain. If DOE decided to construct the railroad, it would be the federal agency with the responsibility for performing the actions necessary to construct and operate the railroad.

In all relevant aspects, this Repository SEIS, the Nevada Rail Corridor SEIS, and the Rail Alignment EIS are consistent (Foreword, Figure 1). For example, the Repository SEIS and the Rail Alignment EIS use the same updated inventory of spent nuclear fuel and high-level radioactive waste and the same number of rail shipments for analysis. Thus, the associated occupational and public health and safety impacts in the Nevada rail corridors under consideration are the same in this Repository SEIS and in the Nevada Rail Corridor SEIS and Rail Alignment EIS. Further, to promote conformity, DOE used consistent analytical approaches where appropriate to evaluate common resource areas. This Repository SEIS includes the potential environmental impacts of national transportation, as well as the potential impacts in Nevada from the construction and operation of a railroad in either the Caliente or Mina rail corridor, to ensure that this SEIS considers the full scope of potential environmental impacts from the proposed construction and operation of the repository. Therefore, this Repository SEIS incorporates by reference Chapter 3, Sections 3.2 and 3.3, and Chapters 4, 5, and 8 of the Rail Alignment EIS.

1.5.3.2 Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada

In June 2006, DOE published the *Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada* (DIRS 178817-DOE 2006, all). In October 2006, the Department decided to prepare this Repository SEIS and not finalize the environmental assessment; however, the Department has incorporated elements of the infrastructure improvements in the Repository

SEIS Proposed Action. The proposed action in the environmental assessment was to repair, replace, or improve certain facilities, structures, roads, and utilities for the Yucca Mountain Project to enhance safety at the Project and to enable DOE to continue ongoing operations, scientific testing, and routine maintenance safely at the *Exploratory Studies Facility* until the NRC decides whether to authorize construction of a repository. Chapter 4 of this Repository SEIS identifies the specific elements, or subelements, of improvements DOE could implement before receiving construction authorization from the NRC. Before implementation, a Record of Decision on this SEIS would identify the improvements DOE decides to make. These actions would be independent of repository construction and would occur under DOE authority.

1.5.3.3 Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste

On July 23, 2007, DOE published the "Notice of Intent To Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste" (72 FR 40135). That EIS will evaluate alternatives for disposal of wastes with a concentration of greater than Class C, as defined in NRC regulations at 10 CFR Part 61, 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 in Idaho, the Los Alamos National Laboratory and the Waste Isolation Pilot Plant in New Mexico, the Nevada Test Site and the proposed *Yucca Mountain Repository* in Nevada, the Savannah River Site in South Carolina, the Oak Ridge Reservation in Tennessee, and the Hanford Site in Washington. The EIS will also evaluate disposal at generic commercial facilities in *arid* and humid locations. In addition, DOE proposes to include DOE *low-level radioactive waste* and *transuranic waste* that have characteristics similar to Greater-Than-Class-C low-level radioactive waste and that might not have an identified path to disposal. These inventories would include materials evaluated in the Yucca Mountain FEIS (referred to as *Special-Performance-Assessment-Required low-level radioactive wastes*). DOE issued the Notice of Intent to invite the public to provide comments on the potential scope of the EIS and participate in public scoping meetings. This Repository SEIS evaluates potential impacts from disposal of Greater-Than-Class-C low-level radioactive waste in Chapter 8 as reasonably foreseeable cumulative impacts.

1.5.3.4 Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership

DOE is preparing the *Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership* (GNEP Programmatic EIS) to consider the potential environmental impacts of implementing GNEP, a proposed 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 United States presently uses a "once-through" fuel cycle in which a nuclear power utility uses nuclear fuel in a reactor only once, and then places the spent nuclear fuel in storage to await disposal. The GNEP Programmatic EIS will evaluate alternative fuel cycles, including a fuel cycle in which the uranium and transuranic materials would be separated from the spent nuclear fuel and reused in thermal and/or advanced nuclear reactors. The GNEP Programmatic EIS will evaluate the impacts of domestic programmatic alternatives. These alternatives involve widespread deployment of fuel technologies that would reduce the volume, thermal output, and/or radiotoxicity of spent nuclear fuel and wastes requiring geologic disposal in the future. The GNEP Programmatic EIS will also evaluate a proposed Advanced Fuel Cycle Facility to conduct research, development, and demonstration at one or more of five DOE sites in the continental United States.

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 materials for reuse in other reactor fuels. The alternatives will include a no-action alternative that assumes continued use of light-water reactors without recycling of spent nuclear fuel. Depending on the specific programmatic alternative, the resultant radiological materials that could require geologic disposal could range from only high-level radioactive waste from recycling spent nuclear fuel to only spent nuclear fuel. The estimates of spent nuclear fuel vary widely among the alternatives. However, all fuel–recycle scenarios would produce high-level radioactive waste that would require disposal.

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) that would affect the successful implementation of an 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 fully implemented. In any event, transition to a new fuel cycle could take many decades to complete.

Chapter 8 of this Repository SEIS addresses the potential cumulative impacts of the GNEP programmatic and project-specific alternatives that could be associated with the impacts of disposal of the additional inventory modules.

Table 1-2 lists the documents published since DOE completed the Yucca Mountain FEIS that relate to the information and analyses in this Repository SEIS.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS).

Document	Relationship to Repository SEIS
Nuclear materials activities	
West Valley Demonstration Project Waste Management Environmental Impact Statement Final (DIRS 179454-DOE 2003, all)	Examines impacts of shipping radioactive wastes that are either in storage or that will be generated from operations over a 10–year period at West Valley to offsite disposal locations, and to continue its ongoing onsite waste management activities.
Record of Decision, "West Valley Demonstration Project Waste Management Activities" (70 FR 35073, June 16, 2005)	Selects offsite shipment of LLW for disposal at commercial sites and storage of canisters of vitrified high-level radioactive waste at the West Valley Demonstration Project site until DOE can ship them to a geologic repository for disposal.
Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement (DIRS 179508-DOE 2002, all)	Examines impacts of treatment, storage, and disposal of INL high-level radioactive waste and facilities disposition. INL high-level radioactive waste is proposed for repository disposal.
Supplement Analysis for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement (DIRS 179524-DOE 2005, all)	Determines if there are substantial changes in the proposed action in the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* that are relevant to environmental concerns or significant new circumstances or information that would require preparation of a supplemental EIS.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS; continued).

Document	Relationship to Repository SEIS
"Office of Environmental Management; Record of Decision for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement" (70 FR 75165, December 19, 2005)	Announces a phased decisionmaking process, meaning DOE will issue amended Records of Decision to address specifically closure of the Tank Farm Facility and the final strategy for high-level radioactive waste calcine disposition. Addresses treatment of sodium-bearing waste using steam reforming technology and management of the waste to enable disposal at the Waste Isolation Pilot Plant near Carlsbad, New Mexico, or at a geologic repository for spent nuclear fuel and high-level radioactive waste. Addresses conduct of performance-based closure of existing facilities directly related to the High-Level Radioactive Waste Program at the Idaho Nuclear Technology and Engineering Center once its missions are complete.
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 (DIRS 157761-NRC 2001, all)	Addresses the proposal of Private Fuel Storage, LLC, to construct and operate an independent spent nuclear fuel storage installation on the reservation of the Skull Valley Band of Goshute Indians.
"Notice of Intent To Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste" (72 FR 40135, July 23, 2007)	Will evaluate alternatives for disposal of wastes with a concentration greater than Class C, as defined in NRC regulations at 10 CFR Part 61, in a geologic repository, in intermediate-depth boreholes, and in enhanced near-surface facilities. In addition, DOE proposes to include DOE LLW and transuranic waste with characteristics similar to GTCC LLW and that might not have an identified path to disposal. This Repository SEIS considers cumulative impacts from disposal of GTCC LLW.
"Notice of Intent To Prepare a Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership" (72 FR 331, January 4, 2007)	GNEP involves a proposal to recycle spent nuclear fuel and destroy the long-lived radioactive components of that spent fuel. This Repository SEIS considers cumulative impacts that could be associated with the proposed GNEP program.
Draft Environmental Assessment for the Proposed Infrastructure Improvements for the Yucca Mountain Project, Nevada (DIRS 178817-DOE 2006, all)	In October 2006, DOE decided to prepare this Repository SEIS. Rather than finalizing this environmental assessment, DOE has incorporated the elements of infrastructure improvements into the SEIS Proposed Action. Chapter 4 of this SEIS identifies the specific elements, or subelements, of these improvements that could be implemented prior to construction authorization from the NRC. Prior to implementation, a Record of Decision on this Repository SEIS will present any decisions DOE might make on the improvements. These actions would be independent of repository construction and would occur under DOE authority.
"Notice of Intent To Prepare a Supplemental Environmental Impact Statement for Surplus Plutonium Disposition at the Savannah River Site" (72 FR 14543, March 28, 2007)	Will analyze the potential environmental impacts of alternative disposition methods of up to about 13 metric tons (14 tons) of non-pit[a] surplus plutonium. These alternatives would result in waste forms (inclusion in high-level radioactive waste canisters produced at Savannah River Site or irradiated mixed-oxide spent fuel) that could be disposed of in a geologic repository.
Regional description and cumulative impact information	
Final Environmental Impact Statement for the Proposed Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory (DIRS 162639-DOE 2002, all)	Evaluates the environmental impacts from relocation of the Technical Area 18 capabilities and materials (presently at Los Alamos) to each of four alternative sites, including the Nevada Test Site.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS; continued).

Document	Relationship to Repository SEIS
"Record of Decision for the Final Environmental Impact Statement for the Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory" (67 FR 79906, December 31, 2002)	Implements the preferred alternative, which would relocate Security Category I and II missions and related materials to the Device Assembly Facility at the Nevada Test Site.
Draft Complex Transformation Supplemental Programmatic Environmental Impact Statement (DIRS 185273-DOE 2007, all)	Analyzes the potential environmental impacts of reasonable alternatives to continue transformation of the U.S. nuclear weapons complex to be smaller, and more responsive, efficient, and secure to meet national security requirements. The proposed action is to continue currently planned modernization activities and select a site for a consolidated plutonium center for long-term research and development, surveillance, and pit[a] manufacturing; consolidate special nuclear materials throughout the complex; consolidate, relocate, or eliminate duplicative facilities and programs and improve operating efficiencies; identify one or more sites for conducting flight test operations; and accelerate nuclear weapons dismantlement activities.
Draft Programmatic Environmental Impact Statement of the Designation of Energy Corridors in the 11 Western States (DIRS 185274-DOE 2007, all)	Addresses the environmental impacts from designation of corridors on federal land in the 11 western states for oil, gas, and hydrogen pipelines and electricity transmission and distribution facilities (energy corridors), as required by Section 368 of the *Energy Policy Act of 2005* (Public Law 109-58). DOE and the Bureau of Land Management co-led this effort, with the U.S. Department of Agriculture's Forest Service, the Department of Defense, and the Department of the Interior's Fish and Wildlife Service participating as federal cooperating agencies.
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)	Presents a systematic environmental impacts review to determine if there were substantial changes in the actions proposed in the 1996 site-wide EIS or significant new circumstances or information relevant to environmental concerns.
Nevada transportation activities	
"Notice of Preferred Nevada Rail Corridor" (68 FR 74951, December 29, 2003)	Announces the Caliente rail corridor, from the five rail corridors studied in the Yucca Mountain FEIS, as DOE's preferred rail corridor in which to construct a rail line.
"Notice of Proposed Withdrawal and Opportunity for Public Meeting; Nevada" (68 FR 74965, December 29, 2003)	Announces the Bureau of Land Management's receipt of a request from DOE to withdraw public land from surface entry and mining for a period of 20 years to evaluate the land for the potential construction, operation, and maintenance of a rail line for the transportation of spent nuclear fuel and high-level radioactive waste in Nevada. Segregates the land from surface entry and mining for as long as 2 years while DOE conducts studies and analyses to support a final decision on the withdrawal application.
Supplement Analysis (DIRS 172285-DOE 2004, all)	Supplement to the Yucca Mountain FEIS. Examines the potential environmental impacts of shipping legal-weight truck casks on railcars from generator sites to Nevada.
"Record of Decision on Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, NV" (69 FR 18557, April 8, 2004)	Selects the mostly rail scenario analyzed in the Yucca Mountain FEIS as the mode of transportation on a national basis and in the State of Nevada. Selects the Caliente rail corridor for alignment, construction, and operation of a proposed rail line to Yucca Mountain.

Table 1-2. NEPA documents and Records of Decision related to this Repository SEIS (since DOE completed the Yucca Mountain FEIS; continued).

Document	Relationship to Repository SEIS
"Notice of Intent to Prepare an Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (69 FR 18565, April 8, 2004)	Announces DOE's intent to prepare an EIS for the alignment, construction, and operation of a rail line for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials from a site near Caliente, Lincoln County, Nevada to a geologic repository at Yucca Mountain, Nye County, Nevada.
Proposed Resource Management Plan/Final Environmental Impact Statement for the Ely Field Office, Nevada (DIRS 184767-BLM 2007, all)	Examines implementation of Bureau of Land Management resource management plans, actions, and goals in the Ely area.
Environmental Assessment for the Proposed Withdrawal of Public Lands Within and Surrounding the Caliente Rail Corridor, Nevada (DIRS 176452-DOE 2005, all)	Examines the environmental impacts of withdrawal of public lands from surface entry and new mining claims for as long as 20 years to enable evaluation of the land for the proposed rail line.
"Public Land Order No. 7653; Withdrawal of Public Lands for the Department of Energy to Protect the Caliente Rail Corridor, Nevada" (70 FR 76854, December 28, 2005)	Withdraws public lands in the Caliente rail corridor from surface entry and the location of new mining claims, subject to valid existing rights, for 10 years to enable DOE to evaluate the lands for the potential construction, operation, and maintenance of a rail line.
"Amended Notice of Intent to Expand the Scope of the Environmental Impact Statement for the Alignment, Construction, and Operation of a Rail Line to a Geologic Repository at Yucca Mountain, Nye County, NV" (71 FR 60484, October 13, 2006)	Announces DOE's intent to expand the scope of the Rail Alignment EIS to incorporate an analysis of the potential environmental impacts of a newly proposed Mina rail corridor.
"Notice of Proposed Withdrawal and Opportunity for Public Meeting; Nevada" (72 FR 1235, January 10, 2007)	Announces the Bureau of Land Management's receipt of an application from DOE to withdraw public lands from surface entry and mining through December 27, 2015, to evaluate the land for the potential construction, operation, and maintenance of a rail line. This covers the Mina rail alignment and segments of the Caliente rail alignment not covered in Public Land Order No. 7653. Segregates the land from surface entry and mining for as long as 2 years while DOE conducts studies and analyses to support a final decision on the withdrawal application.
Nevada Rail Corridor SEIS and Rail Alignment EIS	Examine potential impacts for the alignment, construction, and operation of a railroad in Nevada for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials to a geologic repository at Yucca Mountain, Nye County, Nevada.

a. A pit is the central core of a nuclear weapon, which typically contains plutonium-239 that undergoes fission when compressed by high explosives.

DOE = U.S. Department of Energy.
EIS = Environmental impact statement.
GNEP = Global Nuclear Energy Partnership.
GTCC = Greater-Than-Class-C.
INL = Idaho National Laboratory.
LLW = Low-level radioactive waste.
NRC = U.S. Nuclear Regulatory Commission.

1.5.4 CONFORMANCE WITH DOCUMENTATION REQUIREMENTS

For this Repository SEIS, DOE has performed formal documented reviews of data to identify gaps, inconsistencies, omissions, or other conditions that would cause data to be suspect or unusable.

DOE has planned analyses to ensure consistency and thoroughness in the environmental studies conducted for this Repository SEIS. In addition, DOE has used configuration-control methods to ensure that inputs to this SEIS are current, correct, and appropriate, and that outputs reflect the use of appropriate inputs.

All work products for this Repository SEIS have undergone documented technical, editorial, and managerial reviews for adequacy, accuracy, and conformance to project and DOE requirements. Work products related to impact analyses (for example, calculations, data packages, and data files) also have undergone formal technical and managerial reviews. Calculations (manual or computer-driven) generated to support impact analyses have been verified in accordance with relevant project management procedures.

1.5.5 COOPERATING AGENCY

Pursuant to the NWPA, DOE is responsible for the disposal of spent nuclear fuel and high-level radioactive waste to protect public health, safety, and the environment, and for development and implementation of a plan for transportation of spent nuclear fuel and high-level radioactive waste to a repository at Yucca Mountain. Therefore, DOE is the lead agency responsible for preparation of this Repository SEIS. The Council on Environmental Quality regulations emphasize agency cooperation early in the NEPA process and allow a lead agency to request the assistance of other agencies that either have jurisdiction by law or special expertise about issues considered in an EIS.

Nye County, Nevada, is the situs jurisdiction of the Yucca Mountain Repository and has special expertise on the relationship of DOE's Proposed Action to the objectives of regional and local land use plans, policies and controls, and to the current and planned infrastructure in the county, including public services and traffic conditions. As such, Nye County is a cooperating agency in the development of this Repository SEIS, pursuant to Council on Environmental Quality regulations at 40 CFR 1501.5 and 1501.6, and has provided input (DIRS 182850-Swanson 2007, all).

Consistent with Council on Environmental Quality regulations and guidance on cooperating agencies, Nye County accepted and acknowledges DOE's authority as the lead agency with respect to the Yucca Mountain Project. Participation as a cooperating agency is consistent with the stated county policy of constructive engagement with DOE (Nye County Board of Commissioners Resolution No. 2002-22) and with the objectives of the county's Community Protection Plan (approved August 2006).

Representatives from Nye County attended public, project, and technical working group meetings; participated on interdisciplinary teams; compiled and provided socioeconomic data such as population, housing, and other forecasting information; provided relevant reports and studies prepared or conducted by the county; assisted with the identification of environmental issues and with environmental analyses; reviewed working draft and preliminary draft documents; and assisted with the resolution of comments.

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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.
185301	DOE 2008	DOE (U.S. Department of Energy) 2008. *Yucca Mountain Repository License Application.* DOE/RW-0573. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20080501.0021.
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.
185486	Larson 2008	Larson, N.B. 2008. Right of Way (ROW) Application for a Proposed U.S. Department of Energy Rail Line from a Site Near Caliente, Nevada. Letter from N.B. Larson (DOE/OCRWM) to D. Metcalf (BLM/Ely Field Office) March 4, 2008, 0306082829, with attachments. ACC: CCU.20080306.0002.
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.
182850	Swanson 2007	Swanson, D. 2007. Memorandum of Understanding Between the Office of Civilian Radioactive Waste Management and Nye County, Nevada. Letter from D. Swanson (Nye County) to J. Summerson (YMSCO), April 9, 2007, 0412075994, 07-099-DS (L), with enclosure. ACC: MOL.20070430.0246; MOL.20070430.0247.
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2

Proposed Action and No-Action Alternative

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2. PROPOSED ACTION AND NO-ACTION ALTERNATIVE

Under the *Proposed Action*, the U.S. Department of Energy (DOE or the Department) would construct, operate, monitor, and eventually close a *geologic repository* for the *disposal* of *spent nuclear fuel* and *high-level radioactive waste* at Yucca Mountain. Since publication 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) in 2002, DOE has continued to develop the *repository* design and associated construction and operation plans. 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 design, which includes plans for the repository's surface and *subsurface* facilities and transportation of spent nuclear fuel and high-level radioactive waste to the repository. DOE has submitted the Repository SEIS to the U.S. Nuclear Regulatory Commission (NRC) with its application for construction authorization for a geologic repository.

Section 2.1 discusses the Proposed Action. Section 2.2 incorporates by reference the *No-Action Alternative* presented in the Yucca Mountain FEIS, and Section 2.3 summarizes the findings of this Repository SEIS, which include the findings of the Rail Alignment EIS on the impacts of spent nuclear fuel and high-level radioactive waste transportation in Nevada, and compares the potential environmental impacts of the Proposed Action and the No-Action Alternative. Section 2.4 addresses the collection of information and the analyses DOE performed for this Repository SEIS. Section 2.5 identifies DOE's preferred *alternative*.

2.1 Proposed Action

This introduction provides an overview of the Proposed Action and refers the reader to the sections in this Repository SEIS that contain further detail. Figure 2-1 illustrates the components or activities associated with implementation of the Proposed Action.

Under the Proposed Action, DOE would construct, operate, monitor, and eventually close a geologic repository at Yucca Mountain for the disposal of up to 70,000 *metric tons of heavy metal* (MTHM) of commercial and *DOE spent nuclear fuel* and high-level *radioactive* waste. In its simplest terms, the repository would be a large subsurface excavation with a network of *drifts*, or tunnels, that DOE would use for *emplacement* of spent nuclear fuel and high-level radioactive waste. DOE would dispose of spent nuclear fuel and high-level radioactive waste in the repository using the inherent, natural *geologic* features of the mountain and *engineered* (manmade) *barriers* to help ensure the long-term *isolation* of these materials from the human environment. The NRC, through its licensing process, would regulate repository *construction*, *operations, monitoring*, and *closure*.

Under the Proposed Action, the Department would transport most spent nuclear fuel and high-level radioactive waste from 72 commercial and 4 DOE sites to the repository in NRC-certified *transportation casks* on trains dedicated only to those *shipments*. However, DOE would transport some shipments to the repository in transportation casks by truck over the nation's highways. Naval spent nuclear fuel would be transported to the repository in transportation casks on railcars in general freight service or *dedicated trains.*

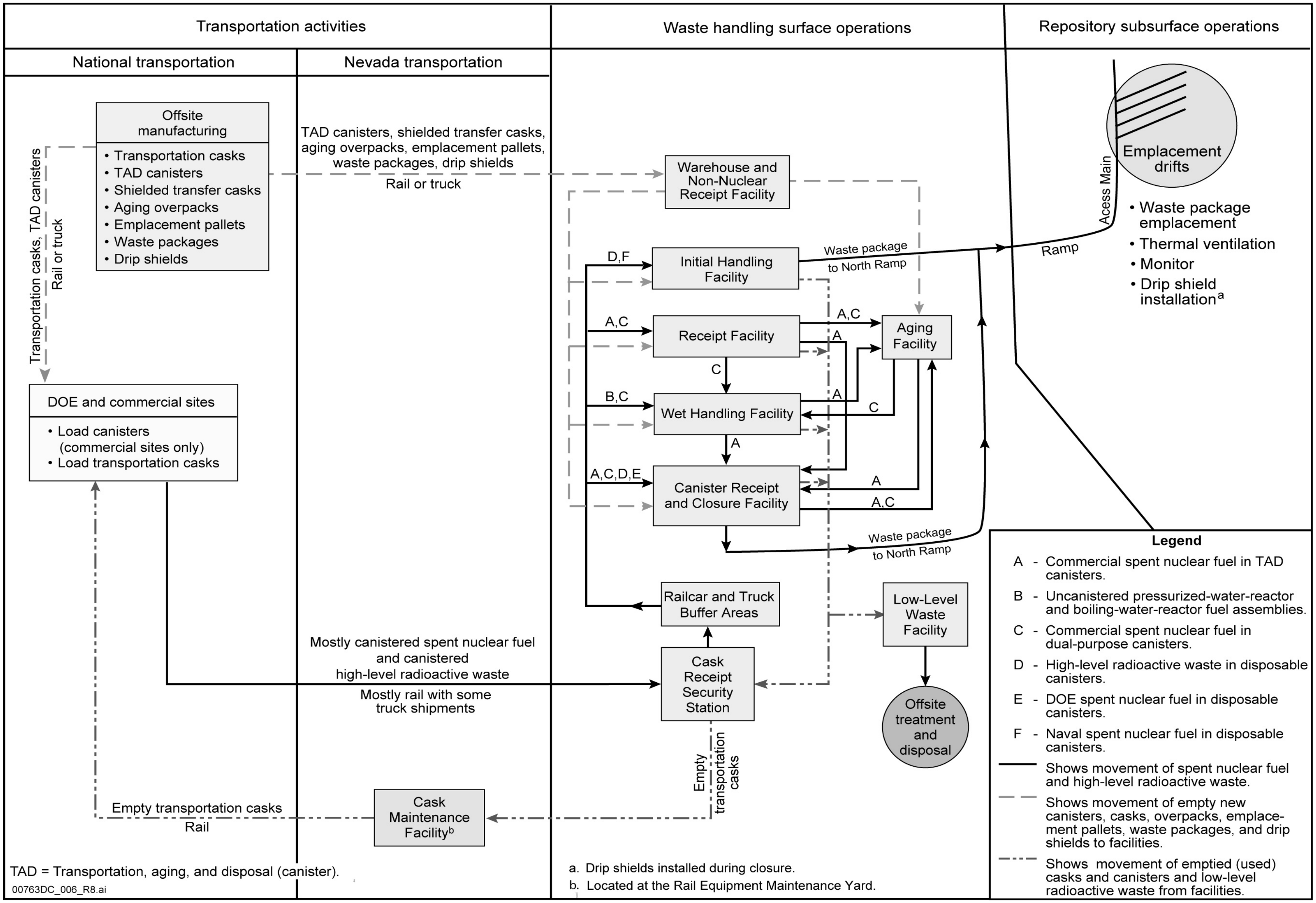


Figure 2-1. Overview flowchart for typical operations of the Proposed Action.

DEFINITION OF METRIC TONS OF HEAVY METAL

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 (for example, the metallic tubes that contain the fuel) 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.

The Yucca Mountain FEIS described the equivalence methods by which MTHM is determined for high-level radioactive waste (pages A-36 to A-37). An MTHM equivalence is needed for high-level radioactive waste because its matrix is mostly silica or glass and almost all of its heavy metal has been removed. In this Repository SEIS, MTHM used in conjunction with high-level radioactive waste means MTHM equivalent, as explained in the Yucca Mountain FEIS.

High-level radioactive waste and DOE spent nuclear fuel would be placed in *disposable canisters* at the DOE sites and shipped to the repository. Although DOE has a small amount of spent nuclear fuel of commercial origin that it could ship to the repository uncanistered in a transportation cask, consistent with the analysis in the Yucca Mountain FEIS, this Repository SEIS assumes that it would transport and receive all DOE spent nuclear fuel and high-level radioactive waste in disposable canisters. As much as 90 percent of the *commercial spent nuclear fuel* would be placed in *transportation, aging, and disposal (TAD) canisters* at the commercial sites before shipment. The remaining commercial spent nuclear fuel (about 10 percent) would be transported to the repository in *dual-purpose canisters* (*canisters* suitable for storage and transportation), or as uncanistered spent nuclear fuel. Spent nuclear fuel shipped in dual-purpose canisters or as uncanistered spent nuclear fuel would be placed in TAD canisters at the repository prior to disposal.

At the repository, DOE would conduct waste handling activities, discussed below, to manage thermal output of the commercial spent nuclear fuel and to package the spent nuclear fuel into TAD canisters. The disposable canisters and TAD canisters would be placed into *waste packages* for disposal in the repository. A waste package is a container that consists of the *barrier* materials and internal components in which DOE would place the canisters that contained spent nuclear fuel and high-level radioactive waste. Section 2.1.1 discusses fuel packaging in TAD canisters and dual-purpose canisters more fully.

DOE would place approximately 11,000 waste packages, containing no more than a total of 70,000 MTHM, of spent nuclear fuel and high-level radioactive waste in the repository at Yucca Mountain. The *Proposed Action inventory,* or materials planned for disposal at the *Yucca Mountain Repository*, includes approximately:

- 63,000 MTHM of commercial spent nuclear fuel from boiling-water and *pressurized-water reactors*, which includes commercial high-level radioactive waste from the West Valley Demonstration Project;
- 2,333 MTHM of DOE spent nuclear fuel, which includes about 65 MTHM of naval spent nuclear fuel; and
- 4,667 MTHM of DOE high-level radioactive waste.

The Yucca Mountain FEIS evaluated the *cumulative impacts* of two additional inventories (Modules 1 and 2). Modules 1 and 2 include spent nuclear fuel and high-level radioactive waste in addition to the Proposed Action inventory, as well as other radioactive wastes generally considered unsuitable for near-surface disposal. Chapter 8 of this Repository SEIS contains updated inventories for Modules 1 and 2.

The handling and disposal of spent nuclear fuel and high-level radioactive waste would take place in an area known as the *geologic repository operations area*. The geologic repository operations area is defined at 10 CFR 63.2, as "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." The surface portion of the geologic repository operations area would include the facilities necessary to receive, package, and support emplacement of spent nuclear fuel and high-level radioactive waste in the repository. The subsurface portion of the geologic repository operations area would include the facilities necessary for emplacement. Section 2.1.2 discusses the geologic repository operations area facilities.

The design for implementation of the Proposed Action has multiple buildings that would enable a phased construction approach, allowing DOE to accept waste as soon as possible as well as being compatible with constrained funding. The primary surface waste handling facilities would include an *Initial Handling Facility*, three separate *Canister Receipt and Closure Facilities*, a *Wet Handling Facility*, and a *Receipt Facility*. In addition, there would be an *Aging Facility* with two *aging pads* for use in thermal management. These facilities would enable preparation for disposal of the various types of radioactive wastes after receipt at the geologic repository operations area. Section 2.1.2.1 discusses the waste handling surface facilities and operations more fully.

Once the spent nuclear fuel and high-level radioactive waste received at the repository were packaged in waste packages, the waste packages would be transferred to the subsurface portion of the geologic repository operations area for emplacement in dedicated tunnels (drifts). The waste packages would be aligned end-to-end in these drifts. Emplacement drifts would be excavated in a series of four panels (Section 2.1.2.2.1), phased to exceed the anticipated throughput rate of the surface waste handling facilities. In addition, the repository would have other underground excavations. These would include, for example, access mains to provide access from the surface to the emplacement drifts, and exhaust mains to direct ventilation air from the emplacement drifts to the surface. Gradually sloping ramps from the surface to the subsurface facilities would allow workers, equipment, and transport and emplacement vehicles access to and from repository operations. Section 2.1.2.2 discusses the subsurface facilities and operations.

Emplacement of the waste packages in the emplacement drifts would be managed according to the thermal energy or thermal output of the waste packages. In addition to being radioactive, spent nuclear fuel and high-level radioactive waste give off heat, which is referred to as thermal energy or thermal output. When these materials are placed in a confined space, such as an emplacement drift where heat cannot readily dissipate, the surrounding area would become hot. Under the Proposed Action, the thermal output of the waste packages would heat the rock surrounding the emplacement drifts to a temperature higher than the boiling point of water at the repository elevation, 96 degrees Celsius (°C) [205 degrees Fahrenheit (°F)]. This would cause the small amounts of water in the rock to turn into steam, which would move away from the drifts to a point where temperatures were below the boiling point of water and the steam could condense back to water. Because DOE wants to provide a path for the mobilized water to move downward past the emplacement drifts, the repository has been designed so there would be a middle region between the drifts (the *midpillar* region) that remained below the boiling point of water.

To accomplish this, DOE would manage the thermal output of the waste packages by selecting for emplacement only those packages that would keep the temperature in the midpillar region below the boiling point of water, as shown in Figure 2-2.

The evaluations of whether a waste package is too thermally hot for emplacement are based on a concept called thermal energy density, which is a measure of how heat is distributed over an area. By knowing the thermal characteristics of waste packages it had emplaced in an area of the repository, and the thermal characteristics of waste packages it had available for emplacement, DOE would select, from the available waste packages, those that would be appropriate for the next emplacement in the repository. DOE would make the selections based on calculations that evaluated the effect of the added thermal energy of the additional waste packages on maintaining the midpillar region below the boiling point of water. Management of an upper limit to the thermal energy density for emplacement would thus rely on selecting or blending of waste packages with specific thermal characteristics.

DOE's repository design includes other surface facilities to support waste handling and disposal. Section 2.1.2.3 describes the Central Control Center Facility, the Warehouse and Non-Nuclear Receipt Facility, the Heavy Equipment Maintenance Facility, the Low-Level Waste Facility, and the Emergency Diesel Generator Facility, as well as other support facilities. Section 2.1.2.4 describes utilities that would support the geologic repository operations area.

DOE would construct the surface and underground facilities and associated infrastructure, such as the onsite road and water distribution networks and emergency response facilities, in phases to accommodate the expected receipt rates of spent nuclear fuel and high-level radioactive waste. The Department would use two areas, the *South Portal development area* and the *North Construction Portal*, to support *underground facility* construction. Section 2.1.3 describes the South Portal development area and the North Construction Portal. Additional facilities outside the geologic repository operations area would support the project; Section 2.1.4 describes these facilities.

Under the Proposed Action, DOE would conduct a Performance Confirmation Program. *Performance confirmation* refers to a focused program of tests, experiments, and analyses DOE would conduct to monitor repository conditions, to assess the adequacy of geotechnical and design parameters, and to preserve the ability to perform waste retrieval, if necessary. The Performance Confirmation Program, would continue until *permanent closure* of the repository. Under the Proposed Action, DOE could retrieve emplaced waste packages for at least 50 years after the start of emplacement. Section 2.1.5 describes the Performance Confirmation Program.

When authorized by the NRC, closure of the repository would begin. DOE would install titanium *drip shields* over the waste packages. The drip shields would divert moisture that could drip from the drift walls, as well as condensed water vapor around the waste packages, to the drift floor, thereby increasing the life expectancy of the waste packages. In addition, drip shields would protect the waste packages from rockfalls. Closure would involve decontamination and dismantling of the surface handling facilities, backfilling of subsurface-to-surface openings, *decommissioning* and demolition of surface facilities, and restoration of the surface to its approximate condition before repository construction. In addition, closure would include erection of a network of monuments and markers around the site surface to warn future generations of the presence and nature of the buried radioactive waste. Section 2.1.6 discusses repository closure further.

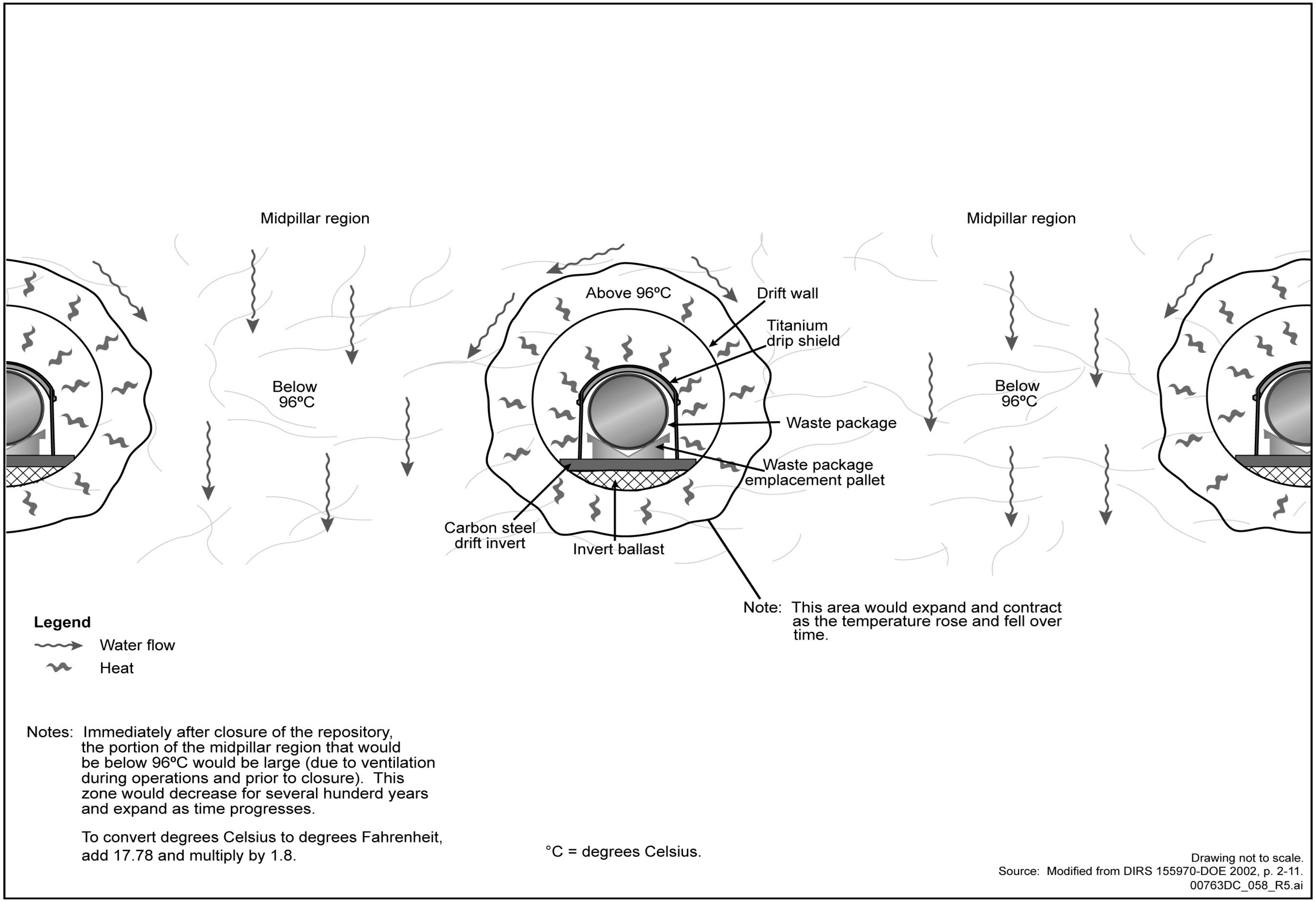


Figure 2-2. Management of waste package emplacement using thermal energy density (artist's concept).

After closure of the *subsurface facility*, the rock around the emplacement drifts would dry, which would minimize the amount of water that could contact the waste packages for hundreds of years. However, a portion of the rock between the drifts would remain at temperatures below boiling, which would promote drainage of water through the midpillar portions of the rock rather than into the emplacement drifts. Section 2.1.6 discusses repository closure further.

The Proposed Action includes construction and operation of a *railroad*, in an *alignment* in the State of Nevada, to connect the *Yucca Mountain site* to an existing *rail line* in Nevada. The Proposed Action also includes the construction and operation of several facilities that would be necessary for the operation of the railroad. The Rail Alignment EIS analyzes the construction and operation of the railroad; DOE summarizes and incorporates that analysis into this Repository SEIS, as discussed further in Section 2.1.7.

DOE has developed preliminary schedules for site preparation, construction, waste receipt, and routine emplacement operations. To the extent they relate to radiological health and safety or preservation of the common defense and security, these activities would not begin inside the geologic repository operations area until DOE received construction authorization from the NRC. Section 2.1.8 presents the schedules.

Best management practices are an integral part of the Proposed Action. DOE has defined best management practices for this 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 design for the repository incorporates them. Chapter 4 discusses resource-specific best management practices for the resource areas to which they apply. Chapter 9 discusses potential mitigation measures.

In summary, in this Repository SEIS DOE considers potential environmental impacts associated with the design for the repository, surface facilities, and transportation. The following subsections describe fuel packaging, geologic repository operations area facilities, construction support, and other facilities that would be necessary to implement the Proposed Action, as summarized above. In addition, they describe the Performance Confirmation Program, repository closure, and transportation activities associated with the Proposed Action.

2.1.1 FUEL PACKAGING

In the Yucca Mountain FEIS, DOE evaluated the receipt of commercial spent nuclear fuel under two packaging scenarios. These included the mostly canistered scenario, in which most commercial spent nuclear fuel would be received in dual-purpose canisters, and the mostly uncanistered scenario, in which most commercial spent nuclear fuel would be received uncanistered. In the mostly canistered scenario, the dual-purpose canisters would be opened at the repository and the spent nuclear fuel would be repackaged into waste packages. In the mostly uncanistered scenario, spent nuclear fuel would be transferred from transportation casks to waste packages. In both scenarios, DOE would handle the fuel at the repository in an uncanistered condition before loading it into waste packages for emplacement. In the

DEFINITIONS OF PACKAGING TERMS

Aging overpack:
A cask specifically designed for aging spent nuclear fuel at the repository. TAD canisters and dual-purpose canisters would be placed in aging overpacks for aging at the Aging Facility.

Disposable canister:
A metal vessel for commercial and 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 in a waste package. There are a number of types of disposable canisters, including DOE standard canisters, multicanister overpacks, naval spent nuclear fuel canisters, and TAD canisters.

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.

Uncanistered spent nuclear fuel:
Commercial spent nuclear fuel assemblies not placed in a canister before placement into a transportation cask. 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 aging overpack.

Shielded transfer cask:
A metal vessel used to transfer horizontal dual-purpose canisters from the Aging Facility to the Wet Handling Facility.

Transportation, aging, and disposal (TAD) canister:
A canister suitable for storage, shipping, aging, and disposal of commercial spent nuclear fuel. Commercial spent nuclear fuel would be placed into a TAD canister at the commercial reactor. At the repository, DOE would remove the TAD canister from the transportation cask and place it 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 transport of spent nuclear fuel or high-level radioactive waste via public transportation routes.

Waste package:
A container that consists of the corrosion-resistant outer container (Allow 22 outer cylinder) and structural inner container (stainless-steel inner cylinder) baskets, and shielding integral to the container. Waste packages would be ready for emplacement in the repository when the inner and outer lid welds were complete and the volume of the inner container had been evacuated and filled with helium gas to achieve an inert condition.

FEIS, all of the DOE materials (spent nuclear fuel and high-level radioactive waste) would be packaged in disposable canisters at the generator sites. These disposable canisters would not have to be opened at the repository and would be placed directly into waste packages for emplacement.

In this Repository SEIS, DOE would operate the repository with a *primarily canistered approach* in which the generator sites would package the majority (potentially as much as 90 percent) of commercial spent nuclear fuel in TAD canisters. DOE would use TAD canisters to transport, age, and dispose of commercial spent nuclear fuel at the repository, thereby eliminating the need to open the canister and handle that spent nuclear fuel at the repository. The remaining commercial spent nuclear fuel (about 10 percent) would arrive at the repository as uncanistered spent nuclear fuel or in dual-purpose canisters. The repository would receive DOE spent nuclear fuel, high-level radioactive waste, and naval spent nuclear fuel in disposable canisters. The Department could ship a small amount of DOE spent nuclear fuel of commercial origin to the repository as uncanistered spent nuclear fuel. At the repository, DOE would place uncanistered spent nuclear fuel directly into TAD canisters. *Aging* of the commercial spent nuclear fuel in TAD or dual-purpose canisters would, as necessary, manage thermal output. DOE would place both types of canisters (disposable and TAD) in waste packages before emplacement in the repository.

The TAD canister is a component of systems that the NRC (1) would certify for the transportation of spent nuclear fuel under 10 CFR Part 71 and would license for surface storage at the respective commercial sites under 10 CFR Part 72; and (2) would license for repository site transfer, aging, and geologic disposal under 10 CFR Part 63. Under this approach, the use of TAD canisters would minimize the handling of spent nuclear fuel assemblies because operators would seal commercial spent nuclear fuel in TAD canisters at generator sites. The TAD canister design would accommodate both *pressurized*- and *boiling-water-reactor* spent nuclear fuel. During transport, aging, and disposal, DOE would place a TAD canister inside another vessel that would provide other necessary functions (for example, radiological shielding, heat dissipation, structural strength, and *corrosion* resistance) as needed for each application. These vessels would include transportation casks, *shielded transfer casks*, *aging overpacks*, and waste packages.

DOE has adopted specifications to provide performance requirements for TAD canisters. The DOE performance specification (DIRS 185304-DOE 2008, all) contains detailed specifications for TAD canisters. Figure 2-3 is a schematic diagram of the TAD canister.

DOE's expectation under the Proposed Action is that potentially as much as 90 percent of commercial spent nuclear fuel would be packaged in TAD canisters by the operators at the generator sites. However, DOE has conducted a sensitivity analysis, provided in Appendix A of this Repository SEIS, that considered the potential case that the operators could place only 75 percent of commercial spent nuclear fuel in TAD canisters at commercial sites, with DOE loading the remainder in TAD canisters at the repository.

2.1.2 FACILITIES IN THE GEOLOGIC REPOSITORY OPERATIONS AREA AND VICINITY

The facilities where DOE would handle spent nuclear fuel and high-level radioactive waste would be in the geologic repository operations area, which is shown in Figure 2-4. The surface portion of the geologic repository operations area would comprise the facilities necessary to receive age, package, and support emplacement of waste. Waste handling operations would be in a *restricted area* in the surface portion of the geologic repository operations area. DOE would locate the restricted area, defined in 10 CFR 63.2, to separate waste handling operations from other activities in the geologic repository operations area. During phased construction, physical barriers would encompass a *protected*

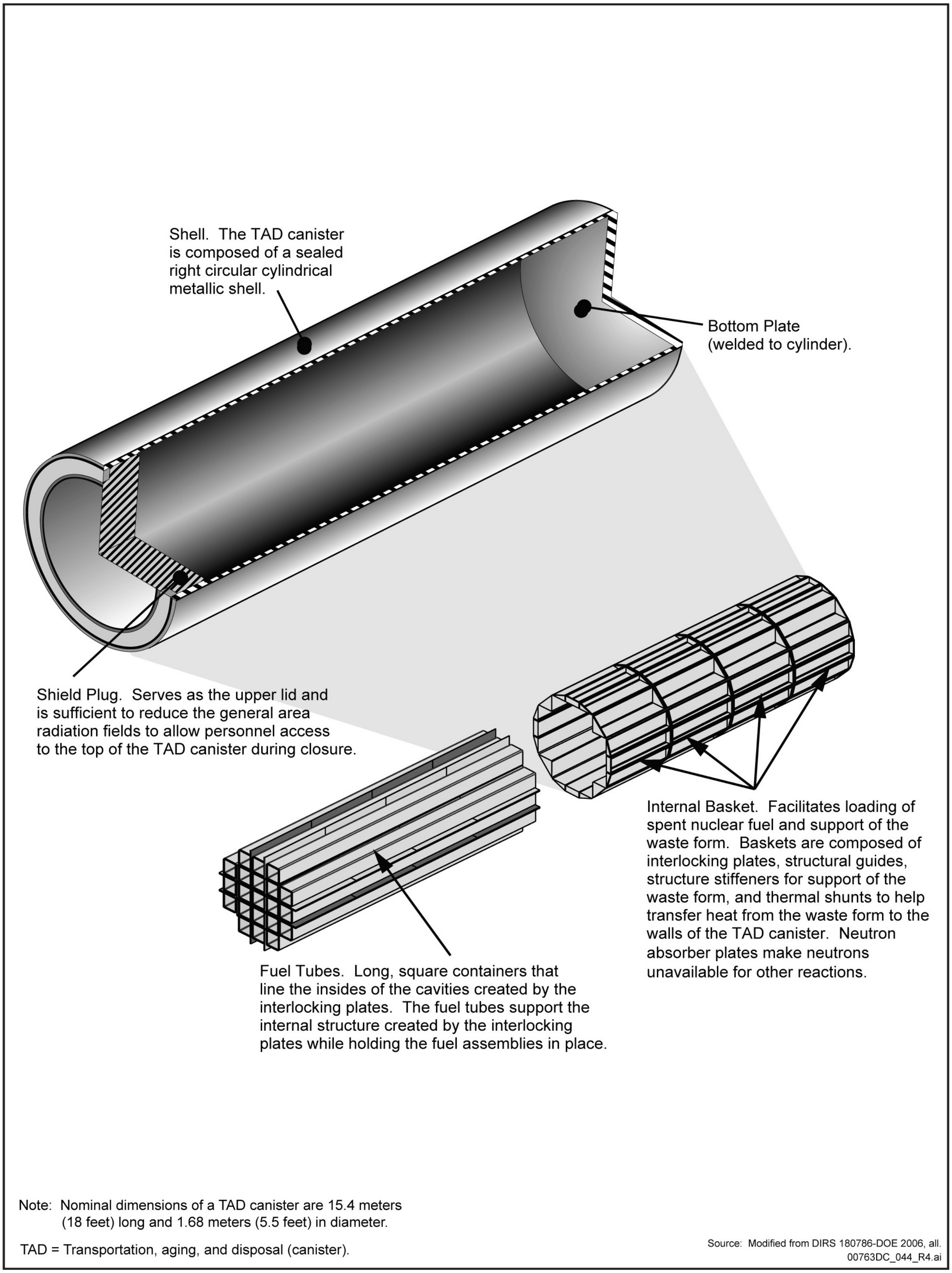


Figure 2-3. TAD canister schematic (artist's concept).

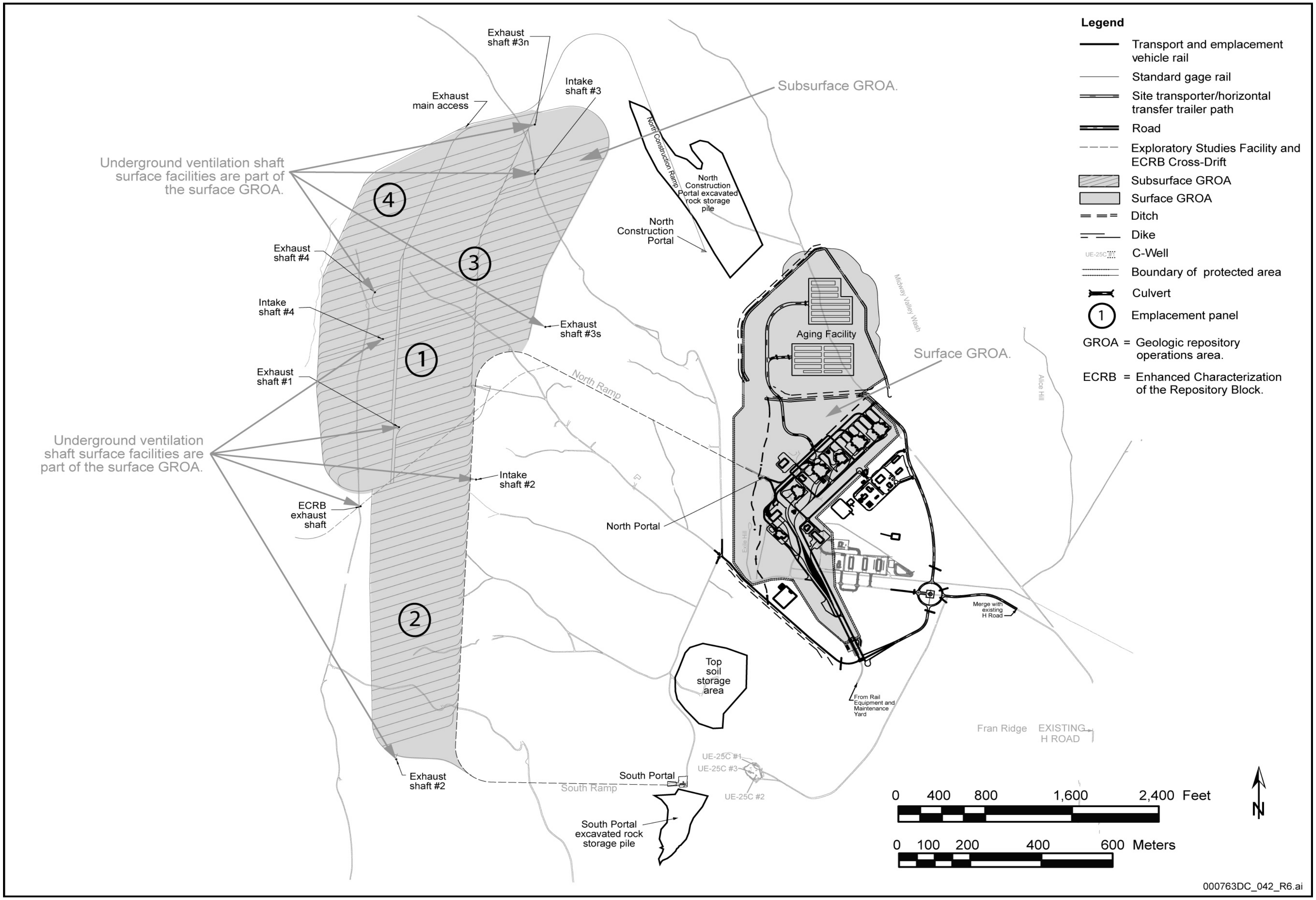


Figure 2-4. Geologic repository operations area.

area to ensure adequate safeguards and security for the spent nuclear fuel and high-level radioactive waste. The subsurface geologic repository operations area would consist of the features and facilities necessary to transport and emplace waste packages and provide ventilation to the emplaced waste packages. These subsurface features and facilities would include excavated drifts, rail lines, waste package emplacement pallets, engineered inverts, and support systems.

This Repository SEIS analyzes implementation of the Proposed Action according to four periods—construction analytical period, operations analytical period, monitoring analytical period, and closure analytical period, as listed in Table 2-1. DOE has defined these four *analytical periods* for use in this Repository SEIS to best evaluate potential *preclosure* environmental impacts that could be associated with the Proposed Action, as explained in further detail in Chapter 4. Various activities could occur in each analytical period, but the name of the analytical period implies the major activity that would occur. For instance, during the operations analytical period, construction would be occurring, but operations would be the major activity. Appendix A addresses the impacts of a potentially longer monitoring period. Table 2-1 also lists the corresponding *operational phases* DOE describes in its application for construction authorization. The four operational phases indicate when DOE expects specific facilities to be operational under the planned phased construction.

Section 2.1.2.1 describes the surface facilities and operations that DOE would use for waste handling. Section 2.1.2.2 describes the subsurface facilities and repository operations, including ventilation. Section 2.1.2.3 describes the balance of plant facilities, and Section 2.1.2.4 describes utilities for the geologic repository operations area and vicinity.

Table 2-1. Repository SEIS analytical periods and associated construction and activities.

Analytical period duration	Infrastructure improvements	Operational phases of surface facilities construction	Subsurface facility development (construction)	Other associated activities
Construction analytical period				
5 years The construction analytical period includes activities that would begin on receipt of the construction authorization from the NRC and that DOE would complete by the time it received spent nuclear fuel or high-level radioactive waste.	• Electrical power and distribution system • Roads and rail • Domestic water systems • Septic tank and leach field/wastewater treatment systems • Sewer and stormwater collection systems • Engineering and Safety Demonstration Facility • Hazardous Materials Collection Depot • Borrow pits • Explosives Storage Area • Offsite Training Facility • Housing for construction workers • Sample Management Facility • Marshalling yard and warehouse • South Portal development area	Phase 1 • Initial Handling Facility • Wet Handling Facility • Canister Receipt and Closure Facility 1 • Low-Level Waste Facility • Central Control Center Facility • Heavy Equipment Maintenance Facility • Aging Facility (pad 17R) • Aging Overpack Staging Facility • Warehouse and Non-Nuclear Receipt Facility • Two Fire Water Facilities • Cask Receipt Security Station • Central Security Station • Transporter Security Gate • Utilities Facility, cooling tower, and evaporation pond • Emergency and Standby Diesel Generator Facilities • Railcar buffer area • Truck buffer area • Helicopter pad	Subsurface facility development would begin with Panel 1, concurrent with surface construction.	• Developing initial ventilation system, which would include shafts, shaft pads, batch plants, and electrical utility transmission lines. • Beginning active ventilation of the repository.

Table 2-1. Repository SEIS analytical periods and associated construction and activities (continued).

Analytical period duration	Infrastructure improvements	Operational phases of surface facilities construction	Subsurface facility development (construction)	Other associated activities
Operations analytical period				
Up to 50 years The operations analytical period includes activities that would begin on receipt of spent nuclear fuel and high-level radioactive waste. The period would include receipt, handling, aging, emplacement, continued active ventilation of the repository, and monitoring of waste, as well as continued construction of surface and subsurface facilities.	• North Construction Portal.	Phase 2 • Receipt Facility • One Fire Water Facility • Administration Facility and two administration security stations • Fire, Rescue and Medical Facility • Warehouse/Central Receiving • Materials/Yard Storage • Vehicle Maintenance and Motor Pool • Diesel Fuel Oil Storage • Fueling stations • Craft shops • Equipment/Yard Storage Phase 3 • Canister Receipt and Closure Facility 2 • Aging Facility (pad 17P) Phase 4 • Canister Receipt and Closure Facility 3 • North Perimeter Security Station	Continued subsurface facility development with Panels 2, 3, and 4 until complete.	• Continuing development of ventilation system.

Table 2-1. Repository SEIS analytical periods and associated construction and activities (continued).

Analytical period duration	Infrastructure improvements	Operational phases of surface facilities construction	Subsurface facility development (construction)	Other associated activities
Monitoring analytical period				
50 years The monitoring analytical period includes activities that would begin with emplacement of the final waste package and continue for 50 years after the end of the operations analytical period.	No infrastructure improvements planned.	Possible surface facility construction to support waste retrieval, if necessary.	No subsurface facility development planned.	• Maintaining active ventilation of the repository for at least 50 years after emplacement of the last waste package. • Remotely inspecting waste packages. • Continuing monitoring of the waste. • Retrieving waste packages, if necessary.
Closure analytical period				
10 years The closure analytical period includes activities that would begin on receipt of a license amendment to close the repository and would last 10 years, concurrent with the last 10 years of the monitoring analytical period.	No infrastructure improvements planned.	No facility construction planned.	No subsurface facility development planned.	• Decontaminating and dismantling the surface handling facilities[a] • Emplacing the drip shields. • Removing concrete inverts from the main drifts. • Backfilling subsurface-to-surface openings. • Constructing monuments to mark the site. • Restoring the surface to its approximate condition before repository construction. • Continuing performance confirmation, as necessary.

a. The timeframe for decontaminating and dismantling the surface handling facilities is dependent on the determination that the surface facilities are no longer necessary to support spent nuclear fuel and high-level radioactive waste handling, processing, emplacement, or retrieval operations. This Repository SEIS assumes that this would occur during the closure analytical period.

DOE = U.S. Department of Energy.

NRC = U.S. Nuclear Regulatory Commission.

DEFINITIONS OF YUCCA MOUNTAIN SITE TERMS

Central operations area:
The central operations area is an area in which DOE would develop approximately 0.8 kilometer (0.5 mile) southeast of the geologic repository operations area for support operations, which would include upgrades and replacement of the subsurface infrastructure in the Exploratory Studies Facility.

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."

North Construction Portal:
Portal that would be used for construction of the subsurface facility.

North Portal:
An existing portal (current 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.

Protected area:
The protected area is an area encompassed by physical barriers and to which access would be controlled, ensuring adequate safeguards and security for the spent nuclear fuel and high-level radioactive waste. The protected area would expand as the additional waste handling facilities are completed.

Portal:
A portal is the opening to the subsurface facility that would provide access for construction, equipment, rock removal, or waste emplacement.

Restricted area:
The restricted area, as defined at 10 CFR 20.1003 and 10 CFR 63.2, is an area in which DOE would separate waste handling operations from other activities in the geologic repository operations area.

South Portal development area:
An existing portal and ramp that DOE would use for construction of the subsurface facility.

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).

Yucca Mountain Repository (repository):
As defined at 10 CFR 63.202, the Yucca Mountain Repository means the excavated portion of the facility constructed underground within the Yucca Mountain site.

2.1.2.1 Waste Handling Surface Facilities and Operations

Waste handling surface facilities would be in the protected area of the geologic repository operations area. Figure 2-5 shows the orientation and layout of the surface facilities in the geologic repository operations area. In Figure 2-5, the surface facilities are grouped according to the four operational phases that would occur under the planned phased construction. The repository would have initial operating capability at the completion of Phase 1 and full operating capability at the completion of Phase 2. The site layout addresses concurrent construction and operations in the geologic repository operations area.

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:

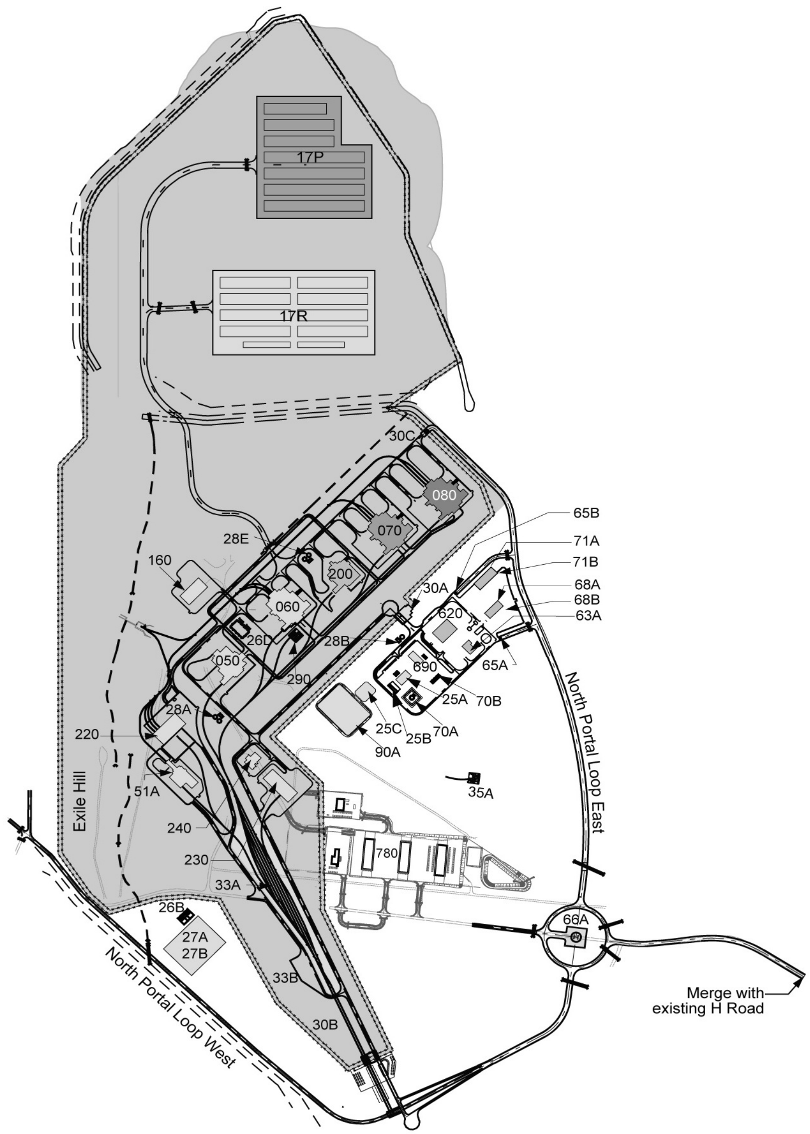
The timeframe from construction authorization to repository closure.

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.



LEGEND

Initial Operating Capability

Phase 1			
17R	Aging Pad R	33B	Truck Buffer Area
25A	Utilities Facility	35A	Septic Tank and Leach Field
25B	Cooling Tower	050	Wet Handling Facility
25C	Evaporation Pond	51A	Initial Handling Facility
26B	Standby Diesel Generator Facility	060	Canister Receipt and Closure Facility 1
26D	Emergency Diesel Generator Facility	66A	Helicopter Pad
27A	Switchyard (138 kilovolts)	90A	Stormwater Retention Pond
27B	13.8-kilovolt Switchgear Facility	160	Low-Level Waste Facility
28A	Fire Water Facility (Central)	220	Heavy Equipment Maintenance Facility
28B	Fire Water Facility (East)	230	Warehouse and Non-Nuclear Receipt Facility
30A	Central Security Station	240	Central Control Center Facility
30B	Cask Receipt Security Station	290	Aging Overpack Staging Facility
33A	Railcar Buffer Area	780	Lower Muck Yard
Full Operating Capability			
Phase 2			
28E	Fire Water Facility (North)	70B	Fueling Stations
63A	Fire, Rescue and Medical Facility	71A	Craft Shops
65A	Administration Security Station	71B	Equipment/Yard Storage
65B	Administration Security Station	200	Receipt Facility
68A	Warehouse/Central Receiving	620	Administration Facility
68B	Materials/Yard Storage	690	Vehicle Maintenance and Motor Pool
70A	Diesel Fuel Oil Storage		
Phase 3			
17P	Aging Pad P	070	Canister Receipt and Closure Facility 2
Phase 4			
30C	North Perimeter Security Station	080	Canister Receipt and Closure Facility 3

Surface geologic repository operations area

Figure 2-5. Layout of the surface geologic repository operations area and vicinity.

> **PRIMARY FUNCTIONS OF WASTE PREPARATION AND HANDLING FACILITIES**
>
> **Aging Facility:**
> Provide two aging pads and associated equipment to age commercial spent nuclear fuel as necessary to meet waste package thermal limits.
>
> **Canister Receipt and Closure Facilities:**
> Receive DOE disposable canisters and TAD canisters, load canisters into waste packages, and close the waste packages.
>
> **Cask Receipt Security Station:**
> Perform initial waste receipt and inspection.
>
> **Initial Handling Facility:**
> Receive high-level radioactive waste and naval spent nuclear fuel canisters, load canisters into waste packages, and close the waste packages.
>
> **Receipt Facility:**
> Transfer TAD and dual-purpose canisters, as appropriate, to the Wet Handling Facility, a Canister Receipt and Closure Facility, or the Aging Facility.
>
> **Wet Handling Facility:**
> Handle uncanistered commercial spent nuclear fuel and open and unload dual-purpose canisters; essential purpose is loading TAD canisters.

DOE would use five types of surface facilities (eight buildings or areas) for waste handling—Initial Handling Facility, three Canister Receipt and Closure Facilities, the Wet Handling Facility, the Aging Facility, and the Receipt Facility—and would build them in phases. In addition, DOE would use a site transportation network to move transportation casks, shielded transfer casks, and aging overpacks between the waste handling facilities and eventually to move waste packages to the subsurface facility.

DOE would conduct waste handling operations in these facilities with mostly remotely operated equipment. The Department would use thick, reinforced concrete shield walls, *shielded* canister transfer, and controlled access techniques to protect workers from *radiation exposure*. The design of the waste handling facilities and equipment would withstand the effects of ground motion from *earthquakes* and other *events*.

The Initial Handling Facility, Canister Receipt and Closure Facilities, Wet Handling Facility, Aging Facility, and Receipt Facility would have a digital control and management information system that would interface with, but have adequate isolation from, the safety components provided with mechanical handling equipment in each facility. In addition, the digital control and management information system would interface with the Central Control Center Facility to enable supervisory control and monitoring of facility operations by Central Control Center Facility operators.

Spent nuclear fuel and high-level radioactive waste would arrive at the repository in a variety of types and sizes, as follows. Figure 2-1 shows an overview of operations DOE would use to receive and handle the various waste forms, as described below.

The repository would receive the vast majority of commercial spent nuclear fuel in TAD canisters that were loaded, internally dried and filled by an inert gas to displace oxygen, and closed by the commercial nuclear utilities. Transportation casks arriving at the repository that contained commercial spent nuclear fuel in TAD canisters that required aging would be unloaded in the Receipt Facility. The TAD canisters would be placed in aging overpacks and moved to the Aging Facility for thermal management. Once the thermal heat output *decayed* to an acceptable level, DOE would move the aging overpacks to a Canister Receipt and Closure Facility for packaging of the TAD canisters in waste packages for subsequent subsurface emplacement. TAD canisters that did not require aging would be sent to a Canister Receipt and Closure Facility for packaging into waste packages for subsequent subsurface emplacement.

A small fraction of commercial spent nuclear fuel could arrive in transportation casks as uncanistered pressurized- and boiling-water-reactor fuel assemblies. DOE would move these transportation casks to the Wet Handling Facility for placement of the uncanistered spent nuclear fuel assemblies in TAD canisters. DOE would dry, close, and backfill these TAD canisters with helium gas to achieve an inert condition. If aging should be necessary, DOE would place the TAD canisters in aging overpacks and move them to the Aging Facility. Once the thermal heat output decayed to an acceptable level, DOE would move the aging overpacks to a Canister Receipt and Closure Facility for packaging of the TAD canisters in waste packages for subsequent subsurface emplacement. If aging was not necessary, the TAD canisters would be placed in aging overpacks and transported to a Canister Receipt and Closure Facility for packaging in waste packages for subsequent subsurface emplacement.

Commercial spent nuclear fuel could also arrive in sealed dual-purpose canisters. Dual-purpose canisters may be oriented either vertically or horizontally. DOE would unload transportation casks that contained commercial spent nuclear fuel in vertical dual-purpose canisters that required aging in the Receipt Facility. The dual-purpose canisters would be placed in aging overpacks and moved to the Aging Facility for thermal management. Transportation casks that contained horizontal dual-purpose canisters would be moved to a cask transfer trailer and from there to a horizontal aging module at the Aging Facility. Horizontal aging modules would be stationed at the Aging Facility and would be used specifically to age spent nuclear fuel in horizontal dual-purpose canisters. DOE would design the cask transfer trailers for docking at the portal of the horizontal aging module. A hydraulic ram system would be necessary to facilitate the transfer of canisters to the horizontal aging module. The hydraulic ram would be inserted through a portal in the appropriate end of the transportation cask and would be used to push the loaded canister into the horizontal aging module. Once the thermal heat output decayed to an acceptable level, DOE would move the aging overpacks that contained vertical dual-purpose canisters to the Wet Handling Facility for transfer of the spent nuclear fuel to TAD canisters. DOE would use the ram to withdraw the horizontally placed dual-purpose canister from the horizontal aging module and transfer it to a shielded transfer cask to enable moving the dual-purpose canister to the Wet Handling Facility. Dual-purpose canisters that arrived at the repository that did not require aging would be sent to the Wet Handling Facility where the spent nuclear fuel would be transferred to TAD canisters. The TAD canisters would then be placed in aging overpacks and moved to a Canister Receipt and Closure Facility for packaging in waste packages for subsequent subsurface emplacement.

High-level radioactive waste, naval spent nuclear fuel, and most DOE spent nuclear fuel would arrive at the repository in disposable canisters. These canisters would be loaded, backfilled with inert gas (except the canisters that contained high-level radioactive waste), sealed, and transported from waste generation and storage sites. Transportation casks that contained naval spent nuclear fuel in disposable canisters would be unloaded in the Initial Handling Facility. These canisters would be packaged separately into waste packages in the Initial Handling Facility for subsequent subsurface emplacement. Transportation casks that contained high-level radioactive waste in disposable canisters could be unloaded in either the Initial Handling Facility or a Canister Receipt and Closure Facility. In either facility, the canisters would be packaged in waste packages for subsequent subsurface emplacement. Transportation casks that contained DOE spent nuclear fuel in disposable canisters would be sent to a Canister Receipt and Closure Facility for unloading and transfer to a waste package for subsequent subsurface emplacement. In the Canister Receipt and Closure Facility, the high-level radioactive waste canisters and DOE spent nuclear fuel canisters could be codisposed in the waste packages. Depending on the waste package configuration, the codisposal would be as follows: five high-level radioactive waste canisters with one spent nuclear fuel canister, four high-level radioactive waste canisters with one spent nuclear fuel canister, or two high-level radioactive waste canisters with two spent nuclear fuel canisters.

Ultimately, the various waste forms would leave the waste handling facilities packaged uniformly in waste packages for repository emplacement.

2.1.2.1.1 *Cask Receipt Security Station*

The *Cask Receipt Security Station* would be at the south end of the surface geologic repository operations area (Figure 2-5, Facility 30B). The Cask Receipt Security Station would be the point of receipt for all transportation casks containing spent nuclear fuel and high-level radioactive waste. Shipments of spent nuclear fuel and high-level radioactive waste would arrive at the Cask Receipt Security Station on commercial railcars that carried rail transportation casks or on truck trailers that carried truck transportation casks. On arrival, the shipments would be inspected and custody of, or responsibility for, the transportation casks would be transferred from the transportation system to the repository. Casks, still on commercial railcars or truck trailers, would be moved from the Cask Receipt Security Station to a buffer area in the protected area of the geologic repository operations area to await processing in one of the waste handling facilities. Incoming empty waste packages, TAD canisters, and shielded transfer casks would also arrive at the Cask Receipt Security Station on railcars and truck trailers before their transfer to the Warehouse and Non-Nuclear Receipt Facility. Empty transportation casks would be held in the buffer area awaiting shipment off the site.

2.1.2.1.2 *Initial Handling Facility*

The Initial Handling Facility would be in the western part of the surface geologic repository operations area (Figure 2-5, Facility 51A). The Initial Handling Facility would receive rail and truck transportation casks that contained high-level radioactive waste canisters or naval spent nuclear fuel canisters; it would handle no other waste forms. This facility would have the capability to prepare truck and rail transportation casks for unloading: transfer disposable canisters to waste packages; and to close and seal the waste packages. The closing and sealing of the waste packages would include welding the inner lid closed, evacuating the waste package inner vessel and backfilling it with helium, and installing the waste package outer lid and welding it closed. The completed waste package would be positioned on an *emplacement pallet* such that a transport and emplacement vehicle could receive it, move it to the subsurface, and emplace it in the repository. Emplacement pallets would support the waste package in a horizontal position in the emplacement drift, as described further in Sections 2.1.2.2.2 and 2.1.2.2.3.

2.1.2.1.3 *Canister Receipt and Closure Facilities*

When the repository became fully operational, there would be three Canister Receipt and Closure Facilities of identical design for the packaging of canisters in waste packages. The three facilities would be in a row in the central part of the surface geologic repository operations area (Figure 2-5, Facilities 060, 070, and 080).

The Canister Receipt and Closure Facilities would have the ability to receive DOE disposable canisters and TAD canisters; to transfer them to waste packages; and to close and seal the waste packages. The closing and sealing of the waste packages would include welding the inner lid closed, evacuating the waste package inner vessel and backfilling it with helium, and installing the waste package outer lid and welding it closed. The completed waste package would be positioned on an emplacement pallet such that a transport and emplacement vehicle could receive it, move it to the subsurface, and emplace it in the repository. The facilities would also have the ability to transfer TAD and vertical dual-purpose canisters from transportation casks into aging overpacks on site transporters for transport to the Aging Facility.

Uncanistered spent nuclear fuel assemblies would not be accepted by the Canister Receipt and Closure Facilities, and canisters would not be opened inside the facility.

2.1.2.1.4 *Wet Handling Facility*

The Wet Handling Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 050). This facility would provide support for cask preparation; receipt and opening of sealed dual-purpose canisters; transfer of commercial spent nuclear fuel into TAD canisters underwater; closure of TAD canisters; loading of TAD canisters into aging overpacks on site transporters for transport to the Aging Facility; and loading of TAD canisters into aging overpacks on site transporters for transfer to a Canister Receipt and Closure Facility. The Wet Handling Facility would have a 15.2-meter (50-foot)-deep pool. The pool would have a limited-capacity in-process spent nuclear fuel staging area. This would consist of storage racks with the capacity to hold approximately 80 pressurized-water-reactor spent nuclear fuel assemblies and 120 boiling-water reactor spent nuclear fuel assemblies.

The Wet Handling Facility would receive dual-purpose canisters in various ways, including (1) in aging overpacks from the Aging Facility, (2) in rail transportation casks, and (3) in horizontal shielded transfer casks from the Aging Facility. The facility also would receive uncanistered spent nuclear fuel assemblies in transportation casks transported from the rail or truck *buffer areas*.

The uncanistered spent nuclear fuel assemblies from the transportation casks and the spent nuclear fuel in the dual-purpose canisters would be repackaged into TAD canisters at the Wet Handling Facility. The transportation casks that contained uncanistered spent nuclear fuel assemblies would be moved to the facility's pool for lid removal and transfer of the uncanistered fuel assemblies to an empty TAD canister or to the pool staging rack. At this point, the spent nuclear fuel assemblies would be blended to ensure that the loaded TAD canister thermal limits would not be exceeded. Dual-purpose canisters would be opened outside the pool and then moved into the pool for transfer of the commercial spent nuclear fuel to TAD canisters or the pool staging rack.

Once the TAD canisters were loaded, dried, sealed, and backfilled with helium gas to achieve an inert condition, they would be transported to either the Aging Facility for thermal management or a Canister Receipt and Closure Facility for packaging in waste packages.

The facility also would contain a remediation area to facilitate the handling and limited repair of casks and TAD canisters. In addition, the facility would prepare the unloaded dual-purpose canisters for removal from the facility.

2.1.2.1.5 *Aging Facility*

The surface layout of the Aging Facility would include two aging pads to provide space for aging commercial spent nuclear fuel. The Aging Facility would be at the north end of the surface geologic repository operations area (Figure 2-5, Facilities 17P and 17R). The pads would enable aging of commercial spent nuclear fuel as necessary to meet waste package thermal limits. The principal components of the Aging Facility, in addition to the aging pads, would be the aging overpacks that contained either TAD canisters or dual-purpose canisters positioned on an aging pad and the overpack transfer component. The aging pads would accommodate up to 21,000 MTHM of commercial spent nuclear fuel. Aging overpacks would be either vertical aging overpacks for dual-purpose and TAD canisters or horizontal aging modules for horizontal dual-purpose canisters. Overpack transfer would involve equipment capable of moving aging overpacks containing TAD or dual-purpose canisters and transportation casks containing horizontal dual-purpose canisters between the handling facilities and the Aging Facility.

The Aging Facility would receive aging overpacks from the Receipt Facility, Wet Handling Facility, and Canister Receipt and Closure Facilities and would send aging overpacks to the Wet Handling Facility and Canister Receipt and Closure Facilities. The Aging Facility would also receive transportation casks that contained horizontal dual-purpose canisters from the Receipt Facility and later send them in shielded transfer casks to the Wet Handling Facility. Of the 2,500 aging spaces provided by the aging pads, about 100 would be for horizontal aging modules.

2.1.2.1.6 *Receipt Facility*

The Receipt Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 200). This facility would transfer TAD and dual-purpose canisters that arrived on commercial railcars carrying rail transportation casks to the Wet Handling Facility, a Canister Receipt and Closure Facility, and the Aging Facility. TAD and dual-purpose canisters would be transferred to these facilities in aging overpacks, and horizontal dual-purpose canisters would be transferred to the Aging Facility in transportation casks. In addition, the Receipt Facility would prepare unloaded transportation casks for return to the national transportation system. Until the Receipt Facility became operational, a Canister Receipt and Closure Facility would provide the receipt function of the Receipt Facility.

2.1.2.1.7 *Site Transportation Network*

The site transportation network would consist of rail lines and roads that connected the waste handling facilities, buffer areas, Aging Facility, and emplacement *portal*. Onsite canister movement would be accomplished in shielded transfer casks, transportation casks, or aging overpacks by site transporters, site prime movers, cask tractors, and cask transfer trailers.

The site transporters would be hydraulically self-propelled and powered by a diesel engine or electric motor when operated outdoors and by an electric motor when used inside buildings. Each site transporter would include a cask restraint system to prevent uncontrolled cask movement during transport. The site transporters would be all-weather vehicles designed to operate in rain and snow over the temperature and humidity range of the site.

The site prime movers would be rail-based vehicles that would work in conjunction with buffer cars at each end to enable placement of rail cask cars in the waste handing building without the site prime mover entering the building.

The cask tractor would be the tow vehicle used to move horizontal dual-purpose canisters. The cask tractor would pull a cask transfer trailer carrying a transportation cask containing a horizontal dual-purpose canister from the Receipt Facility to the Aging Facility. Once aging was complete, the cask tractor would pull the cask transfer trailer carrying a horizontal shielded transfer cask containing a horizontal dual-purpose canister from the Aging Facility to the Wet Handling Facility. There would be two different cask transfer trailers to accommodate the different casks to be carried. Each cask transfer trailer would be a heavy industrial trailer with a support skid mounted on top.

2.1.2.1.8 *Waste Package Transport to the Subsurface Facility*

At the Initial Handling Facility and the Canister Receipt and Closure Facility, the completed waste packages would be positioned on an emplacement pallet such that a transport and emplacement vehicle could receive them, move them to the subsurface, and emplace them in the repository. A transport and emplacement vehicle would transport the waste package on an emplacement pallet from the Initial Handling Facility or Canister Receipt and Closure Facility to a subsurface emplacement drift through the *North Portal* and down the *North Ramp* to the appropriate emplacement drift. The waste package and its emplacement pallet would be transported as a single unit.

The transport and emplacement vehicle would be a specialized, shielded rail vehicle designed to move waste packages safely from the surface facilities into the subsurface facility for emplacement. The vehicle design would prevent uncontrolled movement that could lead to a breach of a waste package and withstand rockfall occurrences without jeopardizing the structural integrity of the waste package. To accommodate the high radiation environment of the emplacement drifts, the transport and emplacement vehicle would be controlled by an onboard, programmable logic controller and monitored by operators in the Central Control Center. Figure 2-6 shows the transport and emplacement vehicle.

2.1.2.2 Subsurface Facilities and Operations, Including Ventilation

DOE would excavate drifts (horizontal tunnels) in Yucca Mountain for waste emplacement. The subsurface facilities would consist of three access mains, which would be 7.6-meter (25-foot)-diameter tunnels that would provide access to smaller emplacement drifts. Emplacement drifts would be 5.5-meter (18-foot)-diameter tunnels. The design is based on an emplacement drift spacing of 81 meters (270 feet). The total repository emplacement area to accommodate 70,000 MTHM is about 6 square kilometers (1,500 acres).

Approximately 68 kilometers (42 miles) of emplacement drifts would be excavated in four panels. About 11,000 waste packages and their emplacement pallets would be placed in these drifts. DOE would use mechanical excavation methods such as electric-powered tunnel boring machines to excavate drifts (Figure 2-7), as well as road headers, drill and blast using explosives, and raise borers, depending on the application of the tunnel or *shaft*.

Ground support would protect workers by providing tunnel stability and preventing rockfall. Ground support would differ for the various types of underground openings. Ground support for emplacement drifts would consist of initial ground support and final ground support.

The initial ground support would provide worker safety until installation of the final ground support system. The initial ground support would consist of carbon-steel frictional rock bolts and wire mesh based on industry standard materials. The initial ground support would be installed in the drift crown only, immediately after excavation. The wire mesh would be removed before installation of the final

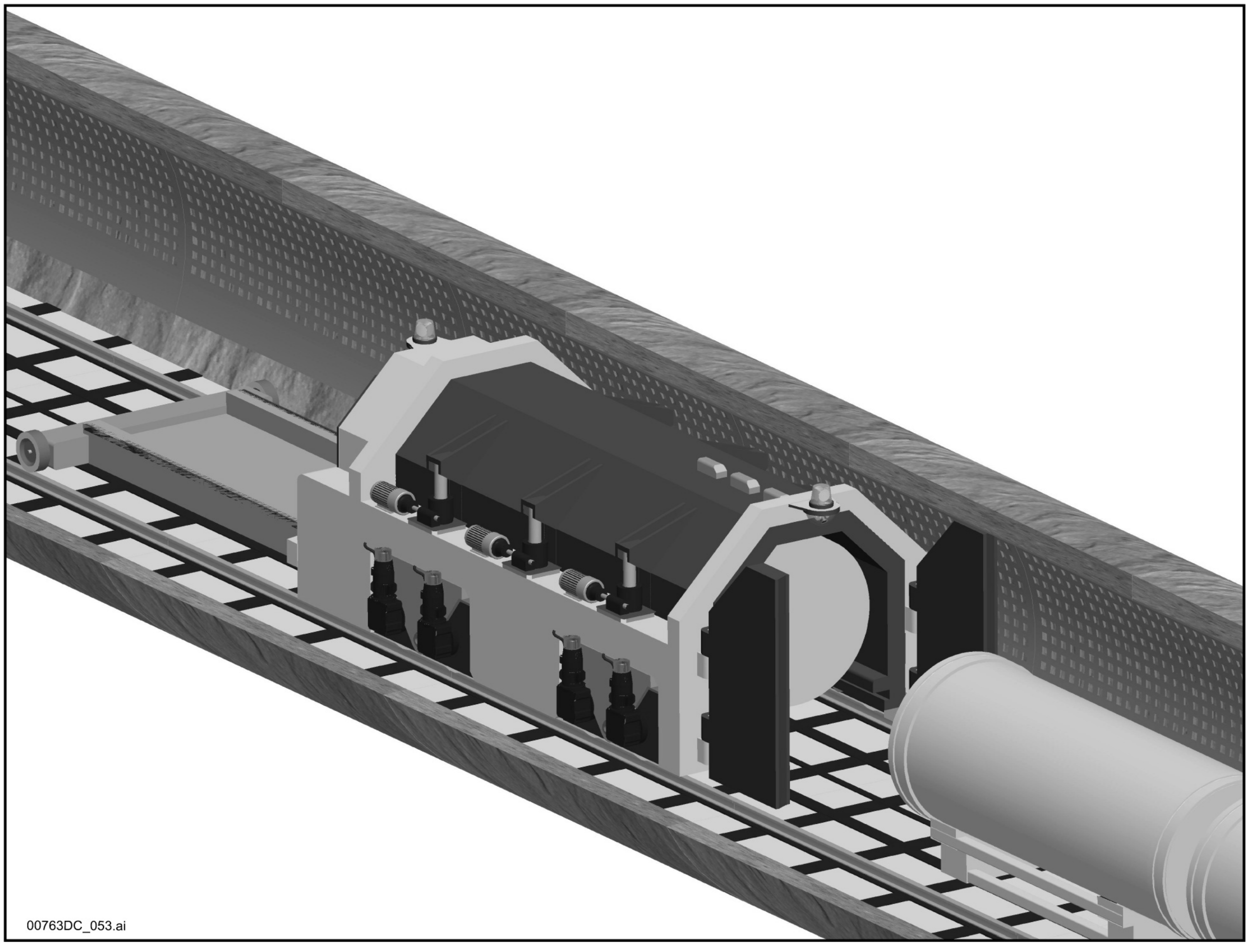


Figure 2-6. Transport and emplacement vehicle placing waste package in emplacement drift (artist's concept).

ground support, while the initial rock bolts would remain in place. The purpose of this initial ground support would be to protect personnel from loosened rock during the tunneling process, and to protect the geologic mapping personnel who could follow the tunnel boring machine in selected locations.

Final ground support for the emplacement drifts would be installed before the drifts were equipped with utilities and *invert* structures. Final ground support would consist of friction rock bolts, 3 meters (9.8 feet) long, spaced at 1.25-meter (4.1-foot)-intervals, and perforated metal sheets, 3 millimeters (0.12 inch) thick, installed in a 240-degree arc around the drift periphery along the entire drift length. Both the friction bolts and perforated metal sheets would be made of Stainless Steel Type 316 or equivalent. This material is corrosion-resistant, and DOE chose it based on the potential corrosion mechanisms in the repository environment during the preclosure analytical periods.

The ground support for the portals would consist of fully grouted rock bolts with fiber-reinforced shotcrete installed around the portal frontal and lateral faces. Due to the functions that the ramps provide as access ways for personnel and, in the case of the North Ramp, for waste package transportation, fully grouted rock bolts would be supplemented with a lining of shotcrete to enhance the ground support function in the three ramps.

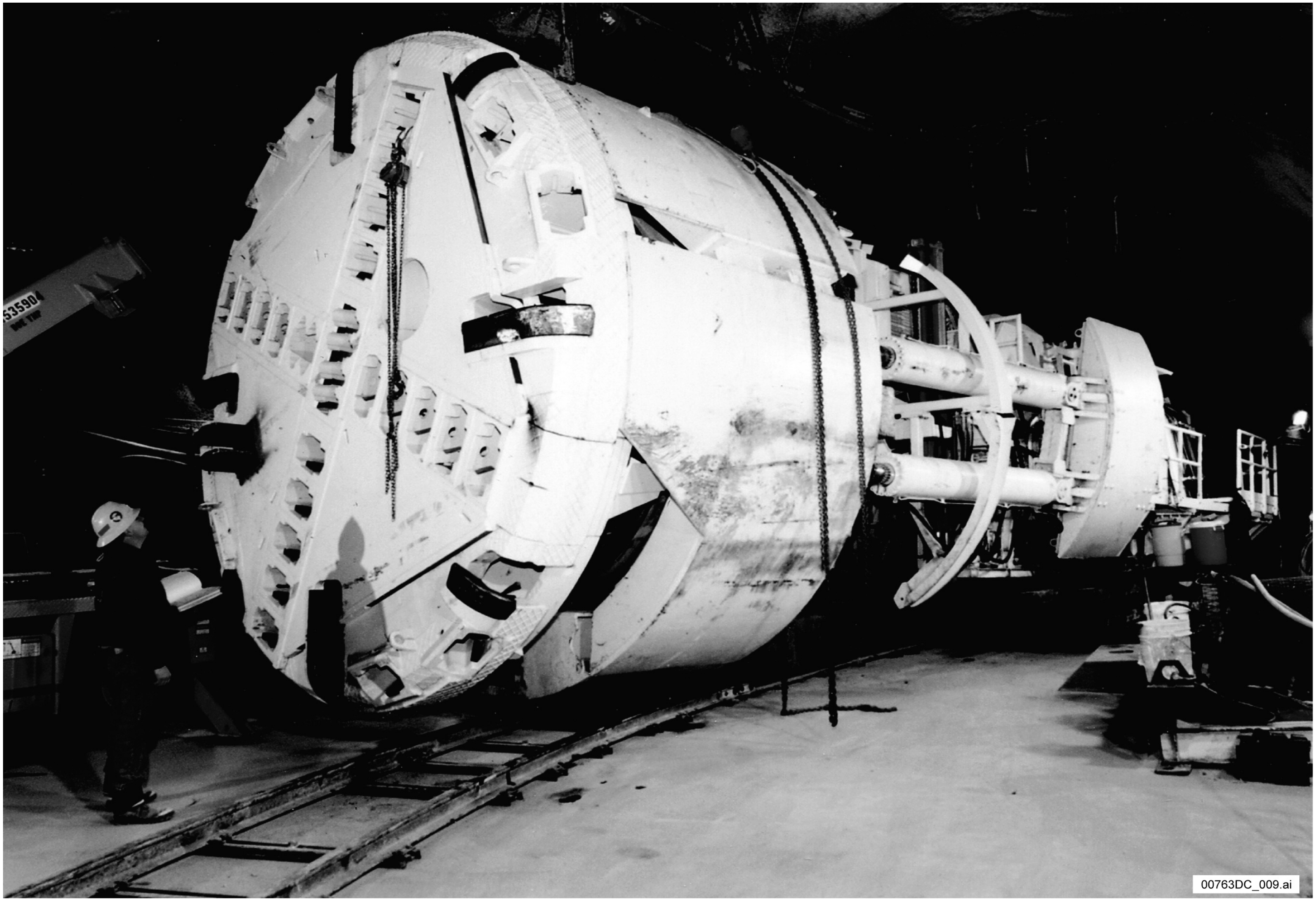


Figure 2-7. Tunnel boring machine.

Ground support design at intersections between the access main drifts and turnouts or between exhaust main drifts and emplacement drifts would consist of fully grouted rock bolts with fiber-reinforced shotcrete and lattice girders as necessary. Fully grouted rock bolts with welded wire mesh would be used for ground support in most of the nonemplacement openings, which would include access mains, exhaust mains, and turnouts.

Ventilation would be necessary for maintenance of airflow to the subsurface facilities during construction (development), emplacement, and monitoring. In addition, DOE would provide positive-pressure ventilation flow for the development of the repository and negative-pressure ventilation flow to the emplacement drifts. The configuration of the subsurface facility ventilation system would change over time as emplacement panels were added, until the repository was fully developed. The subsurface facility ventilation would consist of two operationally independent and separate systems: the development ventilation system and the emplacement ventilation system. Isolation barriers would physically separate the development side from the emplacement areas. These systems would enable concurrent development of emplacement drifts on one side of the isolation barriers and waste emplacement in operational emplacement drifts on the other side. The two systems would have independent airflow networks and fan systems that operated concurrently. The development ventilation system would be a supply system, with the primary purpose of ensuring the health and safety of subsurface personnel. The emplacement ventilation system would be an exhaust system with the primary purpose of attaining thermal goals in the repository. When the repository reached full emplacement, DOE would operate the entire subsurface facility with one subsurface ventilation system. That system would use all the intake and exhaust ventilation airways described in the design, and it would distribute air from the intake air zone into the emplacement drifts and remove heated air from the emplacement drifts to the heated air zone and out to the surface. The continuous forced ventilation to the emplacement drifts for an extended period after emplacement of waste packages would provide heat removal that is considered part of the bases for *postclosure* analyses.

The overall ventilation system would consist of three intake shafts and six exhaust shafts. The three ramps would act as additional ventilation intakes. Ventilation shafts are vertical openings, typically circular, excavated by mechanical means or by drill-and-blast techniques. The repository ventilation shafts would be either 4.9 meters (16 feet) or 7.9 meters (26 feet) in diameter. These nine shafts and three ramps would serve 108 emplacement drifts in the four repository waste *emplacement panels*.

The shafts would be near the crest of Yucca Mountain in an area that would have roads, shaft pads, and electrical utility transmission lines. The ventilation rate across each emplacement drift would be 15 cubic meters per second (approximately 32,000 cubic feet per minute). Figure 2-4 shows the main and emplacement panels and ventilation shafts.

2.1.2.2.1 *Subsurface Facility Emplacement Panels*

The subsurface facility would be divided into four waste emplacement panels that would be developed and made operational in sequence over a period of years, planned to coincide with the receipt of waste. Emplacement panels can best be described as groups of isolated tunnels set aside for waste disposal. Each panel would consist of multiple emplacement drifts in which DOE would dispose of the waste packages. Each panel would share common subsurface facilities for access, monitoring, and ventilation (Figure 2-4). The repository panels and their associated engineered barriers would function in conjunction with the *natural barriers* to provide waste containment and isolation during the preclosure and postclosure periods.

The emplacement panels would be excavated in rock formations that DOE has selected because of their attributes for waste containment and isolation. The excavations dedicated to waste emplacement would be equipped to (1) support waste emplacement and *retrieval* equipment, (2) contain a stable invert structure capable of holding the waste packages on their emplacement pallets and drip shields in stable positions, and (3) provide ground support systems capable of maintaining the safety and integrity of the excavations throughout the preclosure period.

As described below for Panel 1, construction would begin at a location in the existing *Exploratory Studies Facility* tunnel. DOE developed the Exploratory Studies Facility as the main test facility for collection of detailed geologic, hydrologic, and geophysical information on the welded volcanic *tuff* of the Topopah Spring unit identified as the host horizon for permanent spent nuclear fuel and high-level radioactive waste disposal. The Department began construction of the Exploratory Studies Facility in September 1994, using a 7.6-meter (25-foot)-diameter tunnel boring machine that excavated a 7.9-kilometer (4.9-mile), U-shaped tunnel into Yucca Mountain. The Exploratory Studies Facility has three main sections: (1) the North Ramp, which descends 2.8 kilometers (1.7 miles) into the mountain; (2) the main area of the facility, approximately 213 meters (700 feet) below the surface of the ramp entrance and running approximately 3.2 kilometers (2.0 miles) through the Topopah Spring unit of the mountain; and (3) the South Ramp, which ascends 2.2 kilometers (1.4 miles) back to the surface at the South Portal development area.

Panel 1

Construction would start with Panel 1 because this proposed location would be easily accessible from the North Portal. This panel would require the least amount of development work because of its small size and because it would use existing excavations for access. Panel 1 would be in the central section of the overall layout. Excavation and construction of six emplacement drifts would proceed from north to south. DOE would excavate one exhaust shaft during the same period. The Department would use three emplacement drifts for initial emplacement while development of the remaining drifts in the panel continued concurrently with that operation. The use of an observation drift in Panel 1 would support the Performance Confirmation Program at this time. DOE would construct isolation barriers to separate the initial emplacement area from the continuing construction in Panel 1. This panel would have six emplacement drifts.

Panel 2

After Panel 1 excavation was complete, DOE would excavate Panel 2. This panel would be accessed from the South Portal. Aside from Panel 1, Panel 2 would require the least amount of preparation for waste emplacement. Excavation and construction of emplacement drifts would proceed from north to south. This panel would have two exhaust shafts and one intake shaft and would have 27 emplacement drifts.

Panel 3

After Panel 2 excavation was complete, DOE would excavate Panels 3E and 3W. These panels, which would share a common access main, would be excavated alternately from south to north. Substantially more development would be necessary to prepare Panel 3 and associated drifts for emplacement in comparison with Panels 1 and 2. The North Construction Portal and North Construction Ramp, five ventilation shafts, and the excavation of access and exhaust mains would be constructed to support development activities for Panels 3E and 3W. The emplacement drifts for these two panels would be filled alternating from east to west, starting from the south and working north. Panels 3E and 3W would have a combined total of 45 emplacement drifts.

Panel 4

Panel 4 would be excavated in the western limit of the subsurface geologic repository operations area and accessed through the North Construction Portal. Panel 4 would be excavated concurrently with Panel 3. Construction activities would not be as extensive as those for Panels 3E and 3W. However, for reasons related to ventilation isolation, rock haulage, and construction access, waste emplacement in Panel 4 would occur last. The emplacement drifts in Panel 4 would be filled from the south to the north. This panel would have 30 emplacement drifts.

2.1.2.2.2 *Waste Emplacement in the Subsurface Facility*

Waste packages would be emplaced in dedicated emplacement drifts, supported on emplacement pallets, and aligned end-to-end on the drift floor inverts (Figure 2-8). Emplacement pallets would be fabricated from *Alloy 22* and Stainless Steel Type 316, which are corrosion-resistant and which DOE chose based on the potential corrosion mechanisms in the repository environment. The supports would have a V-shaped top surface to accept all waste package diameters. The waste package would not be mechanically attached to the pallet; it would rest on the V-shaped surfaces of the pallet. Because the ends of the waste package would extend past the ends of the emplacement pallet, the waste packages would be placed end-to-end, nominally 10 centimeters (4 inches) from each other, without interference from the pallets.

The emplacement pallet and waste package would be moved as one unit from a Canister Receipt and Closure Facility or the Initial Handling Facility to the emplacement drift. The emplacement pallet would support the waste package in the drift throughout the preclosure period. When the shielded transport and emplacement vehicle arrived at the assigned location in an emplacement drift and the emplacement access doors on the transport and emplacement vehicle opened, the emplacement pallet with its waste package would be lowered from the vehicle to its emplacement location in the drift.

2.1.2.2.3 *Engineered Barrier System*

The following components in the emplacement drifts would collectively comprise an Engineered Barrier System that would contribute to waste containment and isolation: (1) waste package, (2) emplacement pallet, (3) emplacement drift invert, (4) drip shield, and (5) emplacement drift. Figure 2-9 shows a cross section of a waste package, pallet, emplacement drift invert, and drip shield. The following sections summarize the details of these components.

Waste Package

The waste packages would consist of two concentric cylinders. The inner cylinder would be made of a modified Stainless Steel Type 316, and the outer cylinder would be made of corrosion-resistant, nickel-based Alloy 22. The Alloy 22 cylinder would provide long-term protection for the internal components of the waste package, including the stainless-steel inner cylinder, from corrosion and contact with water.

The Stainless Steel Type 316 cylinder would provide structural support for the thinner Alloy 22 cylinder. The basic waste package design would be the same for the various waste forms. However, the sizes and internal configurations would vary to accommodate the different waste forms.

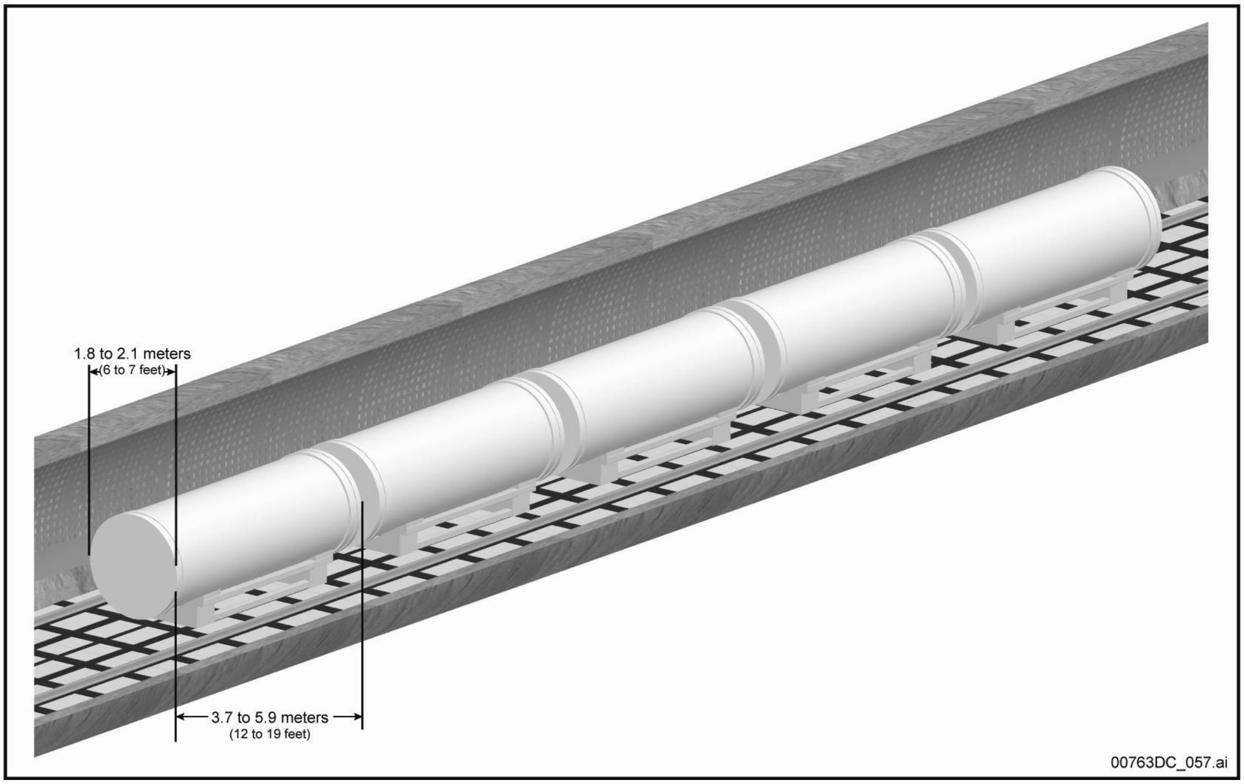


Figure 2-8. Emplacement pallets loaded with waste packages in an emplacement drift (artist's concept).

There would be minor changes to the waste package design from that described in the Yucca Mountain FEIS. Changes include (1) a new outer lid and closure weld techniques; (2) reduced stainless-steel inner lid thickness, including a spread ring closure for all waste packages except the DOE codisposal waste package, which would have a thicker inner lid that also served as a shield plug; (3) removal of the previously used trunnion collars so the waste package would be lifted only by the pallet; and (4) modification of the gap between the inner and outer vessel to better accommodate thermal expansion.

Corrosion tests on Alloy 22 have been and continue to be performed in a variety of thermal and chemical environments. Analyses indicate that Alloy 22 lasts considerably longer than 10,000 years, in the range of expected environments at the proposed repository (DIRS 166894-BSC 2004, all; DIRS 169766-BSC 2004, all; DIRS 170878-BSC 2004, all).

Emplacement Pallet

Emplacement pallets would support the waste packages in the drift. During preclosure and after closure, the emplacement pallet would prevent the waste package from coming into contact with the invert of the drift. The emplacement pallet would continue to fulfill its function of supporting the waste package during a *seismic* event and would maintain the waste package in position separate from other emplacement drift components during the postclosure period.

Emplacement Drift Invert

The emplacement drift invert would include structures and materials at the bottom of the emplacement drifts that supported the pallets and waste packages, drift rail system, and drip shields. The emplacement

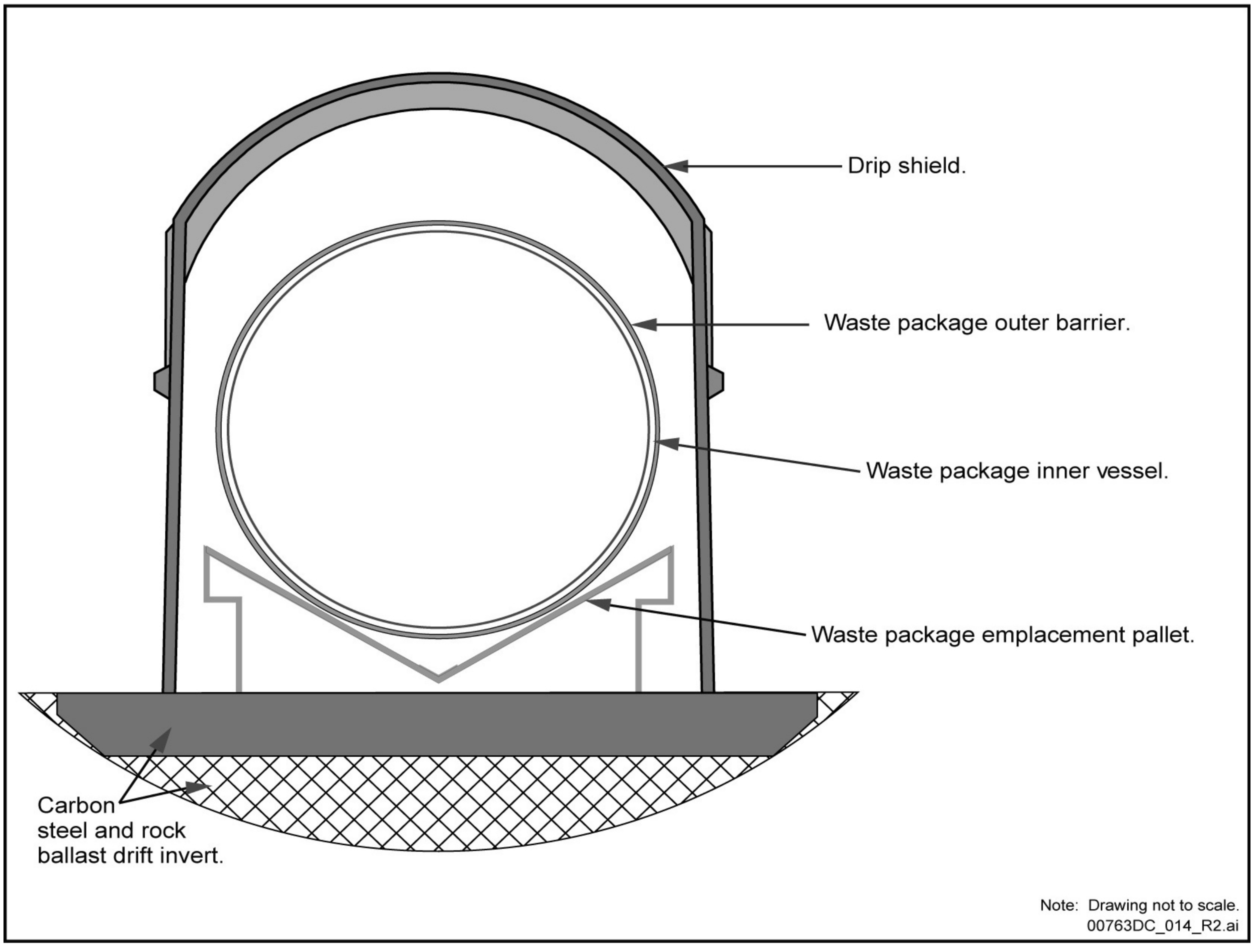


Figure 2-9. Cross section of a waste package, pallet, emplacement drift invert, and drip shield (artist's concept).

drift invert structure would consist of two components: the steel invert structure and the ballast fill. The steel invert structure would provide a platform to support the emplacement pallets, waste packages, and drip shields. The ballast would fill the voids between the drift rock and the invert steel frame, and the level of the ballast would be brought up to the top level of the steel. DOE has selected steel and crushed tuff (from the repository excavations) for the invert components based on their structural strength properties, compatibility with the emplacement drift environment, and expected longevity.

After repository closure, the crushed tuff in the invert would provide a layer of material below the waste packages that would (1) slow the movement of *radionuclides* into the host rock in the event of a waste package breach, and (2) provide support in the event of pallet failure after tens of thousands of years.

Drip Shield

A drip shield would protect each waste package in the repository. After the NRC approved a decision to close the repository, DOE would install titanium drip shields to protect waste packages from dripping water and rockfall. The drip shield would be fabricated from Titanium Grade 7 plates for the water diversion surfaces, Titanium Grade 29 for the structural members, and Alloy 22 for the bases. The Alloy 22 bases would be mechanically attached to the titanium drip shield side plates because the two materials cannot be welded together. The Alloy 22 bases would prevent direct contact between the titanium and the carbon-steel members in the invert, which could result in hydrogen embrittlement of the titanium. All the drip shields would be of a uniform size and would interlock with each other to form a continuous enclosure over all the waste packages.

There would be minor changes to the drip shield design from that proposed in the Yucca Mountain FEIS. The drip shields would be taller, increasing the distance from the waste package to the drip shield to minimize impacts from rockfall. Longitudinal stiffener beams would be added to provide greater strength for bending loads along the axial length of the drip shields, and the new design has simplified the handling and interlocking features.

Emplacement Drift

As described above, the repository would be divided into emplacement panels, each of which would contain a number of emplacement drifts. Panels would vary in size depending on physical and design constraints. The emplacement drift would be part of the Engineered Barrier System because it would provide a stable environment for waste emplacement and monitoring during preclosure. In addition, the emplacement drift would provide the environmental setting for waste packages and other engineered barrier components after repository closure.

2.1.2.3 Balance of Plant Facilities

The balance of plant facilities would be those that would not be directly involved in radioactive waste handling. These facilities would be in the surface geologic repository operations area (Figure 2-4) and would consist of the Central Control Center Facility, Warehouse and Non-Nuclear Receipt Facility, Heavy Equipment Maintenance Facility, Low-Level Waste Facility, Emergency Diesel Generator Facility, and other supporting facilities as discussed in the following sections.

2.1.2.3.1 *Central Control Center Facility*

The Central Control Center Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 240) and would provide centralized communications and sitewide monitoring and control. The facility would provide space and layout for three major areas: the Central Control Center, an alarm station, and a central communications room. The Central Control Center would be the area from which the entire repository was monitored, selected infrastructure systems were controlled, and other systems were controlled on a supervisory level. The primary alarm station would include safeguards and security measures, support the material control and accounting program, and provide protective measures for personnel and property. The central communications room would provide the capability to communicate with offsite locations, including emergency response and other DOE facilities.

2.1.2.3.2 *Warehouse and Non-Nuclear Receipt Facility*

The Warehouse and Non-Nuclear Receipt Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 230). The facility would be a nonradiological facility that would receive empty waste packages, empty TAD canisters, aging overpacks, and emplacement pallets from offsite manufacturers. It would have the capability for inspection, cleaning, and staging of these components for use by the Canister Receipt and Closure Facilities, the Receipt Facility, the Initial Handling Facility, and the Wet Handling Facility.

2.1.2.3.3 *Heavy Equipment Maintenance Facility*

The Heavy Equipment Maintenance Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 220) and would provide the maintenance capability for the heavy-load handling equipment (such as the site transporter) used to transport and handle spent nuclear fuel and high-level radioactive waste in the geologic repository operations area.

The Heavy Equipment Maintenance Facility would have overhead cranes, tow vehicles, forklift trucks, a machine shop, a welding shop, and large maintenance bays for equipment parking and laydown space. In addition, this facility could receive, stage, handle, and manage waste package emplacement pallets. Transport and emplacement equipment would move to the Heavy Equipment Maintenance Facility for repair and routine maintenance.

DOE would use the Heavy Equipment Maintenance Facility to stage equipment and recover from unscheduled mobile equipment outages. Operations that involved tow vehicles, mobile cranes, heavy-lift equipment, and tractor-trailer operations could be planned and implemented from this facility.

2.1.2.3.4 *Low-Level Waste Facility*

The Low-Level Waste Facility would be in the western part of the surface geologic repository operations area (Figure 2-5, Facility 160). The facility design would include the collection, processing, and preparation for offsite shipment for the disposal of *low-level radioactive waste* streams generated during the handling of high-level radioactive waste and spent nuclear fuel. 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.

The Low-Level Waste Facility would contain storage for wastes in boxes, drums, filters, and high-integrity containers. Empty dual-purpose canisters would be stored in the facility for eventual disposal at an offsite low-level waste facility or offsite shipment for recycling.

Waste forms that DOE would handle at this facility include materials such as:

- Dry, solid low-level radioactive waste
  - Plastic, metal, paper, cloth, and rubber items
  - Wood
  - Concrete
  - Empty dual-purpose canisters
- Wet, solid low-level radioactive waste
  - Mechanical filters and material collected by the pool vacuum system
  - Mop heads, wet rags, sponges, and similar wet cleaning products used in contaminated areas
- Liquid low-level radioactive waste

- Equipment drains—including, but not limited to, heating, ventilation, and air conditioning systems condensate; mop water from contaminated areas; and emergency shower and eyewash water

- Decontamination wash water—such as water from decontamination of transportation casks and TAD canisters

- Floor drain system—collected fire suppression water from potentially contaminated areas

DOE would transport liquid waste to the Low-Level Waste Facility from the Initial Handling Facility, the Canister Receipt and Closure Facilities, and the Receipt Facility in tanker trucks or in containers (with shielding being provided as needed) on standard vehicular transport such as an open flatbed truck, or pumped liquid waste from the collection tanks at the Wet Handling Facility. The low-level liquid waste would be transferred to low-level liquid waste tanks outside the facility adjacent to one of the storage bays. Connections would be provided to mobile processing equipment, which would receive the liquid, process the liquid through appropriate cleanup media, and then return processed liquid to the process tanks. The media in the mobile processing equipment would be packaged and transported offsite.

2.1.2.3.5 *Emergency Diesel Generator Facility*

The Emergency Diesel Generator Facility would be in the central part of the surface geologic repository operations area (Figure 2-5, Facility 26D) and would provide power during the loss of normal electric power. During a power loss, the Emergency Diesel Generator Facility would provide 13.8-kilovolt power to maintain load demands in the waste handling surface facilities. Each of the two emergency diesel generators would operate independently. If normal power failed, the emergency diesel generator would start. The underground fuel-oil storage tanks for the emergency diesel generators would be adjacent to the Emergency Diesel Generator Facility.

2.1.2.3.6 *Other Balance of Plant Facilities*

This section discusses other balance of plant support facilities. DOE would develop a *central operations area* approximately 0.8 kilometer (0.5 mile) southeast of the geologic repository operations area for support operations, which would include upgrades and replacement of subsurface infrastructure in the Exploratory Studies Facility. DOE would construct new support buildings and install utilities (power, water, sewer, and communications). The support buildings would include the following:

- Administration Facility. This facility (Figure 2-5, Facility 620) would include area for offices, training, and computer operations.

- Fire, Rescue and Medical Facility. This multifunctional facility (Figure 2-5, Facility 63A) would provide space and layout for fire protection and firefighting services, underground rescue services, emergency and occupational medical services, and radiation protection. The Helicopter Pad (Figure 2-5, Facility 66A) would provide space for emergency medical evacuation.

- Craft Shops. Craft Shops (Figure 2-5, Facility 71A) would include primary shop services for maintenance and repair operations.

- Vehicle Maintenance and Motor Pool. The Vehicle Maintenance and Motor Pool would be near each other (Figure 2-5, Facility 690). The Vehicle Maintenance and Motor Pool would have space for refueling islands to supply diesel, gasoline, propane, and compressed natural gas to construction vehicles and separate facilities for vehicle maintenance and washing.

- Diesel Fuel Oil Storage and Fueling Station (Figure 2-5, Facilities 70A and 70B, respectively) would provide storage for fuel oil and would be the beginning point of the system that would distribute fuel oil throughout the geologic repository operations area, with the exception of fuel for the generators at the Emergency Diesel Generator Facility. The fuel-oil system would consist of tanks, pumps, instrumentation, and ancillary equipment. The main fuel-oil storage tank would provide fuel oil to the hot-water boilers, standby diesel generators, and diesel-driven fire water pumps.

- Warehouse/Central Receiving. This permanent facility (Figure 2-5, Facility 68A) would consist of storage space, a receiving and shipping dock, and general management functions. These facilities would provide space for material receiving, inspection, and storage; material isolation and control; industrial hazardous materials storage; and management of materials.

- Storage Areas. The materials and yard storage area (Figure 2-5, Facility 68B) would provide functional space for storing materials. The equipment yard/storage (Figure 2-5, Facility 71B) would provide functional space for storing equipment. The Aging Overpack Staging Facility (Figure 2-5, Facility 290) would be an outdoor storage area for empty aging overpacks and unloaded (noncontaminated) used aging overpacks not immediately needed by the waste handling facilities, delivered for staging by a site transporter. The railcar buffer area and truck buffer area (Figure 2-5, Facilities 33A and 33B, respectively) would provide space for staging railcars and trucks, respectively.

Other balance of plant facilities would be the Fire Water Facilities and security stations. There would be three Fire Water Facilities in the surface geologic repository operations area and vicinity when the repository was fully operational (Figure 2-5, Facilities 28A, 28B, and 28E). The facilities would provide space for fire water storage tanks, pumping equipment and systems, and support equipment.

DOE would establish security stations at personnel access points to the geologic repository operations area. These would include a Central Security Station, a Cask Receipt Security Station, and a North Perimeter Security Station (Figure 2-5, Facilities 30A, 30B, and 30C, respectively). The Central Security Station would provide space for security functions to control physical access to the geologic repository operations area and would establish the primary interface between the protected area and the other areas of the Yucca Mountain site for personnel and vehicle traffic. The Central Security Station would provide security operational functions (such as portal monitors, personnel access control, and vehicle access), as well as internal functions required by or for the security group. The Cask Receipt Security Station would provide facilities for physical inspections (security and radiological) of outgoing casks and incoming cask shipments by either rail or truck. In addition, the Cask Receipt Security Station would function as the point of custody transfer for the receipt of cask shipments. This facility would not support personnel access or egress under normal operating conditions. The North Perimeter Security Station would function only as an exit facility from the protected area.

2.1.2.4 Utilities

The proposed utilities for the Yucca Mountain site would include electricity, water supply, wastewater and stormwater systems, Utilities Facility and cooling tower, and communications. The following sections discuss each utility.

2.1.2.4.1 *Electrical Power and Distribution*

A new site electrical power system would receive and distribute power to the facilities in the geologic repository operations area and in the vicinity. The electrical power distribution system would include a high-voltage switchyard, a 13.8-kilovolt switchgear facility, an Emergency Diesel Generator Facility with two diesel generators, and a Standby Diesel Generator Facility with four standby diesel generators (Figure 2-5, Facilities 27A, 27B, 26D, and 26B, respectively). The switchyard would provide interface between offsite and onsite electrical power systems.

The Department proposes to install two 138-kilovolt transmission lines (with a capability of 230 kilovolts if necessary) from the existing Lathrop Wells switch station that would terminate at the main substation at the central operations area (Figure 2-10). The transmission lines, which would follow utility corridors parallel to the site access road, could be installed sequentially. As an option, one line could follow a utility corridor parallel to the site access road while another line could follow a separate utility corridor. Routing decisions are not expected to affect the overall impacts of such actions. For safety purposes, one of these transmission lines could be installed to support current site activity. For analytical purposes, installation of the transmission lines were evaluated during the construction analytical period.

From the main substation at the switchyard in the central operations area, the distribution system would branch to several primary electrical distribution points. From the substation at the central operations area, DOE would install two 13.8-kilovolt distribution lines: an approximately 1.6-kilometer (1-mile) replacement line to power the existing Exploratory Studies Facility equipment and a 3.2-kilometer (2-mile) line to a substation at the South Portal to provide power to operate exhaust fans that currently function intermittently on generator power.

2.1.2.4.2 *Water Supply*

The Proposed Action would require both potable and raw, or nonpotable, water systems. The function of the raw water system would be to provide raw water to the North Portal, the North Construction Portal area, and the South Portal. Potable water would be provided to facilities for drinking and for safety fixtures use, such as for emergency showers and eyewashes. Nonpotable water would be provided through the distribution piping as utility water in the nonradiological facilities for washdown and housekeeping. In addition, nonpotable water would be used in the closed-loop hot water and chilled water systems and for decontamination. Deionized water would be provided for makeup water lost from the pool in the Wet Handling Facility.

DOE would upgrade existing site sources of raw water, which would include rework of the C-Wells, piping supply systems, water storage tanks, a booster pump station and booster tanks, a fire water tank, chlorination system, arsenic treatment system, a potable water storage tank, service connections to the water system on the North Portal pad, and controls to meet national standards, such as those of the American Water Works Association and National Fire Protection Association. Water storage tanks would

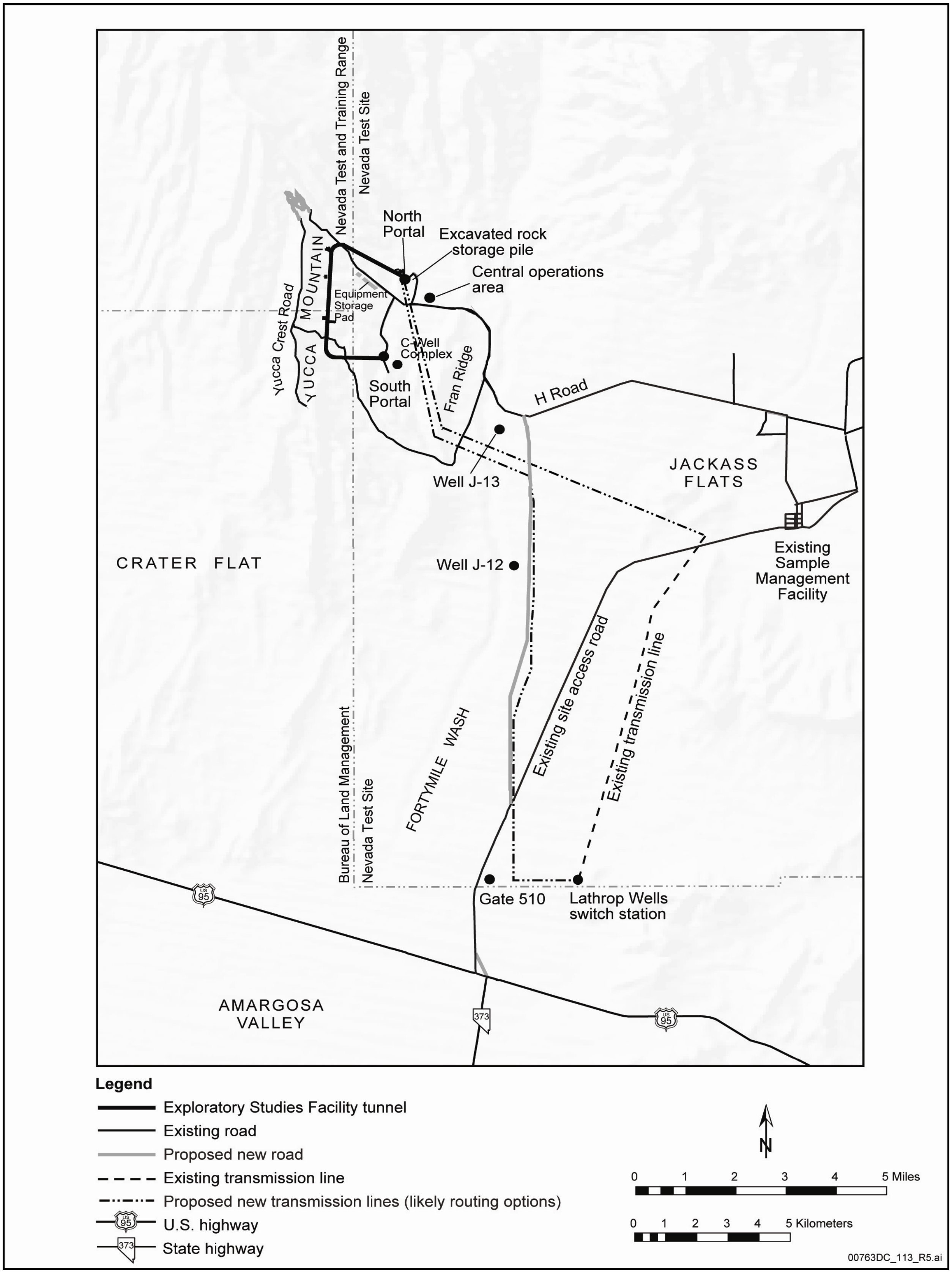


Figure 2-10. Location of features in the vicinity of the Yucca Mountain site.

be installed in the surface geologic repository operations area or in the immediate vicinity. Water would be pumped from existing C-Wells and J-Wells (Figure 2-10). A new well at Gate 510 would provide domestic and fire protection water for the Gate 510 security station, off U.S. Highway 95 at the southern entrance of the *land withdrawal area*.

2.1.2.4.3 *Wastewater and Stormwater Systems*

The *sanitary waste* system would consist of septic tanks and leach fields in the central operations area (Figure 2-5, Facility 35A). As an option, DOE has included an evaluation of the potential benefits and impacts of implementation of a wastewater treatment system in Appendix A of this Repository SEIS.

A stormwater collection system would be installed to collect stormwater from roadways, graded areas, and roof surfaces from the waste handling facilities in the vicinity of the North Portal pad and to route this water to a lined *retention pond* near the Utilities Facility (Figure 2-5, Facility 90A). A retention pond is designed to hold a specific amount of water indefinitely.

Three stormwater *detention pond*s in the vicinity of the surface geologic repository operations area would collect stormwater runoff. A detention pond is a low-lying area that is designed to hold a set amount of water temporarily while slowly draining to another location. Such ponds exist for flood control when large amounts of rain could cause flash flooding if not dealt with properly. The detention ponds would be near the Helicopter Pad and the Cask Receipt Security Station.

During construction and development, DOE would collect excess water from dust suppression applications as well as water from tunnel boring operations and water from concrete mixing and cleanup, and pump it to lined *evaporation ponds* at the South Portal development area and the North Construction Portal. An evaporation pond is a containment pond (with an impermeable lining of clay or synthetic material) to hold liquid wastes and to concentrate the waste through evaporation. Another evaporation pond (Figure 2-5; Facility 25C) would be near the Utilities Facility for collection of blowdown from the cooling tower and liquids from regeneration of water softeners. A fourth evaporation pond would be in the central operations area and would receive process water from two oil-water separators as well as superchlorinated water generated from maintenance of the drinking water system.

2.1.2.4.4 *Utilities Facility and Cooling Tower*

The Utilities Facility (Figure 2-5, Facilities 25A, 25B, and 25C) would include a cooling tower and evaporation pond (described above). The Utilities Facility would house the support systems, equipment, and controls, such as those necessary for the heating, ventilation, and air conditioning; central chilled water and hot water heating subsystems; and other services to support process operations, such as chillers, heaters, and deionized water. DOE would design systems in the building that would interface with radiological operations or facilities with features to prevent radiological cross-contamination of the Utilities Facility.

2.1.2.4.5 *Communications Systems*

Expansion and upgrades to the communications systems would include connectivity between the Yucca Mountain site, the Las Vegas Data Center, the DOE Office of Civilian Radioactive Waste Management, management and operating contractor facilities, and Nye County emergency response facilities. This connectivity would consist of dual fiber-optic lines, cellular telephone towers, microwave systems to Las

Vegas, radio systems, telephone switch systems, dual satellite links, federally approved encryption equipment, and a network operations building.

2.1.3 CONSTRUCTION SUPPORT FACILITIES

For analytical purposes, DOE has included activities to repair, replace, or improve certain facilities, structures, roads, and utilities (collectively referred to as *infrastructure*) for the Yucca Mountain Project to enhance safety at the project and to enable DOE to continue ongoing operations, scientific testing, and routine maintenance safely as part of the Proposed Action. The Department assumed these activities would occur during the construction analytical period. The activities would include demolition or relocation of the existing facilities at the North Portal, excavation of fill material down to the original ground contours, and placement and compaction of engineered *backfill* in the area of waste handling facilities construction. Three concrete batch plants would be in the area. Two plants would have a capacity of 190 cubic meters (250 cubic yards) per hour, and one plant would have a capacity of 115 cubic meters (150 cubic yards) per hour. Aggregate and material storage bins would be collocated with the concrete batch plants.

In addition, the excavated rock currently stored near the North Portal would be removed and either used during construction or moved to an excavated rock storage pile at the South Portal development area. Approximately 600,000 cubic meters (800,000 cubic yards) of fill and excavated rock currently are in the area that would become the surface geologic repository operations area. Improvements would include work at an area previously used for equipment and material storage, about 2.4 kilometers (1.5 miles) southeast of the North Portal. Site preparation of this area would include bringing the site to the appropriate grade, installing underground utilities, improving the entrance, upgrading or constructing access roads and a parking area, and constructing a detention pond.

Development of the Yucca Mountain subsurface facilities would be achieved primarily through the use of two ramps and portals, known as the North Construction Ramp and Portal, at the north end of the repository, and the South Portal development area (which includes a ramp and portal) at the south end of the repository. Figure 2-4 shows the locations of the North Construction Portal and the South Portal. The North Portal would provide access for construction of Panel 1 until receipt of a license to receive and possess radioactive materials.

The North Construction Portal and North Construction Ramp would remain available throughout development of the subsurface after emplacement began and would allow access for the construction of emplacement panels in the north half of the subsurface facility. In addition, the North Construction Portal and North Construction Ramp would accommodate construction ventilation ducting, ancillary ventilation equipment, and rock removal equipment such as a conveyor. Similar to the North Construction Portal, the South Portal development area would accommodate construction support facilities. In addition, the South Portal development area would support the excavation and construction of the repository and occupy about 0.08 square kilometer (20 acres).

Both the North Construction Portal and the South Portal development area would contain:

- Staging facilities for personnel, materials, and equipment.
- Concrete batch plants.

- Equipment maintenance facilities that included wash racks and a change house.

- Excavated rock storage areas. Two separate locations are designated for the storage of excavated rock. Excavated rock initially would be removed from the South Portal and placed in a storage area near the South Portal development area. The remainder of the excavated rock would be removed from the North Construction Portal and placed in a rock storage area north of the Aging Facility and east of the North Construction Portal. The area covered by both excavated rock storage areas would be approximately 0.8 square kilometer (200 acres).

- Utilities services, including electricity, water, and wastewater disposal to a septic tank and leach field.

2.1.4 OTHER PROJECT FACILITIES

This section discusses other project facilities that would support construction, operations, monitoring, and eventual closure of the repository. With the exception of onsite roads, these facilities would be outside the geologic repository operations area.

2.1.4.1 Roads

DOE would construct, improve, or replace paved roads and graded dirt construction and haul roads in the land withdrawal area. In addition, DOE would build (1) a new 13.7-kilometer (8.5-mile)-long, four-lane, paved access road from a point 3.7 kilometers (2.3 miles) north of Gate 510 on the existing access road of the Nevada Test Site to a point about 0.8 kilometer (0.5 mile) east of *Fortymile Wash*, where it would connect to an existing road (H Road), (2) a new 2.1-kilometer (1.3-mile)-long, two-lane, paved road to the crest of Yucca Mountain, and (3) a new 4-kilometer (2.5-mile)-long road leading to Fran Ridge. In total, DOE would construct about 40 kilometers (25 miles) of paved roads (new and replacement roads) within the *Yucca Mountain site boundary* (Figure 2-10).

In addition, DOE would construct a four-lane access road that would extend from U.S. Highway 95 to the existing access road at Gate 510. This access road could be constructed with the use of a phased approach, with initial construction of two lanes, and later widening of the road. A suitable intersection at U.S. Highway 95 also would be constructed.

2.1.4.2 Engineering and Safety Demonstration Facility

The Department would construct an Engineering and Safety Demonstration Facility in the land withdrawal area, approximately 3.2 kilometers (2.0 miles) southeast of the South Portal, at Fran Ridge. Its primary mission would be to provide data for health and safety, engineering, construction, and operations, and as a location for public outreach. The Engineering and Safety Demonstration Facility would demonstrate the following:

- The feasibility of certain features of the design and operation of a repository (for example, emplacement of ground support, waste packages, drip shields, and demonstration of dust and noise control and monitoring techniques);

- Repository constructability (for example, excavation of turnouts and drill-and-blast performance) in different types of rock, excavation of emplacement drifts by different techniques, installation of drip shields, and installation of high-density ballast for emplacement invert; and

- Remote systems (for example, a transport and emplacement vehicle for emplacement and retrieval of waste packages).

The Engineering and Safety Demonstration Facility would require construction of a 3.7-kilometer (2.3-mile)-long, 7.6-meter (25-foot)-diameter tunnel beneath Fran Ridge. The tunnel would be excavated by drilling, blasting, and mechanical techniques. About 150,000 cubic meters (200,000 cubic yards) of rock would be excavated and stored near the South Portal development area.

2.1.4.3 Offsite Training Facility

DOE would construct a training facility near the Yucca Mountain site to support the project prototype testing and the operator training and qualification programs. The facility would not be in the land withdrawal area. DOE has assumed a location near Gate 510 for the environmental impact analysis in this Repository SEIS.

2.1.4.4 Temporary Accommodations

Temporary accommodations for construction workers could be required to support expedited construction of the repository. They would include housing for construction workers; a utility zone dedicated to power supply, temporary trash storage, wastewater, and potable water treatment; eating facilities; laundry facilities; and office space. The temporary accommodations would be prepared by clearing, hauling of gravel fill, leveling, and compaction. Roads and parking areas would be created with gravel fill. Lighting would be installed for security and parking. Utility services would be provided by commercial sources. The accommodations could be expanded as necessary for additional personnel. They would be removed when no longer needed. For a conservative analysis, DOE has assumed a location near Gate 510 for the environmental impact analysis in this Repository SEIS. However, DOE could use the temporary accommodations for railroad construction workers planned for the Crater Flat area as 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.

2.1.4.5 Sample Management Facility

DOE would construct a proposed Sample Management Facility to consolidate, upgrade, and improve storage and warehousing for scientific samples and materials. The facility could be inside the land withdrawal area, but for a more conservative analysis, DOE assumed it would be outside the land withdrawal area near Gate 510. This facility would house a variety of samples collected from studies, including rock cores. The building area would be about 3,900 square meters (42,000 square feet), surrounded by a 3,300-square-meter (36,000-square-foot) fenced area.

2.1.4.6 Surface Facilities for Performance Confirmation Activities

DOE would build surface facilities to support performance confirmation activities. These facilities would be used for administrative functions, test equipment repair and calibration, remote-operated vehicle maintenance, and data acquisition and communications.

2.1.4.7 Marshalling Yard and Warehouse

This proposed facility would consolidate material shipment and receipt into one 0.2-square-kilometer (50-acre) facility outside the land withdrawal area to enable offsite receipt, transfer, and staging of materials for construction activities at the Yucca Mountain site. Material would be hauled to the site on a just-in-time basis. The marshalling yard would require some fencing, offices, warehousing, open laydown, and shops. Some prefabrication, assembly, and other light industrial activities could be performed at this location. DOE has assumed a location near Gate 510 for environmental impact analysis in this Repository SEIS.

2.1.4.8 Borrow Pits

DOE would create borrow pits for the source of aggregate and fill material for building and subsurface and surface facilities. The Department assumed the location of the borrow pits would be in the analyzed land withdrawal area, along the main access road to the geologic repository operations area. Land disturbance would be approximately 0.4 square kilometer (100 acres).

2.1.4.9 Explosives Storage Area

DOE would store explosives in accordance with programs developed under 10 CFR Part 851, considering requirements similar to those of the Bureau of Alcohol, Tobacco and Firearms regulations (27 CFR Part 555) and Occupational Safety and Health Administration Standards (29 CFR 1910.109). DOE would build a permanent Class I magazine for the storage of high explosives. A magazine is a building or structure, other than an explosives manufacturing building, for the storage of explosives. A Class I magazine would be necessary because DOE would probably store more than 22.7 kilograms (50 pounds) of explosives at any one time. The regulations at 29 CFR 1910.109 specify requirements for a Class I magazine, including but not limited to distance from other magazines, posting with signs, construction material type, and ventilation. DOE assumed the location of the explosive storage area would be in the analyzed land withdrawal area, near the South Portal, south of the top soil storage area.

2.1.4.10 Solid Waste Landfill

DOE would construct a State-permitted *solid waste* landfill on the Yucca Mountain site for disposal of *industrial waste*, including construction and demolition debris and sanitary waste. DOE assumed the location of the sanitary landfill would be in the analyzed land withdrawal area, along the main access road to the geologic repository operations area.

2.1.5 PERFORMANCE CONFIRMATION PROGRAM

Performance confirmation refers to the program of tests, experiments, and analyses DOE would conduct to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives at 10 CFR Part 63, Subpart F. Specifically, the Performance Confirmation Program must provide data that indicate, where practicable, (1) actual encountered subsurface conditions and changes in those conditions during construction and waste emplacement operations were within the limits assumed in the licensing review, and (2) natural and engineered systems and components necessary for repository operation and that DOE designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated.

The Yucca Mountain Performance Confirmation Program began during *site characterization* and would continue until permanent closure of the repository, in accordance with 10 CFR 63.131(b). The Performance Confirmation Program would include elements of site testing, repository testing, repository support facilities construction, and waste package testing. If the NRC granted the license for construction authorization, the activities would focus on monitoring and data collection for performance parameters important to the terms and conditions of the license.

The Performance Confirmation Program would consist of a focused program of tests, experiment, and analyses that DOE would use to monitor repository conditions, to assess the adequacy of geotechnical and design parameters, and to preserve the ability to perform waste retrieval of any or all waste packages, if necessary, before closure of the repository in accordance with 10 CFR 63.111(e). Retrieval, as defined at 10 CFR 63.2, would be the act of permanent removal of radioactive waste from the subsurface location at which DOE had emplaced the waste for disposal. Chapter 4, Section 4.2 of this Repository SEIS discusses implementation of a retrieval contingency and the associated environmental impacts.

DOE would build a performance confirmation observation drift about 10 meters (33 feet) below one of the emplacement drifts in the first panel. DOE would drill *boreholes* from the performance confirmation observation drift that would approach the rock mass near the emplacement drift; instruments in these boreholes would gather data on the thermal, mechanical, hydrological, and chemical characteristics of the rock after waste emplacement. DOE would acquire performance confirmation data from instruments in the performance confirmation drift or along the perimeter mains through remote inspections in emplacement drifts and monitoring of ventilation exhaust and water quality in wells.

DOE would use thermally accelerated drifts to obtain confirmatory data about anticipated postclosure conditions in the repository during the preclosure period. The Department would use drifts that were unventilated, and therefore thermally accelerated, to emulate conditions most typical of the postclosure repository. The intent would be to develop thermal environments in emplacement drifts in which DOE could monitor or observe representative postclosure coupled thermal, hydrologic, mechanical, chemical, microbial, and radiological processes and effects. Planned activities in thermally accelerated drifts would monitor in-drift conditions, expose engineered barrier material samples to potential corrosion mechanisms in representative *in situ* environments, monitor drift degradation, and test near-field coupled *processes*. The conceptual design includes at least one thermally accelerated drift at the repository horizon and an observation and instrumentation drift at a lower elevation.

DOE would use the Performance Confirmation Program data to evaluate system performance and predict system response. If the data indicated actual conditions differed from the predictions, DOE would notify the NRC and undertake remedial actions to address any such condition. The repository design includes features to implement the Performance Confirmation Program.

2.1.6 CLOSURE ANALYTICAL PERIOD

Regulations at 10 CFR 63.51(a)(1) and (2) require submittal of a license amendment to the NRC for closure of the repository. Before closure, DOE would submit an application to the NRC seeking permission to close the repository. The application would provide an update of the assessment of repository performance for the period after closure, as well as a description of the program for postclosure monitoring to control or prevent activities that could impair the long-term isolation of waste. The Postclosure Monitoring Program, as required by Section 801(c) of the *Energy Policy Act of 1992* and as required by the NRC (10 CFR Part 63), would include the monitoring activities DOE would conduct around the repository after it closed the facility. The details of this program would be delineated during processing of the license amendment for closure. Deferring the delineation of this program to the closure phase would allow identification of appropriate technology, which could include technology that might not be currently available.

The closure analytical period would last 10 years. Closure of the repository would include the installation of drip shields, removal and salvage of equipment and materials, and backfilling of subsurface-to-surface openings. Backfilling would require fill material from the excavated rock storage area or another source, and processing (screening, crushing, and possibly washing) the material to obtain the required characteristics. Fill material would be transported on the surface in trucks and subsurface in open gondola railcars. A fill placement system would place the material in the subsurface ramps.

Surface facilities would be decontaminated, if required, and dismantled. Equipment and materials would be salvaged, recycled, or reused, if possible. Reclamation would include restoration of the site to as near its preconstruction condition as practicable, which would include the recontouring of disturbed surface areas, surface backfill, soil buildup and reconditioning, site revegetation, site watercourse configuration, and erosion control, as appropriate.

In compliance with 10 CFR Part 63, DOE would erect a network of permanent monuments and markers around the site to warn future generations of the presence and nature of the buried waste, and detailed public records would identify the location and layout of the repository and the nature and hazard of the waste it contains. The Federal Government would maintain *institutional control* of the site. Active and passive security systems and monitoring would prevent deliberate or inadvertent *human intrusion* and any other human activity that could adversely affect the repository.

2.1.7 TRANSPORTATION ACTIVITIES

Under the Proposed Action, DOE would transport spent nuclear fuel and high-level radioactive waste from commercial and DOE sites to the repository. The Naval Nuclear Propulsion Program would transport *naval spent nuclear fuel* from the Idaho National Laboratory to the repository. Section 2.1.7.1 discusses loading activities of these materials at generator sites. Sections 2.1.7.2 and 2.1.7.3 discuss transportation of the materials to the Yucca Mountain site, across the nation and in Nevada, respectively. Chapter 6 and Appendix G of this Repository SEIS provide further discussion of transportation activities and resultant environmental impacts.

2.1.7.1 Loading Activities at Commercial and DOE Sites

The Proposed Action in this Repository SEIS includes the shipping of empty casks and TAD canisters to commercial and DOE sites, as well as loading of spent nuclear fuel and high-level radioactive waste at commercial and DOE sites for transportation to Yucca Mountain. Loading activities would involve preparing the spent nuclear fuel or high-level radioactive waste for shipment including loading the commercial spent nuclear fuel into TAD canisters and loading high-level radioactive waste and DOE spent nuclear fuel into disposable canisters, the subsequent loading of canisters and a small amount of DOE uncanistered spent nuclear fuel assemblies into transportation casks, and placing the transportation casks on a railcar or truck. This Repository SEIS assumes that at the time of shipment, the spent nuclear fuel and high-level radioactive waste would be in a form that met approved acceptance and disposal criteria for the repository.

2.1.7.2 National Transportation

Under the Proposed Action evaluated in this Repository SEIS, DOE would transport spent nuclear fuel and high-level radioactive waste from 76 sites across the country to the repository by mostly rail. The Department would transport some spent nuclear fuel and high-level radioactive waste by truck. Figures 2-11 and 2-12 show the representative national rail and truck routes, respectively, evaluated in this Repository SEIS. For this Repository SEIS, DOE has updated the routes to reflect the current highway and rail routes in the United States and to add routes that support the Mina rail *corridor* that DOE considers in the Rail Alignment EIS. Representative routes are routes that were analyzed but might not be the routes actually used for shipment to the repository. Rail routes are based on maximizing the use of mainline track and minimizing the overall distance and number of interchanges between railroads.

Important elements of DOE’s national transportation plan that have evolved since publication of the Yucca Mountain FEIS include the following:

DOE has established the policy to use dedicated trains for shipments of commercial and DOE spent nuclear fuel and high-level radioactive waste. This policy would not apply to shipments of naval spent nuclear fuel. Shipments of commercial and DOE spent nuclear fuel and high-level radioactive waste would consist of from one to five casks that contained spent nuclear fuel or high-level radioactive waste per train. For shipments of naval spent nuclear fuel, this analysis assumed regular freight service and from 1 to 12 casks that contained spent nuclear fuel per train. In both cases, two *buffer cars*, two to three locomotives, and one to two *escort cars* would be present. A buffer car would be a railcar 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. An escort car would be a railcar in which escort personnel would travel on trains that carried spent nuclear fuel or high-level radioactive waste.

- Trucks that carried transportation casks probably would be overweight rather than legal weight. In the Yucca Mountain FEIS, DOE estimated that the trucks carrying truck casks would have gross vehicle weights less than 36,000 kilograms (80,000 pounds) and would be, therefore, legal weight (23 CFR 658.17). DOE has since determined that trucks carrying truck casks would be more likely to have gross vehicle weights in the range of 36,000 kilograms to 52,000 kilograms (115,000 pounds). These *overweight trucks* would be subject to the additional permitting requirements in each state through which they traveled.

- This Repository SEIS evaluates transportation of spent nuclear fuel and high-level radioactive waste from 72 commercial sites and 4 DOE sites, for a total of 76 locations (one less than in the Yucca Mountain FEIS because DOE will ship spent nuclear fuel currently stored at Fort St. Vrain, Colorado, to the Idaho National Laboratory for packaging and then to the repository). This Repository SEIS analyzes the shipment of approximately 9,500 rail casks and 2,700 truck casks of spent nuclear fuel and high-level radioactive waste. The Yucca Mountain FEIS analyzed approximately 9,600 rail casks and 1,100 truck casks under the mostly rail shipping scenario. The estimated number of truck and rail casks changed primarily due to the use of TAD canisters and revised information on interface capabilities and cask handling capabilities at U.S. nuclear facilities.

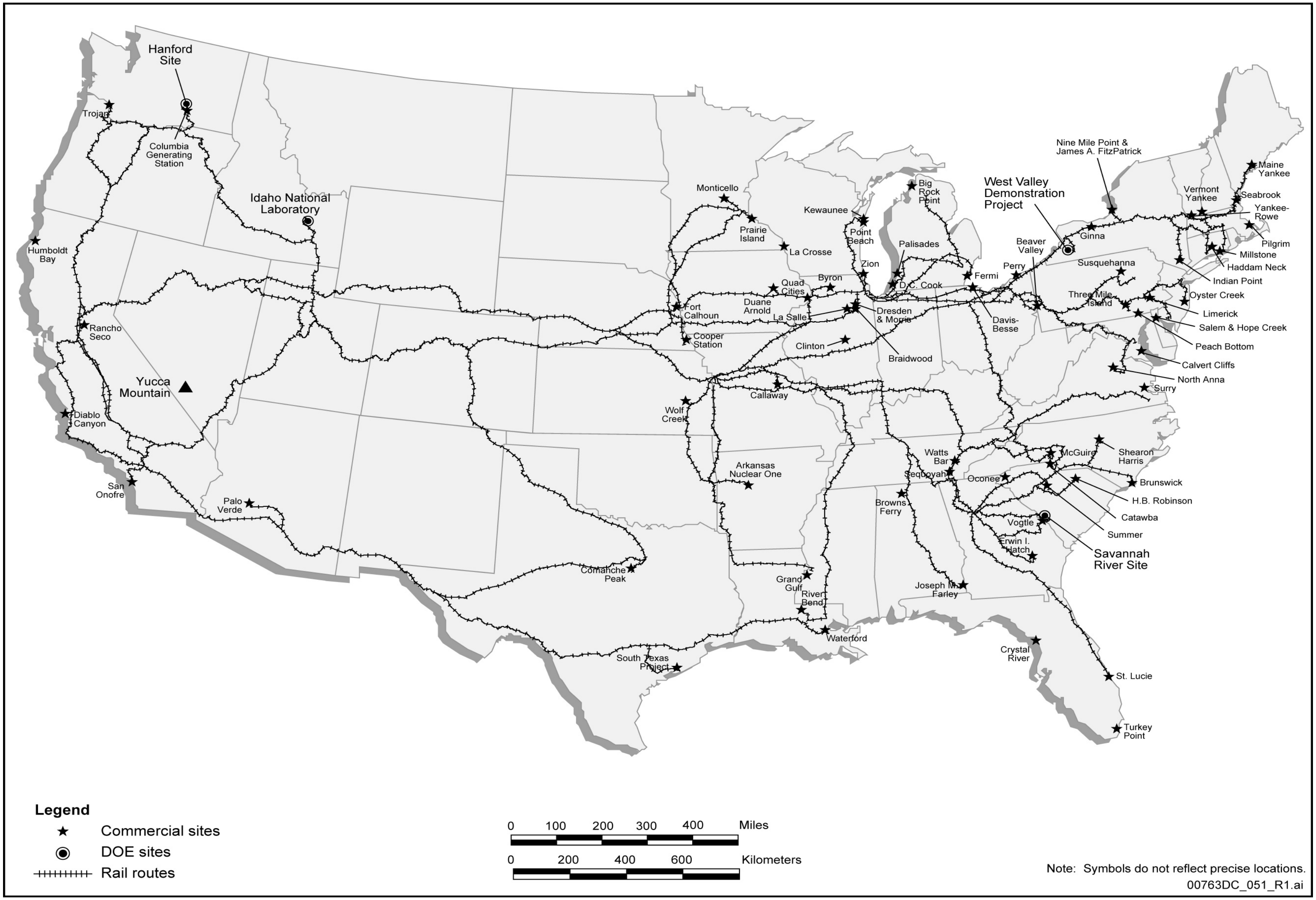


Figure 2-11. Representative national rail routes considered in the analysis for this Repository SEIS.

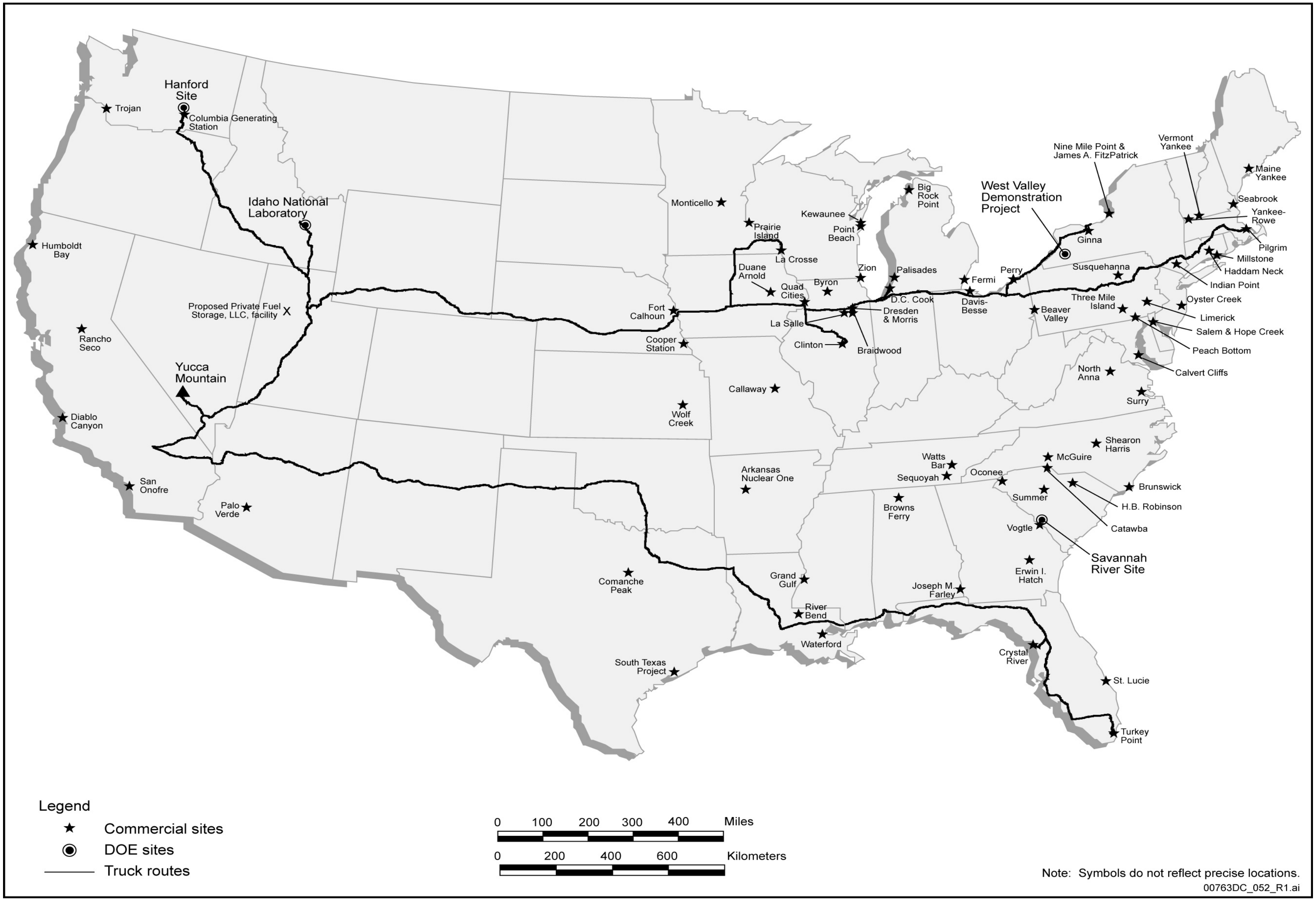


Figure 2-12. Representative national truck routes considered in the analysis for this Repository SEIS.

- Based on interim compensatory measures now required by the NRC and that DOE would follow, at least two security escorts would be present in all areas (urban, suburban, and rural) during the shipment of spent nuclear fuel and high-level radioactive waste.

2.1.7.3 Nevada Transportation

Concurrent with this Repository SEIS, DOE has prepared the Nevada Rail Corridor SEIS and Rail Alignment EIS to make further decisions on transportation in the State of Nevada. In the Nevada Rail Corridor SEIS, DOE considers the feasibility and environmental impact of using the Mina rail corridor, which it had excluded from consideration in the Yucca Mountain FEIS, as explained in the Foreword of this Repository SEIS. In addition, DOE updates environmental information for three other *rail corridors* it considered in the Yucca Mountain FEIS, specifically the Carlin, Jean, and Valley Modified rail corridors. DOE examines both the Caliente and Mina rail corridors at the alignment level in the Rail Alignment EIS. DOE had selected the Caliente rail corridor in which to examine potential alignments for construction and operation of a railroad in its April 8, 2004, *Record of Decision* (69 FR 18557).

To serve as a supplement to the Yucca Mountain FEIS, this Repository SEIS includes the impacts of transportation of spent nuclear fuel and high-level radioactive waste to the repository, with the rail shipments occurring in either the Caliente or Mina rail corridor (Figure 2-13). This SEIS summarizes and incorporates Chapter 3, Sections 3.2 and 3.3, and Chapters 4, 5, and 8 the Rail Alignment EIS. The Foreword of this document describes the incorporation of the results of the Rail Alignment EIS impact analysis.

Under the Proposed Action in the Rail Alignment EIS, DOE analyzes specific potential impacts of constructing and operating a railroad along common segments and alternative segments in the Caliente and Mina rail corridors to determine an alignment in which to construct and operate a railroad for shipments of spent nuclear fuel and high-level radioactive waste from an existing rail line in Nevada to a geologic repository at Yucca Mountain. To aggregate potential impacts associated with transportation of spent nuclear fuel and high-level radioactive waste to the repository, this Repository SEIS summarizes and incorporates by reference those portions of the Rail Alignment EIS addressing the impacts associated with construction and operation of a railroad in Nevada, including cumulative impacts. This Repository SEIS provides direction to those portions of the Rail Alignment EIS that do not deal directly with the aggregation of impacts that would be associated with the SEIS Proposed Action. The following sections summarize the Proposed Action DOE examines in the Rail Alignment EIS.

2.1.7.3.1 *Summary of the Proposed Action in the Rail Alignment EIS*

In the Rail Alignment EIS, DOE analyzes a Proposed Action and a No-Action Alternative. The Proposed Action is to determine an alignment (in a corridor) and construct, operate, and potentially abandon a railroad in Nevada to transport spent nuclear fuel, high-level radioactive waste, and other Yucca Mountain Project materials to a repository at Yucca Mountain. There are two implementing alternatives under the Proposed Action—the Caliente Implementing Alternative, under which the Department would construct the proposed railroad in the Caliente rail corridor, and the Mina Implementing Alternative, under which the Department would construct the proposed railroad in the Mina rail corridor. The Caliente Implementing Alternative is the DOE preferred alternative. The Mina Implementing Alternative is nonpreferred.

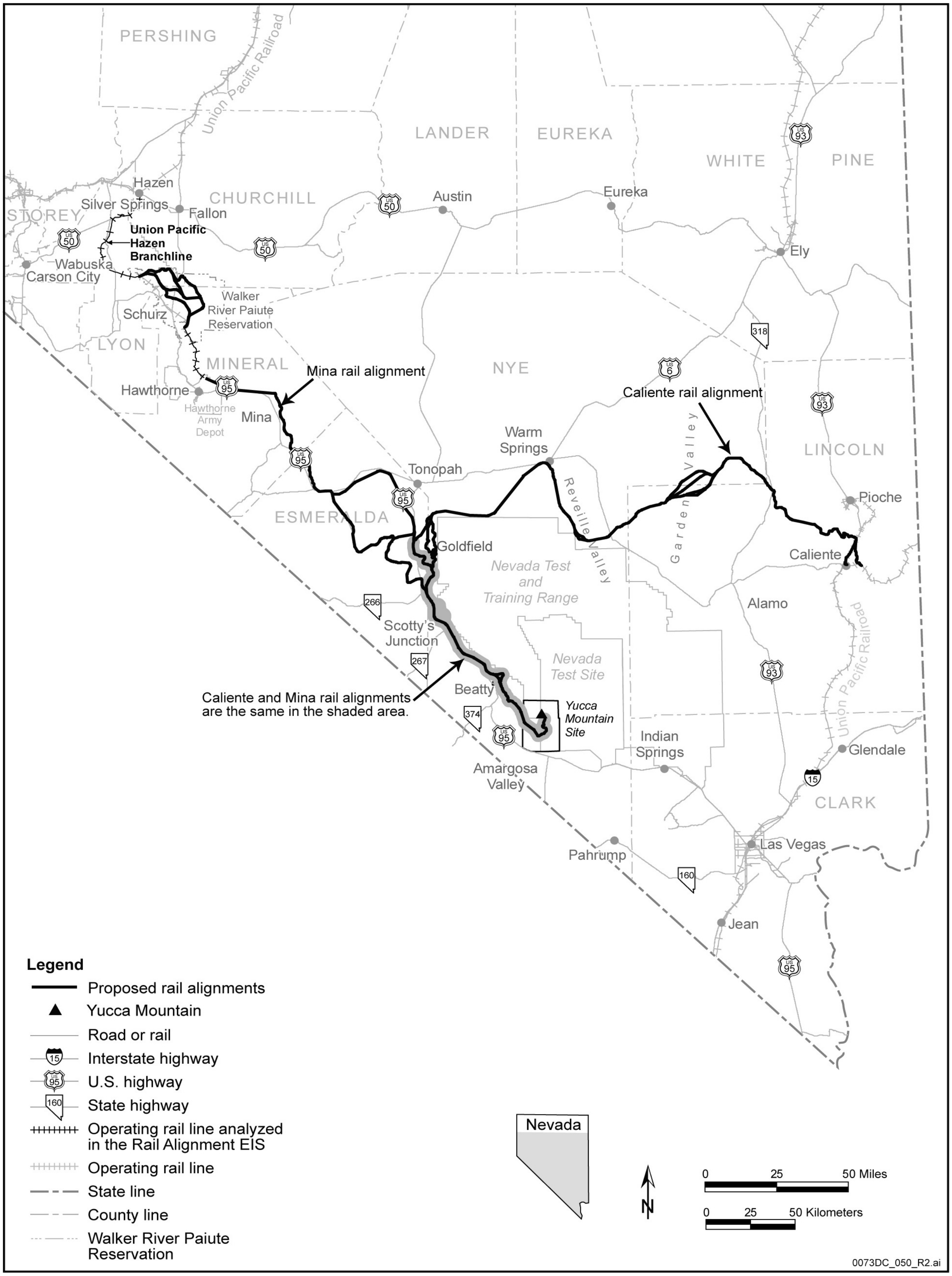


Figure 2-13. Caliente and Mina rail alignments.

In the Rail Alignment EIS, DOE considers a series of *common segments* and a range of *alternative segments* during development of the Proposed Action. The identified alternative rail segments are a subset of the Proposed Action and are not standalone alternatives. The Rail Alignment EIS compares and contrasts the alternative segments and identifies the preferred alternative segments. In addition, the Rail Alignment EIS identifies segments that DOE has eliminated from detailed analysis.

Under the Rail Alignment Proposed Action, the proposed railroad would be dedicated to DOE transport of spent nuclear fuel, high-level radioactive waste, and other Yucca Mountain Project materials. However, for each implementing alternative in the Rail Alignment EIS, DOE analyzed a Shared-Use Option under which the Department would allow commercial shippers to use the railroad for general freight shipments. General freight would include stone and other nonmetallic minerals, petrochemicals, nonradioactive waste materials, or other commodities that private companies would ship or receive.

DOE would use the railroad primarily to ship approximately 9,500 casks containing spent nuclear fuel and high-level radioactive waste from either the Caliente or Hawthorne area (the towns where construction of the new railroad would begin in the Caliente or Mina rail corridor, respectively) to the repository over a 50-year *operations analytical period*. DOE also would ship approximately 29,000 railcars of other materials, which would include repository construction materials, materials necessary for day-to-day operations of the railroad and the repository, and waste materials for disposal, such as scrap metal and solid waste.

The Rail Alignment Proposed Action includes the construction and operation of several facilities that would be necessary for the operation of the railroad. These facilities would include the Staging Yard, the Interchange Yard (Caliente Implementing Alternative), the Maintenance-of-Way Facilities, the Rail Equipment Maintenance Yard, the Cask Maintenance Facility, the Nevada Railroad Control Center, and the National Transportation Operations Center. DOE would construct these facilities at the same time it constructed the railroad and would coordinate facility construction with railroad construction.

Under the No-Action Alternative in the Rail Alignment EIS, DOE would not implement the Proposed Action in the Caliente or Mina rail corridor. DOE would relinquish the public lands withdrawn from surface entry and mineral entry for the purpose of evaluating the lands for the potential construction, operation, and maintenance of a railroad. These lands would then become available for surface and mineral entry. In the event that DOE did not select a *rail alignment* in the Caliente or Mina rail corridor, the future course it would pursue to meet its obligation under the NWPA is highly uncertain. DOE recognizes that it could pursue other possibilities, including evaluating the three other rail corridors to determine an alignment for the construction and operation of a rail line to transport spent nuclear fuel and high-level radioactive waste to the repository at Yucca Mountain; the Department analyzed these possibilities in the Yucca Mountain FEIS. Further consideration of these possibilities could require additional reviews, as appropriate, under the *National Environmental Policy Act*.

2.1.7.3.2 *Rail Equipment Maintenance Yard and the Repository Interface*

The railroad would approach Yucca Mountain from the northwest, terminating at the Rail Equipment Maintenance Yard (Figure 2-14). The geologic repository operations area would be on the north end of the Rail Equipment Maintenance Yard, another 2.2 kilometers (1 mile) northeast. The interface would consist of a double-track spur that led into the surface geologic repository operations area for delivery of casks and supplies to the repository.

This area would include a Satellite Maintenance-of-Way Facility, a locomotive repair facility, a car repair shop, and an escort car service facility, and it could serve as the location of the Nevada Railroad Control Center and the National Transportation Operations Center.

The Rail Equipment Maintenance Yard would include a shop for washing, inspection, and repair of locomotives and railcars; communications equipment; and housing for train crews and escort personnel (in the same building as the Nevada Railroad Control Center and National Transportation Operations Center if they were at the Rail Equipment Maintenance Yard). The facility would be on a 0.41-square-kilometer (100-acre) site.

2.1.7.3.3 *Cask Maintenance Facility*

The primary purpose of the Cask Maintenance Facility would be to process transportation casks and to ensure that all casks were road-ready and configured with the correct equipment. The basic functions of the facility would be those necessary to ensure compliance with an NRC-issued Certificate of Compliance. The Cask Maintenance Facility would be at the Rail Equipment Maintenance Yard, which would enable the facility to service the casks before their return to the commercial or DOE sites. The Cask Maintenance Facility would require about 0.08 square kilometers (20 acres).

2.1.8 PRELIMINARY SCHEDULE FOR PROPOSED ACTION IMPLEMENTATION

Consistent with 10 CFR 63.21(b)(2) and in compliance with NWPA Section 114(e)(1), DOE has developed preliminary schedules for site preparation, construction, waste receipt, and routine emplacement operations. The schedules address the development of infrastructure inside and outside the geologic repository operations area, including site preparation and construction activities. To the extent they relate to radiological health and safety or preservation of the common defense and security, these activities would not begin inside the geologic repository operations area until DOE received construction authorization from the NRC.

The primary assumptions DOE used in developing the schedules for design, construction, testing, and initial operation are:

- No site preparation or construction activities related to radiological health and safety or preservation of the common defense and security would begin in the geologic repository operations area until after DOE received construction authorization from the NRC,
- DOE would accomplish construction and operation of surface facilities by a phased approach, and
- DOE would accomplish underground panel construction by a phased approach.

The schedules in this section include a conceptual schedule for construction, testing, and initial operation (startup) of the railroad. It would take a minimum of 4 years to construct the proposed railroad under either implementing alternative. Assumptions that DOE used in developing the schedule for the railroad include:

- Construction of the rail roadbed would begin simultaneously at multiple points along the rail alignment;

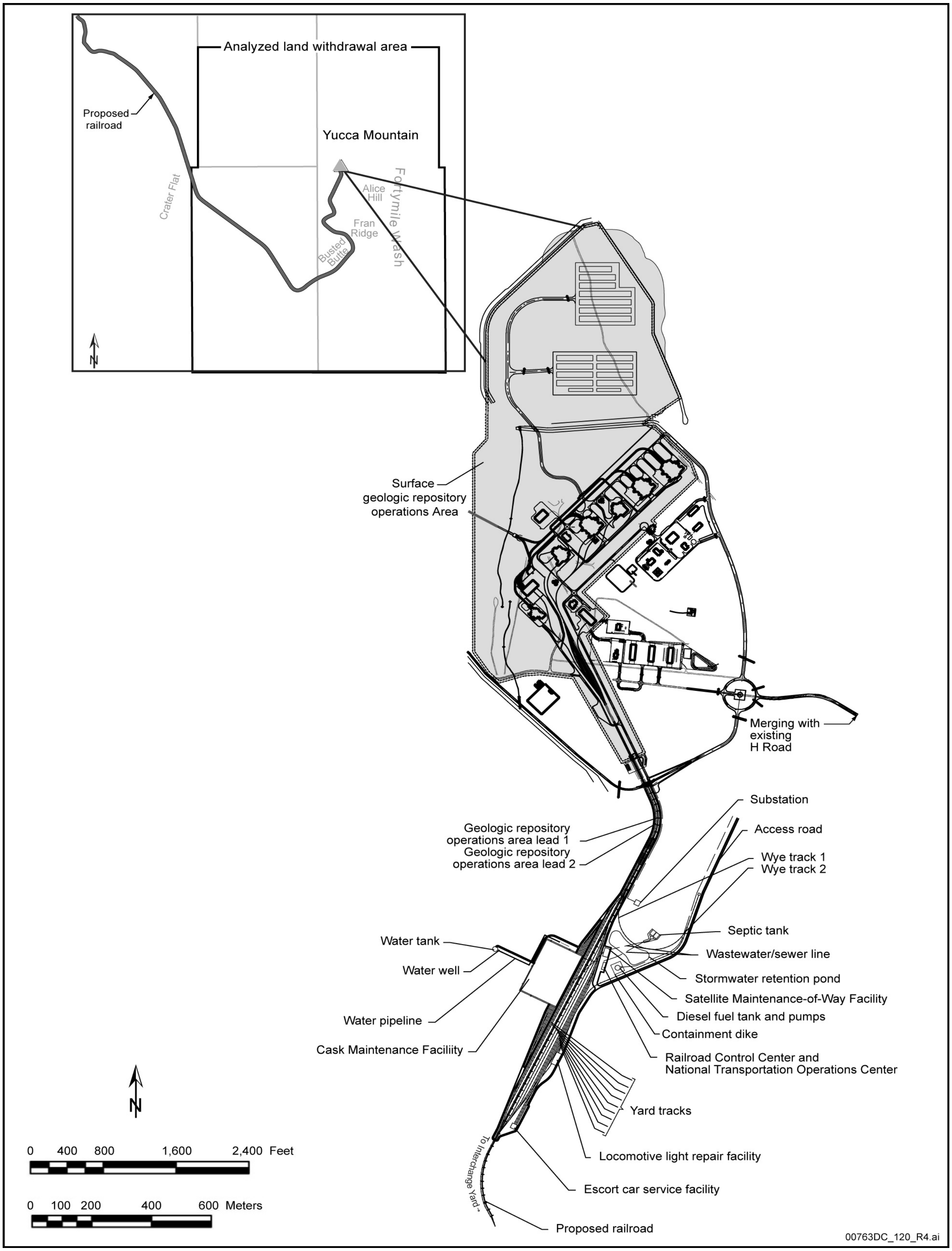


Figure 2-14. Interface of the surface geologic repository operations area with the proposed Rail Equipment Maintenance Yard and the railroad.

- Each time a section of the track was completed and the signals and communications systems installed and tested, integrated testing would begin using train equipment to validate that all components were operating as designed; and

- Although construction would take a minimum of about 4 years, the Rail Alignment EIS accounts for the possibility that it could take longer (up to 10 years) because annual funding levels might not be sufficient to complete construction in 4 years. The construction sequence under a 10-year schedule would be largely the same as that for the 4-year schedule, but under the 10-year schedule construction of the rail roadbed would occur sequentially, starting at the beginning of the rail alignment and moving toward Yucca Mountain.

2.1.8.1 Initial Operating Capability

Figure 2-14a shows the schedule for the Proposed Action construction, startup, and initial operating capability. The objective of Phase 1, or the initial operating capability, would be to develop the capability to start operations, including the development of assets necessary to achieve a reasonable ramp-up of operations during the first several years of waste receipt.

The Initial Handling Facility, the first Canister Receipt and Closure Facility (Canister Receipt and Closure Facility 1), the first aging pad at the Aging Facility, the Wet Handling Facility, and components of subsurface Panel 1 would provide the initial operating capability, Phase 1 construction. Some of the infrastructure DOE would develop outside the geologic repository operations area would include the railroad, communication system improvements, and electric transmission lines. It would take a minimum of 4 years to construct the proposed railroad under either implementing alternative.

Table 2-1 lists other infrastructure and supporting facilities that DOE would construct during Phase 1.

2.1.8.2 Full Operating Capability

Figure 2-14b shows the schedule for the remainder of the Proposed Action construction and startup to full operating capability, which encompasses Phases 2, 3, and 4. The objective of these operating phases would be to develop full operating capability for receiving and emplacing the 70,000 MTHM currently authorized by law for the repository.

To increase throughput capabilities, the full operating capability would include additional high-throughput handling facilities similar to those developed for the initial operating capability. In Phase 2, the Receipt Facility would complement the three handling facilities operable from Phase 1. DOE would complete the Canister Receipt and Closure Facility 2 and the second aging pad ath the Aging Facility in Phase 3, and Canister Receipt and Closure Facility 3 in Phase 4 to complete the full operating capability. The Department would complete the remainder of subsurface Panels 1 and 2 during Phase 2, with the ongoing construction of Panels 3 and 4 throughout Phases 2, 3, and 4.

Table 2-1 lists other infrastructure and supporting facilities that DOE would construct during Phases 2, 3, and 4.

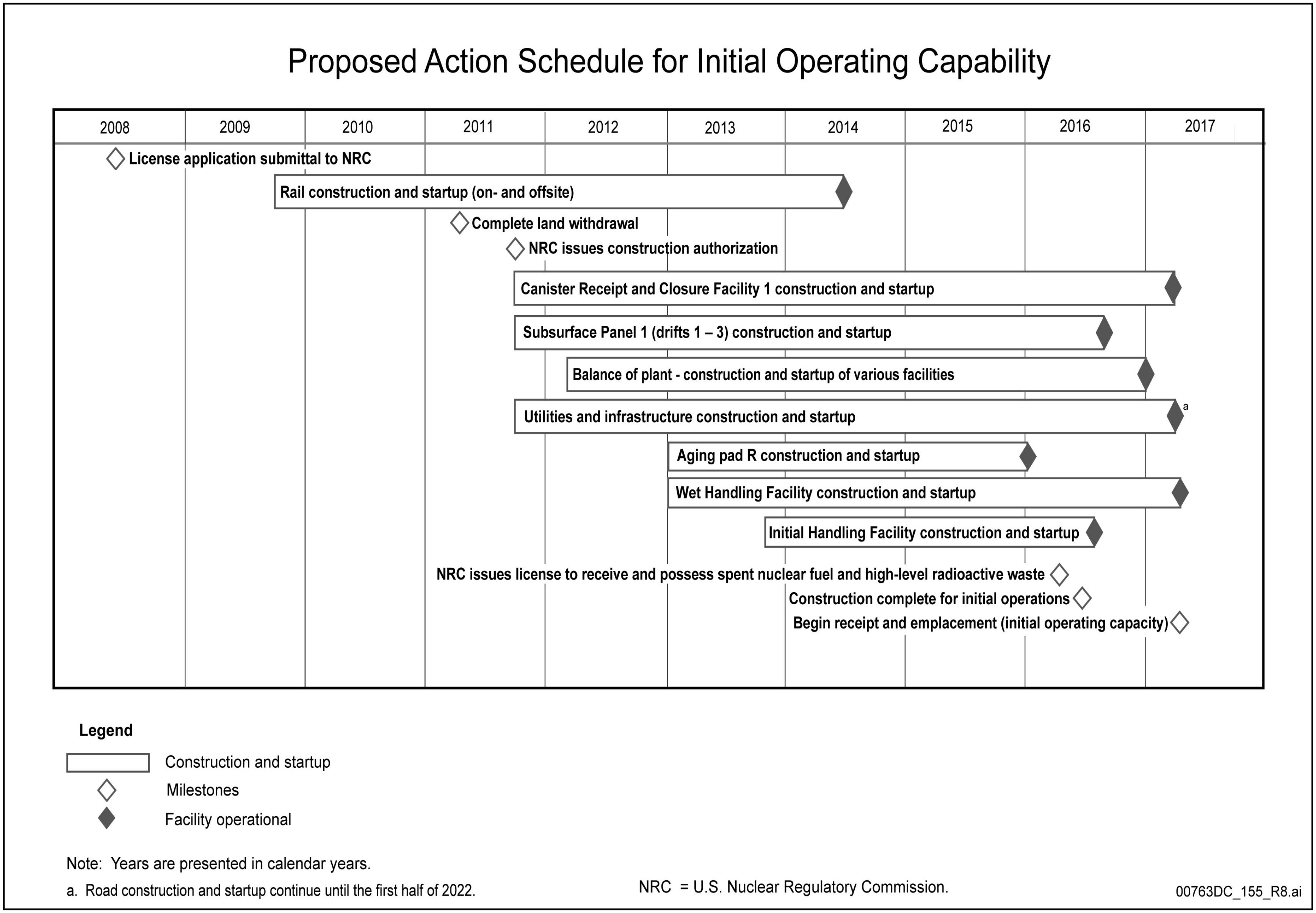


Figure 2-14a. Schedule for the Proposed Action construction, startup, and initial operating capability – Phase 1.

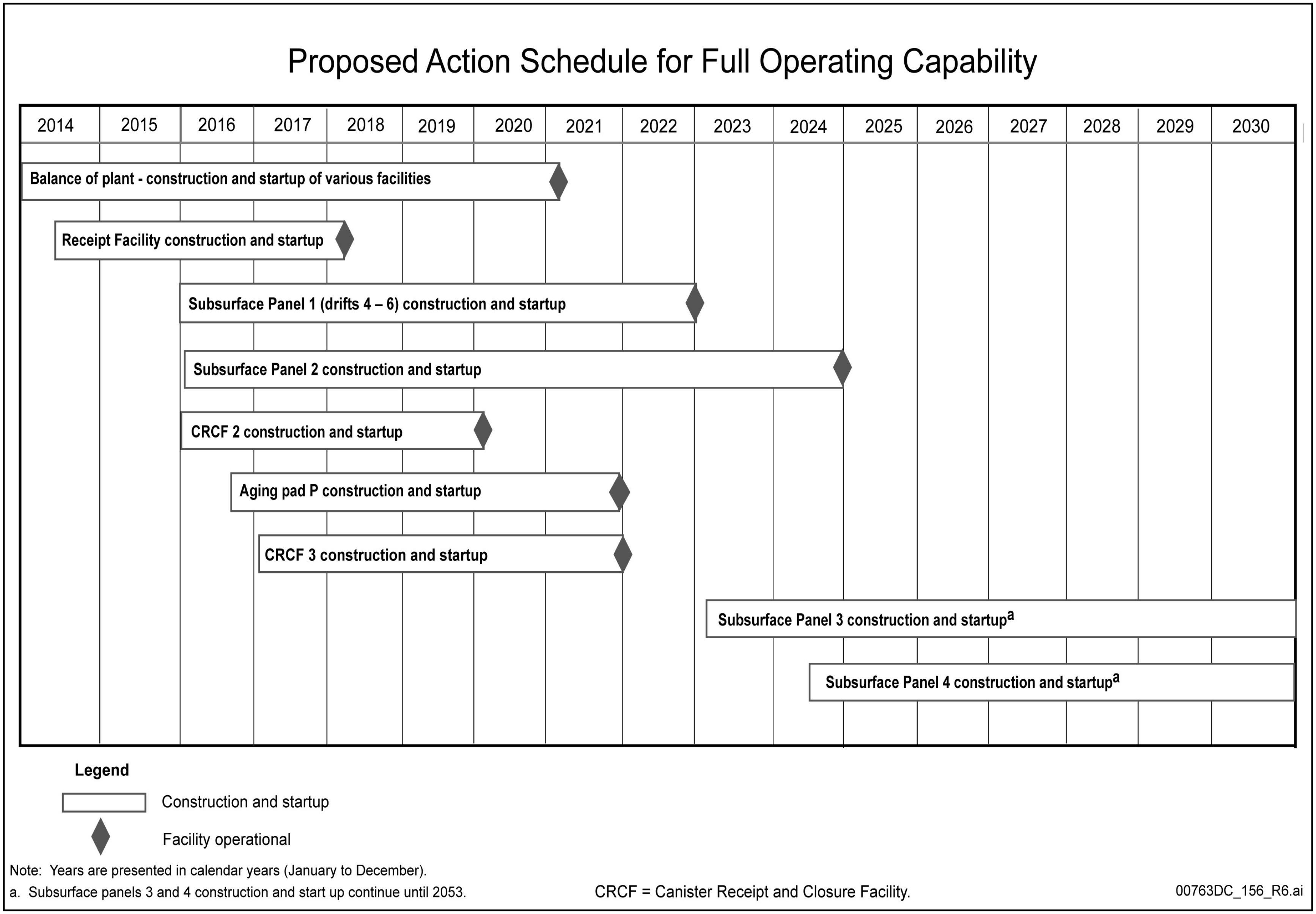


Figure 2-14b. Schedule for the Proposed Action construction and startup to full operating capability – Phases 2, 3, and 4.

2.2 No-Action Alternative

This section summarizes and incorporates by reference Section 2.2 of the Yucca Mountain FEIS.

The No-Action Alternative provides a basis for comparison with the Proposed Action. Under the No-Action Alternative, DOE would curtail activities at Yucca Mountain and undertake site reclamation. Commercial nuclear power utilities and DOE would continue to manage the 76 identified generator sites under one of the following two scenarios. Under No-Action Scenario 1, long-term storage of the spent nuclear fuel and high-level radioactive waste would occur at the current storage sites with effective institutional control for at least 10,000 years. Under institutional control, these facilities would be maintained to ensure that workers and the public were protected in accordance with current federal regulations. The storage facilities would be evaluated for life-extension or replaced every 100 years under Scenario 1. Under No-Action Scenario 2, long-term storage of the spent nuclear fuel and high-level radioactive waste would occur at the current storage sites with no effective institutional control after about 100 years. Beyond that time, the scenario assumes 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 that the radioactive materials in them could eventually escape to the environment.

DOE used a regional approach that divided the continental United States into five regions to analyze the No-Action Alternative. In the Yucca Mountain FEIS, DOE recognized that the future course Congress, DOE, and the commercial utilities would take, if Yucca Mountain was not approved, is uncertain. A number of possibilities could be pursued, including continued storage at existing sites or at one or more centralized locations, study and selection of another location for a geologic repository, the development of new technologies, or reconsideration of alternatives to geologic disposal. The Yucca Mountain FEIS listed representative studies on centralized or regionalized interim storage and summarized relevant environmental considerations. However, because of these uncertainties, DOE decided to illustrate the range of potential environmental impacts by analyzing the aforementioned two scenarios.

While the No-Action Alternative has not changed, DOE has recognized the State of Nevada's concerns about the No-Action Alternative expressed during scoping meetings by reconsidering the validity of the No-Action Alternative's analytical scenarios in this Repository SEIS. DOE has elaborated on the uncertainties, and thus unpredictability, of future actions in the event the Proposed Action for Yucca Mountain is not approved. This discussion is found in Chapter 7 of this Repository SEIS.

2.3 Summary of Findings and Comparison of the Proposed Action and the No-Action Alternative

This section summarizes the potential impacts of the Proposed Action and the No-Action Alternative. For the Proposed Action, this summary includes preclosure impacts and postclosure impacts for the proposed repository as well as those from transportation both nationally and in the State of Nevada. Preclosure impacts are those that would occur during the construction, operations, monitoring, and eventual closure of the proposed repository; postclosure impacts are those that would occur after permanent repository closure, for which DOE analyzed impacts for the first 10,000 years and the post-10,000-year period (up to 1 million years). This section updates the information in the Yucca Mountain FEIS and incorporates relevant new information or new environmental considerations.

DOE has characterized potential impacts in this Repository SEIS as direct or indirect. A *direct impact* is 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. An *indirect impact* is an effect that would be related to but removed from the Proposed Action by an intermediate step or process. Examples include surface-water quality changes from soil erosion at construction sites, reductions in productivity from changes in soil temperature, and job growth due to repository employment.

DOE has quantified impacts where possible; in addition, the Department has provided qualitative assessments with these descriptors:

- Small. Environmental effects would not be detectable or would be so minor that they would not destabilize or noticeably alter any important attribute of the resource.
- Moderate. Environmental effects would noticeably alter but not destabilize important attributes.
- Large. Environmental effects would be clearly noticeable and would destabilize important attributes.

This summary and comparison of the Proposed Action and No-Action Alternative impacts is based on the impact analyses in the following chapters of this Repository SEIS:

- Chapter 4 describes potential preclosure environmental impacts during construction, operations, monitoring, and closure of the repository and includes those from the manufacture of waste packages, TAD canisters, and transportation casks.
- Chapter 5 describes the potential postclosure environmental impacts from the disposal of spent nuclear fuel and high-level radioactive waste in the repository.
- Chapter 6 describes the potential impacts of the transportation of spent nuclear fuel, high-level radioactive waste, other materials, and personnel to and from the repository. It includes the impacts of construction and operation of a railroad in Nevada, which DOE presents in more detail in the Rail Alignment EIS.
- Chapter 7 describes the potential impacts of the No-Action Alternative.
- Chapter 8 describes potential cumulative impacts in relation to other activities in the regions of influence.

Section 2.3.1 summarizes the potential preclosure and postclosure impacts of the proposed repository. Section 2.3.2 summarizes the potential impacts of national and Nevada transportation. Section 2.3.3 summarizes the potential impacts of the No-Action Alternative. Section 2.3.4 combines, and adds together where possible, the impacts from the repository and transportation analyses to present the total estimated impacts of the Proposed Action. It identifies where the regions of influence overlap for this Repository SEIS and the Rail Alignment EIS and describes impacts in those overlap areas.

2.3.1 POTENTIAL PRECLOSURE AND POSTCLOSURE IMPACTS ASSOCIATED WITH THE REPOSITORY

For preclosure impacts, DOE assessed potential impacts during the construction, operations, monitoring, and closure analytical periods for 13 resource areas and included impacts from the two connected actions, manufacturing repository components and airspace restrictions (Chapter 4). The analysis led to the following conclusions:

- For most resource areas, preclosure impacts would be small. Preclosure impacts to groundwater would range from small to moderate, and preclosure impacts to socioeconomics and materials use related to offsite manufacturing of repository components would be moderate.
- The potential health and safety impacts indicate that the repository could be constructed and operated without significant impacts to workers or the public.

For postclosure impacts, DOE assessed the potential impacts from the release of radiological and nonradiological hazardous materials over much longer periods (the first 10,000 years and the post-10,000-year period) after the permanent closure of the repository (Chapter 5). The Department based these projections on the best available scientific techniques and focused the assessment of postclosure impacts on human health, biological resources, and surface- and groundwater resources. The analysis led to the following conclusions:

- There could be very low levels of *contamination* in the groundwater in the *Amargosa Desert* for a long period.
- The proposed repository would release radionuclides over a long period. The analysis demonstrated that the postclosure performance of the proposed repository over the first 10,000 years would result in mean and median annual individual *doses* that would not exceed 0.24 *millirem* and 0.13 millirem, respectively, to a *reasonably maximally exposed individual* (RMEI) hypothetically located 18 kilometers (11 miles) from the repository. The analysis of the post-10,000-year period resulted in a mean and median annual individual dose that would not exceed 2.0 millirem and 0.96 millirem, respectively, to the RMEI at the same location. There would be no significant adverse health effects to individuals from these projected doses.

Table 2-2 summarizes preclosure and postclosure impacts associated with the repository. The table identifies the sections of this Repository SEIS that contain more information about the impacts.

Table 2-2. Potential preclosure and postclosure impacts associated with the repository.

Resource area	Preclosure impacts	Postclosure impacts
Land use and ownership	Small; about 9 km^2 (2,200 acres) of disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use. (Section 4.1.1)	Small; potential for limited access into the area; reclamation of disturbed land would restore preconstruction conditions; the only surface features remaining would be markers. (Section 5.0)
Air quality	Small; concentrations well below regulatory limits (less than 3 percent) for all criteria pollutants except particulate matter. Maximum concentrations of PM_{10} would be 40 percent of limit at land withdrawal area boundary. Maximum annual releases of carbon dioxide, a greenhouse gas from the burning of fossil fuels and the manufacture of concrete would be about 69,000 metric tons (76,000 tons). This would be less than 0.15 percent of the 2004 State of Nevada total carbon dioxide emissions. (Sections 4.1.2.5 and 4.1.2.6)	Small; population doses from release of gaseous radionuclides would be on the order of 1×10^{-8} person-rem in the 84-km (52-mile) radius around the repository. (Section 5.6)
Hydrology		
Surface water	Small; land disturbance would result in minor changes to runoff and infiltration rates; minimal potential for contaminants to be released and reach surface water; only ephemeral drainage channels would be affected. Facilities would be above flood zones, or constructed dikes and diversion channels would keep floodwaters away; floodplain assessment concluded impacts would be small. (Section 4.1.3.1)	Small; potential sources for surface-water contamination would no longer be present. (Section 5.0)
Groundwater	Small to moderate; minimal potential to change recharge rates and for contaminants to be released and reach groundwater; peak water demand (460 acre-feet per year)[a] below the lowest estimate of the groundwater basin's perennial yield (580 acre-feet); after construction, water demand would decrease to 330 acre-feet per year or less. Groundwater would be withdrawn from existing wells and possibly a new well to support Gate 510 facilities. (Section 4.1.3.2)	Estimated releases over the first 10,000 years would result in a mean and median annual individual dose that would not exceed 0.24 millirem and 0.13 millirem, respectively, to an RMEI hypothetically located 18 kilometers (11 miles) from the repository. The analysis of the post-10,000-year period resulted in a mean and median annual individual dose that would not exceed 2.0 millirem and 0.96 millirem, respectively, to the RMEI at the same location. Expected uptakes from nonradioactive hazardous chemicals would all be less than the oral reference doses for any of these substances. (Section 5.5)
Biological resources and soils	Small; loss of up to 9 km^2 (2,200 acres) of desert soil, habitat, and vegetation, but no loss of rare or unique habitat or vegetation; adverse impacts to individual threatened desert tortoises and loss of a small amount of low-density tortoise habitat, but no adverse impacts to the species as a whole; reasonable and prudent measures would minimize impacts; no adverse impacts to wetlands. (Section 4.1.4)	Small; slight increase in surface soil temperature directly over repository, lasting from approximately 200 to 10,000 years, could result in a temporary shift in plant and animal communities in the affected area; impacts to individual threatened desert tortoises would decrease as activity level at repository decreased; no temperature-driven change in desert tortoise sex ratio would be likely; sediment load in ephemeral water courses could temporarily increase coincident with changes to soil and vegetation characteristics. (Section 5.10)

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Cultural resources	Small; minimal ground disturbances and activities that could destroy or modify the integrity of archaeological or cultural resource sites through avoidance of sites and mitigation. Mitigation of indirect impacts that could result from easier physical access to the land withdrawal area, such as unauthorized excavation and collection of artifacts, by training, monitoring and establishing long-term management of sites. Opposing American Indian viewpoint exists. (Section 4.1.5)	Small; potential for limited access into the area; opposing American Indian viewpoint. (Section 5.0)
Socioeconomics		
New jobs (percent of workforce in affected counties)	Construction: Small impacts in region; peaks are 0.05 percent above baseline in Clark County and 1.5 percent above baseline in Nye County. Operations: Small impacts in region; peaks are 0.06 percent above baseline in Clark County and 2.0 percent above baseline in Nye County. (Section 4.1.6)	Small; very few workers. (Section 5.0)
Peak real disposable personal income	Construction: Small impacts in region; peaks are $41.7 million (0.05-percent increase) in Clark County and $17.1 million (1.16-percent increase) in Nye County. Operations: Small impacts in region; peaks are $58.3 million (0.05-percent increase) in Clark County and $27.7 million (1.15-percent increase) in Nye County. (Section 4.1.6)	Small; very few workers. (Section 5.0)
Peak incremental Gross Regional Product	Construction: Small impacts in region; peaks are $58.9 million (0.05-percent increase) in Clark County and $22.7 million (1.42-percent increase) in Nye County. Operations: Small impact in region; peaks are $98.7 million (0.05-percent increase) in Clark County and $68.9 million (2.65-percent increase) in Nye County. (Section 4.1.6)	Small; very few workers. (Section 5.0)
Occupational and public health and safety		
Public, Radiological		
MEI (probability of an LCF)	0.00032 (Section 4.1.7)	1.4×10^{-7} (Section 5.5)
Population (LCFs)	8.0 (Section 4.1.7)	Not calculated.

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Occupational and public health and safety (continued)		
Public, Nonradiological		
Fatalities due to emissions	Small; exposures well below regulatory limits. (Section 4.1.7)	Small; exposures well below regulatory limits. (Section 5.0)
Workers (involved and noninvolved)		
Radiological (LCFs)	3.5 (Section 4.1.7)	Small; very few workers. (Section 5.0)
Nonradiological fatalities (includes commuting traffic fatalities)	38 (Section 4.1.7)	Small, very few workers. (Section 5.0)
Accidents, Radiological		
Public MEI (probability of an LCF)	2.6×10^{-11} to 2.1×10^{-5} (Section 4.1.8)	Less than 1×10^{-7} probability.
Public Population (LCFs)	9.0×10^{-7} to 1.9×10^{-2} (Section 4.1.8)	Less than 1×10^{-7} probability.
Workers	5.8×10^{-4} to 3.5 rem (3.5×10^{-7} to 2.1×10^{-3} LCF) (Section 4.1.8)	Less than 1×10^{-7} probability.
Noise and vibration	Small; impacts to public would be small due to large distances to residences; workers exposed to elevated noise levels—controls and protection would be used as necessary. (Section 4.1.9)	Small; minimal activities, therefore, minimal noise or ground vibration. (Section 5.0)
Aesthetics	Small; the presence of exhaust ventilation stacks on the crest of Yucca Mountain would be an aesthetic aggravation to American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several kilometers, especially west of Yucca Mountain. (Section 4.1.10)	Small; the only constructed surface features remaining would be markers. (Section 5.0)
Utilities, energy, materials, and site services	Small; use of materials would be small in comparison with amounts used in the region; electric power delivery system to the Yucca Mountain site would need enhancement. (Section 4.1.11)	Small; minimal use of materials or energy. (Section 5.0)

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Waste and hazardous materials	Construction/demolition debris – 476,000 cubic meters (620,000 cubic yards) Industrial wastewater – 1.2 million cubic meters (320 million gallons) Sanitary sewage – 2.0 million cubic meters (530 million gallons) Sanitary/industrial waste – 100,000 cubic meters (130,000 cubic yards) Hazardous waste – 8,900 cubic meters (12,000 cubic yards) Low-level radioactive waste – 74,000 cubic meters (97,000 cubic yards) None of the projected volumes of waste would exceed regional capacities for disposal or management. (Section 4.1.12)	Small; minimal waste generated or hazardous materials used. (Section 5.0)
Environmental justice	No identified disproportionately high and adverse potential impact to any populations; no identified subsections of the population, including minority or low-income populations that would receive disproportionate impacts. DOE acknowledges the opposing American Indian viewpoint. (Section 4.1.13)	Small; no disproportionately high and adverse impacts to minorities or low-income populations; DOE acknowledges the opposing American Indian viewpoint. (Section 5.0)
Airspace restrictions	Small; if necessary, DOE would obtain exclusive control of a lightly used 48-km^2 (19-square-mile) airspace and implement specific restrictions to the Nevada Test Site restricted airspace; airspace restrictions could be lifted once operations were complete. (Section 4.1.15)	Not applicable.
Manufacturing repository components		
Air quality	Small; annual pollutant emissions from component manufacturing would be 0.4 percent or less of the regional emissions for a typical manufacturing location. (Section 4.1.14)	Not applicable.
Occupational and public health and safety	Small; 1,700 reportable occupational injuries and illnesses and 0.61 fatality over entire manufacturing campaign. (Section 4.1.14)	Small.
Socioeconomics	Moderate; the area of a typical manufacturing site could see increases of up to 4.7 percent in the average annual output; up to 2.6 percent in the average annual income; and up to 0.63 percent in the average annual employment. (Section 4.1.14)	Not applicable.

Table 2-2. Potential preclosure and postclosure impacts associated with the repository (continued).

Resource area	Preclosure impacts	Postclosure impacts
Manufacturing repository components (continued)		
Materials use	Moderate; annual use of nickel in component manufacturing would be 3.6 percent of U.S. imports in 2007 when there was no significant domestic production, but almost as much was recovered from nickel scrap as was imported. Annual use of palladium would be 59 percent of U.S. production in 2007, but when imports are included, annual use would be reduced to 6.8 percent of the palladium used in the United States in 2007. Annual use of titanium would be 22 percent of U.S. imports in 2007 when there was limited domestic production, but increased domestic production is forecast for the future. (Section 4.1.14)	Not applicable.
Waste generation	Small; a typical manufacturing facility would generate as much as 7.5 metric tons (8.3 tons) of liquid waste and 1 metric ton (1.1 tons) of solid waste per year. (Section 4.1.14)	Small.
Environmental justice	Disproportionately high and adverse impacts to minority or low-income populations would be unlikely from the manufacturing activities. (Section 4.1.14)	Not applicable.

a. To convert acre-feet to cubic meters, multiply by 1,233.49. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

km = kilometer.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.
RMEI = Reasonably maximally exposed individual.

2.3.2 POTENTIAL IMPACTS OF NATIONAL AND NEVADA TRANSPORTATION

DOE analyzes the impacts from national and Nevada transportation in Chapter 6 of this Repository SEIS and in the Rail Alignment EIS, respectively. Table 2-3 summarizes the range of transportation impacts both nationally and in Nevada under the mostly rail scenario and with the use of dedicated trains.

The impact analysis for national transportation addressed health and safety impacts from the movement of spent nuclear fuel and high-level radioactive waste from the 72 commercial and 4 DOE sites across the nation to the Yucca Mountain site. It includes the impacts of the loading of these materials at the generator sites and their transportation on U.S. railroads and highways.

As Chapter 6 discusses in more detail, shipments of spent nuclear fuel and high-level radioactive waste would represent a very small fraction of the annual traffic levels on the nation's railroads and highways (0.0002 percent for trucks, 0.006 percent for railcars, and about 0.1 percent for trains). The analysis of national transportation led to the following conclusions:

- The environmental impacts from shipments to 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.

- The radiological health impacts to the public and workers for national transportation activities would be small.

- The transportation *accident* that is reasonably foreseeable and that would have the highest (or maximum) consequences (the maximum reasonably foreseeable accident) would have an estimated frequency of about 8×10^{-6} per year. This accident would involve a long-duration, high-temperature fire that would engulf a cask. If the accident occurred in an urban area, the estimated population radiation dose would be about 16,000 *person-rem*. In the exposed population, this would result in an estimated 9 *latent cancer fatalities*. 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 in the exposed population would be 0.012 (1 chance in 80).

- For sabotage events involving penetration of a spent nuclear fuel rail cask with a high-energy-density device, DOE estimated that there would be 19 latent cancer fatalities in the exposed population if the sabotage event occurred in an urban area. If the sabotage event took place in a rural area, DOE estimated that the probability of a single latent cancer fatality in the exposed population would be 0.029 (1 chance in 30).

For rail transportation in Nevada, Table 2-3 summarizes the impacts from both the Caliente and Mina Implementing Alternatives to show the differences between impacts of the two alignments. The impacts are from the summary tables in Chapter 2 of the Rail Alignment EIS. Potential impacts under the Shared-Use Option would be generally the same as impacts under the Proposed Action without shared use, unless otherwise noted. The impacts from construction and operation of a railroad in Nevada would be linear in nature and would occur over a range from 452 to 541 kilometers (281 to 336 miles).

Table 2-3 illustrates that the Mina Implementing Alternative would be environmentally preferable in comparison with the Caliente Implementing Alternative. In general, the Mina Implementing Alternative would have fewer impacts to private land use, less surface disturbance, lower *wetlands* impacts, and lower *air quality* impacts 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.

Table 2-3. Potential impacts from national and Nevada transportation.

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative
Corridor length		Total length (all new construction): 528 to 541 km (328 to 336 miles).	Total length: 452 to 502 km (281 to 312 miles).
Land use and ownership	Small (Section 6.3)[b]	Total surface disturbance: 55 to 61 km^2 (14,000 to 15,000 acres); would result in topsoil loss and increased potential for erosion.	Total surface disturbance: 40 to 48 km^2 (9,900 to 12,000 acres) would result in topsoil loss and increased potential for erosion.
		Loss of prime farmland soils: 1.2 to 1.8 km^2 (300 to 440 acres). Less than 0.1 percent of prime farmland soils in Lincoln and Nye counties.	Loss of prime farmland soils: 0.011 to 0.015 km^2 (2.6 to 3.6 acres). Less than 3 percent of the prime farmland soils of the Walker River Paiute Reservation.
		Land use change on public lands for operations right-of-way.	Land use change on public lands and on Walker River Paiute Reservation for operations right-of-way.
		Private parcels the rail line would cross: 7 to 66. Area of affected private land: 0.49 to 1.25 km^2 (120 to 310 acres).	Private parcels the rail line would cross: 1 to 39. Area of affected private land: 0.21 to 0.81 km^2 (52 to 199 acres).
		Private land needed for facilities: 0.65 to 0.89 km^2 (159 to 219 acres)	
		Active grazing allotments the rail line would cross: 23 to 25. Animal unit months lost: 999 to 1,034. [An animal unit 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.]	Active grazing allotments the rail line would cross: 6 to 9. Animal unit months lost: 179 to 199.
		Sections with unpatented mining claims that would be crossed: 37 to 42.	Sections with unpatented mining claims that would be crossed: 43 to 50.
Air quality	Small (Section 6.3)[b]	Rail line construction would not result in exceedances of the NAAQS in Esmeralda, Lincoln, or Nye counties with the possible exception of 24-hour PM_{10} in Nye County near a potential quarry.	Rail line construction would not result in exceedances of the NAAQS in Churchill, Lyon, Esmeralda, or Nye counties. In Mineral County the potential exists for exceedances of the NAAQS for PM_{10} and $PM_{2.5}$.
		Rail line operations would add less than about 20 percent to the 2002 countywide burden of all criteria air pollutants for Lincoln County, less than 6 percent for Esmeralda County, and less than 40 percent for Nye County. Rail line operations would not lead to an exceedance of air quality standards. Construction and operation of a proposed quarry in Lincoln County would not result in exceedances of the NAAQS.	Rail line operations would add less than 35 percent to the 2002 countywide burden of all criteria air pollutants for both Esmeralda and Nye counties and less than about 1 percent to the 2002 countywide burden of all criteria air pollutants for Churchill and Lyon counties. Rail line operations would lead to an exceedance of air quality standards.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative
Air quality (continued)		Construction and operation of a proposed quarry in Nye County could result in exceeding 24-hour PM_{10} limit, but measures required by the Surface Disturbance Permit would greatly reduce PM_{10} emissions, making an exceedance of the NAAQS unlikely. Churchill County. Not applicable. Lyon County. Not applicable. Mineral County. Not applicable.	Operation of a proposed quarry in Esmeralda County near Hawthorne could result in exceeding the 24-hour PM_{10} standards. Construction of the Staging Yard at Hawthorne in Mineral County could result in exceeding 24-hour PM_{10} and $PM_{2.5}$ standards and annual PM_{10} standards. Rail line construction near Mina could result in exceeding the 24-hour PM_{10} standard. Rail line construction near Schurz could result in exceeding 24-hour PM_{10} and $PM_{2.5}$ standards and annual PM_{10} standards. Operating restrictions in the required Surface Disturbance Permit would likely reduce PM_{10} and $PM_{2.5}$ emissions making exceedances of the NAAQS unlikely. Lincoln County. Not applicable.
Hydrology			
Surface water	Small (Section 6.3)[b]	Up to approximately 0.225 km^2 (56 acres) of wetlands could be filled.	Not more than 28 m^2 (0.007 acres) of wetlands would be filled.
Groundwater	Small (Section 6.3)[b]	Physical impacts to existing groundwater resource features such as existing wells or springs resulting from railroad construction and operation would be small. Groundwater withdrawals during construction would not be expected to impact groundwater resources or users except in a few specific locations. However, mitigation measures such as reducing the pumping rate or relocating some of the proposed wells would minimize these impacts. The impact of proposed groundwater withdrawals on groundwater quality would be small to negligible. The proposed withdrawals would not conflict with water quality standards protecting groundwater resources.	Physical impacts to existing groundwater resource features such as existing wells or springs from railroad construction and operations would be small. Groundwater withdrawals during would not be expected to impact groundwater resources or users except in a few specific locations. However, in such instances, mitigation measures such as reducing the pumping rate or relocating some of the proposed wells would minimize these impacts. The impact of proposed groundwater withdrawals on groundwater quality would be small to negligible. The proposed withdrawals would not conflict with water quality standards for groundwater resources.
Biological resources	Small (Section 6.3)[b]	Short-term impact to 0.014 to 0.28 km^2 (3.4 to 69 acres) wetland/riparian habitat. Long-term impacts to 0.011 to 0.18 km^2 (2.7 to 45 acres) wetland/riparian habitat.	Short-term impact to 0.013 to 0.035 km^2 (3.19 to 8.7 acres) wetland/riparian habitat. Long-term impacts to 0 to 0.0015 km^2 (0 to 0.37 acre) wetland/riparian habitat.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a] Caliente Implementing Alternative	Nevada transportation[a] Mina Implementing Alternative
Biological resources (continued)		Impacts would vary by alternative segment, be localized, and could include: • Short-term moderate impact on riparian and wetland vegetation • Small to moderate impacts on raptor nesting sites • Short-term moderate impacts to desert big horn sheep	Impacts would vary by alternative segment, be localized, and could include: • Short-term moderate impact on riparian and wetland vegetation • Small to moderate impacts on raptor nesting sites • Short-term moderate impacts to desert big horn sheep • Small to moderate long-term impacts to Inter-Mountain Basins Mixed Salt Desert Scrub and Inter-Mountain Basins Greasewood Flat land cover types • Small short-term and long-term impacts to Western snowy plover • Moderate impact to winterfat communities • Long-term moderate impacts to Inter-Mountain Basins Mixed Salt Desert Scrub and Inter-Mountain Basins Big Sagebrush Shrubland land cover types
Cultural resources	Small (Section 6.3)[b]	Numerous archaeological sites identified along segments of alignments subject to sample inventory. Construction could result in impacts to the early Mormon colonization cultural landscape, Pioche-Hiko silver mining community route, 1849 Emigrant Trail campsites, American Indian trail systems, and more than 50 sites eligible for the *National Register of Historical Places* identified along segments of alignments subjected to sample inventory. Indirect effects to a National Register-eligible rock art site are likely from two quarry sites. No direct impacts to known paleontological resources.	Numerous archaeological sites, including more than 60 National Register-eligible sites, identified along segments of alignments subject to sample inventory. Potential direct and indirect impacts to sites eligible for the *National Register of Historical Places* and to other sites that might be identified during the complete survey. No direct impacts to known paleontological resources.
Socioeconomics			
New jobs (percent of workforce in affected counties)	Small (Section 6.3)[b]	Construction: Ranges from 0.1-percent increase in Clark County to 5.6-percent increase in Lincoln County. Operation: Ranges from less than 0.1-percent increase in Clark County to 3.9-percent increase in Lincoln County.	Construction: Ranges from 0.02-percent increase in Lyon County to 14-percent increase in Esmeralda County. Operation: Ranges from 0.01-percent increase in Lyon County to 14-percent increase in Esmeralda County.
Peak real disposable personal income	Small (Section 6.3)[b]	Construction: Ranges from 0.2-percent increase in Clark County to 7.6-percent increase in Esmeralda County. Operation: Ranges from less than 0.1-percent increase in Clark County to 4.7-percent increase in Lincoln County.	Construction: Ranges from 0.03-percent increase in Lyon County to 27-percent increase in Esmeralda County. Operation: Ranges from 0.01-percent increase in Lyon County to 10-percent increase in Esmeralda County.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]: Caliente Implementing Alternative	Nevada transportation[a]: Mina Implementing Alternative
Socioeconomics (continued)			
Peak incremental Gross Regional Product	Small (Section 6.3)[b]	Construction: Ranges from 0.2-percent increase in Clark County to 28-percent increase in Lincoln County. Operation: Ranges from less than 0.1-percent increase in Clark County to 5.2-percent increase in Lincoln County.	Construction: Ranges from 0.04-percent increase in Lyon County to 57-percent increase in Esmeralda County. Operation: Ranges from less than 0.01-percent increase in Lyon County to 24-percent increase in Esmeralda County.
Occupational and public health and safety[d]			
Public, Radiological			
MEI (probability of an LCF)	1.3×10^{-4}	4.7×10^{-6}	4.7×10^{-6}
Population (LCFs)	0.73 to 0.79	6.3×10^{-5} to 1.5×10^{-4}	8.2×10^{-4} to 8.6×10^{-4}
Workers (involved and noninvolved)			
MEI (probability of an LCF)[c]	0.015	0.015	0.015
Radiological (LCFs)	9.9 to 10	0.78	0.77 to 0.79
Nonradiological fatalities (includes commuting traffic and vehicle emissions fatalities)	63 to 65	21	22
Maximum reasonably foreseeable transportation accident (LCFs)	0.012 (rural area) to 9.4 (urban area)	0.0012 (rural area) to 0.46 (suburban area) (no urban areas exist along the Caliente Implementing Alternative)	0.0089 (rural area) to 1.2 (suburban area) (no urban areas exist along the Mina Implementing Alternative)
Noise and vibration	Small (Section 6.3)[b]	Noise from construction activities in Caliente would exceed Federal Transit Administration guidelines. Noise from rail construction would be temporary. Noise from operations would create adverse impacts at three noise-sensitive receptors in Caliente. There would be no adverse vibration impacts from construction trains or from operational train activity.	Noise from construction would cause temporary adverse impacts at two locations. Noise from operations would create adverse noise impacts at eight noise-sensitive receptors in Silver Springs and one noise-sensitive receptor in Wabuska. There would be no vibration impacts from construction trains or from operational train activity.
Aesthetics	Small (Section 6.3)[b]	Small to large impact along rail alignment (depending on segment) from operations and the installation of linear track, signals, communications towers, power poles connecting to the grid, access roads, Staging Yard, and quarries.	Small to large impact along rail alignment (depending on segment) from operations and the installation of linear track, signals, communications towers, power poles connecting to the grid, access roads, Staging Yard, and quarries.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative
Utilities, energy, materials, and site services	Small (Section 6.3)[b]	Utility interfaces: Potential for short-term interruption of service during construction. No permanent or long-term loss of service or prevention of future service area expansions. Public water systems: Most water would be supplied by new wells; small effect on public water systems from population increase attributable to construction and operation employees. Wastewater systems: Dedicated wastewater treatment systems would be at construction camps and operations facilities; small impact on public systems from population increase attributable to construction and operation employees. Fossil fuels: Fossil-fuel demand would be approximately 6.5 percent of statewide use during construction and less than 0.25 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers. For the Shared-Use Option, demand would be less than 0.3 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers. Materials: Material requirements such as steel, concrete, and ballast would generally be very small in relation to supply capacity.	Utility interfaces: Potential for short-term interruption of service during construction. No permanent or long-term loss of service or prevention of future service area expansions. Public water systems: Most water would be supplied by new wells; small effect on public water systems from population increase attributable to construction and operation employees. Wastewater systems: Dedicated wastewater treatment systems would be at construction camps and operations facilities; small impact on public systems from population increase attributable to construction and operation employees. Fossil fuels: Fossil-fuel demand would be approximately 6 percent of statewide use during construction and less than 0.25 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers. For the Shared-Use Option, demand would be less than 0.3 percent of statewide use during operation. Demand could be met by existing regional supply systems and suppliers. Materials: Material requirements such as steel, concrete, and ballast would generally be very small in relation to supply capacity.
Hazardous materials and waste	Small (Section 6.3)[b]	Small (Apex Landfill) to moderate (smaller landfills) impacts from nonhazardous waste (solid and industrial and special waste) disposal. Small impacts from use of hazardous materials. Small impacts from hazardous waste disposal. Small impacts from low-level radioactive waste disposal for wastes that would be generated at the Cask Maintenance Facility.	Small (Apex Landfill) to moderate (smaller landfills) impacts from nonhazardous waste (solid and industrial and special waste) disposal. Small impacts from use of hazardous materials. Small impacts from hazardous waste disposal. Small impacts from low-level radioactive waste disposal for wastes that would be generated at the Cask Maintenance Facility.
Environmental justice	Small (Section 6.3)[b]	Constructing and operating the proposed rail line along the Caliente rail alignment would not result in disproportionately high and adverse impacts to minority or low-income populations.	Constructing and operating the proposed rail line along the Mina rail alignment would not result in disproportionately high and adverse impacts to minority or low-income populations.

Table 2-3. Potential impacts from national and Nevada transportation (continued).

Resource area	National transportation	Nevada transportation[a]	
		Caliente Implementing Alternative	Mina Implementing Alternative

a. Short-term impacts for the Rail Alignment EIS would occur during the construction phase (4 to 10 years). Long-term impacts would occur throughout and beyond the life of the railroad operations phase (up to 50 years).

b. With the exception of occupational and public health and safety impacts, 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.

c. Based on a worker who would receive the administrative dose limit of 500 millirem per year (DIRS 156764-DOE 1999, p. 2-3).

d. Impacts are composed of the industrial safety and transportation impacts from Chapter 4 of the Rail Alignment EIS and Chapters 4 and 6 of this Repository SEIS. Included in the impacts are radiation-related latent cancer fatalities, nonradiological industrial accident fatalities, vehicle emission fatalities, and traffic fatalities, as appropriate. Impacts may occur nationally or in Nevada. Impacts may include workers or members of the public.

CO = Carbon monoxide.
km = kilometer.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NAAQS = National Ambient Air Quality Standards.
NO_x = Nitrous oxides.
$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.
SO_2 = Sulfur dioxide.
VOC = Volatile organic compounds.

2.3.3 POTENTIAL IMPACTS OF THE NO-ACTION ALTERNATIVE

Table 2-4 summarizes the potential impacts of the No-Action Alternative from Chapter 7 of this Repository SEIS. Because there would be no construction or operation of a railroad under the No-Action Alternative for the Rail Alignment EIS, there would be no impacts. Therefore, this section does not further discuss the No-Action Alternative for the Rail Alignment EIS.

For the No-Action Alternative for the Proposed Action, short-term actions would include termination of activities and reclamation at the Yucca Mountain site as well as continued management and storage of spent nuclear fuel and high-level radioactive waste at the commercial and DOE sites across the United States. The information in Table 2-4 shows that the short-term (up to 100 years) environmental impacts for the No-Action Alternative would generally be small.

Under No-Action Alternative Scenario 1, DOE would continue to manage spent nuclear fuel and high-level radioactive waste at the DOE sites, and commercial utilities would continue to manage their spent nuclear fuel at their sites, on a long-term basis to isolate the material from human access with institutional control. Under Scenario 2, DOE assumed there would be no effective institutional control after 100 years. The spent nuclear fuel and high-level radioactive waste storage facilities would begin to deteriorate, and radioactive materials could escape to the environment and contaminate the local atmosphere, soils, surface water, and groundwater, thereby representing a considerable human health *risk*, as Table 2-4 indicates.

The analysis led to the following conclusions:

- For Scenario 2, from 0.04 to 0.4 square kilometer (10 to 100 acres) of land at each generator site could become contaminated to the extent that the land would not be usable for long periods. There would be no such impacts for Scenario 1.

- For Scenario 2, there could be low levels of contamination in the surface watershed and high concentrations of *contaminants* in the groundwater downstream of the commercial and DOE sites for long periods. There would be no such impacts for Scenario 1.

- For Scenario 2, estimated long-term radiological impacts to the public would be high (1,000 latent cancer fatalities over 10,000 years) in comparison with the first 10,000 years for the Proposed Action.

- For Scenario 1, estimated long-term (10,000 years) fatalities would be about 1,100, primarily to the workforce at the storage sites.

- For both scenarios, the risks in relation to sabotage and diversion of fissionable materials at the commercial and DOE sites would be much greater than they would be if the materials were in a deep geologic repository.

Table 2-4. Potential impacts from the No-Action Alternative.

Resource area	Repository	Commercial and DOE sites: Short-term 100 years	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 1	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 2
Land use and ownership	DOE would require no new land to support decommissioning and reclamation. Decommissioning and reclamation would include removal or shutdown of existing surface and subsurface facilities and restoration of disturbed lands, including soil stabilization and revegetation of disturbed areas.	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) around each of the existing commercial and DOE sites.
Air quality	Dismantling and removal of existing structures, recontouring, and revegetation would generate fugitive dust that would be below the regulatory limit.	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				
Surface water	Recontouring of terrain to restore the natural drainage and managing potential surface-water contaminant sources would minimize surface-water impacts.	Small; minor changes to runoff and infiltration rates.	Small; runoff during storage and reconstruction would be controlled in stormwater holding ponds; active monitoring would ensure quick response to leaks or releases; commercial and DOE sites for storage probably would be outside flood zones.	Large; potential for radiological releases and contamination of drainage basins downstream of commercial and DOE sites (concentrations potentially exceeding current regulatory limits).
Groundwater	DOE would use a small amount of groundwater during the decommissioning and reclamation.	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.
Biological resources and soils	Reclamation would result in the restoration of 1.4 km^2 (346 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.	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).

Table 2-4. Potential impacts from the No-Action Alternative (continued).

		Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
Resource area	Repository	100 years	Scenario 1	Scenario 2
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.	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; therefore, no impacts.
Socioeconomics	Loss of approximately 4,700 jobs (1,800-person workforce for decommissioning and reclamation, 1,400 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.	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)	None.	0.0000052[a]	0.0000016[a]	(b)
Public – Population (LCFs)	0.001	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.	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)	0.09	24[a]	15[a]	No workers; therefore, no impacts.
Workers – Nonradiological fatalities (includes commuting traffic fatalities)	Less than 0.15	9	1,080	No workers; therefore, no impacts.

Table 2-4. Potential impacts from the No-Action Alternative (continued).

Resource area	Repository	Commercial and DOE sites: Short-term 100 years	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 1	Commercial and DOE sites: Long-term (100 to 10,000 years) Scenario 2
Accidents				
Public – Radiological MEI (probability of an LCF)	None.	None.	None.	Not applicable.
Public – Population (LCFs)	None.	None.	None.	4 to 16[d]
Workers	Accident impacts would be limited to those from traffic and typical industrial hazards during construction or excavation activities. These were estimated at 94 total recordable cases and 45 lost workday cases.	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.
Traffic and transportation	Less than 0.15 traffic fatality would be likely during decommissioning and reclamation.	Small; local traffic only.	Small; local traffic only.	No activities, therefore no traffic.
Noise and vibration	Noise levels would be no greater than the current baseline noise environment at the Yucca Mountain site.	Small; transient and not excessive, less than 85 dBA.	Small; transient and not excessive, less than 85 dBA.	No activities, therefore, no noise.
Aesthetics	Site decommissioning and reclamation would improve the scenic value of the site, which DOE would return as close as possible to its predisturbance state.	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	Decommissioning would consume electricity, diesel fuel, and gasoline. The amounts of use would not adversely affect the utility, energy, or material resources of the region.	Small; materials and energy use would be small in comparison with total regional use.	Small; materials and energy use would be small in comparison with total regional use.	No use of materials or energy; therefore, no impacts.
Waste management	Decommissioning would generate some waste that would require disposal in existing Nevada Test Site or regional landfills. DOE would minimize waste by salvaging most equipment and many materials.	Small; waste generated and materials used would be small in comparison with total regional generation and use.	Small; waste generated and materials used would be small in comparison with total regional generation and use.	No generation of waste or use of hazardous materials; therefore, no impacts.

Table 2-4. Potential impacts from the No-Action Alternative (continued).

		Commercial and DOE sites		
		Short-term	Long-term (100 to 10,000 years)	
Resource area	Repository	100 years	Scenario 1	Scenario 2
Environmental justice	The No-Action Alternative at the repository location would not result in disproportionately high and adverse impacts to minority or low-income populations.	The No-Action Alternative during the first 100 years at commercial and DOE sites would not result in disproportionately high and adverse impacts to minority or low-income populations.	The No-Action Alternative under Scenario 1 at commercial and DOE sites would not result in disproportionately high and adverse impacts to minority or low-income populations.	The No-Action Alternative under Scenario 2 at commercial and DOE sites could result in disproportionately high and adverse impacts to minority or low-income populations.

a. Updated using a conversion factor of 0.0006 latent cancer fatality per person-rem; no change to external dose coefficients.
b. With no effective institutional controls, the maximally exposed individual 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 latent cancer fatality per person-rem and ingestion dose coefficients that overall are about 25 percent of the coefficients for the Yucca Mountain FEIS.
d. Updated using a conversion factor of 0.0006 latent cancer fatality per person-rem and inhalation dose coefficients that are approximately the same as coefficients for the Yucca Mountain FEIS.

dBA = A-weighted decibels.
DOE = U.S. Department of Energy.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.

2.3.4 SUMMARY OF POTENTIAL PRECLOSURE IMPACTS OF THE PROPOSED ACTION

This section presents the total estimated environmental impacts for the Proposed Action. It combines the environmental impacts from the construction analytical period, operations analytical period, monitoring analytical period, and closure analytical period of the repository (Table 2-2) with the environmental impacts from transportation activities (Table 2-3).

As construction of the rail corridor approached the physical location of the repository and its surface facilities, the potential for impacts to overlap would increase. In most instances, DOE evaluated the potential impacts qualitatively and judged them to be small. However, there are several air quality and groundwater impacts from the repository and the rail actions that DOE could sum and quantify. The following paragraphs discuss those results.

2.3.4.1 Air Quality

Chapter 4, Section 4.1.2 describes air quality impacts for the repository. Chapter 6, Section 6.4 discusses air quality impacts from rail construction and operation. The air quality impacts from simultaneous construction of the proposed repository and of the railroad and associated rail facilities would not produce *criteria pollutant* concentrations that exceeded the regulatory limits at the boundary of the *analyzed land withdrawal area*. Table 2-5 shows the combined estimated concentrations of criteria pollutants at the land withdrawal boundary. Simultaneous operation of the repository, railroad, and its facilities would not produce criteria pollutant concentrations that exceeded the regulatory limit at the land withdrawal area boundary. In addition, while DOE would implement dust suppression measures during construction of both the repository and railroad to reduce releases of *particulate matter*, the Department did not take credit for such measures in the analysis. Therefore, the analysis was conservative.

The analyses indicate that even if the background concentrations of the criteria pollutants were added to the estimated maximum concentrations of all construction activities, the resultant concentrations would be below the *National Ambient Air Quality Standards*.

Carbon dioxide, a greenhouse gas, would be produced by the burning of fossil fuels and the manufacture of concrete during repository and railroad construction and operations. The amount of carbon dioxide emitted would be a small addition to existing State of Nevada and total U.S. carbon dioxide emissions. 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.

2.3.4.2 Groundwater

Groundwater withdrawals would occur for both the repository and rail actions from the same *hydrographic area*, specifically Area 227A, *Jackass Flats*. For the analysis, DOE assumed the rail corridor construction in the Jackass Flats area would start 2 years prior to repository construction. Figure 2-15 shows annual water demands for the time of greatest fluctuation, including the years of peak water demand. The highest combined annual water demand for rail and repository activities 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. For the peak years, the combined demand would be less than even the lowest estimated value of perennial yield [720,000 cubic meters

Table 2-5. Maximum construction analytical period concentrations of criteria pollutants at the analyzed land withdrawal area boundary from both repository and rail construction activities (micrograms per cubic meter).[a,b]

Pollutant	Averaging time	Regulatory limit[c]	Maximum concentration[d]	Percent of regulatory limit
Carbon monoxide	8-hour	10,000	300	3.0
	1-hour	40,000	2,400	5.9
Nitrogen dioxide	Annual	100	2.8	2.8
Sulfur dioxide	Annual	80	0.0022	0.0027
	24-hour	365	0.18	0.048
	3-hour	1,300	0.86	0.066
PM_{10}	24-hour	150	130	86
$PM_{2.5}$	Annual	15	0.16	1.1
	24-hour	35	13	37
Cristobalite	Annual	10[e]	0.048	0.48

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. Does not include background concentrations. (Appendix B contains more information.)
e. There are no regulatory limits for public exposure to cristobalite. An EPA health assessment states that the risk of silicosis is less than 1 percent for a cumulative exposure of 1,000 micrograms per cubic meter × years. Using a 70-year lifetime, an approximate annual average concentration of 10 micrometers per cubic meter was established as a benchmark for comparison.

$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.

(580 acre-feet)] for the western two-thirds of this hydrographic area. Coupled with the demand for Nevada Test Site activities in Jackass Flats, the total annual water demand would still be slightly 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 rail, 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.

Table 2-6 lists the accumulated impacts of the Proposed Action (repository, national transportation, and construction and operation of a railroad in Nevada). It provides ranges of impacts that encompass impacts from both the Caliente and Mina implementing alternatives. In addition, it identifies repository and Nevada transportation impacts that would occur within overlapping regions of influence.

Considering the preclosure and postclosure impacts presented in this Repository SEIS, it can be concluded that the potential impacts associated with the repository design and operational plans assessed in this Repository SEIS are similar in scale to impacts presented in the Yucca Mountain FEIS.

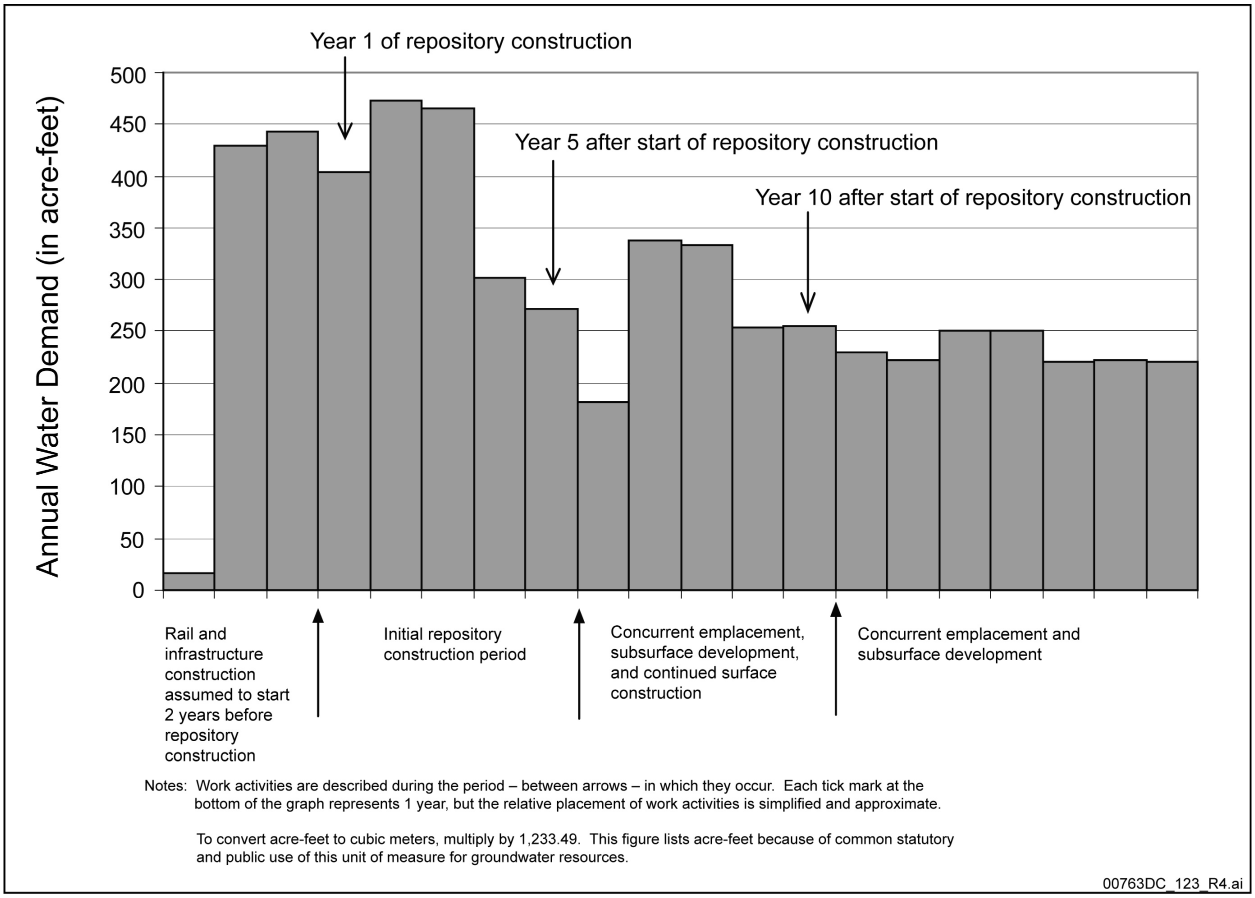


Figure 2-15. Combined annual water demand during the repository and rail construction period and the initial phases of operations.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action.[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Land use and ownership	Approximately 49 to 70 km^2 (12,000 to 17,000 acres) of total disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use. Loss of prime farmland soils would range from 0.011 to 1.8 km^2, (2.6 to 440 acres) which would be less than 0.1 percent of prime farmland soils in Lincoln and Nye Counties and less than 3 percent of the prime farmland soils of the Walker River Paiute Reservation. Land use change would occur on public lands and on Walker River Paiute Reservation for operations right-of-way. Private parcels the rail line would cross would range from 1 to 66; area of private land affected would range from 0.21 to 1.25 km^2 (53 to 310 acres). Private land needed for facilities: 0.65 to 0.89 km^2 (159 to 219 acres) Active grazing allotments the rail line would cross would range from 6 to 25. Animal unit months lost would range from 179 to 1,034. Sections with unpatented mining claims that the rail line would cross would range from 37 to 50.	About 12 km^2 (3,000 acres) of disturbed land; 600 km^2 (150,000 acres) of land withdrawn from public use.
Air quality	Releases from construction and operation of the repository would be well below regulatory limits (less than 3 percent) for all criteria pollutants except particulate matter. Maximum releases of PM_{10} would be 40 percent of limit at boundary of land withdrawal area. Rail line construction emissions would be distributed over the entire length of the rail alignment; therefore, no air quality standard would be exceeded. Rail line operations would not lead to an exceedance of air quality standards. Table 2-3 provides more detail about emissions by county.	Nye County is the only location where Nevada transportation impacts would overlap the repository region of influence. The Nevada transportation emissions would be distributed over the entire county and only the southern portion of the emissions from Nye County would be within the repository region of influence. Modeled concentrations of criteria pollutants at the boundary of the land withdrawal area would not exceed regulatory limits during simultaneous construction of the repository and railroad. Concentrations of all criteria pollutants except for particulate matter would be less than 6 percent of the regulatory limit. Concentrations of $PM_{2.5}$ would not exceed 37 percent, and concentrations of PM_{10} would not exceed 87 percent of the regulatory limit. The simultaneous operation of the repository and railroad would not exceed regulatory limits.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Hydrology		
Surface water	Repository land disturbance would result in minor changes to runoff and infiltration rates. At repository site, potential for contaminants to be released and reach surface water would be minimal; only ephemeral drainage channels would be affected; there are no other surface-water resources at the site. Repository facilities would be above flood zones, or constructed dikes and diversion channels would keep floodwaters away; floodplain assessment concluded impacts would be small. Up to 0.22 km^2 (56 acres) of wetlands could be filled.	Construction of repository surface facilities would affect at least two drainage channels and floodplains (Busted Butte Wash and Drill Hole Wash) that the rail line would cross.
Groundwater	Potential for repository actions to change recharge rates and for contaminants to be released and reach groundwater would be minimal. Physical impacts to existing groundwater resource features such as existing wells or springs from railroad construction and operation would be small. Repository peak water demand (460 acre-feet per year)[b] would be below the lowest estimate of perennial yield (580 acre-feet) for the western two-thirds of the groundwater basin; after construction water demand would decrease to 330 acre-feet per year or less. Groundwater withdrawals during rail construction in some areas could affect existing groundwater resources and users. However, mitigation measures such as reducing the pumping rate or relocating some of the proposed wells would minimize these impacts. Groundwater for repository facility use would be withdrawn from wells in Jackass Flats. Groundwater for rail construction would mostly be withdrawn from new wells.	Water identified for rail line construction includes 572 acre-feet (over four years) plus 6 acre-feet per year for operations, all from the same groundwater basin as for repository activities. A peak annual water demand of 470 acre-feet would result from the combined Nevada transportation and repository needs, assuming primary construction periods did not overlap. This high level would last only 2 years and would occur during the second and third years after start of repository construction. The average annual water demand for the combined construction period would be 400 acre-feet. All combined water demand levels would be below the lowest estimate of perennial yield (580 acre-feet) for the western two-thirds of the groundwater basin. The two years of highest water demand would not result in a well drawdown that could affect the nearest public or private wells. Modeling for the Yucca Mountain FEIS showed small to moderate impacts from the Proposed Action groundwater withdrawals that are still applicable. The model's assumed withdrawal rate of 430 acre-feet per year is lower than the peak water demand, but over the life of the project is still conservatively high.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Biological resources and soils	Loss of between 49 to 70 km^2 (12,000 to 17,000 acres) of desert soil, habitat, and vegetation. Adverse impacts to desert big horn sheep and special status species including western snowy plover and desert tortoise. Short-term impact of up to 0.28 km^2 (69 acres) wetland/riparian habitat. Long-term impact of up to 0.18 km^2 (45 acres) wetland/riparian habitat.	Loss of up to 12 km^2 (3,000 acres) of desert soil, habitat, and vegetation, but no loss of rare or unique habitat or vegetation; adverse impacts to individual threatened desert tortoises and loss of a small amount of low-density tortoise habitat, but no adverse impacts to the species as a whole; reasonable and prudent measures would minimize impacts.
Cultural resources	Numerous archaeological sites, as many as 60 eligible for the *National Register of Historic Places*, along segments of alignments subject to sample inventory and 3 sites in the repository region of influence. Opposing American Indian viewpoint. Construction could result in impacts to the early Mormon colonization cultural landscape, Pioche-Hiko silver mining community route, 1849 Emigrant Trail campsites, American Indian trail systems. Indirect effects to a National Register-eligible rock art site are likely from two quarry sites. No direct impacts to known paleontological resources.	Small potential for impacts; including three prehistoric sites eligible for the *National Register of Historic Places*; opposing American Indian viewpoint.
Socioeconomics		
New jobs (percent of workforce in affected counties)	Construction: Peaks would range from 0.05 percent above baseline in Clark County to 14-percent increase in Esmeralda County. Operation: Peaks would range from 0.01-percent increase in Lyon County to 14-percent increase in Esmeralda County.	Peak increases would be small, less than 1 percent in the region, Clark County, and Nye County when construction of repository and rail overlapped.
Peak real disposable income	Construction: Peak percent increases are: • Nye: 1.16 (repository); 0.4 to 0.9 (rail) • Clark: 0.05 (repository); 0.1 (rail) • Lincoln: 4.1 (rail) • Esmeralda: 7.6 to 27 (rail) • Lyon: 0.03 (rail) • Walker River Paiute Reservation: up to $386,000 • Mineral: 4.5 (rail) • Washoe County/Carson City: less than 0.3 (rail)	For Repository: In Clark County (2034), 58.3 million; in Nye County (2035) $27.5 million For Rail: In Clark County (2011) $100.6 million; in Nye County (2012) $9.6 million.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Socioeconomics (continued)		
	Operations: Peak percent increases are: • Nye: 1.15 (repository); 0.1 to 0.3 (rail) • Clark: 0.05 (repository); less than 0.1 (rail) • Lincoln: 4.7 (rail) • Esmeralda: 2.9 to 10 (rail) • Lyon: 0.01 (rail) • Walker River Paiute Reservation: included in Mineral County • Mineral: 2.8 (rail) • Washoe County/Carson City: less than 0.1 (rail)	
Peak incremental Gross Regional Product	Construction: Peak percent increases are: • Nye: 1.42 (repository); 1.0 to 3.5 (rail) • Clark: 0.05 (repository); less than 0.1 to 0.1 (rail) • Lincoln: 28 (rail) • Esmeralda: 9.5 to 57 (rail) • Lyon: 0.04 (rail) • Walker River Paiute Reservation: up to $1.4 million • Mineral: 14 (rail) • Washoe County/Carson City: less than 0.3 (rail) Operations: Peak percent increases are: • Nye: 2.65 (repository); 0.2 to 0.5 (rail) • Clark: 0.05 (repository); less than 0.1 (rail) • Lincoln: 5.2 (rail) • Esmeralda: 3.8 to 24 (rail) • Lyon: 0.01 (rail) • Walker River /Paiute Reservation: included in Mineral County • Mineral: 1.9 (rail) • Washoe County/Carson City: less than 0.1 (rail)	For Repository: In Clark County (2034), $98.7 million; in Nye County (2034) $68.9 million. For Rail: In Clark County (2012), $154.5 million; in Nye County (2012), $42.8 million

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Occupational and public health and safety		
Public, Radiological		
MEI (probability of an LCF)	3.2×10^{-4} (repository) 1.3×10^{-4} (transportation)	2.9×10^{-4} (repository) 1.3×10^{-4} (transportation)
Population (LCFs)	8.7 to 8.8 (total)	8.0
Public, Nonradiological		
Fatalities due to emissions	Small; exposures well below regulatory limits.	Small; exposures well below regulatory limits.
Workers (involved and noninvolved)		
Radiological (LCFs)	13 to 14	4.4 to 4.9.
Nonradiological fatalities (includes commuting traffic and vehicle emissions fatalities)	64 to 66 (total)	56 to 59.
Maximum reasonably foreseeable transportation accident (LCFs)	0.012 (rural area) to 9.4 (urban area)	0.012 (rural area) to 9.4 (urban area)
Accidents		
Public, Radiological		
MEI (probability of an LCF)	2.6×10^{-10} to 2.1×10^{-5} (repository accidents)	2.6×10^{-10} to 2.1×10^{-5} (repository accidents)
Population (LCFs)	9.0×10^{-7} to 1.9×10^{-2} (repository accidents)	9.0×10^{-7} to 1.9×10^{-2} (repository accidents)
Workers, Radiological	5.8×10^{-4} to 3.5 rem (3.5×10^{-7} to 2.1×10^{-3} LCF) (repository accidents)	5.8×10^{-4} to 3.5 rem (3.5×10^{-7} to 2.1×10^{-3} LCF) (repository accidents)
Noise and vibration	Impacts to public would be small due to large distances from the repository to residences; workers exposed to elevated noise levels – controls and protection used as necessary. Noise from rail construction activities in Caliente would exceed Federal Transit Administration guidelines. Noise from rail construction would be temporary. Noise from operations would create adverse impacts at a maximum of nine noise-sensitive receptors. There would be no adverse vibration impacts from construction or operations.	Impacts to public would be small due to large distances from the repository to residences; workers exposed to elevated noise levels – controls and protection used as necessary.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Aesthetics	The exhaust ventilation stacks on the crest of Yucca Mountain would be seen as an adverse aesthetic impact by American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several kilometers, especially west of Yucca Mountain. Aesthetic impacts would range from small to large along rail alignments (depending on segment) from operations and the installation of linear track, signals, communications towers, power poles connecting to the grid, access roads, Staging Yard, and quarries.	The exhaust ventilation stacks on the crest of Yucca Mountain would be seen as an adverse aesthetic impact by American Indians. If the Federal Aviation Administration required beacons atop the stacks, they could be visible for several kilometers, especially west of Yucca Mountain.
Utilities, energy, materials, and site services	Use of materials would be small in comparison with regional use; some effect on public water systems and public wastewater treatment facilities due to population growth from construction and operations employment; annual fossil-fuel use would be less than 7 percent of statewide use during construction and less than 2 percent of statewide use during operation; electric power delivery system to the Yucca Mountain site would have to be enhanced.	Use of materials would be small in comparison with regional use; some effect on public water systems and public wastewater treatment facilities due to population growth from construction and operations employment; annual fossil-fuel use would be less than 7 percent of statewide use during construction and less than 2 percent of statewide use during operation; electric power delivery system to the Yucca Mountain site would have to be enhanced.
Waste and hazardous materials	Small impacts from nonhazardous waste (solid and industrial waste) disposal to regional solid waste facilities. Small impacts from use of hazardous materials. Small impacts from hazardous-waste disposal to regional licensed hazardous waste facilities. Small impacts from low-level radioactive waste disposal to a DOE low-level waste disposal site, Agreement State site, or an NRC-licensed site.	Small impacts from nonhazardous waste (solid and industrial waste) disposal to regional solid waste facilities. Small impacts from use of hazardous materials. Small impacts from hazardous-waste disposal to regional licensed hazardous waste facilities. Small impacts from low-level radioactive waste disposal to a DOE low-level waste disposal site, Agreement State site, or an NRC-licensed site.
Environmental justice	No identified high and adverse impact to members of the general public; no identified subsections of the population, including minority or low-income populations that would receive disproportionate impacts; no identified unique exposure pathways, sensitivities, or cultural practices that would expose minority or low-income populations to disproportionately high and adverse impacts. (Section 4.1.13) DOE acknowledges the opposing American Indian viewpoint.	Constructing and operating the proposed geologic repository at Yucca Mountain and constructing and operating the railroad to transport spent nuclear fuel and high-level radioactive waste from commercial and DOE sites to the repository would not result in disproportionately high and adverse impacts to minority or low-income populations.

Table 2-6. Summary of potential preclosure impacts of the Proposed Action (continued).[a]

Resource area	Summary of all preclosure impacts (all preclosure impacts resulting from the repository, national transportation, and Nevada transportation)	Summary of repository and Nevada transportation impacts that would occur within overlapping regions of influence
Manufacturing repository components	Small impacts to all resources with the exception of moderate socioeconomic and materials impacts.	Not applicable.
Airspace restrictions	Small impact to airspace use; airspace restriction could be lifted once operations had been completed.	Small impacts to airspace use; airspace restriction could be lifted once operations had been completed.

a. Short-term impacts for the Rail Alignment EIS are impacts limited to the construction phase (4 to 10 years). Long-term impacts for the Rail Alignment EIS are impacts that could occur throughout and beyond the life of the railroad operations phase (up to 50 years).

b. To convert acre-feet to cubic meters, multiply by 1,233.49. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

DOE = U.S. Department of Energy.
km^2 = square kilometer.
LCF = Latent cancer fatality.
MEI = Maximally exposed individual.
NRC = U.S. Nuclear Regulatory Commission.
$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.

2.4 Collection of Information and Analyses

As stated in the Yucca Mountain FEIS, some of the studies to obtain or evaluate the information necessary for the assessment of Yucca Mountain as a repository were ongoing and, therefore, some of the information was incomplete. The complexity and variability of any natural system, including that at Yucca Mountain, will result in some uncertainty associated with scientific analyses and findings. It is important to understand that research can produce results or conclusions that might disagree with other research. The interpretation of results and conclusions has led to the development of views that differ from those that DOE has presented.

During the scoping process for this Repository SEIS, DOE received input from a number of organizations interested in the Proposed Action or No-Action Alternative or from potential recipients of impacts from those actions. These organizations included the State of Nevada, local governments, and American Indian tribes. Their input included documents that present research or information that, in some cases, disagrees with the views that DOE presents in this Repository SEIS. The Department reviewed these documents and evaluated their findings for inclusion as part of this Repository SEIS analyses. If the information represented a substantive view, DOE has made every effort to incorporate that view in this Repository SEIS and to identify its source.

2.4.1 INCOMPLETE OR UNAVAILABLE INFORMATION

DOE and others have continued to gather information since the publication of the Yucca Mountain FEIS. As a result, this Repository SEIS includes information that was not available for the Yucca Mountain FEIS

2.4.2 UNCERTAINTY

DOE has continued to conduct analyses, one purpose of which is to better define or reduce uncertainties associated with repository performance and to reduce health and safety risks during operation of the repository. The conclusions of analyses continue to have some associated uncertainty as a result of the assumptions DOE used and the complexity and variability of the analyzed process. Chapter 5 of this Repository SEIS provides a further description of uncertainties associated with postclosure impacts.

2.4.3 OPPOSING VIEWS

As was the case in the Yucca Mountain FEIS, opposing views are defined in this Repository SEIS as differing views or opinions currently held by organizations or individuals outside DOE. These views are considered to be opposing if they include or rely on data or methods with which DOE is not in agreement.

DOE has attempted to identify and address the range of opposing views in this Repository SEIS. The Department identified potential opposing views by reviewing public comments received during the scoping process and on the Draft Repository SEIS, as well as published or other information in the public domain. Sources of information included reports from universities, other federal agencies, the State of Nevada, counties, municipalities, other local governments, and American Indian tribes. DOE reviewed the potential opposing views to determine if they:

- Have arisen since the Yucca Mountain FEIS was published;

- Address issues analyzed in this Repository SEIS;
- Differ from the DOE position;
- Are based on scientific, regulatory, or other information supported by credible data or methods that relate to the impacts analyzed in this Repository SEIS; or
- Have significant basic differences in the data or methods used in the analysis or to the impacts described in this Repository SEIS.

DOE has included opposing views that meet the above criteria in this Repository SEIS where it discusses the particular topic.

2.4.4 PERCEIVED RISK AND STIGMA

In the Yucca Mountain FEIS, DOE evaluated *perceived risk* and *stigma* associated with construction and operation of a repository at Yucca Mountain and from the transportation of spent nuclear fuel and high-level radioactive waste. In the Yucca Mountain FEIS, DOE recognized that nuclear facilities can be perceived to be either positive or negative, depending on the underlying value systems of the individual forming the perception. Thus, perception-based impacts would not necessarily depend on the actual physical impacts or risk of repository operations, including transportation. A further complication is that people do not consistently act in accordance with negative perceptions, and thus the connection between public perception of risk and future behavior would be uncertain or speculative at best.

> **PERCEIVED RISK AND STIGMA**
>
> DOE uses the term **risk perception** to mean how an individual perceives the amount of risk from a certain activity. Studies show that perceived risk varies with certain factors, such as whether the exposure to the activity is voluntary, the individual's degree of control over the activity, the severity of the exposure, and the timing of the consequences of the exposure.
>
> DOE uses **stigma** to mean an undesirable attribute that blemishes or taints an area or locale.

DOE concluded that, although public perception regarding the proposed geologic repository and transportation of spent nuclear fuel and high-level radioactive waste could be measured, there is no valid method to translate these perceptions into quantifiable economic impacts. Researchers in the social sciences have not found a way to reliably forecast linkages between perceptions or attitudes reported in surveys and actual future behavior. At best, only a *qualitative* assessment is possible about what broad outcomes seem most likely. The Yucca Mountain FEIS did identify some studies that report, at least temporarily, a small relative decline in residential property values might result from the designation of transportation corridors in urban areas.

The Yucca Mountain FEIS presented the following conclusions regarding perceived risk and stigma:

- While in some instances risk perceptions could result in adverse impacts on portions of a local economy, there are no reliable methods whereby such impacts could be quantified with any degree of certainty.
- Much of the uncertainty is irreducible.

- Based on a qualitative analysis, adverse impacts from perceptions of risk would be unlikely or relatively small.

DOE has incorporated the more detailed discussion of perceived risk and stigma related to the Proposed Action in this Repository SEIS by reference to Chapter 2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 2-95 and 2-96).

An independent economic impact study (DIRS 172307-Riddel et al. 2003, all) conducted since the publication of the Yucca Mountain FEIS examined, among other things, the social costs of perceived risk to Nevada households living near transportation routes. The study developed such an estimate in terms of households having a willingness to accept compensation for different levels of perceived risk and a willingness to pay to avoid risk. The results of the study indicated that during the first year of transport, net job losses (and associated drop in residential real estate demand and decreases in gross state product) relative to the baseline would occur in response to people moving to protect themselves from transport risk. However, the initial impact would be offset rapidly, as the population shifted to a more risk-tolerant base. The results of this study are similar to those studies identified in the Yucca Mountain FEIS.

Other conclusions of this study are that the public and DOE have widely divergent risk beliefs and that the public is very uncertain about the risks they face. At the same time, over 40 percent of the respondents in a public survey conducted as part of this study felt that DOE information is reliable or very reliable, while another 40 percent feel that DOE's information is somewhat reliable. These results suggest social costs could be mitigated by reducing the risk people perceive from transport through information and education programs that are well researched and effectively presented.

While stigmatization of southern Nevada can be envisioned under some scenarios, it is not inevitable or numerically predictable. Any such stigmatization would likely be an aftereffect of unpredictable future events, such as serious accidents, which may not occur. As a consequence, DOE did not attempt to quantify any potential for impacts from risk perceptions or stigma in this Repository SEIS.

2.5 Preferred Alternative

DOE's preferred alternative—to proceed with 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—has not changed since the Department published the Yucca Mountain FEIS. The preferred alternative includes using mostly rail as the mode of transportation for spent nuclear fuel and high-level radioactive waste, both nationally and in the State of Nevada. The preferred alternative also includes construction and operation of the proposed railroad along the Caliente rail alignment in the State of Nevada, and to implement the Shared-Use Option as set forth in the Rail Alignment EIS. The analyses in this Repository SEIS, including incorporated portions of the Rail Alignment EIS, have not identified any new potential environmental impacts that would be the basis for not proceeding with the Proposed Action.

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3

Affected Environment

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3. AFFECTED ENVIRONMENT

To analyze potential environmental *impacts* that could result from the implementation of the *Proposed Action*, the U.S. Department of Energy (DOE or the Department) has compiled extensive information about the *environment* that the Proposed Action could affect. The Department used this information to establish the baseline against which it measured potential impacts (Chapter 4). Chapter 3 describes (1) environmental conditions that currently exist at and in the region of the proposed *repository* site at Yucca Mountain (Section 3.1); (2) environmental conditions along the proposed transportation *corridors* in Nevada that DOE could use to ship *spent nuclear fuel* and *high-level radioactive waste* to the *Yucca Mountain site* (Section 3.2); and (3) environmental conditions at the 72 commercial and 4 DOE sites in the United States that manage spent nuclear fuel and high-level *radioactive* waste (Section 3.3).

Where noted in 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), DOE summarizes, incorporates by reference, and updates Chapter 3 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. 3-1 to 3-227) (Yucca Mountain FEIS) and presents new information, as applicable, from studies and investigations that continued after the completion of the Yucca Mountain FEIS. If the Department did not use information from the FEIS, but rather based the information in a subsection on input from continuing studies and investigations, the introduction to that subsection so states and does not reference the FEIS. To help 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 3.1.

3.1 Affected Environment at the Yucca Mountain Repository Site

To define the existing environment at and in the region of the proposed repository, DOE has compiled environmental baseline information for 13 resource and subject areas. This environment includes the manmade structures and physical disturbances from DOE-sponsored site selection studies (1977 to 1988), *site characterization* studies to determine the suitability of the site for a repository (1989 to 2001), and disturbances from *maintenance* of the *Yucca Mountain Repository* site (2001 to present). This chapter and supporting documents contain baseline information for:

- Land use and ownership. Land use practices and land ownership information in the Yucca Mountain region, which includes overflight restrictions in the Yucca Mountain region (Section 3.1.1);
- *Air quality* and climate. The quality of the air in the Yucca Mountain region and the area's climatic conditions (such as temperature and precipitation) (Section 3.1.2);
- Geology. The *geologic* characteristics of the Yucca Mountain region at and below the ground surface, the frequency and severity of *seismic* activity, volcanism, and mineral and energy resources (Section 3.1.3);

- *Hydrology*. Surface-water and *groundwater* features in the Yucca Mountain region and the quality of the water (Section 3.1.4);

- Biological resources and soils. Plants and animals that live in the Yucca Mountain region, the occurrence of special-status species and *wetlands*, and the kinds and quality of soils in the region (Section 3.1.5);

- Cultural resources. Historic and archaeological resources in the Yucca Mountain region, the importance those resources hold and for whom (Section 3.1.6);

- Socioeconomics. The labor market, population, housing, some public services, *real disposable personal income*, *Gross Regional Product*, government spending, and DOE payment equal to taxes in the Yucca Mountain region (Section 3.1.7);

- Occupational and public health and safety. The levels of *radiation* that occur naturally in the Yucca Mountain air, soil, animals, and water; radiation *dose* estimates for Yucca Mountain workers from *background radiation*; radiation *exposure*, dispersion, and accumulation in air and water for the Nevada Test Site area from past nuclear testing and current operations; and public radiation dose estimates from background radiation (Section 3.1.8);

- Noise and vibration. Noise and vibration sources and levels of noise and vibration that commonly occur in the Yucca Mountain region during the day and at night, and the applicability of Nevada standards for noise in the region (Section 3.1.9);

- Aesthetics. The visual resources of the Yucca Mountain region in terms of land formations, vegetation, and color, and the occurrence of unique natural views in the region (Section 3.1.10);

- Utilities, energy, and site services. The amounts of power supplied to the region; the means by which power is supplied; the availability of gasoline, diesel, natural gas, and propane; and the availability of construction materials (Section 3.1.11);

- Waste and hazardous materials. Ongoing *solid* and *hazardous waste* and wastewater management practices at Yucca Mountain, the kinds of waste generated by current activities at the site, the means by which DOE disposes of its waste, and DOE recycling practices (Section 3.1.12); and

- *Environmental justice*. The locations of *low-income* and *minority* populations in the Yucca Mountain region and the income levels among *low-income populations* (Section 3.1.13).

DOE evaluated the existing environment in regions of influence for each of the 13 areas. Table 3-1 defines these regions, which are specific to each resource or subject area in which DOE could reasonably expect to predict impacts, if any, related to the repository. The Department assessed human health *risks* from exposure to airborne *contaminant* emissions for an area within approximately 84 kilometers (52 miles), and economic effects, such as job and income growth, in a two-county socioeconomic region.

The vicinity around Yucca Mountain has been the subject of a number of studies in support of mineral and energy resource exploration, nuclear weapons testing, and other DOE activities at the Nevada Test Site. From 1977 to 1988, the Yucca Mountain Project performed studies to assist in the site selection

Table 3-1. Regions of influence for the proposed Yucca Mountain Repository.

Resource/subject area	Region of influence
Land use and ownership	The analyzed land withdrawal area, lands DOE proposes for an access road from U.S. Highway 95 and where DOE could construct offsite facilities (Section 3.1.1).
Air quality and climate	An approximate 84-kilometer (52-mile) radius around the repository and at the boundary of the analyzed land withdrawal area (Section 3.1.2).
Geology	The physiographic setting (characteristic landforms), stratigraphy (rock strata), and geologic structure (structural features that result from rock deformations) of the region and of Yucca Mountain (Section 3.1.3).
Hydrology	Surface water: Construction areas that would be susceptible to erosion, areas that permanent changes in flow would affect, and areas downstream of the repository that eroded soil or potential spills of contaminants would affect. Groundwater: Aquifers that would underlie areas of construction and operations, aquifers that could be sources of water for construction and operations, and aquifers downstream of the repository that repository use or postclosure performance of the repository could affect (Section 3.1.4).
Biological resources and soils	Area that contains all potential surface disturbances that would result from the Proposed Action plus additional area to evaluate local animal populations, roughly equivalent to the analyzed land withdrawal area, as well as land proposed for an access road from U.S. Highway 95 and land where DOE could construct offsite facilities (Section 3.1.5).
Cultural resources	Area that contains all potential surface disturbances that would result from the Proposed Action, as well as land proposed for an access road from U.S. Highway 95 and land where DOE could construct offsite facilities (Section 3.1.6).
Socioeconomics	The two-county (Clark and Nye) area in which repository activities could most influence local economies and populations (Section 3.1.7).
Occupational and public health and safety	Workers at the repository and potentially affected workers at nearby Nevada Test Site facilities and members of the public who reside within an 84-kilometer (52-mile) radius of the geologic repository operations area (Section 3.1.8).
Noise and vibration	The Yucca Mountain site and existing and future residences to the south in the town of Amargosa Valley (Section 3.1.9).
Aesthetics	The approximate boundary of the analyzed land withdrawal area, an area west of the boundary from where people could see the ventilation stacks, and the area south of the boundary where DOE would construct the access road from U.S. Highway 95 and several buildings (Section 3.1.10).
Utilities, energy, and site services	Public and private resources on which DOE would draw to support the Proposed Action (for example, private utilities and cement suppliers) (Section 3.1.11).
Waste and hazardous materials	On- and offsite areas, which would include landfills and hazardous and radioactive waste processing and disposal sites, in which DOE would dispose of site-generated repository waste (Section 3.1.12).
Environmental justice	Varies with resource area and corresponds to the region of influence for each resource area (Section 3.1.13).

DOE = U.S. Department of Energy.

process for a repository. These studies, which involved the development of roads, drill holes, trenches, and seismic stations, along with non-Yucca Mountain activities, disturbed about 2.5 square kilometers

(620 acres) of land in the vicinity of Yucca Mountain. Yucca Mountain site characterization activities began in 1989 and continued through 2001. These activities included surface and *subsurface* excavations and borings, and testing to evaluate the suitability of Yucca Mountain as the site for a repository. As of 2001, these activities had disturbed about an additional 1.5 square kilometers (370 acres) in the vicinity of Yucca Mountain. Since 2001, there has been minimal additional land disturbance. Reclamation activities have started and will continue to occur as DOE releases areas from further study.

The existing environment at Yucca Mountain includes the *Exploratory Studies Facility* [which includes the tunnel (*drift)*], the North and South portal pads and supporting structures, an excavated rock storage area, a topsoil storage area, borrow pits, *boreholes*, trenches, roads, and supporting facilities and disturbances from site characterization activities.

3.1.1 LAND USE AND OWNERSHIP

The *region of influence* for land use and ownership includes the *analyzed land withdrawal area*, land proposed for an access road from U.S. Highway 95, and land where DOE would construct offsite facilities. The analysis for this Repository SEIS assumed DOE would build the proposed offsite facilities on Bureau of Land Management land near Gate 510 of the Nevada Test Site. This section summarizes, incorporates by reference, and updates Section 3.1.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-6 to 3-12). The following sections summarize important characteristics of land use and ownership. Section 3.1.1.1 discusses regional land use and ownership. Section 3.1.1.2 discusses current land use and ownership at Yucca Mountain. Section 3.1.1.3 discusses the American Indian treaty issue. Section 3.1.1.4 discusses current airspace use near the Yucca Mountain site.

3.1.1.1 Regional Land Use and Ownership

This section summarizes, incorporates by reference, and updates Section 3.1.1.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-6 and 3-7). The Federal Government manages more than 85 percent of the land, about 240,000 square kilometers (93,000 square miles), in Nevada. About 42,000 square kilometers (16,000 square miles) are under state, local, or private ownership, and about 5,000 square kilometers (2,000 square miles) are American Indian lands. The Yucca Mountain site is in Nye County, which has an area of approximately 47,000 square kilometers (18,000 square miles) and is the largest county in Nevada. The Federal Government manages almost 98 percent of the land in the county, which includes the Nevada Test and Training Range (formerly Nellis Air Force Range), the Nevada Test Site, Bureau of Land Management-administered lands, a portion of Death Valley National Park, and portions of the Humboldt-Toiyabe National Forest. Private land uses in Nye County include residences, commercial facilities, and industrial sites that are largely, but not exclusively, within the boundaries of unincorporated towns, and agricultural and mining properties inside and outside these towns. The closest year-round housing near the repository is at what was once referred to as Lathrop Wells, about 22 kilometers (14 miles) south of the site; this location is now part of the unincorporated town of Amargosa Valley.

The Bureau of Land Management controls most of the lands to the south of the analyzed land withdrawal area and manages them in accordance with the *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement* (DIRS 176043-BLM 1998, all). This resource management plan designates land in the town of Amargosa Valley adjacent to the repository site entrance for *disposal* to the private sector, which indicates that the land has limited public use. Some land in the vicinity of the intersection of U.S. Highway 95 and Nevada State Route 373 is privately owned.

In 1999, Congress directed the Bureau of Land Management to expedite the conveyance of disposal lands in the vicinity of the intersection of U.S. Highway 95 and State Route 373 for conveyance to Nye County (Public Law 106-113). On March 9, 2001, the Bureau of Land Management issued a notice of realty action (66 FR 14194) to announce the noncompetitive sale of public lands (N-66239) and a recreation and public purpose conveyance in Nye County, Nevada (N-54086), which are both near this intersection (DIRS 181688-Bowlby 2007, all). The Bureau offered realty action N-66239 as a noncompetitive sale of approximately 1.4 square kilometers (350 acres) of public land to Nye County. Under the conditions of sale, Nye County had the exclusive right to purchase any and all of the proposed land at fair market value for a commercial purpose for a period of 5 years. Nye County purchased approximately 0.247 square kilometer (61 acres). The exclusive right to purchase expired on November 28, 2004. Although the exclusive right to purchase under special legislation has expired, Nye County has requested to purchase an additional 1.198 square kilometers (296 acres) by direct sale. Once the appraisal is complete, the Bureau will issue a *Federal Register* notice to notify the public of the potential sale and opportunity for comment. The process is likely to take a minimum of 6 months before Nye County may obtain possession of these 1.198 square kilometers, if the Bureau of Land Management approves a sale. Realty action N-54086 is a conveyance of 1.902 square kilometers (470 acres) of public land to Nye County for recreational or public purposes. The published intent of Nye County, once the land action is complete, is to lease the land to the Nevada Science and Technology Center, a nonprofit corporation, for the development of the Nevada Space Museum, outdoor exhibit areas, and associated facilities. Nye County and the Bureau of Land Management are involved in ongoing planning efforts for this area. The Nye County Yucca Mountain Project Gateway Area Concept Plan presents a land use concept to ensure orderly and compatible development of an approximate 23-square-kilometer (9-square-mile) area around the repository site entrance (DIRS 182345-Giampaoli 2007, all).

3.1.1.2 Current Land Use and Ownership at Yucca Mountain

This section summarizes, incorporates by reference, and updates Section 3.1.1.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-9). *The Yucca Mountain Development Act of 2002* (Public Law 107-200; 116 Stat. 735) designated the Yucca Mountain site for development as a *geologic repository*. For this Repository SEIS, the Yucca Mountain site is synonymous with the analyzed land withdrawal area. Figure 3-1 shows land use and ownership near Yucca Mountain, including land use agreements and the analyzed land withdrawal area. The analyzed land withdrawal area includes approximately 600 square kilometers (150,000 acres) and comprises approximately 320 square kilometers (79,000 acres) administered by DOE (Nevada Test Site), approximately 96 square kilometers (24,000 acres) administered by the U.S. Air Force (Nevada Test and Training Range), approximately 180 square kilometers (44,000 acres) administered by the Bureau of Land Management, and approximately 0.81 square kilometer (200 acres) of private land (Patented Mining Claim No. 27-83-0002). Patented Mining Claim No. 27-83-0002 is an active mining operation for Cind-R-Lite to mine volcanic cinders for use as a sole-source raw material in the manufacture of cinderblocks.

Most of the land controlled by the Bureau of Land Management in the analyzed land withdrawal area is associated with the Bureau's current right-of-way (N-47748) for previous Yucca Mountain site characterization activities. On December 20, 2007, the Bureau of Land Management extended this right-of-way until December 31, 2014 (DIRS 184655-BLM 2007, all). This land is open to public use with the

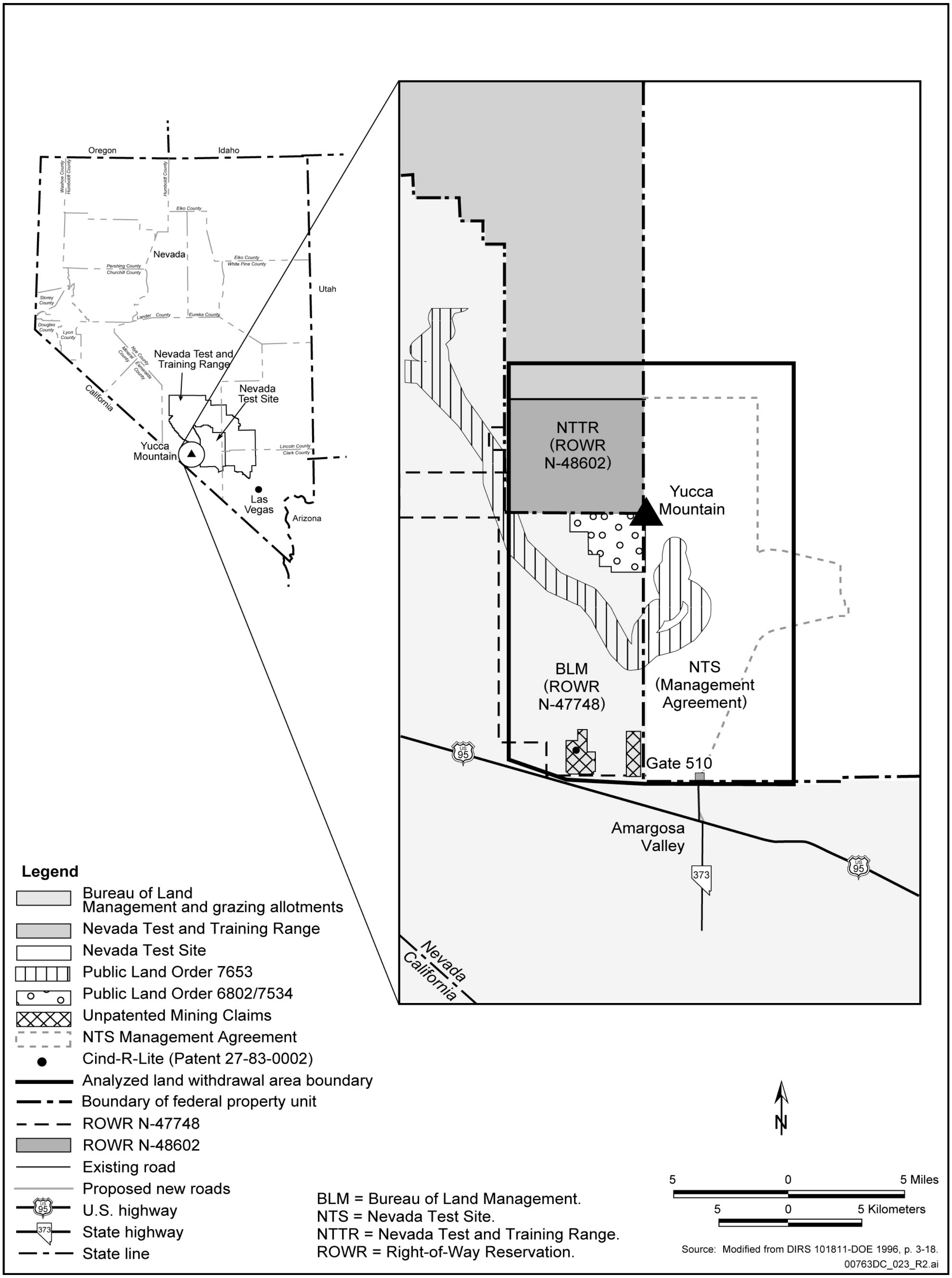

Figure 3-1. Land use and ownership near Yucca Mountain.

exception of approximately 17.22 square kilometers (4,255.50 acres) near the site of the proposed repository [Public Land Order 6802, extended via Public Land Order 7534 until January 31, 2010 (67 FR 53359)] and the existing patented mining claim.

The Bureau of Land Management manages surface resources on the Nevada Test and Training Range and granted DOE right-of-way N-48602 in 1994 to use about 75 square kilometers (19,000 acres) of land for site characterization activities. On April 4, 2004, the Bureau renewed the right-of-way, which was effective from April 10, 2004, through January 6, 2008. On January 2, 2008, the Bureau granted a 60-day extension and on March 6, 2008, the Air Force concurred with a 6-year renewal of the right-of-way (DIRS 185209-Domm 2008, all). This land is closed to public access and use.

The Bureau of Land Management issued Public Land Order 7653 in the *Federal Register* on December 28, 2005 (70 FR 76854). The order withdrew approximately 1,249 square kilometers (308,600 acres) of public land in Nevada in the Caliente *rail corridor* from surface entry and new mining claims for 10 years to enable DOE to evaluate the land for the potential construction, operation, and maintenance of a *rail line* for the transportation of spent nuclear fuel and high-level radioactive waste. Approximately 49 square kilometers (12,000 acres) of these lands are inside the analyzed land withdrawal area [approximately 26.3 square kilometers (6,500 acres) on Bureau of Land Management land and approximately 23 square kilometers (5,700 acres) on Nevada Test Site land] (Figure 3-1).

The Bureau of Land Management announced the receipt of a land withdrawal application on January 10, 2007, from DOE that requested the withdrawal of approximately 842 square kilometers (208,037 acres) of public land in Nevada from surface entry and mining through December 27, 2015, to evaluate the land for the potential construction, operation, and maintenance of a rail line for the transportation of spent nuclear fuel and high-level radioactive waste (72 FR 1235). The notice segregated the land from surface entry and mining for as long as 2 years (until January 9, 2009) while DOE conducts studies and analyses to support a final decision on the withdrawal application. Approximately 6.3 square kilometers (1,600 acres) of these lands are inside the analyzed land withdrawal area for the repository. Of the 6.3 square kilometers, approximately 1.4 square kilometers (350 acres) are small areas immediately adjacent to the Bureau of Land Management lands withdrawn by Public Land Order 7653. The additional 4.9 square kilometers (1,200 acres) are small areas immediately adjacent to the Nevada Test Site lands withdrawn by Public Land Order 7653 and an area that extends that withdrawal to the north by approximately 1.6 kilometers (1 mile).

The Bureau of Land Management land open to public use contains a number of unpatented mining claims. The Bureau permits off-road vehicle use and there is a designated utility corridor in the southern portion of these lands. A portion of an unused grazing allotment overlaps the analyzed land withdrawal area. This nonactive allotment has no permittees. More detailed information for the land controlled by the Bureau of Land Management in the region of Yucca Mountain is available in the *Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement* (DIRS 176043-BLM 1998, all).

Geodetic control monuments could exist in the analyzed land withdrawal area or areas to the south that DOE has proposed for an access road from U.S. Highway 95 and offsite facilities. Geodetic control monuments are physical reference objects placed in the ground for the purpose of surveying. Monuments serve to mark points used for geodetic control networks as well as points used to reference property boundaries. The National Geodetic Survey defines and manages a national geodetic control network that provides the foundation for transportation and communication; mapping and charting; and a multitude of scientific and engineering applications.

In addition to disturbances from repository site characterization and confirmation activities, the Nevada Test Site and the U.S. Department of Defense have actively used the land proposed for the repository. To analyze the amount of previously undisturbed land that construction, operations, and *monitoring* of the repository would disturb, DOE considered that 2.43 square kilometers (600 acres) were previously disturbed.

3.1.1.3 American Indian Treaty Issue

This section summarizes, incorporates by reference, and updates Section 3.1.1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-11 and 3-12). The Western Shoshone Tribe maintains that the Ruby Valley Treaty of 1863 gives them rights to 97,000 square kilometers (37,000 square miles) in Nevada, which includes the Yucca Mountain region. A legal dispute with the Federal Government led to a monetary award as payment for the land. However, the Western Shoshone have not accepted this award and maintain that there is no settlement. The U.S. Treasury is holding the monies in an interest-bearing account. In 1985, the U.S. Supreme Court ruled that even though the money has not been distributed the United States has met its obligations with the Commission's final award and the payment of the award into an interest-bearing trust account in the United States Treasury (DIRS 148197-United States v. Dann 1985, all).

In July 2004, President George W. Bush and Congress approved payment to the Western Shoshone Tribe of more than $145 million in compensation and accrued interest based on the 1872 value of 97,000 square kilometers (37,000 square miles) (Public Law 108-270; 118 Stat. 805). Under provisions of the law, payment by the United States Government officially subsumed Western Shoshone claims to 97,000 square kilometers of land in Nevada, Utah, California, and Idaho, based on the Ruby Valley Treaty of 1863. The law will distribute approximately $145 million in funds that the Indian Land Claims Commission awarded the Tribe. There are approximately 6,000 eligible tribal members, and the law sets aside a separate revenue stream for educational purposes.

On March 4, 2005, the Western Shoshone National Council filed a lawsuit against the United States, DOE, and the U.S. Department of the Interior in the federal district court in Las Vegas, Nevada. The complaint sought an injunction to stop federal plans for the use of Yucca Mountain as a repository based on the five established uses of the land within the boundaries of the 1863 Ruby Valley Treaty. On May 17, 2005, the U.S. District Court rejected a request from the Western Shoshone National Council for a preliminary injunction to stop DOE from applying for a license for the Yucca Mountain Project. The District Court dismissed the case for lack of jurisdiction in a judgment entered on November 1, 2005.

3.1.1.4 Airspace Use near Yucca Mountain

There are three types of airspace in the proximity of Yucca Mountain: Class A, Class G, and special use. Class G airspace is that airspace from the ground level to 5,500 meters (18,000 feet) above mean sea level; Class G airspace is uncontrolled airspace, over which air traffic control does not exercise authority. Class A airspace is airspace above 18,000 feet above mean sea level. Special-use airspace is airspace "wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both" (DIRS 182869-FAA 2007, all). Special-use airspace is further subdivided into *restricted areas* and military operations areas, as well as four other categories that this Repository SEIS does not discuss. The Federal Aviation Administration defines the two types of special-use airspace that occur in the proximity of Yucca Mountain as follows:

- Restricted areas are a type of special-use airspace that separate or confine air activities that are considered dangerous or unsafe to aircraft not involved in the activity. Regulations prohibit flights by nonparticipating military and civilian or commercial aircraft in this airspace without the controlling authority authorization. Restricted airspace can be designated for joint use, in which air traffic controllers can route nonparticipating civilian or military aircraft when there is no conflict with scheduled activities. If the area is not designated for joint use, nonparticipating aircraft are normally not permitted at any time. Restricted areas are rulemaking actions that are implemented by a formal amendment to 14 CFR Part 73.

- Military operations areas are a type of special-use airspace that allow for the separation of military training activities from other air traffic. Military operations areas are nonrulemaking actions.

Figure 3-2 shows the types of airspace in the vicinity of Yucca Mountain. The figure shows the proximity of the special-use airspace, including restricted areas and military operations areas, to Yucca Mountain and the analyzed land withdrawal area. The Yucca Mountain site is several kilometers from restricted areas R-4806, R-4807, and R-4809, which occupy approximately 12,100 square kilometers (4,700 square miles). The U.S. Air Force uses these restricted areas, which are part of the Nevada Test and Training Range, extensively for training and test flights. The Air Force provides operational control for restricted areas R-4806, R-4807, and R-4809.

DOE is the controlling authority for activities in restricted area R-4808, which is part of the Nevada Test Site. Restricted area R-4808 covers about 4,400 square kilometers (1,700 square miles) and consists of two areas, north (R-4808N) and south (R-4808S) (Figure 3-2). The Federal Aviation Administration has designated R-4808N as non-joint use. Portions of R-4808N overlay the footprint of the proposed repository. R-4808S is designated a joint-use area for the Nevada Test Site, Nellis Air Traffic Control Facility, and the Federal Aviation Administration Los Angeles Air Route Traffic Control Center to use on an as-needed basis.

Between the military operations area in California and the restricted airspace in Nevada, there is a corridor of Class A and Class G airspace that commercial, military, and private aircraft use (Figure 3-2). Within this corridor, there is airspace within 1.6 kilometers (1 mile) from the planned repository surface facilities, bordered to the north and east by the DOE restricted airspace and to the south by the Class A and G airspace, that is designated a low-altitude tactical navigation area. This airspace is used by the U.S. Air Force for A-10 aircraft and helicopter flights. The Air Force makes approximately 30 flights a week in this area. Other aircraft in this airspace generally consist of small piston-engine airplanes, helicopters, and gliders. *Identification of Airplane Hazards* discusses a ground survey of this area and concludes that there is little civilian air activity (DIRS 181770-BSC 2007, pp. 22 and 23).

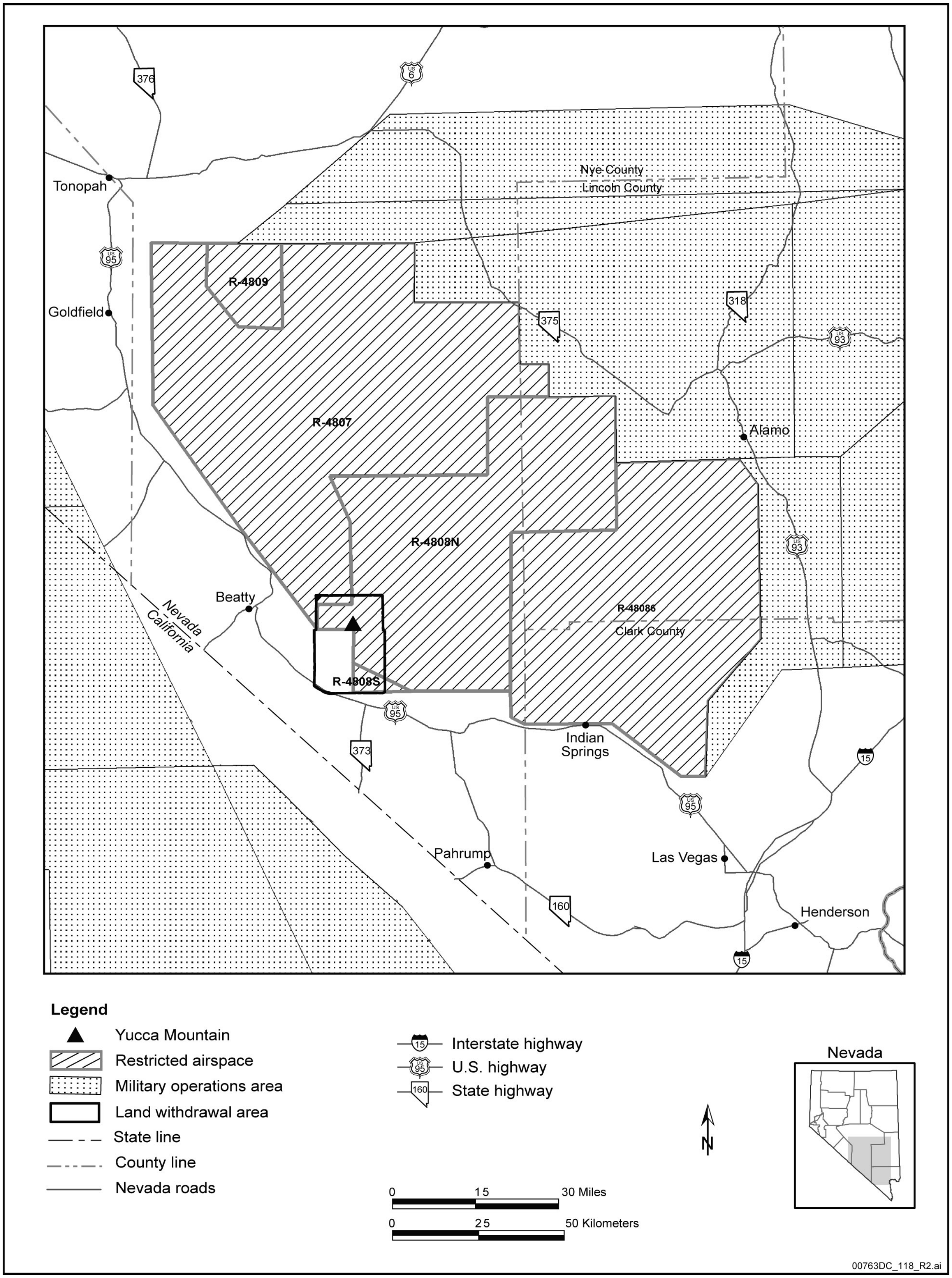

Figure 3-2. Airspace use near Yucca Mountain.

3.1.2 AIR QUALITY AND CLIMATE

> **AMBIENT AIR**
>
> The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.

The region of influence for air quality and climate is an area within a radius of approximately 84 kilometers (52 miles) around the Yucca Mountain site. This region encompasses portions of Esmeralda, Clark, Lincoln, and Nye counties in Nevada and a portion of Inyo County, California.

To determine the air quality and climate for Yucca Mountain, DOE site characterization activities included *ambient air* and meteorological data collection. DOE has monitored the air for *criteria pollutants:* gases (*carbon monoxide*, *nitrogen dioxide*, *ozone*, and *sulfur dioxide*) and PM_{10}. PM_{10} is *particulate matter* with an aerodynamic diameter of 10 micrometers or less. This section summarizes, incorporates by reference, and updates Section 3.1.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-12 to 3-17).

3.1.2.1 Air Quality

Air quality is determined by measuring concentrations of certain pollutants (called criteria pollutants) in the atmosphere. The U.S. Environmental Protection Agency (EPA) established the *National Ambient Air Quality Standards*, as directed by the *Clean Air Act* (42 U.S.C. 7401 et seq.), to define the levels of air quality that are necessary to protect the public health (primary standards) and the public welfare (secondary standards) with an adequate margin of safety. The National Ambient Air Quality Standards specify the maximum pollutant concentrations and frequencies of occurrence for specific averaging periods.

> **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.

The criteria pollutants under the National Ambient Air Quality Standards are ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead. The Nevada Administrative Code defines the Nevada standards of quality for *ambient* air for each criteria pollutant. The Nevada standards are the same as the National Ambient Air Quality Standards with the exception of a more restrictive carbon monoxide standard in locations with a ground elevation above 5,000 feet. The EPA designates an area as being in attainment for a particular pollutant if the concentration of that pollutant in ambient air is below the EPA standards. Areas in violation of one or more of these standards are called "*nonattainment areas*." If an area has not been designated as nonattainment and if there are no representative air quality data, the area is listed as "unclassifiable." For regulatory purposes, unclassifiable areas are considered to be in attainment. Section 176(c)(1) of the *Clean Air Act* 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 a smaller air quality region). The EPA general conformity regulations (40 CFR 93, Subpart B) contain guidance for determination of whether a proposed federal action would cause emissions to be above certain levels in locations designated as nonattainment or maintenance areas. By definition, a “maintenance area” is a region that was previously in nonattainment, but that EPA or the state has redesignated as an attainment area with a requirement to develop a maintenance plan.

The Prevention of Significant Deterioration program of the *Clean Air Act* controls air quality in attainment areas; its goal is to prevent significant deterioration of existing air quality. This program is applicable only to point sources and does not apply to transportation sources. Under the Prevention of Significant Deterioration provisions, Congress established a land classification scheme for areas of the country with air quality better than the National Ambient Air Quality Standards. Under this scheme, Class I allows very little deterioration of air quality, Class II allows moderate deterioration, and Class III allows more deterioration, but in all cases the pollution concentrations must not violate any National Ambient Air Quality Standard. Congress designated certain areas as mandatory Class I, which precludes redesignation to a less-restrictive class to acknowledge the value of maintaining these areas in relatively pristine condition. In addition, Congress protected other nationally important lands by originally designating them as Class II and restricting redesignation to Class I only. All other areas were initially classified as Class II, with the possibility of redesignation as Class I or Class III.

The quality of the air at the Yucca Mountain site and the nearby parts of the Nevada Test Site, Nevada Test and Training Range (including southwestern Lincoln County), southwestern Esmeralda County, and southern Nye County within the air quality region of influence is unclassifiable because there are limited air quality data (40 CFR 81.329). However, the limited data collected at the site indicate that the air quality is within applicable National Ambient Air Quality Standards and is, therefore, in attainment.

While the air quality in most of Nye County is unclassifiable, a portion of Hydrologic Basin 162 (near the Town of Pahrump) has a maintenance status. Historical monitoring data since 2000 for PM_{10}, collected by the Nevada Division of Environmental Protection, documented exceedences of the National Ambient Air Quality Standards. Nye County and Pahrump, in cooperation with the Nevada Division of Environmental Protection, successfully negotiated with the EPA to enter into a Memorandum of Understanding. The Memorandum requires the parties to prepare a Clean Air Action Plan for the portion of Basin 162 within the Pahrump Regional Planning District, where rapid growth and development have affected air quality with increased *fugitive dust* levels. As required by the Memorandum, Nye County has enacted an ordinance to regulate construction and other ground-disturbing activities and has implemented a mandatory program of Best Practicable Methods for use on all ground disturbances of 0.5 acre or greater.

The portions of Clark County within the air quality region of influence are in attainment with National Ambient Air Quality Standards and Nevada standards. Inyo County, California, is in attainment with national and California ambient air quality standards for carbon monoxide, nitrogen dioxide, and sulfur dioxide. Portions of Inyo County in the air quality region of influence are in attainment with the national PM_{10} standard, but are in nonattainment with the more restrictive California standard (DIRS 179903-California Air Resources Board 2006, all). In the region of influence, all areas are designated Class II. One area, Death Valley National Park, is a protected Class II area. Death Valley National Park could be redesignated Class I, which would make the allowable deterioration less than that currently allowed. The nearest boundary of Death Valley National Park is approximately 35 kilometers (22 miles) southwest of the proposed Yucca Mountain site development areas.

The construction and operation of a facility in an attainment area could be subject to the requirements of the Prevention of Significant Deterioration program if the facility received a classification as a major point source of air pollutants. At present, the proposed Yucca Mountain site development areas and the Nevada Test Site have no sources subject to those requirements.

DOE maintains an air quality operating permit from the State of Nevada. The permit places specific operating conditions on equipment such as generators and compressors that DOE used during site characterization and uses during current activities. These conditions include limiting the emission of criteria pollutants; defining the number of hours per day and per year a system is allowed to operate; and determining the testing, monitoring, and recordkeeping necessary for the system. Nevada renewed the air quality operating permit in 2006 (DIRS 179968-DeBurle 2006, all).

DOE began monitoring PM_{10} in 1989 as part of site characterization activities and later as part of the Nevada air quality operating permit requirements. Monitoring for PM_{10} continues even though it is no longer a requirement of the air quality operating permit. Concentration levels of PM_{10} remain well below applicable National Ambient Air Quality Standards (Table 3-2). From October 1991 through September 1995, DOE monitored gaseous criteria pollutants (carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide) as part of site characterization. During air monitoring for gaseous pollutants, the concentration levels of each pollutant, except ozone, were well below applicable National Ambient Air Quality Standards and Nevada standards (Table 3-2). The maximum 1-hour ozone concentration was 80 percent of the National Ambient Air Quality Standard, which was revoked in 2005. An 8-hour ozone concentration was not measured. DOE did not monitor for particulate matter with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$) as part of site characterization. $PM_{2.5}$, which is a subset of PM_{10}, was not regulated under the National Ambient Air Quality Standards until 1997. Sources of $PM_{2.5}$ include smoke, power plants, and gasoline and diesel engines.

3.1.2.2 Climate

The region around Yucca Mountain has a semiarid climate, with annual precipitation totals that range between approximately 10 and 25 centimeters (4 and 10 inches). Mean nighttime and daytime air temperatures typically range from 22 to 34 degrees Celsius (°C) [72 to 93 degrees Fahrenheit (°F)] in the summer and from 2° to 10.5°C (34° to 51°F) in the winter. Temperature extremes range from -15° to 45°C (5° to 113°F). On average, the daily range in temperature change is about 10°C (18°F).

In the valleys, local topography channels airflow, particularly at night during stable conditions. With the exception of the nearby confining terrain, which includes washes and small canyons on the east side of Yucca Mountain, local wind patterns have a strong daily cycle of daytime winds from the south and nighttime winds from the north. Confined areas also have daily cycles, but the wind directions are along terrain axes, typically upslope in the daytime and downslope at night. Figure 3-3 shows the wind patterns in the vicinity of the proposed repository, and illustrates the fluctuations in data from different heights and times of day.

Severe weather can occur in the region, usually in the form of summer thunderstorms. These storms can generate an abundance of lightning, strong winds, and heavy and rapid precipitation. Tornadoes can occur, although they are not a substantial threat.

Table 3-2. Comparison of criteria pollutant concentrations measured at the Yucca Mountain site with national, Nevada, and California ambient air quality standards.

Criteria pollutant	Primary and Secondary NAAQS (except as noted)		Highest concentration measured at Yucca Mountain[b,c]	Nevada standards[d]	California standards[e]
	Averaging period	Concentration[a]			
Sulfur dioxide	Annual[f]	0.03 part per million	0.002	Same	None
	24-hour[g]	0.14 part per million	0.002	Same	0.04 part per million
Sulfur dioxide (secondary)	3-hour[g]	0.5 part per million	0.002	Same	None
PM_{10}[h]	24-hour[i]	150 micrograms per cubic meter	67	Same	50 micrograms per cubic meter
$PM_{2.5}$	Annual[j]	15 micrograms per cubic meter	NA[k]	None	12 micrograms per cubic meter
	24-hour[l]	35 micrograms per cubic meter	NA	None	No separate state standard
Carbon monoxide	8-hour[g]	9 parts per million	0.2	Same[m]	Same
	1-hour[g]	35 parts per million	0.2	Same	20 parts per million
Nitrogen dioxide	Annual[f]	0.053 part per million	0.002	Same	None
Ozone	8-hour[n]	0.075 part per million	NA	None	0.07 part per million
	1-hour[o]	None	0.096	0.12 part per million	0.09 part per million
Lead	Quarterly average	1.5 micrograms per cubic meter	NA	Same	1.5 micrograms per cubic meter for 30-day average

a. Source: 40 CFR 50.4 through 50.12.
b. Units correspond to the units listed in the concentration column.
c. Source: DIRS 155970-DOE 2002, p. 3-13.
d. Source: Nevada Administrative Code 445B.22097.
e. Source: DIRS 179903-California Air Resources Board 2006, all.
f. Average not to be exceeded in the period shown.
g. Average not to be exceeded more than once in a calendar year.
h. PM_{10} annual standard was revoked effective December 17, 2006. Available evidence does not suggest a link between long-term exposure to PM_{10} and health problems.
i. Number of days per calendar year exceeding this value should be less than 1.
j. Expected annual arithmetic mean should be less than the value shown.
k. No $PM_{2.5}$ monitoring data have been collected at Yucca Mountain. NAAQS regulations for $PM_{2.5}$ were not issued until 1997, which was after site characterization monitoring had finished. Ongoing monitoring for fugitive dust (PM_{10}) does not monitor for $PM_{2.5}$; $PM_{2.5}$ is created by fossil-fuel combustion and is not a major component of fugitive dust.
l. 98th-percentile value should be less than value shown. Effective December 17, 2006.
m. The Nevada ambient air quality standard for carbon monoxide is 9 parts per million at less than 5,000 feet above mean sea level and 6 parts per million at or above 5,000 feet; Nevada Administrative Code 445B.22097.
n. On March 12, 2008, the U.S. Environmental Protection Agency revised the 8-hour ozone standards from 0.08 parts per million to 0.075 parts per million, to be effective on May 27, 2008. To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed this 0.075 parts per million.
o. As of June 15, 2005, the EPA revoked the 1-hour ozone standard in all areas except the 14, 8-hour ozone nonattainment Early Action Compact Areas (DIRS 181491-EPA 2007, all). None of the areas is in Nevada.

NA = Not available.
NAAQS = National Ambient Air Quality Standard.
PM_{10} = Particulate matter with an aerodynamic diameter of 10 micrometers or less.
$PM_{2.5}$ = Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.

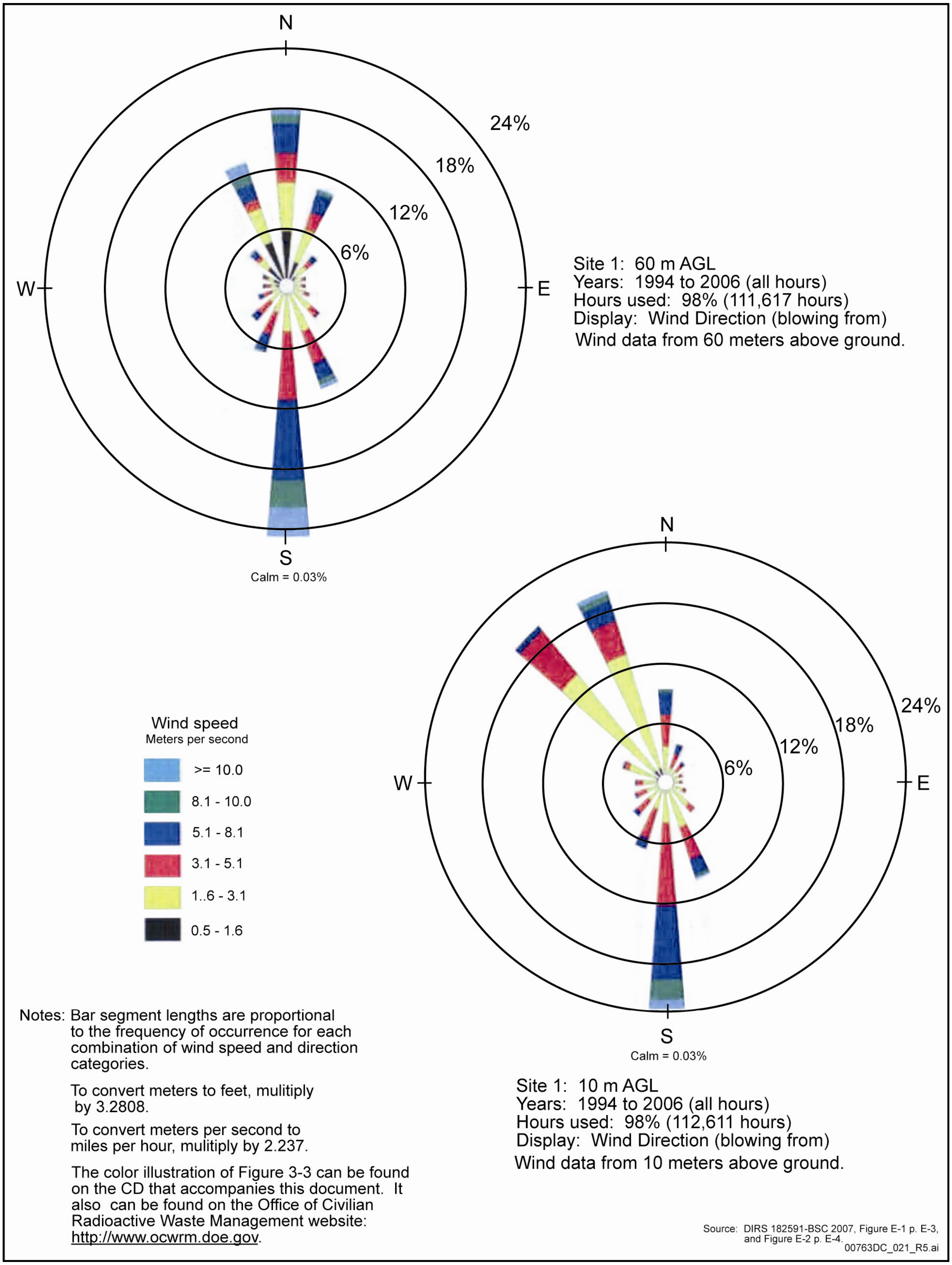

Figure 3-3. Wind patterns in the Yucca Mountain vicinity.

Paleoclimatology

Paleoclimatology is the study of ancient climates by examination of biological and geological proxy indications of climatic conditions in the geologic past. The primary assumption to predict future climatic conditions in the Yucca Mountain region is that climate is cyclical and, therefore, a study of past climates provides an insight into potential future climates. Studies indicate that past climatic conditions at Yucca Mountain, which therefore could occur in the future, fall into the following categories: (1) a warm and dry interglacial period similar to the present-day climate, (2) a warm and wet monsoon period characterized by hot summers and increased summer rainfall, and (3) a cool and wet glacial-transition period (DIRS 170002-BSC 2004, all). The interglacial period has the lowest annual precipitation and highest annual temperatures of the climate periods, and represents the current climate at Yucca Mountain.

The following compares the three climate categories (DIRS 170002-BSC 2004, all; DIRS 161591-Sharpe 2003, all):

1. The warm and dry interglacial period would be similar to the present-day climate, which has a mean annual temperature of 13°C (55°F) and a mean annual precipitation of 12 centimeters (5 inches).

2. The warmer and wetter monsoon period would have mean annual temperatures that ranged from approximately 13° to 17°C (55° to 63°F) and mean annual precipitation between 12 and 40 centimeters (5 and 16 inches).

3. The cooler and wetter intermediate glacial-transition period would have mean annual temperatures that ranged from approximately 8° to 10°C (46° to 50°F) and mean annual precipitation between 20 and 45 centimeters (8 and 18 inches).

3.1.3 GEOLOGY

In the Yucca Mountain FEIS, DOE described the region of influence for geology as the physiographic setting (characteristic landforms), *stratigraphy* (rock strata), and geologic structure (structural features that result from rock deformations) of the region and of Yucca Mountain. DOE also addressed *seismicity* (*earthquake* activity) and volcanism in the Yucca Mountain region as geologic phenomena that could affect a repository. In addition, DOE described the potential for mineral and energy resources to occur at or near the site of the proposed repository. This Repository SEIS addresses the same region of influence and associated factors. This section summarizes, incorporates by reference, and updates Section 3.1.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-17 to 3-34) and presents new information, as applicable, from studies and investigations that have continued since completion of the Yucca Mountain FEIS.

Since 1997, Nye County, Nevada, has been performing investigations under a cooperative agreement with DOE to address technical issues and data gaps in the physical characterization of the land between Yucca Mountain and the potentially *affected environment* where Nye County residents live and work. These efforts, under Nye County's Independent Scientific Investigations Program and Early Warning Drilling Program, have included drilling of exploratory boreholes and monitoring wells, sampling of borehole cuttings and cores, and geologic and geophysical logging. DOE considered the information these programs gathered in the geology and hydrology discussions in the Yucca Mountain FEIS and has incorporated, as applicable, information it has collected since the completion of the Yucca Mountain FEIS into this Repository SEIS, particularly in the Section 3.1.4 hydrology discussion. More information on the Nye County programs is available from the County's Internet site at http://www.nyecounty.com.

Inyo County, California, has also performed investigative work under a cooperative agreement with DOE. The focus of the Inyo County work has been the investigation of geologic and hydrologic features related to potential groundwater transport of radionuclides into the county, particularly the connection between the lower carbonate aquifer and the surface environment (DIRS 185423-ICYMRAO n.d., p. 1). In its work, Inyo County supported a U.S. Geological Survey effort to update a geologic map of the southern Funeral Mountains, including groundwater discharge sites. This effort involved geophysical studies in the southern Funeral Mountains, the Amargosa Valley area, and the Devils Hole area to better understand the subsurface in those areas. In addition, the County completed several deep exploratory wells to locate and characterize the lower carbonate aquifer in the area of the southern Funeral Mountains and Amargosa Desert. Because a primary purpose of the Inyo County efforts was to obtain a better characterization of the carbonate aquifer in these areas, Section 3.1.4 addresses results of these studies further. Inyo County has posted reports from its efforts at the Inyo County Yucca Mountain Repository Assessment Office Web site (http://www.inyoyucca.org/lsn.html).

3.1.3.1 Physiography (Characteristic Landforms)

Yucca Mountain is in the southern part of the *Great Basin*, which is characterized by generally north-trending, linear mountain ranges separated by intervening valleys, or basins. The mountain ranges are mostly the result of past episodes of faulting that resulted in the elevation differences between the ranges and the adjacent valleys. Erosion of the mountains filled the adjacent valleys with rock debris that ranges from very coarse boulders to sand and silt. Within this setting, Yucca Mountain is part of the southwestern Nevada volcanic field, a volcanic plateau that formed between about 14 and 11.5 million years ago. As a result, Yucca Mountain is a product of both volcanic activity and faulting. Most of the volcanic rocks now at or near the surface of Yucca Mountain erupted from the Timber Mountain caldera (one of the centers of the southwestern Nevada volcanic field), the remnants of which are north of Yucca Mountain.

In general, west-facing slopes at Yucca Mountain are steep and east-facing slopes are gentle. The crest of Yucca Mountain reaches elevations from 1,500 to 1,900 meters (4,900 to 6,300 feet) above sea level, while the bottoms of the adjacent valleys are approximately 650 meters (2,100 feet) lower. Pinnacles Ridge borders the mountain on the north, Crater Flat is to the west, the *Amargosa Desert* is south, and the Calico Hills and *Jackass Flats* are on the east side. Figure 3-6 of the Yucca Mountain FEIS shows these and other physiographic features in the vicinity of Yucca Mountain. Crater Flat, which is between Bare Mountain to the west and Yucca Mountain to the east, contains four prominent volcanic cinder cones that rise above the valley floor. Jackass Flats is an oval-shaped valley surrounded (in a clockwise direction) by Yucca, Shoshone, Skull, and Little Skull mountains. Both Crater Flat and Jackass Flats drain southward to the *Amargosa River*. Drainage from Jackass Flats is via *Fortymile Wash*, a prominent drainage along the east side of Yucca Mountain.

3.1.3.1.1 *Site Stratigraphy and Lithology*

A thick series of volcanic rocks (including those of Yucca Mountain) that overlie much older *sedimentary rocks* of largely marine origin dominate the rock strata, or *stratigraphic units*, in the region of Yucca Mountain. Table 3-3 lists the generalized rock units of the region by the geologic age of their deposition.

Table 3-3. Highly generalized stratigraphy for the Yucca Mountain region.

Geologic age designation	Major rock types (lithologies)
Cenozoic Era	
Quaternary Period (less than 1.6 Ma)	Alluvium and colluvium; basalt.
Tertiary Period (65 – 1.6 Ma)	Silicic ash-flow tuffs; minor basalts. Predominantly volcanic rocks of the southwestern Nevada volcanic field (includes Topopah Spring Tuff, host rock for the proposed repository).
Mesozoic Era (240 – 65 Ma)	Rocks of this age are of minor significance to the Yucca Mountain region. Small Mesozoic igneous intrusions occur near Yucca Mountain.
Paleozoic Era (570 – 240 Ma)	Three major lithologic groups (lithosomes) predominate: a lower (older) carbonate (limestone, dolomite) lithosome deposited during the Cambrian through Devonian periods, a middle fine-grained clastic lithosome (shale, sandstone) formed during the Mississippian Period, and an upper (younger) carbonate lithosome formed during the Pennsylvanian and Permian periods.
Precambrian Era (greater than 570 Ma)	Quartzite, conglomerates, shale, limestone, and dolomite that overlie older igneous and metamorphic rocks that form the crystalline "basement."

Source: DIRS 155970-DOE 2002, p. 3-21.
Ma = Approximate years ago in millions.

Only Tertiary Period and younger rocks are exposed at Yucca Mountain, but older rock units are exposed at Bare Mountain, the Calico Hills, and the Striped Hills, to the west, northeast, and southeast of Yucca Mountain, respectively. Detailed information about the characteristics of the older rocks beneath Yucca Mountain is sparse because only one borehole, about 2 kilometers (1.2 miles) east of Yucca Mountain, has penetrated these rocks. Paleozoic Era carbonate rocks occur in this borehole at a depth of about 1,250 meters (4,100 feet). Investigations by Nye County, Nevada, and Inyo County, California, have completed other exploratory boreholes in the Paleozoic carbonate rocks to the south of Yucca Mountain.

DOE has studied the Tertiary Period volcanic units in which it would emplace spent nuclear fuel and high-level radioactive waste at Yucca Mountain in great detail. These units consist mostly of tuffaceous rock, or *tuff*, which forms when a mixture of volcanic gas and ash violently erupts, flows, and settles in large sheets. The different volcanic units or layers are characterized based on changes in depositional features, the development of zones of welding and crystallization, and the development of alteration products in some rocks. DOE used mineral and chemical composition and properties such as density and porosity to distinguish some units. Table 3-7 of the Yucca Mountain FEIS listed the units that form the Tertiary volcanic rock sequence at Yucca Mountain from youngest (about 11.5 million years old) to oldest (more than 14 million years old) and provided characteristics of each. Tuffs of the Paintbrush Group, primarily bracketed by the Timber Mountain Group tuffs above and the Calico Hills Formation below, are of primary significance to the Proposed Action because of their proximity to the proposed repository *emplacement* level. At the base of the Paintbrush Group is the Topopah Spring Tuff, in which DOE tunneled the Exploratory Studies Facility and where the emplacement area would be. Figure 3-4 is a map of the general bedrock geology of the proposed repository location; the Yucca Mountain FEIS contained a similar figure. Figure 3-4 shows the updated shape and location of the repository outline (the proposed drift boundary). Figure 3-5 is a vertical cross section through the southern part of the area in Figure 3-4. The cross section shows the subsurface expression of the mapped units, including such structural aspects as the east-dipping rock units and the predominantly west-dipping normal *faults*.

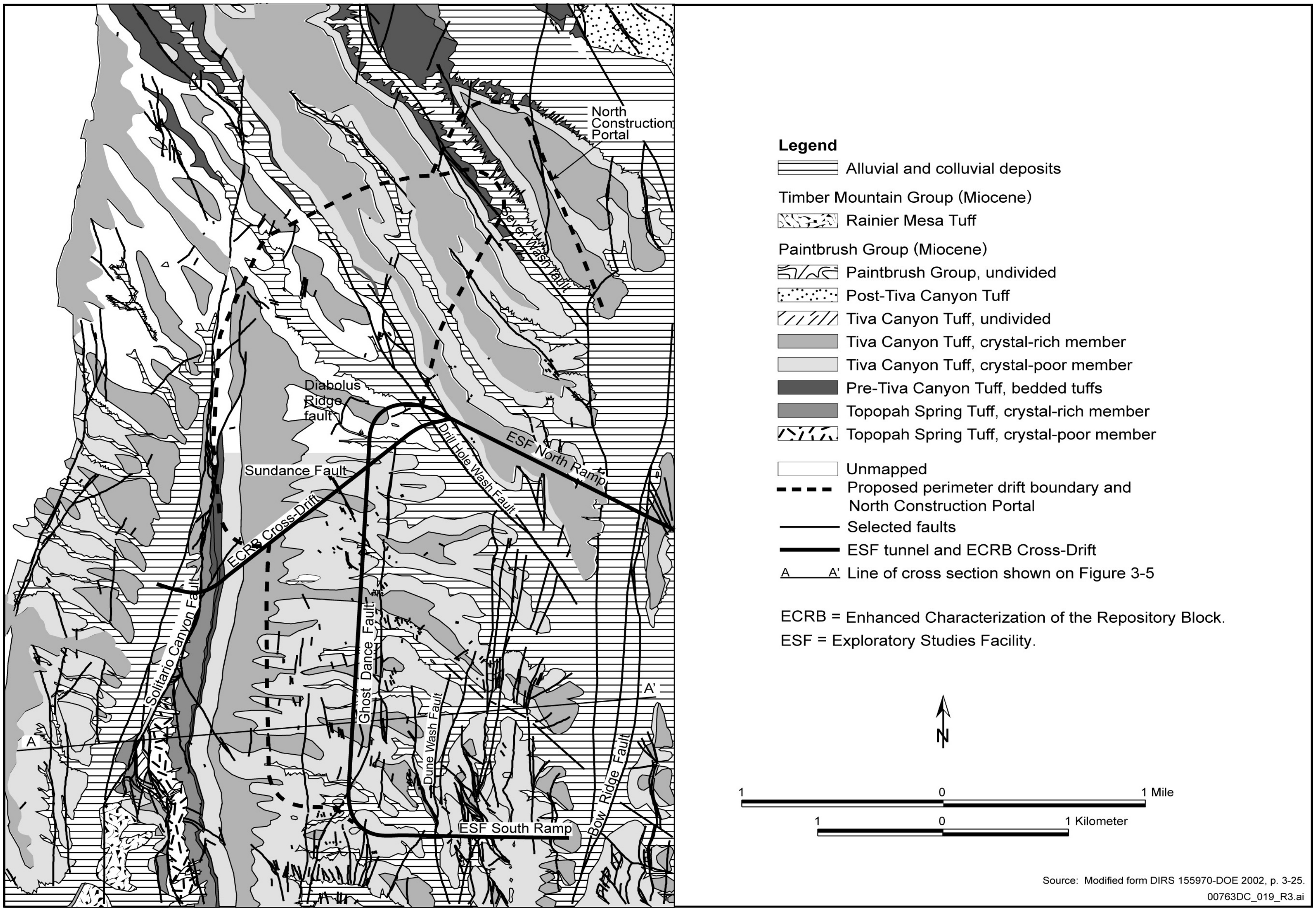

Figure 3-4. General bedrock geology of the proposed repository.

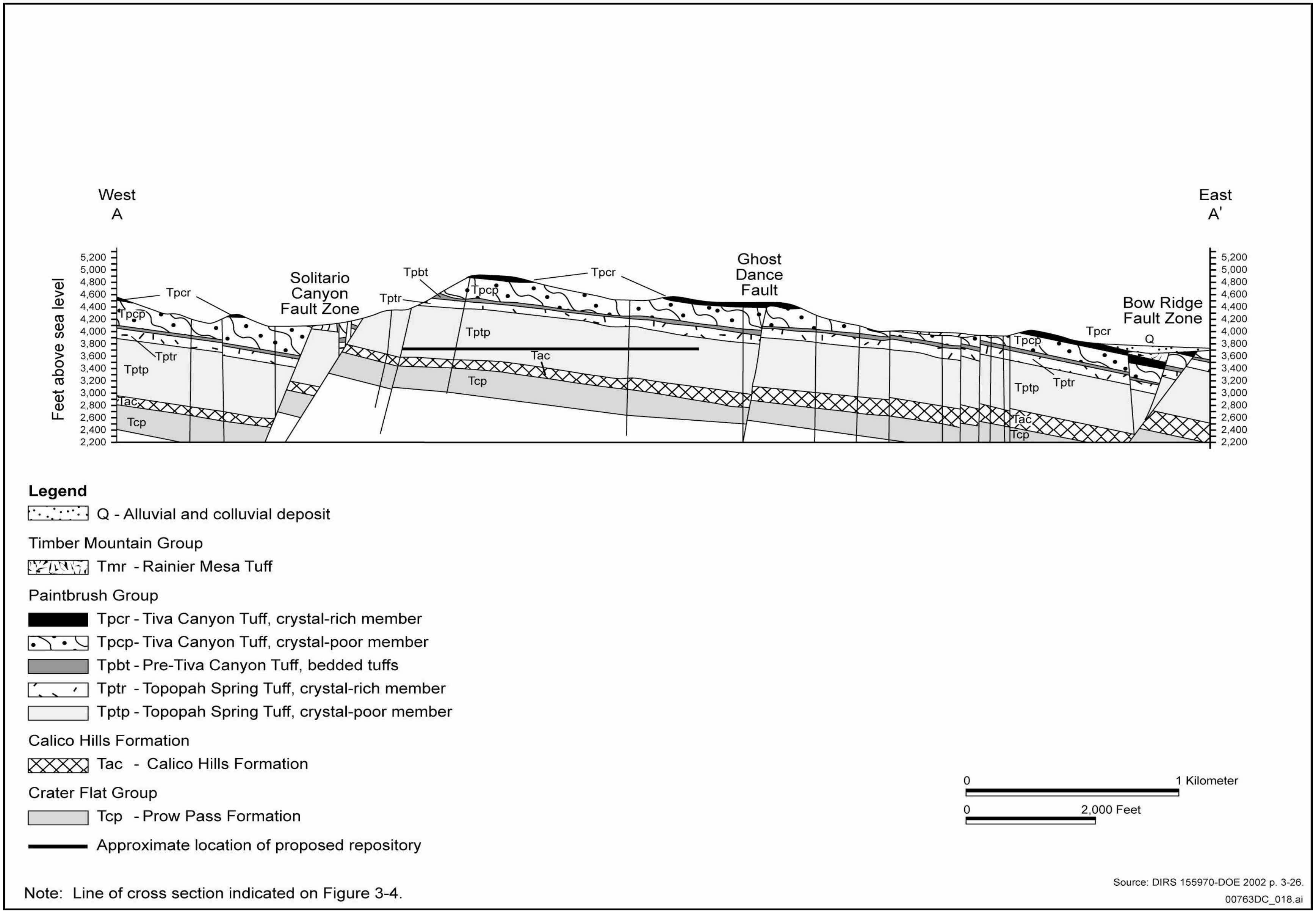

Figure 3-5. Simplified geologic cross section of Yucca Mountain, west to east.

The volcanic rock units in Figures 3-4 and 3-5 formed during the Tertiary Period and, although younger volcanic rocks occur locally in the Yucca Mountain vicinity, they are of limited extent and represent low-volume eruptions. The younger rock formations typically consist of a single main cone surrounded by a small field of basalt flows. Four northeast-trending cinder cones in the center of Crater Flat (to the west of Yucca Mountain) are primary examples of volcanic remnants that are younger than the Tertiary Period rock sequences. These four cinder cones are about 1 million years old. The youngest basaltic center in the vicinity is the 70,000- to 90,000-year-old Lathrop Wells center, a single cone about 16 kilometers (10 miles) south of the Yucca Mountain *South Portal development area*. The youngest stratigraphic units at Yucca Mountain are the surficial deposits shown in Figures 3-4 and 3-5 as alluvial (stream) and colluvial (hill slope) deposits.

3.1.3.1.2 *Selection of Repository Host Rock*

DOE based the selection of the repository emplacement area on several considerations: (1) depth below the ground surface sufficient to protect spent nuclear fuel and high-level radioactive waste from exposure to the surface environment, (2) extent and characteristics of the host rock, (3) location of major faults that could adversely affect the stability of underground openings or act as pathways for water flow, and (4) location of the *water table* in relation to (below) the proposed repository. DOE would use the same middle to lower portion of the Topopah Spring Tuff (Figure 3-5) for the emplacement area, as the Yucca Mountain FEIS described.

Experience and information that DOE has gained from the excavation of the Exploratory Studies Facility, excavation of the Enhanced Characterization of the Repository Block *Cross-Drift*, and associated studies show this section of rock meets the selection criteria. DOE has demonstrated that it can construct stable openings in this rock, that the rock's thermal and mechanical properties enable it to accommodate the anticipated range of temperatures, that the location of the volume of rock necessary to host the repository is between faults with evidence of displacement during the Quaternary Period (that is, in the past 1.6 million years and, in this case, the faults are the major north-trending, block-bounding faults), and that the location of the water table is well below the selected repository horizon [more than 210 meters (690 feet) (DIRS 185301-DOE 2008, p. 1-3)] .

3.1.3.1.3 *Potential for Volcanism at the Yucca Mountain Site*

There have been extensive investigations of the volcanic geology and stratigraphy at Yucca Mountain and the surrounding region, and DOE has used this information to evaluate the potential for future eruptions to occur that could adversely affect long-term performance of the proposed repository. In 1995 and 1996, a panel of 10 recognized experts from federal agencies, national laboratories, and universities evaluated the potential for disruption of the repository by a volcanic intrusion, also known as a dike. The result of that effort was an estimate of the average *probability* of 1 chance in 7,000 that a volcanic dike could intersect or disrupt the repository during the first 10,000 years after *repository-closure*. As the Yucca Mountain FEIS reported, DOE increased this probability to 1 chance in 6,300 to account for a slightly larger repository footprint than the expert panel considered (DIRS 155970-DOE 2002, p. 3-27). The likelihood of an intersection increases by small amounts if the footprint size increases because the larger area presents a larger "target" for the dike to intersect, should an *event* occur.

Since DOE completed the Yucca Mountain FEIS, the size and shape of the repository footprint has changed slightly, and so has the probability of a dike intersection. DOE based the new calculation on the work in 1995 and 1996 by the panel of experts. The estimated probability of a dike intrusion is now 1 chance in 5,900 during the first 10,000 years, with 5th- and 95th-percentile values of 1 chance in 133,000 and 1 in 1,800, respectively (DIRS 169989-BSC 2004, pp. 7-1 and 7-2, and Table 7-1).

DOE has collected additional aeromagnetic and ground magnetic data about the Yucca Mountain vicinity since 2002. As reported in *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (DIRS 169989-BSC 2004, p. 6-79), there were 20 to 24 identified magnetic anomalies in Crater Flat and northern Amargosa Valley. These anomalies could represent buried basaltic volcanoes. At the time, the expert elicitation effort of 1995 and 1996 knew of eight of these anomalies and included them in the evaluations. DOE evaluated the effect of the additional anomalies on the probability calculations for a volcanic dike intersection. Using several assumptions, which included that the anomalies actually represent basaltic volcanic centers, the mean annual frequency of intersection could increase (DIRS 169989-BSC 2004, pp. 6-79 to 6-83). In 2004, DOE completed a high-resolution aeromagnetic survey, then initiated a drilling program in the areas of the anomalies to determine the age and other characteristics of encountered basalts. The Department completed seven new drill holes at locations it selected to include each major cluster or alignment of anomalies. Four of the anomalies are buried basalt; three of these were dated as Miocene basalts with ages ranging from about 11.1 to 9.4 million years, and the other was dated as younger Pliocene basalt with an age of about 3.8 million years (DIRS 182132-NRC 2007, pp. 58 and 59). The other three drill holes found only tuff material, though one might include basalt. If basalt was present at a depth greater than the drill hole in this last case, it would probably be of Miocene age. These findings reduce some of the uncertainty about buried basalts in the region and could lower estimates of the probability of a dike intrusion of the repository because Miocene basalts, being much older, would have limited influence on models or estimates of future volcanic recurrence. In addition, it was significant for future estimates of volcanic recurrence that none of the younger, post-Miocene basalt occurred in drill holes on the east side of Yucca Mountain. Thus, there is no evidence that the younger volcanic zone in Crater Flat extends east through Yucca Mountain (DIRS 182132-NRC 2007, pp. 62 and 165). DOE is conducting an update of the 1995 and 1996 expert elicitation to review and interpret the new information. For the analysis in this Repository SEIS, the Department used the information derived from the 1995 and 1996 panel of experts.

3.1.3.2 Geologic Structure

Geologic structures, such as folds and faults, result from the deformation of rocks after their original formation. The Yucca Mountain FEIS discussed the north-trending, block-bounding faults that crustal extension has formed during the last 20 million years and the intrablock and subsidiary faults that occur between the block-bounding faults. The estimated total displacement along the major block-bounding faults in the Yucca Mountain region during the last 12 million years ranges from less than 100 to more than 500 meters (330 to 1,600 feet). Displacements on these faults during the Quaternary Period (the last 1.6 million years) range from 0 to 6 meters (0 to 20 feet), with most about 1 to 2.5 meters (3.3 to 8.2 feet). In terms of the amount of movement per seismic event, the block-bounding faults of primary significance to Yucca Mountain have moved from 0 to 1.7 meters (0 to 5.6 feet) per event. The Solitario Canyon Fault along the west side of Yucca Mountain and the Bow Ridge Fault along the east side are the major block-bounding faults that bracket the emplacement area. Within this block, there is no clear evidence of any Quaternary movement along the intrablock and subsidiary faults (that is, the age of the last movement along these intrablock and subsidiary faults is either pre-Quaternary or undetermined).

In addition to rock *fractures* from faulting, there are fractures (or joints) in the rock at Yucca Mountain where there has been no displacement of the sides in relation to each other. These joints are divided into different types based on how and when they form. The Yucca Mountain FEIS described early cooling joints, later tectonic joints, and joints due to erosional unloading. Joints do not typically form through-going features like faults, but do have geoengineering aspects (those in relation to rock excavation) and hydrologic aspects (groundwater movement in rock) that DOE considered in the repository performance analysis.

The Yucca Mountain FEIS provided details on the geologic structure of the Yucca Mountain region and the location of the proposed repository. This information included Figure 3-10 of the FEIS, which showed the locations of the major faults at Yucca Mountain superimposed on the outline of the repository emplacement area, and Table 3-8 of the FEIS, a list of major faults by name, with descriptions and summaries of displacement characteristics.

3.1.3.3 Modern Seismic Activity

The Yucca Mountain FEIS described the nature of seismic activity at the Nevada Test Site since 1978 and included a description of the largest recorded historic earthquake within 50 kilometers (30 miles) of Yucca Mountain, which was the Little Skull Mountain earthquake in 1992 about 20 kilometers (12 miles) southeast of Yucca Mountain. This seismic event had a Richter scale magnitude of 5.6 and was apparently triggered by a 7.3-magnitude earthquake at Landers, California, 300 kilometers (190 miles) to the south of Yucca Mountain, which occurred 20 hours earlier (DIRS 169734-BSC 2004, p. 4-38). The Little Skull Mountain event caused no damage at Yucca Mountain, but some damage did occur at the Field Operations Center in Jackass Flats about 5 kilometers (3 miles) north of the epicenter.

Since the completion of the Yucca Mountain FEIS, the largest earthquake to occur in the vicinity of Yucca Mountain from 2002 through 2006 was a magnitude 4.4 event in June 2002, also at Little Skull Mountain in the aftershock zone of the 1992 earthquake (DIRS 172053-von Seggern and Smith 2003, pp. 20 and 25). There are no known reports of damage to facilities or changes in the subsurface rock at Yucca Mountain from the June 2002 event. The 1992 event is still the largest recorded event within 50 kilometers (30 miles) of Yucca Mountain. During report years 2003 through 2005, no earthquakes of magnitude 3 or greater occurred in the Yucca Mountain vicinity and in 2006 one earthquake occurred with a magnitude greater than 3 (reported at 3.4) (DIRS 184947-Smith and von Seggern 2007, p. 11; DIRS 184948-von Seggren and Smith 2007, p.7; DIRS 184946-Smith 2007, p.15).

Seismic Hazard

The Yucca Mountain FEIS described DOE's effort to use historical records of earthquakes, evidence of prehistoric earthquakes, and observed ground motions during modern earthquakes to predict the nature and frequency of future seismic events at Yucca Mountain. The Department convened two panels of scientific experts, one to characterize future earthquakes in relation to the potential for surface fault displacement and the other to consider the associated ground motion and how it would diminish with distance. The *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada* (DIRS 103731-CRWMS M&O 1998, all) provided the results of the two-panel effort and resulted in the preliminary bases for the design of facilities at Yucca Mountain and for forecasting elements of the repository's long-term performance in the Yucca Mountain FEIS. Key conclusions, which DOE has carried into subsequent evaluations (DIRS 176828-SNL 2007, pp. 6-25 to 6-33 and 6-208 to 6-211), include estimates of annual probabilities for different fault displacements and ground motion magnitudes that could occur at Yucca Mountain as a result of seismic events. For example, the analyses concluded (as the Yucca Mountain FEIS described) that faults, other than major block-bounding faults, are likely to experience displacement of more than 0.1 centimeter (0.04 inch) less than once in 100,000 years.

The Yucca Mountain FEIS noted that DOE needed to complete additional investigations of ground motion site effects before development of a final seismic design basis for the surface facilities. Since the completion of the FEIS, DOE has continued its seismic investigations and evaluations, resulting in numerous reports and a refined seismic analysis and design methodology. The most recent *Project Design Criteria Document* (DIRS 179641-BSC 2007, pp. 209 and 210) includes derived ground motion criteria at surface and subsurface (at the repository elevation) locations for 1,000-, 2,000-, and 10,000-year return period earthquakes. The design criteria document identifies baseline ground motion distributions (horizontal and vertical ground acceleration by frequency) and posted updates from further studies. The Project's *Seismic Analysis and Design Approach Document* (DIRS 184494-BSC 2007, all) and *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report* (DIRS 181572-DOE 2007, all) documented the details of how DOE uses these earthquake data. These documents detailed DOE's use of the "risk-informed" approach in seismic design, which requires that facilities and structures with more severe failure consequences have lower probabilities of failure from seismic events. According to the Design Approach document (DIRS 184497-BSC 2007, pp. 10 to 13), DOE designed project structures, systems, and components not important to safety in accordance with standard criteria from the International Building Code 2000 (DIRS 173525-ICC 2003, all), and designed those that are important to safety in accordance with applicable codes and standards for the design of nuclear power plants as identified in NUREG-0800 (DIRS 138431-NRC 1987, all). Facilities, systems, and components important to safety would include those where spent nuclear fuel would be managed, for example, the Wet Handling Facility (described in Section 2.1.2.1.4); those not important to safety would include, for example, the Administration Facility and Craft Shops (described in Section 2.1.2.3.6), where there would be no nuclear materials managed and activities would be more routine in nature.

DOE would achieve seismic safety for structures, systems, and components important to safety through a combination of two important aspects: (1) the assignment of an appropriate seismic design basis (that included the inherent conservatism in design codes, standards, and acceptance criteria), and (2) the probabilistic assessments of the seismic hazard that demonstrated capacity to support regulatory compliance. DOE would design structures, systems, and components important to safety to meet one of the following objectives: (1) that an earthquake magnitude that could cause a failure would have a probability of occurrence of less than 1 in 10,000 before repository-closure; or (2) if a seismic event with a higher probability of occurrence than 1 in 10,000 could cause failure before repository-closure, the related radiological dose consequences of such an event would have to meet the performance objectives set by regulatory requirements. In other words, facilities can incorporate less stringent seismic design considerations if a failure caused by a seismic event would have minimal consequences.

The Yucca Mountain FEIS discussion of seismic hazard referenced a study in *Science* magazine that reported unusually high crustal strain rates in the Yucca Mountain area (DIRS 103485-Wernicke et al. 1998, all). The article concluded that, if these high strain rates were correct, DOE's analysis could underestimate the potential for volcanic and seismic hazards. As the Yucca Mountain FEIS described, DOE continued its investigations on the crustal strain rate in the Yucca Mountain region through a grant to the University of Nevada and with an improved array of geodetic monitoring stations. In an article in the *Journal of Geophysical Research* (DIRS 175199-Wernicke et al. 2004, Abstract), the authors concluded that the high crustal strain rates between 1991 and 1997 were associated with the 1992 Little Skull Mountain earthquake. They noted that the strain rates from after 1998 (specifically from 1999 to 2003) did not appear to show an effect due to the earthquake and were notably lower. However, the lower strain rates were still higher than geologic predictions; that is, the geodetic estimates of deformation rates were not consistent with the low magnitude of Quaternary Period displacement that generally occurs in faults at Yucca Mountain. The findings of an independent interpretation of the geodetic information by University of Nevada researchers supported this conclusion (DIRS 180378-Hill and Blewitt 2006, all). In addition, this later effort suggested the possibility that the higher-than-expected strain rates might be due to relaxation of geologic features from a number of past earthquakes. DOE installed several new network stations in 2005 and, according to Hill and Blewitt, continued monitoring could help to test *alternative* scenarios for the cause of this apparent inconsistency.

Locations worldwide, including other locations in the Basin and Range Province, have observed differences between strain measured from geodetic stations and expectations from geologic data (DIRS 185127-Quittmeyer 2008, all; DIRS 185128-Coopersmith 2008, all). This is a broad field of ongoing scientific inquiry and the scientific community is considering other reasons for these differences, including the possibility that some strain might be released aseismically (that is, without seismic activity) (DIRS 185127-Quittmeyer 2008, all) or that short-term irregularities in strain rates are simply not observable in the geologic record (DIRS 185128-Coppersmith 2008, all). DOE considered the new strain data in evaluations of the probability for seismic activity at Yucca Mountain and determined that they did not affect the probability values concluded by the effort (DIRS 185335-Smistad 2008, all).

3.1.3.4 Mineral and Energy Resources

The Yucca Mountain FEIS described the concern that the Yucca Mountain analyzed land withdrawal area could have the potential for mineral resources that could lead to future exploration and inadvertent *human intrusion* into the repository. The Yucca Mountain FEIS also described DOE's efforts to investigate that potential and the resultant conclusion that the potential for economically useful mineral or energy resources within a conceptual *controlled area* around Yucca Mountain is low.

The Cind-R-Lite quarry is a mineral extraction operation (Section 3.1.1.2) outside the land area DOE evaluated for mineral resources, but it is inside the analyzed land withdrawal area. This operation is at a volcanic cinder cone approximately 10 kilometers (6 miles) northwest of the town of Amargosa Valley, just north of U.S. Highway 95, and includes the mining of cinder for the manufacture of light-weight, high-strength cinder blocks. As described in Section 3.1.1.2, this operation is on a patented mining claim, which is private property.

3.1.4 HYDROLOGY

In the Yucca Mountain FEIS, DOE described the region of influence for hydrology in terms of surface water and groundwater. The region of influence for surface water included areas of land disturbance that could be susceptible to erosion, areas that permanent changes in surface-water flow could affect, and areas downstream of the proposed repository that eroded soil or potential spills of contaminants could affect. The groundwater region of influence included *aquifers* that underlie areas of construction and operations, aquifers that could be sources of water for construction and operations, and aquifers downgradient of the proposed repository that repository use could affect, which included long-term releases of radioactive materials. This Repository SEIS addresses the same regions of influence. This section summarizes, incorporates by reference, and updates Section 3.1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-34 to 3-69) and provides new information, as applicable, from studies and investigations that continued after completion of the FEIS.

In its introduction to hydrology, the Yucca Mountain FEIS described several key characteristics of the hydrologic system of the Yucca Mountain region of influence, which included its very dry climate, limited surface water, high potential evaporation, and deep aquifers. Yucca Mountain is in the Death Valley regional groundwater flow system (or simply Death Valley region) where the floor of Death Valley is the regional hydrologic sink and surface water and groundwater generally do not leave except by *evapotranspiration*. Because there are no changes to the information, this Repository SEIS incorporates by reference the more detailed discussion in the Yucca Mountain FEIS of the key characteristics of the hydrologic system in the Yucca Mountain region.

3.1.4.1 Surface Water

3.1.4.1.1 *Regional Surface Drainage*

Yucca Mountain is in the southern Great Basin, which has few perennial streams and other surface-water bodies. The Amargosa River and its tributaries, which are dry along most of their lengths, drain Yucca Mountain and surrounding areas. The exceptions are short stretches of the river channel that are fed by groundwater discharges (that is, springs and seeps). The Amargosa River drainage terminates in the Badwater Basin in Death Valley. The nearest surface-water impoundments to Yucca Mountain are several ponds and reservoirs in the Ash Meadows National Wildlife Refuge, approximately 50 kilometers (30 miles) to the southeast. The impoundments and springs in the Ash Meadow area drain to the Amargosa River through Carson Slough.

The Amargosa River is an interstate water because it flows from Nevada into California and at least some portions of this ephemeral stream could be classified as waters of the United States as defined in 33 CFR Part 328 and regulated under Section 404 of the *Clean Water Act* (33 U.S.C. 1251 et seq.). Fortymile Wash, a tributary of the Amargosa River, and some of its tributaries in and near the *geologic repository operations area* might also be waters of the United States. In June 2007, the EPA and the U.S. Army Corps of Engineers released interim guidance that addresses the jurisdiction over waters of the United States (72 FR 31824, June 8, 2007). Based on this new guidance, it is less likely that the ephemeral washes and riverbeds in this area would be considered waters of the United States. However, for construction actions proposed in these washes, the Corps of Engineers would still have to determine the limits of jurisdiction under Section 404 of the *Clean Water Act*.

3.1.4.1.2 *Yucca Mountain Surface Drainage*

This section summarizes occurrences of past floods and the DOE evaluation of flood potential in the areas DOE would use for the Proposed Action.

Occurrence

There are no perennial streams, natural bodies of water, or naturally occurring wetlands in the analyzed land withdrawal area. Several named washes on the east side of Yucca Mountain drain into Fortymile Wash, as shown in Figure 3-6 (along with estimated flood zones). Solitario Canyon Wash collects

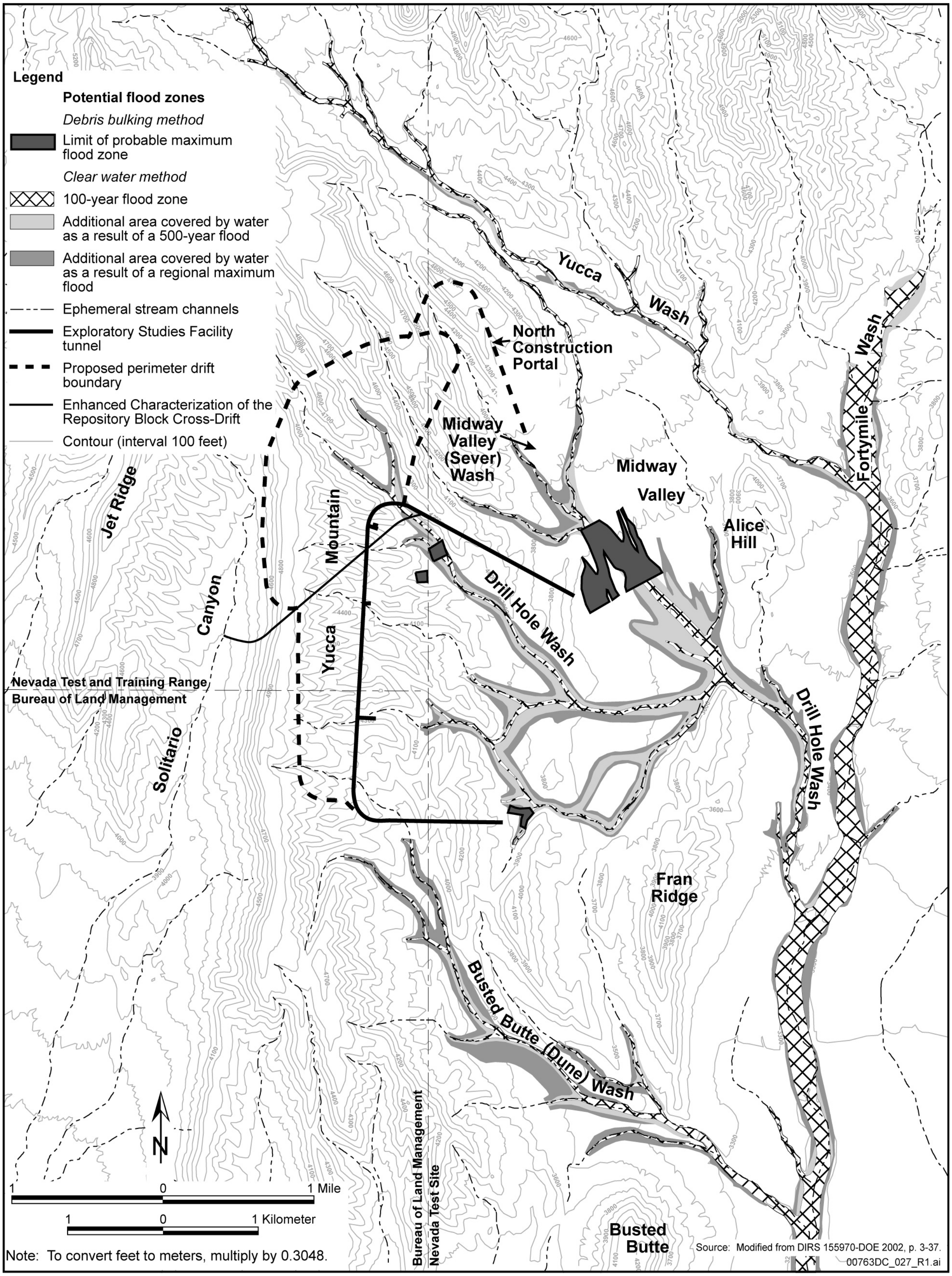

Figure 3-6. Site topography and potential flood areas.

drainage from the west side of Yucca Mountain. Both the west and east sides of Yucca Mountain drain into the ephemeral Amargosa River. Washes at Yucca Mountain carry water only in response to intense precipitation events and rapid snowmelt. Instances in which a large portion of the drainage system carries water at the same time are infrequent because they require the generation of runoff over a large area at the same time, and intense precipitation events in this region are generally confined to small areas. In March 1995 and February 1998, Fortymile Wash and the Amargosa River flowed simultaneously through their primary channels to Death Valley. The 1995 event represented the first documented case of this flow condition. Although not documented, similar incidents probably occurred during the preceding 30 years when there were several instances for which records show sections of the primary channels flowing with floodwater.

Flood Potential

Although water flow in washes at Yucca Mountain is an unusual occurrence, flooding can occur as a result of intense summer thunderstorms or sustained winter precipitation. As a result, DOE has used several different, recognized methodologies to calculate estimates of predicted flood levels, which include a probable maximum flood. Figure 3-6 shows these flood levels. The three flood levels for each of the prominent washes are the 100-year, 500-year, and regional maximum floods. The *100-year flood* is of a magnitude that is likely to occur, on average, only once every 100 years. This means there is a probability of 0.01 that a flood of this size would occur in any 1 year. A 500-year flood would be likely to occur, on average, only once in 500 years and there would be a probability of 0.002 that it would occur in any 1 year. The regional maximum flood is a larger flood that considers size of the extreme floods that occur elsewhere in Nevada and in nearby states.

Figure 3-6 also shows the results of a fourth flood level estimate using the probable maximum flood method, which is based on American National Standards Institute and American Nuclear Society Standards for Nuclear Facilities (DIRS 103071-ANS 1992, all) and is considered the most severe reasonably possible flood. DOE calculated potential flood levels for the probable maximum flood only for specific locations on certain washes (the isolated segments of dark shading in Figure 3-6). The Department selected these specific locations for the calculations to verify that specific repository features, which would include the openings to the subsurface, would not be in the inundation zone of the probable maximum flood. This flood calculation incorporated the effects of mud and debris the flood would carry, which would significantly increase the volume of the flood flow and the lateral extent of area it would cover.

The flood levels in Figure 3-6 are the same as those in the Yucca Mountain FEIS. The FEIS also presented estimates of the peak discharges due to these flood levels. Appendix C of this Repository SEIS is a floodplain and wetlands assessment DOE prepared that further addresses flooding issues in relation to the ephemeral washes at Yucca Mountain.

Surface-Water Quality

DOE has collected stream-water samples (at times of flow) at and near Yucca Mountain for comparison with groundwater samples. The Department analyzed these samples for general chemical characteristics (that is, mineral content) and summarized the results in the Yucca Mountain FEIS. Stream-water samples contained a lower mineral content than groundwater samples, which suggests less interaction between the rock and water.

3.1.4.2 Groundwater

This section discusses groundwater first in the region, in general, then more specifically at Yucca Mountain. Section 3.1.4.2 of the Yucca Mountain FEIS discussed differences of opinion on the groundwater system (DIRS 155970-DOE 2002, pp. 3-39 to 3-69).

3.1.4.2.1 *Regional Groundwater*

Yucca Mountain is in the Death Valley region, which is complex, with many aquifers and confining units that can vary greatly in their characteristics over distance. In some areas, confining units allow movement between aquifers, and in other areas they can be sufficiently impermeable to support artesian conditions where water will rise in a well to a higher elevation than that first encountered. In general, the principal water-bearing units in the Death Valley region can be classified as volcanic aquifers, alluvial aquifers, and carbonate aquifers. The mountainous areas in the north-central portion of the Death Valley region are mostly of volcanic origin and contain associated volcanic aquifers. Alluvial aquifers occur in the basin-fill areas between mountains and include the large Amargosa Desert (Figure 3-7). This discussion uses "alluvial aquifers" as a simplification for the basin- or valley-fill materials specific to the Amargosa Desert. Studies by the U.S. Geological Survey (DIRS 173179-Belcher 2004, all) and by Nye County (DIRS 156115-Nye County Nuclear Waste Repository Project Office 2001, all) identify multiple units in their characterizations of these basin-fill materials. The hydrogeologic framework model the Survey developed describes the unconsolidated basin-fill sediments as including two alluvial aquifers, two alluvial confining units, an interfingered limestone aquifer, and two volcanic units (DIRS 173179-Belcher 2004, pp. 39 and 40). These units differ in their makeup and in their manner of deposition, as well as in their hydraulic parameters. In this discussion, alluvial aquifer refers to the various unconsolidated materials in the Amargosa Desert through which groundwater moves. DOE recognizes that this portion of the groundwater flow path has a complex geology.

Carbonate rocks occur at widely different depths throughout the Death Valley region, including at the surface, and often are very thick in a particular location. Beneath Yucca Mountain and the northern Amargosa Desert, the carbonate aquifers occur at great depths below the volcanic and alluvial aquifers. Carbonate rocks are often characterized as the most *permeable* rocks in the region; the *permeability* is due primarily to fractures, faults, and solution channels (DIRS 173179-Belcher 2004, p. 65). However, these rocks formed during the Paleozoic Era (Table 3-3) and have been subject to a long, complex history of tectonic activity (DIRS 156115-Nye County Nuclear Waste Repository Project Office 2001, p. F53) and associated structural deformations. The carbonate aquifers are regionally extensive, particularly in the eastern and southern portions of the Death Valley region, but there are differing opinions among investigators on how extensively they are interconnected over the region. Because of the structural deformations, some investigators view the carbonate aquifer as often occurring in compartments (DIRS 156115-Nye County Nuclear Waste Repository Project Office 2001, p. F53) that might have a hydraulic connection to the carbonate rock in an adjacent compartment. Other investigators view the lower carbonate aquifer as highly connected over the region. They reason that because of the great thickness of the carbonate rock in most areas, even large fault displacements often result in carbonate rock-to-carbonate rock contacts across the fault, providing a route for transmission of water. This latter model views the lower carbonate aquifer as acting, where applicable, to integrate individual valleys into a single groundwater basin (DIRS 185423-ICYMRAO n.d., p. 88). Both views agree that when hydraulically connected, carbonate aquifers provide a path for flow between groundwater basins (DIRS 173179-Belcher 2004, p. 65).

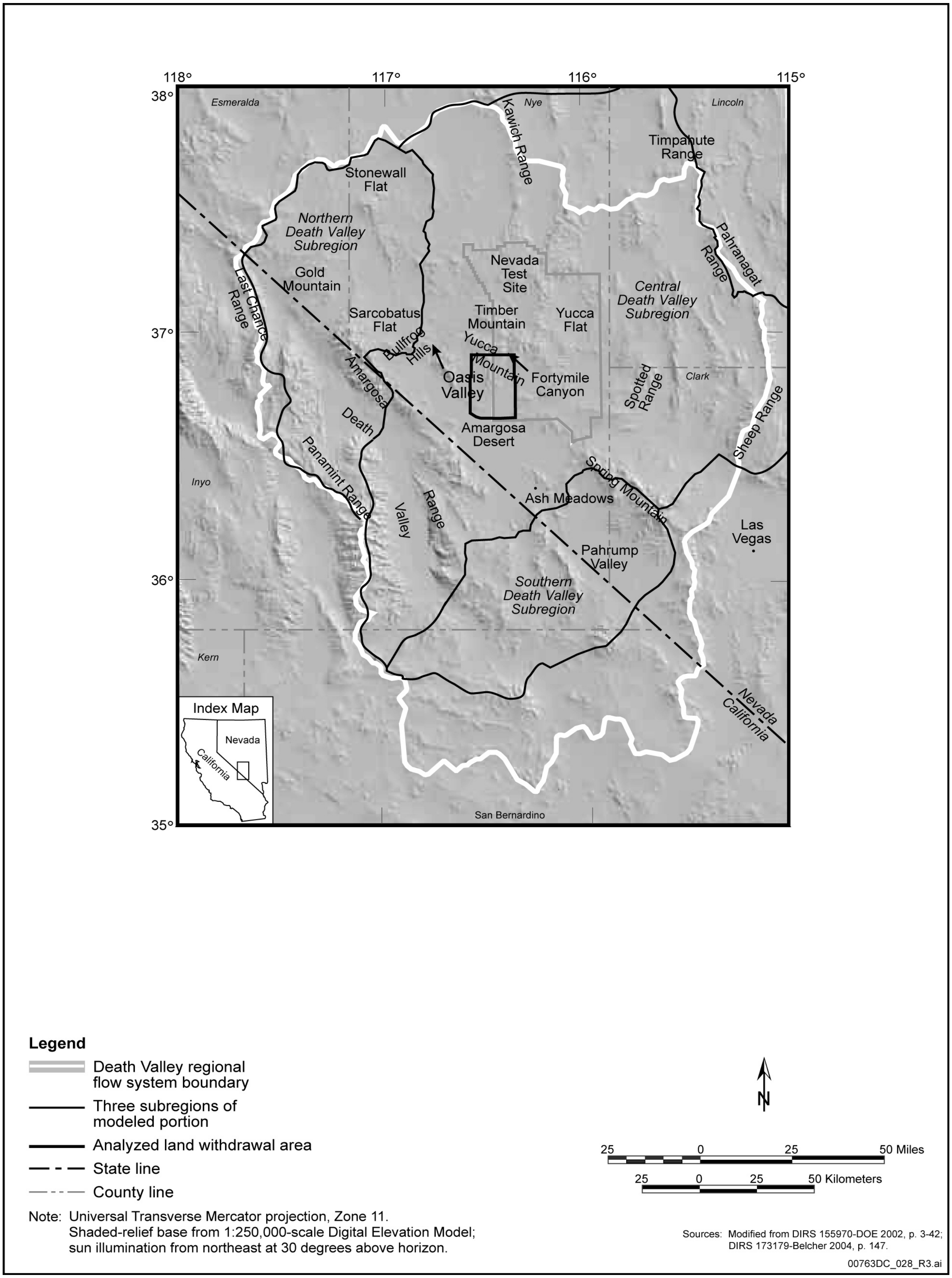

Figure 3-7. Boundaries of Death Valley regional groundwater flow system.

The alluvial aquifers below the Amargosa Desert receive underflow from groundwater basins to the east and the north, including the aquifers that underlie Yucca Mountain. Deep drill holes indicate the presence of a carbonate aquifer below Yucca Mountain that extends into the Amargosa Desert. Groundwater flow in the northwest Amargosa Desert is generally to the southeast toward the central part of the basin and then south toward the discharge area at Alkali Flat with some of the flow perhaps moving into Death Valley. In contrast, flow in the southeastern portion of Amargosa Desert is generally to the west and southwest. Some of the flow in the southeast part of Amargosa Desert discharges via springs and evapotranspiration at the Ash Meadows area. The remainder of the flow from the east merges with the more southerly flow in the south-central portion of Amargosa Desert and continues toward Alkali Flat.

Basins

Studies of the Death Valley region often divide the area into the Northern, Central, and Southern Death Valley subregions (Figure 3-7). As shown in Figure 3-8, the Central subregion is further divided into three groundwater basins: (1) Pahute Mesa-Oasis Valley, (2) Ash Meadows, and (3) Alkali Flat-Furnace Creek (which contains Yucca Mountain). The Yucca Mountain FEIS discussed each of these basins in detail, which included the identification of areas of recharge and discharge (if any), the general direction of groundwater flow, and where subsurface flow leaves the basin. The remaining information in this section, summarized from the Yucca Mountain FEIS, focuses on the Alkali Flat-Furnace Creek groundwater basin, which the Proposed Action could affect the most.

The Alkali Flat-Furnace Creek groundwater basin is so named because of the evidence that the groundwater in this basin discharges mainly at Alkali Flat (also known as Franklin Lake Playa) and potentially to the Furnace Creek area of Death Valley (Figure 3-8). Fortymile Wash and precipitation that infiltrates the surface are sources of recharge near Yucca Mountain, but the primary sources of recharge to the Alkali Flat-Furnace Creek groundwater basin are the high mountains to the north of Yucca Mountain and those to the south and southwest across the Amargosa Desert. Water that infiltrates at Yucca Mountain joins with water in the Fortymile Canyon section of the basin (Figure 3-8) and flows south to the Amargosa Desert and a primary discharge area of Alkali Flat, with some flow potentially moving into Death Valley along the same general course followed by the Amargosa River channel (DIRS 173179-Belcher 2004, pp. 155 and 156). DOE has recently updated a model of net infiltration for the Yucca Mountain site (DIRS 174294-SNL 2007, all) (Section 3.1.4.2.2). For the Yucca Mountain FEIS, estimates from this infiltration model are directly comparable with published estimates of the amount of water that moves through the Amargosa Desert to reach a conclusion that contributions from recharge at Yucca Mountain would be a very small percentage of the total flow. DOE has performed modeling studies of the *saturated zone* groundwater flow path from Yucca Mountain and estimated it would take 810 years for 50 percent of a conservative, nonsorbing radionuclide in the absence of *decay* added to groundwater beneath Yucca Mountain to travel 18 kilometers (11 miles) along the flow path. Some of the tracer would reach that distance faster, but half would take longer (DIRS 177392-SNL 2007, p. 6-31).

As groundwater in the Alkali Flat-Furnace Creek groundwater basin moves south beneath the Amargosa Desert, underflow from the Ash Meadows groundwater basin joins it. A line of springs fed by Ash Meadows basin groundwater marks a portion of the boundary between the two basins and supports *habitat* in the Ash Meadows National Wildlife Refuge. Devils Hole, a groundwater-filled cave in a fault zone, is in this area. As the Yucca Mountain FEIS noted, there is evidence that the carbonate aquifer feeds the line of springs in the Ash Meadows area. In this area, there is a relatively sharp decrease in

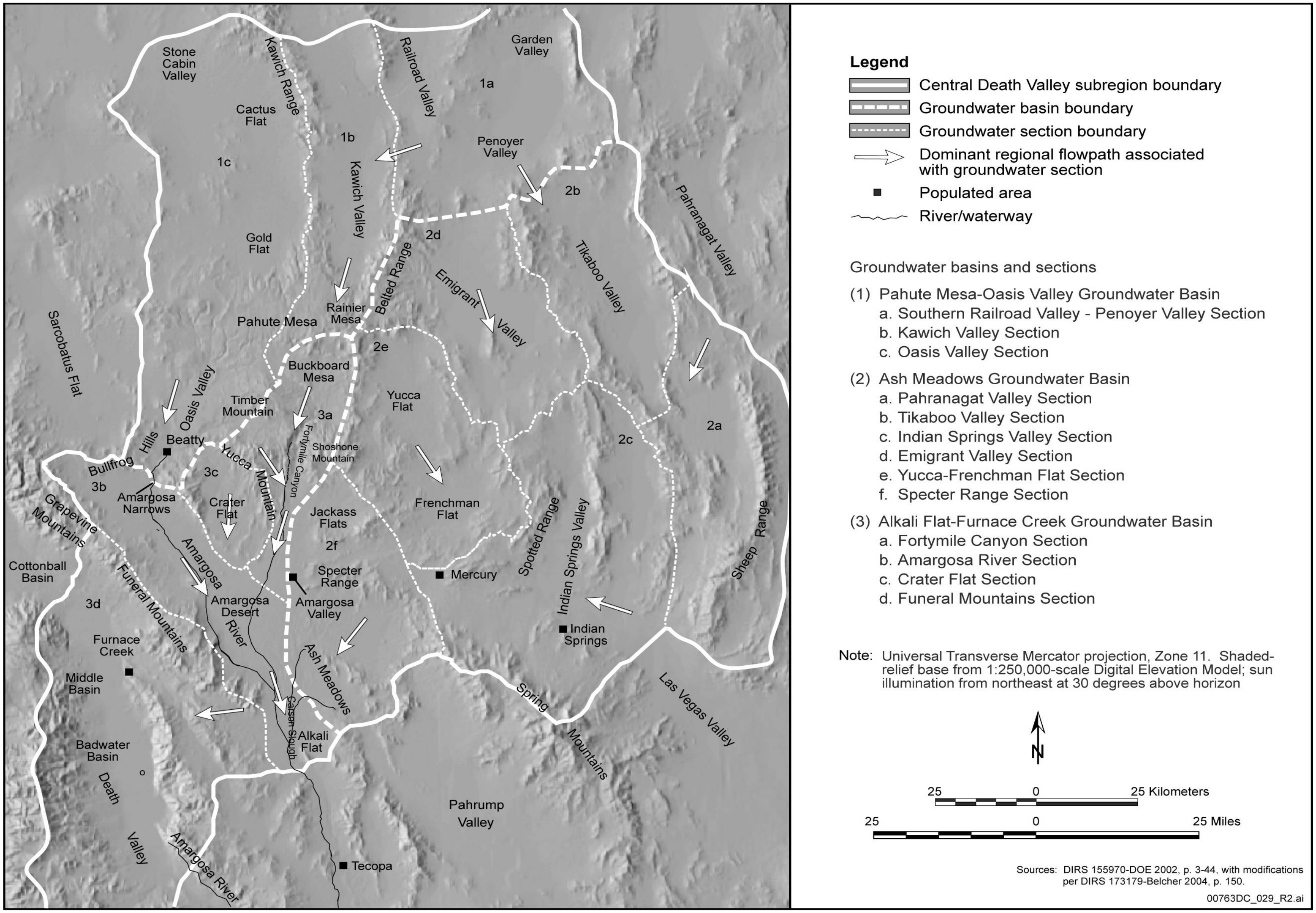

Figure 3-8. Groundwater basins and sections of the Central Death Valley subregion.

groundwater head, or elevation, from east to west, so it is clear that groundwater at Ash Meadows moves into the Alkali Flat-Furnace Creek basin rather than the opposite.

The Yucca Mountain FEIS described studies that DOE and others have initiated to reduce uncertainties about the regional groundwater flow system, particularly studies by Nye County under a cooperative agreement with DOE. Since the completion of the Yucca Mountain FEIS, DOE has established a similar program with Inyo County in California. The Department has obtained new borehole data and other information from these ongoing County efforts (DIRS 180739-Williams 2003, p. A-4) and incorporated them in the regional hydrogeologic framework model, which the U.S. Geological Survey developed (DIRS 173179-Belcher 2004, all) and which continues to evolve, to simulate groundwater conditions and movement in the Death Valley region. A primary change to the model since the completion of the Yucca Mountain FEIS is characterization of the depth and extent of the alluvial layers and the alluvial aquifer in the area south of Yucca Mountain (DIRS 180739-Williams 2003, p. 2-39), which is the focus of the Nye County drilling program. A recent update to the hydrogeologic framework model (DIRS 174109-SNL 2007, all) includes data collected through Phase IV of the Nye County program. One of the many objectives of the Nye County program has been to locate the tuff-*alluvium* contact—the zone where water moving south from Yucca Mountain changes from primarily flowing in the fractured rock of the volcanic aquifer to dispersed flow through the relatively porous material of the alluvial aquifer. The Nye County report on its Phase IV drilling program interprets the Highway 95 Fault as the southern boundary of the volcanic aquifers (DIRS 182194-NWRPO 2005, p. 70). The Highway 95 Fault is a Tertiary fault that roughly aligns with U.S. Highway 95 in the area where Fortymile Wash enters the Amargosa Desert. Drilling results show volcanic aquifers on the north side of the fault that line up with older Tertiary sedimentary rocks on the south side. Nye County speculated that contact with the less permeable Tertiary rock forces the southward groundwater flow up into the overlying alluvial aquifer system, which continues into lower Fortymile Wash and the Amargosa Desert (DIRS 182194-NWRPO 2005, p. 70). These and other updates to the hydrogeologic framework model have resulted in an increasingly more realistic representation of the groundwater flow system, which supports a more detailed understanding of the potential long-term effects of the Proposed Action.

A primary focus of the Inyo County efforts has been the investigation of the source of the water that discharges from springs on the east side of Death Valley and if there is a hydraulic connection between those springs and the groundwater moving beneath Yucca Mountain. Inyo County has supported the following work: (1) updates to geologic mapping of the southern Funeral Mountains; (2) drilling of exploratory monitoring wells in the southwest Amargosa Desert area near the southern Funeral Mountains; (3) geophysical surveys in the area from the southern Funeral Mountains on the west to the Devils Hole area of Ash Meadows on the east, and including the portion of the Amargosa Desert in between; and (4) analysis of geochemical data on spring waters in the area of Death Valley National Park and in the Yucca Mountain study area (DIRS 185423-ICYMRAO n.d., all). From the mapping, drilling, and geophysical survey data and information from the U.S. Geological Survey's regional model (DIRS 173179-Belcher 2004, all), Inyo County generated two groundwater flow models to evaluate possible flow characteristics in the lower carbonate aquifer in the subregion south from Yucca Mountain. The first model was a simple flow model of the lower carbonate aquifer that demonstrated the possibility of a relatively fast pathway from beneath Yucca Mountain to the springs in Death Valley. Inyo County based the second model on two interpretive maps for the base of the lower carbonate aquifer in the southern Funeral Mountains, where upper portions of the rocks that comprise the lower carbonate aquifer are exposed (DIRS 173179-Belcher 2004, pp. 28 and 33). Both maps supported the presence of two subsurface spillways where water in the lower carbonate aquifer could flow across the Furnace Creek Fault to the southwest and supply water to the Funeral formation, which is the primary source for the Death Valley springs (DIRS 185423-ICYMRAO n.d., pp. 96 to 100). Inyo County used flow system parameters based on the configuration of these maps and several measured parameters to establish the second groundwater flow model, which simulated Death Valley spring discharge rates "quite well." The County concluded that this second model demonstrated the feasibility of flow from the carbonate aquifer in the Amargosa Desert to the major springs in the Furnace Creek area of Death Valley.

The primary conclusions from the Inyo County efforts are that the lower carbonate aquifer appears to be a significant contributor to the springs in the Furnace Creek area of Death Valley and this aquifer represents a potentially rapid pathway for contaminants to reach the biosphere. Inyo County and DOE agree that the pathway simulated in the simple flow model is not a viable pathway for contaminants originating at the repository site as long as there is an upward gradient in the carbonate aquifer, which has been observed in boreholes in the Yucca Mountain vicinity. Inyo County efforts provide additional support to the conceptual model of regional flow DOE considered in the evaluation of repository postclosure performance (summarized in Chapter 5 of this Repository SEIS). The conceptual model of flow is, and has been, that the groundwater in the Amargosa Desert area contributes to the discharges from the springs in the Furnace Creek area of Death Valley. Slightly different from the Inyo County conclusions, the conceptual flow model DOE used indicates that contaminants from the repository could find their way to the Death Valley springs even if they did not reach the lower carbonate aquifer at Yucca Mountain. The U.S. Geological Survey's regional hydrogeologic framework model cites earlier studies of the region to conclude that the carbonate rocks beneath the Funeral Mountains might provide pathways for flow from the alluvial aquifers beneath the Amargosa Desert toward Death Valley (DIRS 173179-Belcher 2004, p. 155). The predominant flow in the alluvial aquifer of the Amargosa Desert is south to discharge areas at Alkali Flat and along the Amargosa River, but some of the flow is probably toward the southwest to the Furnace Creek area of Death Valley. Further, the relatively rapid flow path generated by the Inyo County flow model is consistent with the low end of the range of travel times to the accessible environment that the saturated zone flow and transport abstraction model (DIRS 183750-SNL 2008, pp. 6-109 to 6-112), which DOE used to evaluate postclosure performance of the repository, considered. The accessible environment location DOE evaluated for postclosure performance is not a spring discharge in Death Valley; rather, it is the *reasonably maximally exposed individual* much closer to the repository. As described in Chapter 5, impacts at the Death Valley springs can be conservatively assumed to be no different from those at the evaluated location, even under the unexpected condition of all contaminant migration moving toward the springs.

DOE has incorporated hydrogeologic information that Nye and Inyo counties collected in studies to define groundwater flow paths based on naturally occurring chemical and isotopic constituents in the water. Chloride and sulfate are primary examples of the chemical constituents under study, and deuterium (hydrogen-2) and oxygen-18 are examples of isotopes the studies are tracking. The concentrations of these constituents in groundwater depend on such parameters as the location and time the water first infiltrated from the surface, the rock materials through which it passed on its route and the resulting rock-water interactions, and the mixing that has occurred in the groundwater. Groundwater samples from different locations have different chemical signatures that reflect individual *pathway* histories (DIRS 177391-SNL 2007, Appendix A, pp. A-1 and A-83). The regional groundwater flow paths these geochemical signatures identify are consistent with the general flow directions that were developed from the potentiometric surface of the groundwater (DIRS 177391-SNL 2007, p. 7-36), as summarized above and described in more detail in the Yucca Mountain FEIS.

An objective of Inyo County's analysis of geochemical data from spring waters in the area was to determine the source of the water that moves beneath the Funeral Mountains to discharge points (springs) in the Furnace Creek area of Death Valley. The analysis was able to link the Death Valley springs to the carbonate aquifer, but the ultimate source of those waters remains partially unknown. The Inyo County effort concluded, as described in earlier studies, that the water probably originated as recharge in (1) the area of the Nevada Test Site, including Yucca Mountain, (2) the Amargosa Basin, or (3) the area to the east that includes the Ash Meadows springs, or a combination of the three (DIRS 185423-ICYMRAO n.d., p. 85). DOE's evaluation of geochemical data on water from various locations in the area concluded that the chemical and isotopic characteristics of the Death Valley discharges are similar to those in the Ash Meadows basin and dissimilar in several chemical concentrations to groundwater from the alluvial aquifer in the Amargosa Desert. This suggests that the deep underflow of groundwater from the underlying carbonate aquifer (rather than the alluvial aquifer in the Amargosa Desert) that contributes to discharges in the Ash Meadows area is the primary source of the spring discharge in Death Valley (DIRS 177391-SNL 2007, Appendix A, pp. A-212 to A-214). This implies a westward component of flow in the underlying carbonate aquifer in this area of the Amargosa Desert where the general direction of flow in the alluvial aquifer is south and even a little to the southeast. Geochemical investigations by the University of Nevada, Las Vegas (DIRS 181435-Koonce et al. 2006, all) support the conclusion that spring discharge in Death Valley involves primarily carbonate-derived groundwater. Conclusions of this study suggest there could be a contribution of volcanic aquifer groundwater from areas to the north of Ash Meadows and north of the Amargosa Desert in the Death Valley discharges. In terms of groundwater flow from beneath the area of Yucca Mountain, connection of this flow with spring discharge in Death Valley appears to substantiate the basis for the name of the Alkali Flat-Furnace Creek groundwater basin. That is, the predominant flow in the basin might contribute to discharges in the Furnace Creek area of Death Valley. Water moving south from the volcanic aquifers (as from the Yucca Mountain area) and into the alluvial aquifer of the Amargosa Desert might contribute to those discharges but, based on the geochemical data, does not appear to be the primary source (DIRS 177391-SNL 2007, Appendix A, p. A-214).

Use

The Yucca Mountain FEIS discussed the concept of *hydrographic areas*, which the State of Nevada uses as basic map units in its water planning and appropriation efforts, and which often have slightly different boundaries than the sections shown in Figure 3-8. Figure 3-9 shows the hydrographic areas in the general area of Yucca Mountain. The FEIS characterized use of water from the Fortymile Canyon-Jackass Flats hydrographic area (Area 227A) for the Yucca Mountain Project and the Nevada Test Site, but identified the highest water use in the nearby region as in the Amargosa Desert hydrographic area (Area 230) immediately to the south of Area 227A (Figure 3-9). Table 3-11 of the FEIS summarized pertinent information on the hydrographic areas in the immediate area of Yucca Mountain, including estimates of annual groundwater withdrawals from each hydrographic area (DIRS 155970-DOE 2002, p. 3-48). Table 3-4 updates this information. Water withdrawal quantities, with the exception of those for Oasis Valley, are the annual averages from 2000 to 2004, which are the last 5 years of available record published by the U.S. Geological Survey. The withdrawals for Jackass Flats, Crater Flat, and the Amargosa Desert each show a slight decrease from those in the Yucca Mountain FEIS. The decrease for Jackass Flats is attributable to a decrease in characterization activities at Yucca Mountain. The largest amount of water withdrawal continues to be in the Amargosa Desert, where the annual volume is about 16 million cubic

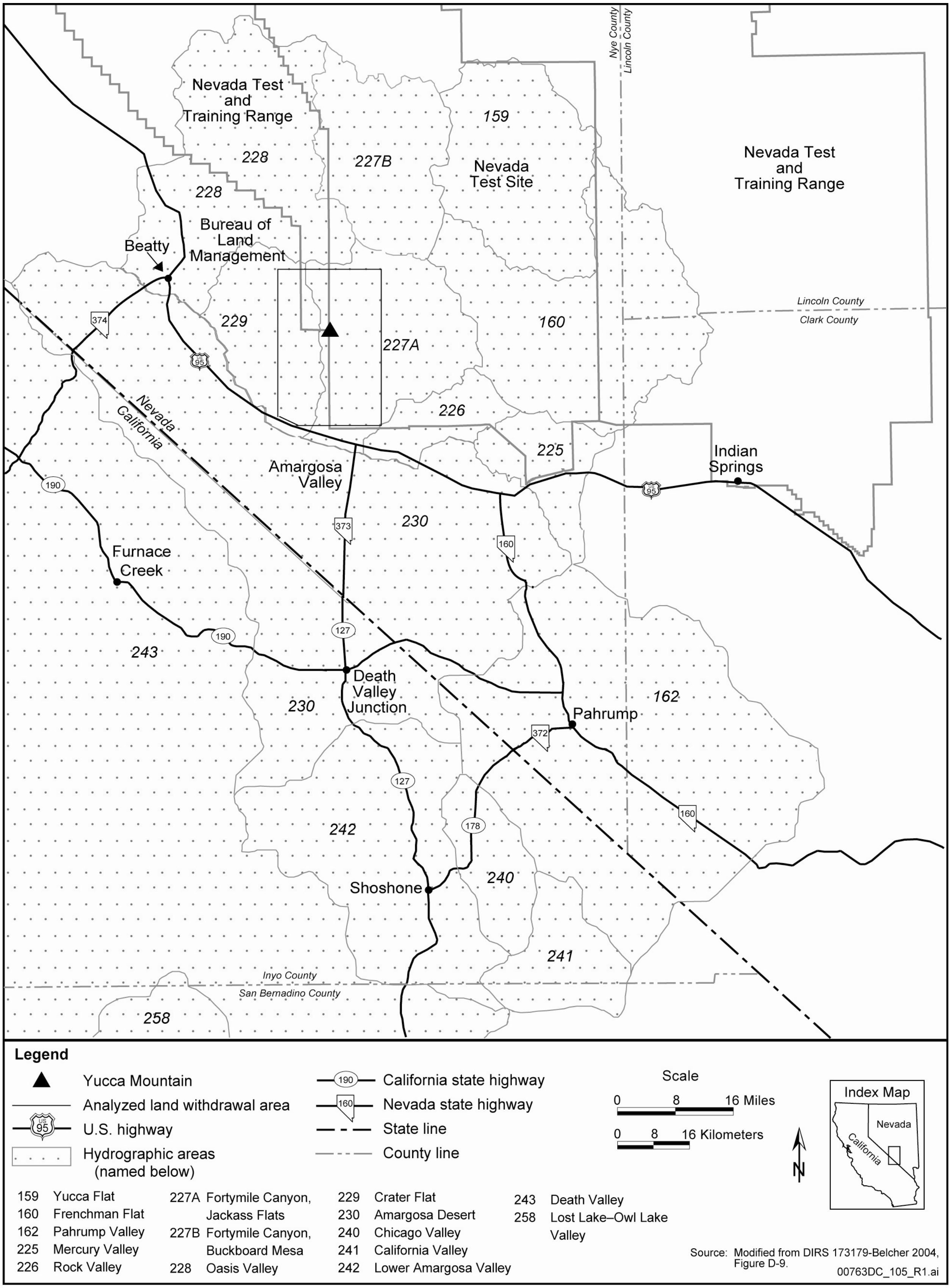

Figure 3-9. Hydrographic areas in the Yucca Mountain region.

Table 3-4. Perennial yield and water use in the Yucca Mountain region.

Hydrographic area[a]	Perennial yield[b,c,d] (acre-feet per year)[e]	Current appropriations/ committed resources[f,g] (acre-feet per year)	Average annual withdrawals, 2000 to 2004, unless noted otherwise (acre-feet)	Chief uses
Jackass Flats (Area 227A)	880[h] – 4,000	58[i]	89[j,k]	Nevada Test Site programs and minor amounts for the Yucca Mountain Project
Crater Flat (Area 229)	220 – 1,000	1,100	63[j]	Mining, minor amounts for the Yucca Mountain Project
Amargosa Desert (Area 230)	24,000 – 34,000	25,000[l]	13,000[j,l]	Irrigation, mining, livestock, quasi-municipal or commercial, and domestic
Oasis Valley (Area 228)	1,000 – 2,000	1,300	130 (for 2000)[g]	Irrigation and municipal

Note: To convert acre-feet to cubic meters, multiply by 1,233.49. This table lists acre-feet because of common statutory and public use of this unit of measure for groundwater resources.

a. A specific area in which the State of Nevada allocates and manages the groundwater resources.

b. The quantity of groundwater that can be withdrawn annually from a groundwater reservoir, or basin, for an indefinite period without depleting the reservoir; also referred to as safe yield.

c. Source: DIRS 147766-Thiel 1999, pp. 8 and 10 to 12.

d. In many of its planning documents, the Nevada Division of Water Resources identifies a combined perennial yield of 24,000 acre-feet for Hydrographic Areas 225 through 230.

e. An acre-foot is a commonly used hydrologic measurement of water volume equal to the amount of water that would cover an acre of ground to a depth of 1 foot.

f. The amount of water that the State of Nevada authorizes for use; the amount used might be much less. These appropriations are for underground rights only, and do not cover Federal Reserve Water Rights held by the Nevada Test Site or U.S. Air Force. This latter exclusion is the reason withdrawals from Area 227A are shown as exceeding the identified appropriations (that is, the Nevada Test Site withdrew water under its Federal Reserve Water Rights).

g. Source (except for Crater Flat): DIRS 182821-Converse Consultants 2005, pp. 99 and 100 for committed resources, p. 38 for annual withdrawal from Oasis Valley.
Source (for Crater Flat): DIRS 178726-State of Nevada 2006, all.

h. The low estimate for perennial yield from Jackass Flats breaks the quantity down into 300 acre-feet for the eastern third of the area and 580 acre-feet for the western two-thirds. The Yucca Mountain Project production wells are in the western portion of this hydrographic area.

i. Based on the southern boundary of Area 227A, as defined in a 1979 Designation Order by the State Engineer, there should be only 17 acre-feet of committed resources in Area 227A. However, water rights information from the Nevada Division of Water Resources shows 58 acre-feet in committed resources for this area. The apparent discrepancy appears to be the result of 41 acre-feet of committed resources (including one certificate for domestic use and one for commercial use) being inside the pre-1979 boundary and outside the post-1979 boundary. Both certifications are for wells near U.S. Highway 95. The remaining 17 acre-feet of committed resources (which appear to be in Area 227A) are attributed to two certificates the Bureau of Land Management owns for stock watering wells.

j. Sources: DIRS 178692-La Camera et al. 2005, pp. 72 and 73 for water withdrawals from 2000 to 2003; DIRS 178691-La Camera et al. 2006, p. 69 for water withdrawals in 2004. (Includes only Nevada Test Site water use in Area 227A.)

k. Sources include only Nevada Test Site water use from Area 227A. The sources for the Yucca Mountain Project water use from Area 227A (about 21 acre-feet per year) are DIRS 181575-Wade 2000, all; DIRS 181576-Wade 2000, all; DIRS 181577-Wade 2000, all; DIRS 181578-Wade 2001, all; DIRS 181580-Wade 2002, all; DIRS 181581-Wade 2003, all; DIRS 181582-Wade 2004, all; and DIRS 181583-Wade 2005, all.

l. A recent ruling (Ruling 5750; DIRS 185182-Taylor 2007, all) by the Nevada State Engineer identifies 24,000 acre-feet as the best estimate of perennial yield for the Amargosa Desert area, but stipulates that the 24,000-acre-feet value includes 17,000 acre-feet annually of spring discharges at Ash Meadows to satisfy the certificated rights of the U.S. Fish and Wildlife Service for wildlife purposes (and which is not included in the 25,000 acre-feet annually of committed resources shown in the table). This position results in only 7,000 acre-feet of the perennial yield remaining for traditional groundwater withdrawals.

meters (13,000 acre-feet). As listed in Table 3-4, water appropriations in the Amargosa Desert continue to be higher than the amount of water actually withdrawn. As noted in footnote "l" in Table 3-4, a recent ruling from the Nevada State Engineer describes the spring discharges at Ash Meadows as a committed portion of the Amargosa Desert's perennial yield. Under this interpretation, it can be seen in Table 3-4 that the remaining portion of the perennial yield is exceeded by the current levels of pumping from that hydrographic area.

The Yucca Mountain FEIS described the U.S. Supreme Court decision (DIRS 148102-Cappaert et al. v. United States et al. 1976, all) in 1976 to restrict groundwater withdrawal in the Ash Meadows area to protect the water level in Devils Hole and the endangered Devils Hole pupfish. Ash Meadows is in the Amargosa Desert hydrographic area. Although Table 3-4 lists total combined groundwater withdrawals from the Amargosa Desert, the U.S. Geological Survey tracks withdrawals in the Ash Meadows area separately from those in other parts of the Amargosa Desert. Withdrawals from Ash Meadows are a very small portion (less than 1 percent) of the total withdrawals.

Regional Groundwater Quality

The Yucca Mountain FEIS described the results from a 1997 survey of several wells and springs in the Yucca Mountain region to assess the quality of the regional groundwater. The survey collected samples from five groundwater sources in the Amargosa Desert, which consisted of three wells and two springs, and from three wells at Yucca Mountain. Table 3-12 of the FEIS summarized the results from this sampling effort and compared them with EPA drinking water standards (DIRS 155970-DOE 2002, p.3-49), with the recognition that these standards are for public water supply systems, not for potential water sources for such systems. The evaluation concluded that the overall quality of the regional groundwater is good and that the tested groundwater sources in the Amargosa Desert area met primary drinking-water standards. However, a few sources exceeded secondary and proposed standards.

Specifically, four Amargosa Desert sources exceeded a proposed standard for radon; one of those four exceeded secondary standards for sulfate and total dissolved solids and a proposed standard for uranium. Since the completion of the Yucca Mountain FEIS, the proposed standard for natural uranium has gone into effect but the proposed standard for radon is still pending. The standard for uranium is 0.03 milligram per liter [40 CFR 141.66(e)], which is slightly higher than the proposed standard considered in the FEIS. The single Amargosa Desert source that exceeded the proposed standard for uranium with a reported concentration of 0.02 milligram per liter would meet the new standard. Section 3.1.4.2.2 of this Repository SEIS addresses the radon and uranium results and the associated standards further in the discussion of water quality at Yucca Mountain. In addition, since the completion of the Yucca Mountain FEIS, the primary drinking-water standard for arsenic was lowered from 0.05 milligram per liter to 0.01 milligram per liter (40 CFR 141.23). The five samples from the Amargosa Desert area had arsenic levels that ranged from 0.01 to 0.022 milligram per liter (DIRS 104828-Covay 1997, all), so only the single source with an arsenic level of 0.01 milligram per liter would meet the current standard.

3.1.4.2.2 *Groundwater at Yucca Mountain*

This section summarizes the characteristics of groundwater at Yucca Mountain in both the *unsaturated zone* and the saturated zone.

Unsaturated Zone

Water Occurrence. The Yucca Mountain FEIS stated that the occurrence of water in the unsaturated zone at Yucca Mountain extended from the crest of the mountain approximately 750 meters (2,500 feet) down to the top of the water table. In this zone, DOE has found water in the rock *matrix*, along faults and other fractures, and in isolated pockets of saturated rock termed *perched water*. DOE provided the conceptual model shown in Figure 3-10 with the discussion of the movement and presence of water in the unsaturated zone. Although the conceptual model shows water moving throughout the unsaturated zone, the representation shows the pathways, not the amount of water. At the time of FEIS completion, DOE had excavated more than 10.6 kilometers (6.6 miles) of tunnels and testing *alcoves* in Yucca Mountain

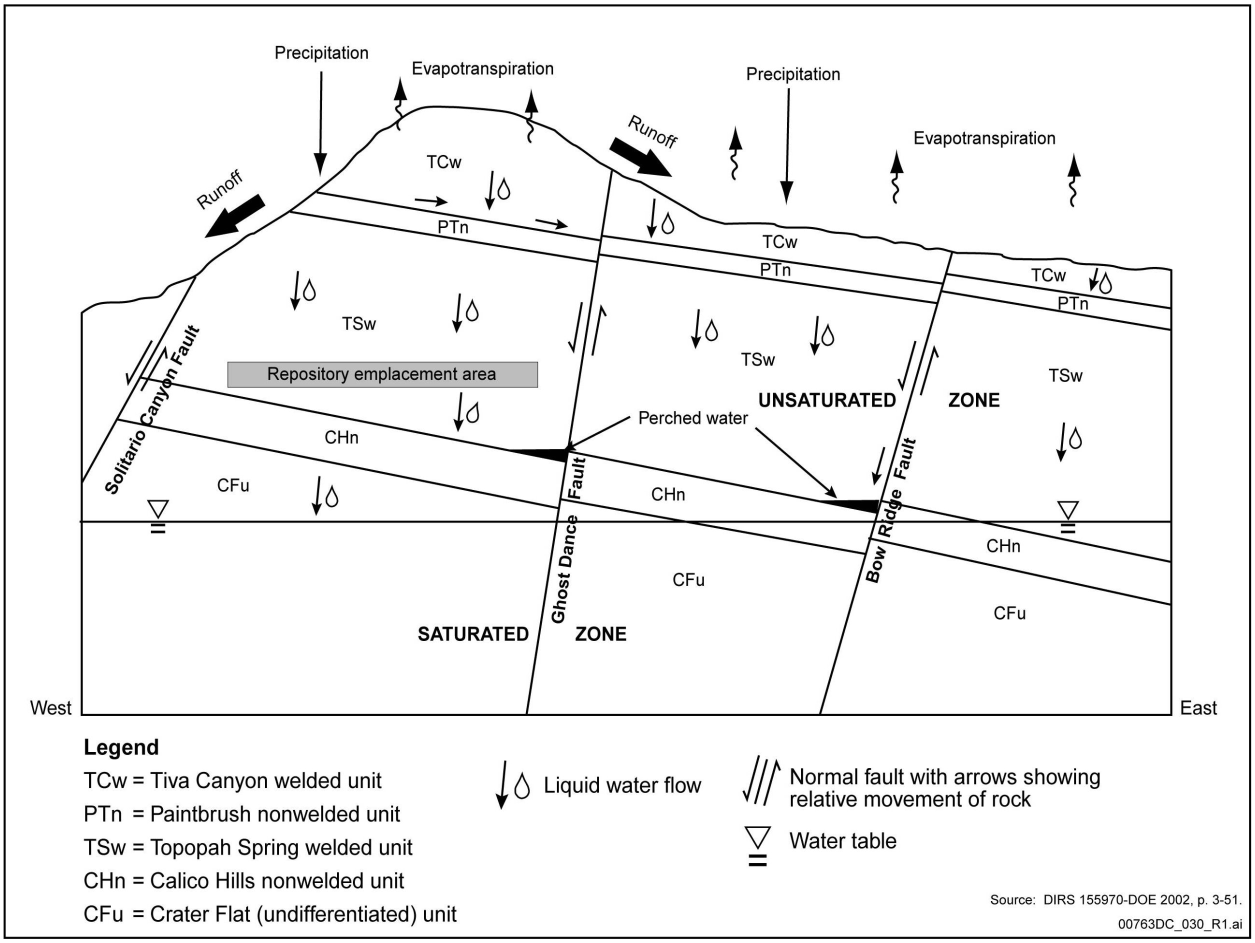

Figure 3-10. Conceptual model of water flow at Yucca Mountain.

and found no active flow of water; the Department observed only one fracture in the rock to be moist. Since the completion of the FEIS, DOE has observed and documented a seepage event, which occurred in February 2005 in the South Ramp of the Exploratory Studies Facility after a period of extremely high precipitation in the area. The recorded precipitation from October 2004 through February 2005, at 32.5 centimeters (12.8 inches), was roughly 3.5 times the average for the preceding 9 years (1995 to 2004) for the months of October though February (DIRS 177754-Finsterle and Seol 2006, p.1). The seepage or dripping occurred in strata of the Tiva Canyon welded unit, above the Paintbrush nonwelded unit (Figure 3-10). The Paintbrush nonwelded unit acts to slow the downward movement of water and the Tiva Canyon welded unit is likely to exhibit relatively fast flow. No seepage was observed in the proposed repository area, which is in the Topopah Spring welded unit below the Paintbrush nonwelded unit. An evaluation in May 2006 (DIRS 177754-Finsterle and Seol 2006, all) verified that the seepage event was consistent with conceptual models of the site. The evaluation minimally adapted the modeling approach used to estimate long-term ambient seepage into emplacement areas of the repository to estimate short-term seepage into the South Ramp. It found that the model and approach developed for the long-term performance of the repository estimated seepage in the South Ramp area reasonably consistent with observations in February 2005 (DIRS 177754-Finsterle and Seol 2006, p. 17). DOE reported the detection of the seepage to the U.S. Nuclear Regulatory Commission (NRC) (DIRS 173954-Ziegler 2005, all), but did not identify it as a "Technically Significant Condition" because DOE's conceptual models of the site predicted this type of seepage under high-precipitation conditions.

DOE's investigations of the unsaturated zone at Yucca Mountain found that water in the pores of rock is older and chemically distinct from water in fractures and in the perched water bodies. Water that moves along fractures probably is responsible for recharge of the perched water where the moving water encounters less-*permeable* rock and fault fill materials. As shown in Figure 3-10, perched water bodies occur near the base of the Topopah Spring welded unit, about 100 to 200 meters (330 to 660 feet) below the proposed repository horizon. To help characterize the nature of water movement in the unsaturated zone, DOE has performed carbon dating on samples of perched water and found apparent ages, or residence times, of 3,500 to 11,000 years. Because there are limitations on the use of carbon dating in this type of circumstance, DOE looked for the presence of tritium in the perched water, which would indicate contributions from water after 1952, which atmospheric nuclear weapons testing would have affected. The results indicated that tritium levels, if present, were too small for reliable detection.

Hydrologic Properties of Rock. The Yucca Mountain FEIS described the layers of rock and deposited materials at Yucca Mountain and the areas immediately surrounding it. The FEIS presented the layers, from the top down, in terms of stratigraphic units, which are defined by geologic properties of the rock, and hydrogeologic units, which reflect the manner in which water moves through the rock. In general, the origin of the rock and the manner of its deposition determine the stratigraphic units. Changes in these characteristics often coincide with changes in how water moves, so stratigraphic and hydrogeologic units might start or stop at the same observed physical change in the rock strata. In other instances, however, they might not coincide. For example, deposition of a sequence of volcanic rock might have occurred through one continuous event that formed a single stratigraphic unit, but if the upper portions of the sequence were more fractured, enhancing the potential for water movement, it would probably be designated as a separate hydrogeologic unit from the lower portion of the sequence. Figure 3-17 of the Yucca Mountain FEIS showed the strata, or layers, that DOE mapped through subsurface investigations in the Yucca Mountain vicinity (DIRS 155970-DOE 2002, p. 3-52). The layers are in terms of the stratigraphic units discussed in the geology sections of the affected environment and the hydrogeologic units that provide the basis for hydrology discussions. Table 3-13 of the FEIS listed the specific hydrogeologic units in the unsaturated zone at Yucca Mountain (DIRS 155970-DOE 2002, p. 3-53). Both provided descriptive characteristics of the identified rock layers.

Water Source and Movement. Precipitation at Yucca Mountain runs off, evaporates, or infiltrates into the ground where it is subject to later evaporation or *transpiration* by vegetation. Some of the water infiltrates deeply enough to be out of the influence of surface effects and can continue to move downward if conditions support such movement. DOE efforts since the completion of the Yucca Mountain FEIS have included development of a new model of net infiltration for the Yucca Mountain site (DIRS 174294-SNL 2007, all). According to this model, net infiltration under the current climate averages

14.3 millimeters (0.56 inch) per year over the study area of 125 square kilometers (30,900 acres), roughly centered over the Yucca Mountain site, and 17.6 millimeters (0.69 inch) per year over the repository footprint (DIRS 174294-SNL 2007, p. 6-170). Over smaller areas, the model shows wide variations in infiltration due to physical parameters such as soil, bedrock, vegetation, and the amount of lateral runoff. Soil depth is one of the most significant factors in estimates of local infiltration. The model estimates that areas of shallow [with average depths of 0.4 meter (1.3 feet)] or no soil comprise about 58 percent of the land area within the 125-square-kilometer study area, but account for almost 97 percent of the total infiltration (DIRS 174294-SNL 2007, p. 6-82 and p. 6-195). To assess the long-term performance of the proposed repository, the infiltration model includes estimates of infiltration during a monsoon climate and a cooler and wetter glacial-transition climate. These are the three climates (present-day, monsoon, and glacial-transition) DOE has predicted and modeled to occur up to 10,000 years into the future for the Yucca Mountain area (DIRS 174294-SNL 2007, p. 1-1). Both the monsoon and glacial-transition climates involve predicted net infiltration rates that are higher than those for the present-day climate (DIRS 174294-SNL 2007, p. 6-203).

Once through surface alluvium, water in the unsaturated zone at Yucca Mountain moves either very slowly through pore spaces in the rock or relatively rapidly through faults and fractures. Flow through faults and fractures probably occurs in episodic events that correspond to periods of high surface infiltration and, as noted above, is the likely source of the isolated perched water bodies under the zone where DOE would construct the proposed repository. The nature of this downward movement depends on the hydrogeologic properties of the rock layers. The Tiva Canyon welded unit (Figure 3-10) at the top of the rock sequence (and below the alluvium in many areas) at Yucca Mountain supports fairly rapid water transport through factures, but the underlying Paintbrush nonwelded unit has high porosity and low fracture density and tends to slow the water. DOE studies described in the Yucca Mountain FEIS investigated the presence of the naturally occurring radioactive isotope chlorine-36 in the Exploratory Studies Facility. Those studies suggested that some isolated pathways in the Paintbrush nonwelded unit allow small amounts of water to reach the underlying Topopah Spring welded unit fairly rapidly. The repository would be in the Topopah Spring welded unit, which has extensive fracturing that allows relatively rapid water movement. At the base of the Topopah Spring welded unit, water encounters low-permeability zones that include the top of the Calico Hills nonwelded unit. All of these rock layers, or hydrogeologic units, dip (slant) as shown in Figure 3-10, so water continues to move downward, but laterally, over the top of the low-permeability zone until it reaches a vertical pathway, such as a fault. Perched water bodies can form when the water encounters less permeable rock and *fault-gouge material* that block it from reaching a fault such that lateral and vertical movement is blocked and the water accumulates. As shown in Figure 3-10, water moving through the Calico Hills nonwelded unit (or past the unit through fault zones) encounters the Crater Flat unit and the water table.

Although the preceding discussion included terms such as “slow” and “rapid” in the description of water movement in the unsaturated zone at Yucca Mountain, it describes water movement in one hydrogeologic unit in comparison with another, so movement speed is relative. DOE has developed models of groundwater movement in the unsaturated zone (DIRS 184614-SNL 2007, all) that begin with the results of the net infiltration model described above and model the flow of water down to the water table. DOE ran the models under many infiltration scenarios for the present-day climate to construct a range of possible outcomes and to identify the scenario having the best correlation with measured field conditions and other modeled results (DIRS 184614-SNL 2007, p. 6-79). Adjusting the models to simulate transport of tracers, the most likely infiltration scenario estimates it would take about 8,000 years for 50 percent of a conservative (no loss through degradation, decay, or adsorption) tracer, moving at the same rate as the infiltrating water, to move roughly 300 meters (980 feet) from the repository to the underlying water table. (The depth to the water table is an approximate value because it varies over the lateral extent of the repository.) Ten percent of the tracer would reach the water table in about 300 years, but half would take longer than 8,000 years (DIRS 184614-SNL 2007, p. 6-102).

The Yucca Mountain FEIS described chlorine-36 studies in detail because the results suggested that infiltrating water pathways of 50 years or less could exist from the surface to the subsurface level of the proposed repository. Because of the significance of these results and the complexities and uncertainties of the analyses, DOE initiated additional studies to determine if independent laboratories and related isotopic studies could corroborate the findings. Since the completion of the Yucca Mountain FEIS, DOE and the U.S. Geological Survey completed a significant element of these studies in the form of a validation study (DIRS 179489-BSC 2006, all). The U.S. Geological Survey designed the study to include investigations for chlorine-36 and tritium (another radioactive isotope). In addition to the U.S. Geological Survey, study participants included two DOE national laboratories. The validation study resulted in mixed findings. One study participant ran the analyses, but the results did not show evidence of chlorine-36-to-total-chlorine ratios that would indicate the presence of recent bomb-pulse water. Another participant reproduced the results from the earlier studies that the Yucca Mountain FEIS discussed. The concurrent tritium studies concluded that water extracted from rock in areas of known faulting indicated the presence of modern water (water that entered the unsaturated zone after 1952) (DIRS 179489-BSC 2006, pp. v and vi). The report of the validity study includes recommendations to improve the study and to understand better the results obtained (DIRS 179489-BSC 2006, pp. 59 and 60). These findings, although inconsistent and inconclusive, have not precluded the presence of relatively fast pathways for small amounts of water in some subsurface locations.

Unsaturated Zone Groundwater Quality. The Yucca Mountain FEIS compared the water chemistry of pore water and perched water collected at Yucca Mountain. The pore water was higher in dissolved minerals than the perched water, particularly chloride, which indicates that perched water had little interaction with rock. This, in turn, provided strong evidence that flow through faults and fractures is the primary source of perched water.

Saturated Zone

Water Occurrence. The Yucca Mountain FEIS described the aquifers and confining units in the *saturated zone* at Yucca Mountain. It indicated that the upper and lower volcanic aquifers consisted primarily of the Topopah Spring Tuff and the lower tuffs of the Crater Flat Group, respectively. As shown in Figure 3-10, the upper Topopah Spring Tuff (or the equivalent hydrogeologic unit, the Topopah Spring welded unit) in which the upper volcanic aquifer occurs, is above the water table in the area of the proposed repository and below the water table to the east and south of the repository footprint. Further south of the Yucca Mountain site and downgradient in the groundwater flow path, the volcanic aquifers gradually change or, as the recent Nye County investigations indicate, abruptly end when they reach a fault and groundwater movement continues in the alluvial aquifer into the valley-fill materials of the Amargosa Desert. Underlying the volcanic and alluvial aquifers is the lower carbonate aquifer (generally referred to as the carbonate aquifer in this document), as shown in the highly stylized and simplified cross section of Figure 3-11. The carbonate aquifer, which is more than 1,250 meters (4,100 feet) below the proposed repository horizon, consists of Paleozoic carbonate rocks (limestone and dolomite) that were extensively fractured during many periods of mountain building. Studies indicate that this deep aquifer

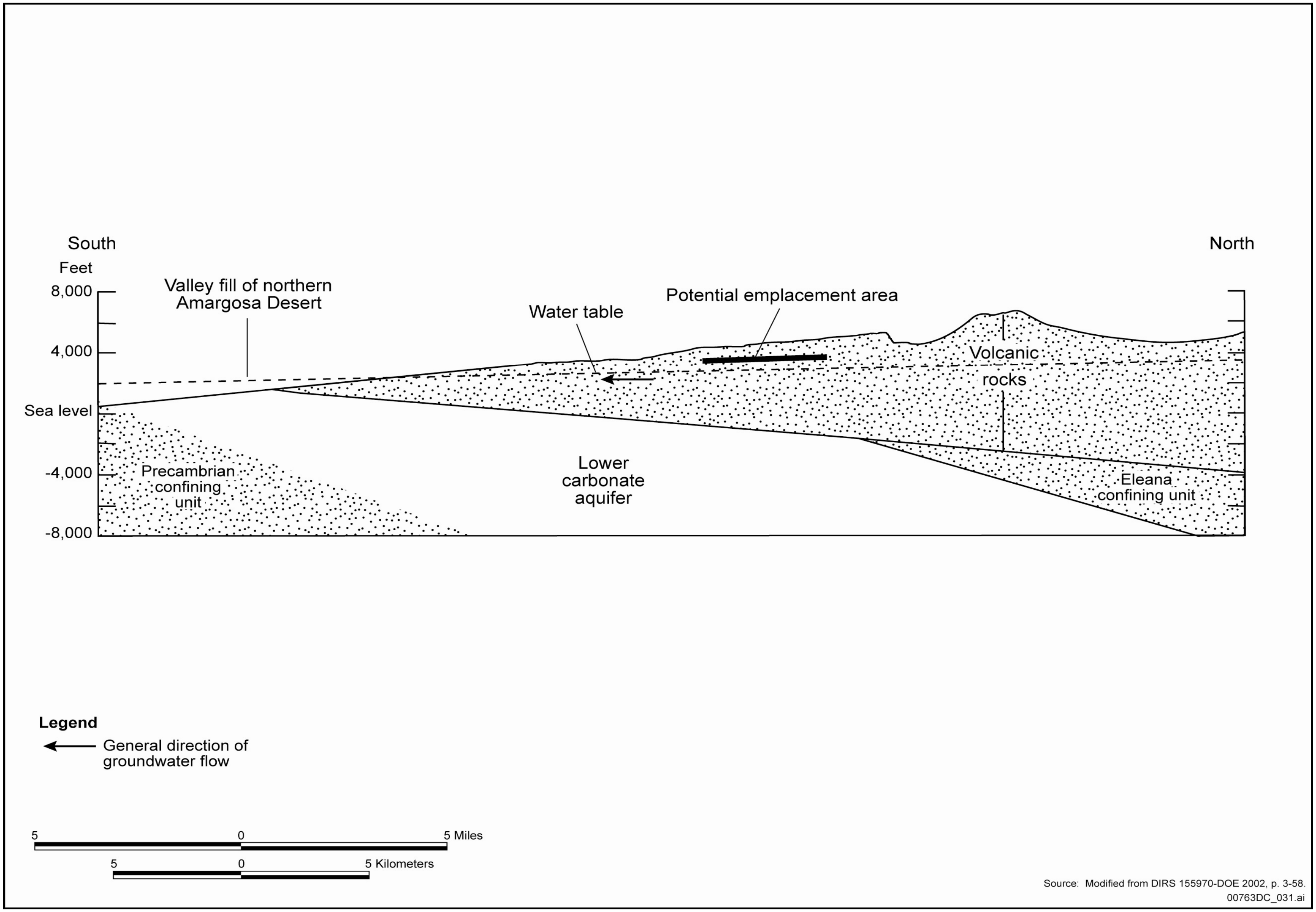

Figure 3-11. Cross section from northern Yucca Mountain to northern Amargosa Desert, showing generalized geology and the water table.

represents a regionally extensive system, though fragmented, that can transmit large amounts of groundwater when compartments are hydraulically connected.

Data from the few wells that penetrate the lower carbonate aquifer indicate that it has an upward gradient; that is, on well penetration, water rises in the well to an elevation above the aquifer. This occurred at a deep well near Yucca Mountain where the water level, or potentiometric head, of the carbonate aquifer was about 20 meters (66 feet) higher than the water level in the overlying volcanic aquifer. It also occurred in a well drilled for the Nye County program about 19 kilometers (12 miles) south of the repository site where the water rose 8 meters (26 feet) higher than the water in the overlying volcanic aquifer. Several other wells near Yucca Mountain that extend as deep as the confining unit at the base of the lower volcanic aquifer show higher potentiometric levels in that unit than in the overlying volcanic aquifers. This might be another indication of an upward hydraulic gradient in the carbonate aquifer.

Since completion of the Yucca Mountain FEIS, Inyo County installed a monitoring well to the carbonate aquifer. This well, in the southern Amargosa Desert in California, is about 50 kilometers (31 miles) south from the deep well near Yucca Mountain. Inyo County reported water in this well at an elevation 3.3 meters (almost 11 feet) higher than in an adjacent well [only 6 meters (20 feet) away] in the overlying alluvial aquifer (DIRS 185423-ICYMRAO n.d., pp. 4 to 8). The upward hydraulic gradient in the carbonate aquifer is important because it prevents water in the overlying volcanic aquifers of Yucca Mountain, and possibly in the overlying alluvial aquifers in the Amargosa Desert, from moving downward. This is significant in the assessment of the *postclosure* performance of the proposed repository (see Chapter 5 of this Repository SEIS) because it constrains the pathway by which *radionuclides* could move after repository-closure.

DOE has studied mineralogical data, isotopic data, and natural features at Yucca Mountain, as well as evidence of climate changes over the past few hundred thousand years, to evaluate how groundwater levels changed in the past and how they might change in the future. Based on this research, DOE concluded that the water table might have been as much as 85 meters (280 feet) above the present level beneath Yucca Mountain during the last 1 million years, which would have included climates cooler and wetter than those for the present (DIRS 177391-SNL 2007, pp. 6-82 and 6-83). Efforts to model the groundwater response to wetter climates have, in some cases, resulted in the prediction of higher water tables, including a simulated water table rise of 60 to 150 meters (200 to 490 feet) in a regional flow system model developed earlier in the Yucca Mountain Project (DIRS 169734-BSC 2004, pp. 8-105 and 8-106). However, DOE believes that limitations in this model, primarily due to its coarse (or large) numerical grid, appear to have resulted in overestimates of water table rise (DIRS 177391-SNL 2007, p. 6-83). In any case, both physical indicators of historic conditions and model projections of future wetter climates indicate that the repository horizon would remain well above maximum water tables.

The Yucca Mountain FEIS discussed opposing views on the historical water level at Yucca Mountain and on the level to which the water could rise in the future. One of the opposing views suggested that deposits of calcium carbonate and opaline silica in some rock fractures at Yucca Mountain could have been deposited by hydrothermal fluids from below that were driven upward by earthquakes or hydrothermal processes that could occur in the future. Another opposing view, presented several years later, looked at the presence of the carbonate-opal veinlets at Yucca Mountain and concluded that the water inclusions in the deposits were formed at elevated temperatures, which supported the conclusion they were formed by warm upwelling water rather than by precipitation moving downward.

In 1990, DOE convened a panel of experts that included members of the National Academy of Sciences to review the evidence of the first opposing view. The panel concluded that the mechanism suggested for causing water upwelling could not raise the water table more than a few tens of meters and that the carbonate-rich deposits in rock fractures were from surface-down processes (precipitation) rather than the opposite. In 1998, a second group of independent experts, including U.S. Geological Survey and university representatives, reviewed the second theory of warm upwelling. The group of independent experts disagreed with some of the central scientific conclusions put forth by the second opposing view. In this case, as reported in the Yucca Mountain FEIS, both parties agreed additional research was necessary to resolve the issue; DOE supported an independent investigation by the University of Nevada, Las Vegas, and invited the U.S. Geological Survey and the State of Nevada to participate.

Since the completion of the Yucca Mountain FEIS, the University of Nevada, Las Vegas reported on the results of its study (DIRS 182120-Wilson and Cline 2002, all; DIRS 182121-Wilson et al. 2002, all; DIRS 163589-Wilson et al. 2003, all). The study looked at 155 samples from tunnels in the Exploratory Studies Facility at Yucca Mountain and considered several different means to investigate how the carbonate-opal veinlets were deposited. It included the analysis of secondary mineral deposits and the isotope signatures of those deposits. It also included use of uranium-lead techniques to date the silica minerals associated with fluid inclusions. The researchers believed that the results supported a detailed time-temperature history of fluid migration through rock pores at Yucca Mountain during the past 8 to 9 million years (DIRS 182121-Wilson et al. 2002, p. 4). The conclusion of the study was that carbonate-opal veinlets were the result of descending meteoric water (that is, water infiltrating from above), not from the upwelling of hydrothermal fluids (DIRS 182120-Wilson and Cline 2002, p. 25; DIRS 182121-Wilson et al. 2002, p. 26).

An October 2003 letter (DIRS 181056-Swainston 2003, all) sent to the Nuclear Waste Technical Review Board by a lawyer who represented proponents of the upwelling fluids scenario included a review of the University of Nevada, Las Vegas report (DIRS 182120-Wilson and Cline 2002, all; DIRS 182121-Wilson et al. 2002, all). According to the letter, the scientists who proposed the opposing view disagreed with the conclusions in the University report and “are convinced, based on many lines of evidence, that the secondary minerals were deposited by hydrothermal fluids driven from deep beneath Yucca Mountain and that episodes of such deposition are recent in geologic time.” A February 2004 letter of response from the Nuclear Waste Technical Review Board (DIRS 181239-Parizek 2004, all) indicated that the information provided “would not alter the Board’s previous conclusion that the evidence presented does not make a credible case for the hypothesis of ongoing, intermittent hydrothermal activity at Yucca Mountain,” but recognized that differences of opinion might still exist.

Hydrologic Properties of Rock. The Yucca Mountain FEIS provided definitions for the hydrologic properties of transmissivity, conductivity, and porosity and, in Table 3-15, listed typical values or ranges of values for the three aquifers and two interlying confining units at Yucca Mountain (DIRS 155970-DOE 2002, p. 3-62). The discussion presented some considerations in the interpretation or understanding of the values in the table. This included findings at Yucca Mountain that showed rock with the highest porosity often had low transmissivity. This is attributable to a condition in which the rock contains many voids that result in high porosity, but the voids are not interconnected and the rock is in an area of low fracturing. With low amounts of interconnected void spaces and few fracture seams, water pathways are limited and the transmissivity is low. Other factors to consider in understanding the values include the limited number of tests performed on the carbonate aquifer due to the limited number of wells that reach that depth and the ability to measure only apparent values from single boreholes; that is, the measured values are representative of a small area around the borehole, and might change significantly in the immediate area if water-bearing fractures are in the tested well zone.

Water Source and Movement. As reported in the Yucca Mountain FEIS, DOE has studied groundwater levels at Yucca Mountain for years and found them to be very stable. Excluding changes due to pumping, the observed fluctuations in groundwater level were attributed to natural phenomena such as barometric pressure changes and Earth tides; short-term fluctuations have been linked to apparent recharge events and earthquakes.

Hydrologists typically generate maps that show the elevation of the groundwater surface, also called the potentiometric surface, with contour lines of equal elevation. Lines perpendicular to the contour lines represent the direction of slope of the groundwater surface, which is the implied direction of groundwater flow. At Yucca Mountain, the potentiometric surface consists of three zones. On the west side of the mountain, the potentiometric surface slopes moderately to the southeast, dropping in elevation about 20 to 40 meters (66 to 130 feet) in 1 kilometer (0.6 mile). The east boundary of this zone is the Solitario Canyon fault on the west side of Yucca Mountain. The fault zone apparently impedes flow, and on its east side is the second zone where the water surface has a very gentle slope, dropping only 0.1 to 0.4 meter per kilometer (0.5 to 2 feet per mile). This zone of gentle slope underlies Yucca Mountain. The southeast direction of the slope is a local condition in the regional southward groundwater flow. The third zone is an area of steep slope in the potentiometric surface north of Yucca Mountain. In this zone, the groundwater appears to drop sharply toward the south; about 110 meters vertically over a horizontal distance of 1 kilometer (about 580 feet per mile), which generates a hydraulic gradient of 0.11 (DIRS 170009-BSC 2004, p. 6-20). The Yucca Mountain FEIS described possible reasons for this steep slope, but concluded that there were no obvious geologic reasons and that it was still under investigation. Figure 3-12 shows the potentiometric surface contours for the area of Yucca Mountain, which are consistent with the preceding discussion and which this discussion refers to as the Version A contours.

Since the completion of the Yucca Mountain FEIS, DOE investigations of this steep hydraulic gradient have continued, but the efforts have not reached an unequivocal explanation (DIRS 170009-BSC 2004, p. 6-21). DOE based the predictions of the groundwater elevation contours in the area of the steep gradient, to a large extent, on measured groundwater elevations in three different boreholes north of Yucca Mountain. These three boreholes (UE-25 WT 6, USW G-2, and USW WT-24) are within a circle about 1.6 kilometers (1 mile) in diameter (DIRS 170009-BSC 2004, p. 1-3). Two of the boreholes have measured water elevations notably higher than the one farthest to the south (USW WT-24). The Yucca Mountain FEIS identified a possible reason for the steep hydraulic gradient—that water in at least some of the boreholes in this area is perched water and not part of the regional water table. In pursuing this possibility, DOE has regenerated the potentiometric surface map (Version B) of the Yucca Mountain vicinity with the assumption that water in boreholes UE-25 WT 6 and USW G-2 is perched water (DIRS 170009-BSC 2004, p. 6-17); that is, of the three boreholes in the area immediately north of Yucca Mountain, DOE used only the water elevation measured in USW WT-24 along with other area data points in the development of the revised contours in this area. Version B (Figure 3-13) shows that, without the use of data from the two boreholes, the elevation contours at the north portion of Yucca Mountain have smoother curves and are slightly further apart than those in Figure 3-12. As a result of the more widely spaced contour lines, the hydraulic gradient in the area of the steep zone declines to 0.06 to 0.07. Possibly of more significance, DOE evaluated both the perched and nonperched scenarios in its groundwater model and found them to yield similar flow characteristics. This supports earlier findings of an expert panel that concluded that, whether the steep slope was due to perched water or not, it would

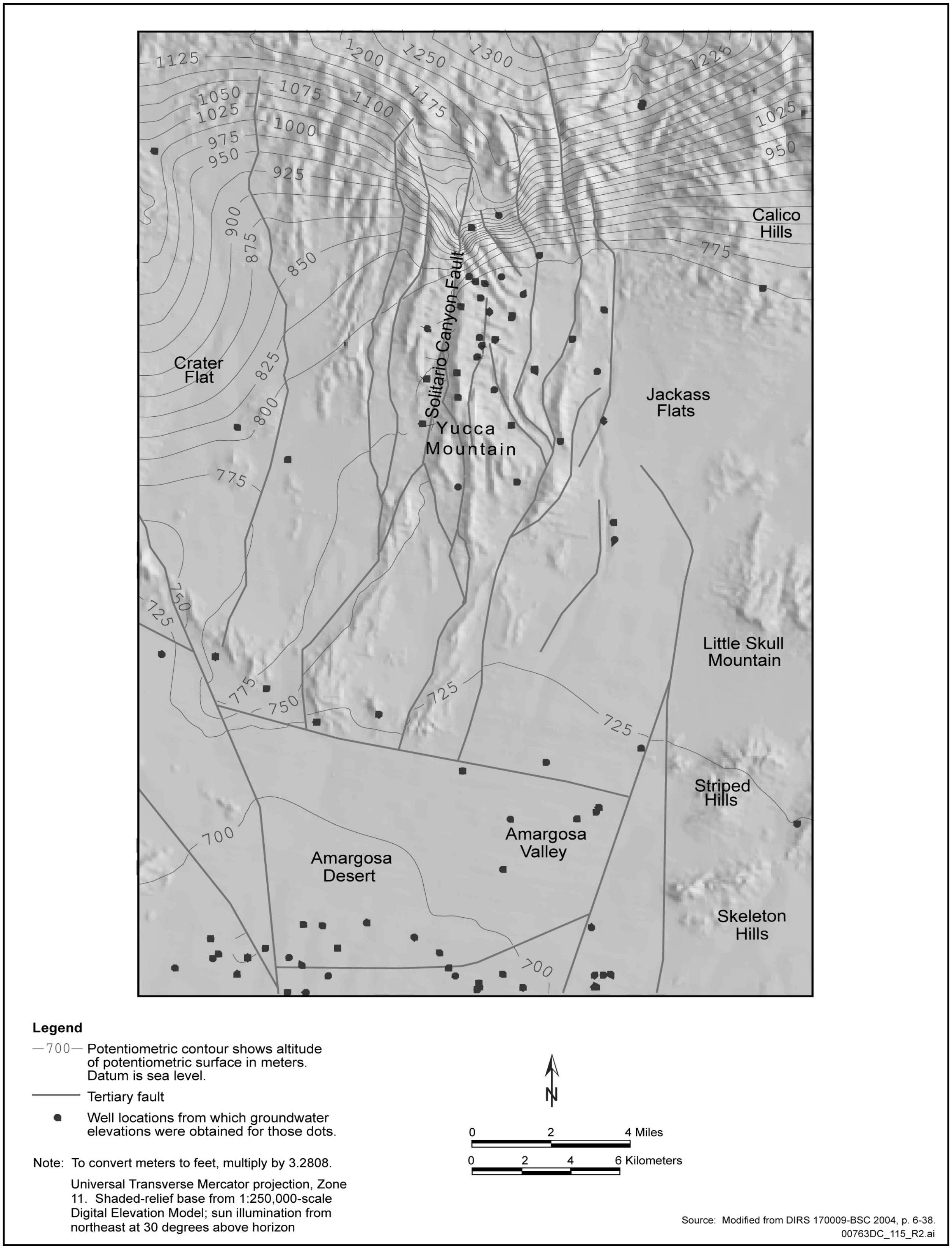

Figure 3-12. Original potentiometric surface map for the Yucca Mountain area (considering groundwater elevations in all applicable boreholes).

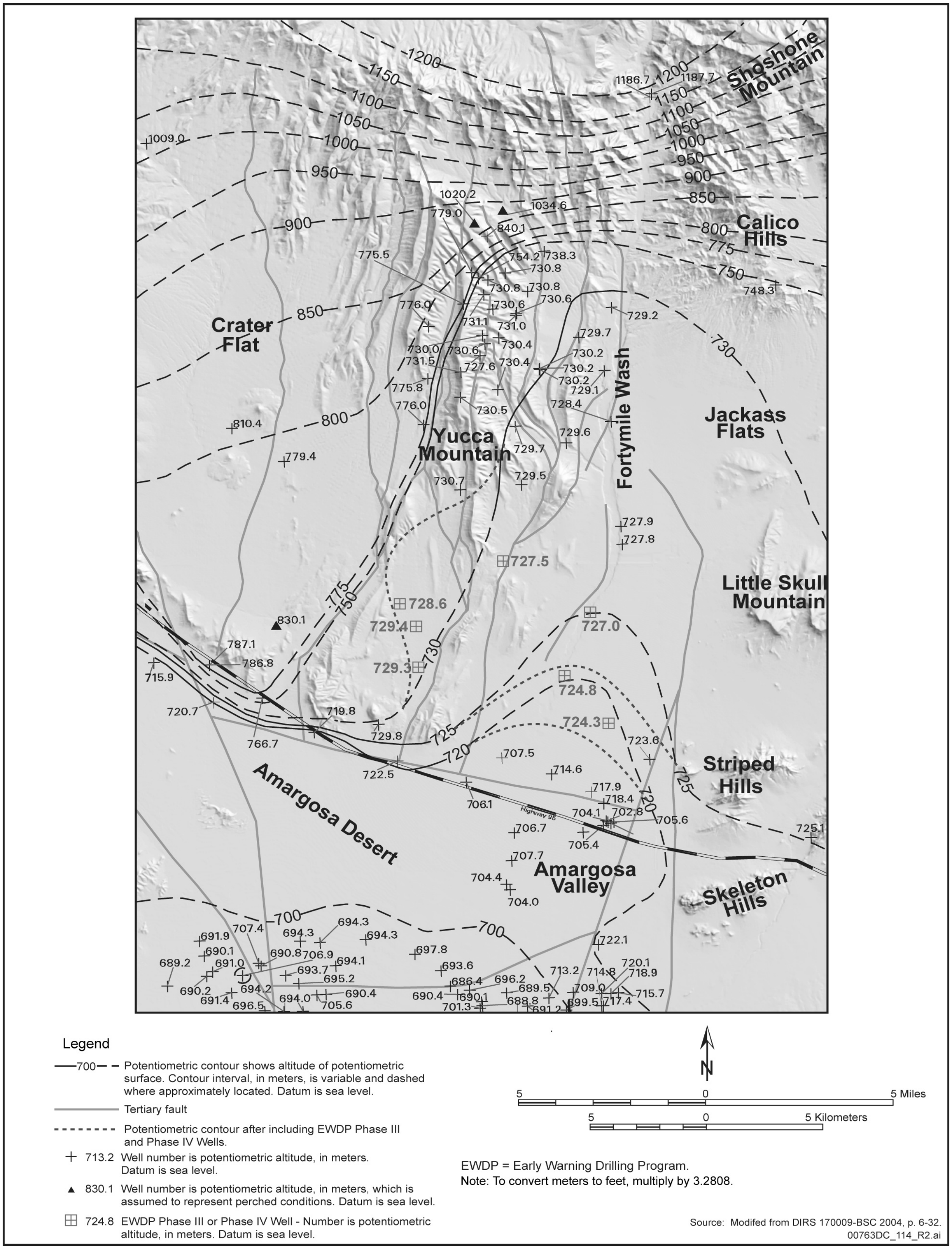

Figure 3-13. Revised potentiometric surface map for the Yucca Mountain area (excluding groundwater elevations from boreholes UE-25 WT 6 and USW G-2).

have no effect on repository performance (DIRS 170009-BSC 2004, p. 6-21). The lower central portion of Figure 3-13 shows several possible changes to contours as a result of recent findings from the Nye County drilling program.

The Yucca Mountain FEIS described an opposing view to the stability of groundwater levels at Yucca Mountain that suggested earthquakes in the area could cause substantial rises of the water table, and could even flood the repository. The FEIS also described the expert panel review of the information and theory behind this view and the conclusion of the panel that a rise of groundwater to the level of the repository was essentially improbable. DOE has received no additional support for this opposing view since it completed the FEIS.

Inflow to Volcanic Aquifers at Yucca Mountain. The Yucca Mountain FEIS described the four potential sources of inflow to the volcanic aquifers in the vicinity of Yucca Mountain: (1) lateral flow from volcanic aquifers north of Yucca Mountain, (2) recharge along Fortymile Wash from occasional stream flow, (3) precipitation at Yucca Mountain, and (4) upward flow from the underlying carbonate aquifer. DOE does not know the actual amounts of water inflow from these potential sources and cannot measure them on a large-scale basis, but it has developed estimates for incorporation into regional- and site-scale models of the unsaturated and saturated zones. According to these estimates, which are based on data collected and tests performed, the amount of inflow due to precipitation at Yucca Mountain is small in comparison with inflow from volcanic aquifers to the north, and it is less than estimates of recharge along the length of Fortymile Wash. The higher potentiometric surface of the carbonate aquifer in the area of Yucca Mountain would support inflow to the overlying volcanic aquifer where pathways existed. Based on hydrochemical analyses of the groundwater beneath Yucca Mountain, it appears a small amount (generally less than 5 percent) of the water in the volcanic aquifer can be attributed to upwelling from the carbonate aquifer (DIRS 177391-SNL 2007, Appendix A, p. A-164).

Outflow from Volcanic Aquifers at and near Yucca Mountain. The Yucca Mountain FEIS described the three pathways by which water might leave the volcanic aquifers in the vicinity of Yucca Mountain as (1) downgradient movement into other volcanic and alluvial aquifers in the Amargosa Desert, (2) downward movement into the carbonate aquifer (though evidence indicates this does not occur), and (3) upward movement into the unsaturated zone. The Yucca Mountain FEIS mentioned a fourth pathway, pumping of water from the aquifer. With the exception of pumping from wells, the actual amounts of water outflow along these pathways are unknown. Based on investigations of the area and the potentiometric surface of the groundwater, the pathway for groundwater beneath Yucca Mountain is southerly through volcanic aquifers before it encounters the alluvial aquifer of the Amargosa Desert.

Available data on the potentiometric head of the carbonate aquifer indicate that any movement of water between carbonate and volcanic aquifers in the area of Yucca Mountain would be upward. Upward movement of water to the unsaturated zone is the third pathway for water to leave the volcanic aquifer. However, based on collected data, DOE believes there is a net downward movement of water in the unsaturated zone.

Use. The Yucca Mountain FEIS described the historical use of groundwater in the immediate area of Yucca Mountain, which largely consisted of DOE water withdrawals. Two wells, J-12 and J-13, are in Jackass Flats (Hydrographic Area 227A) on the east side of Yucca Mountain and are the nearest production wells to the proposed repository site (DIRS 155970-DOE 2002, p. 3-65). DOE has used these wells to support water needs for Area 25 of the Nevada Test Site and the Yucca Mountain Project. The

Department has pumped groundwater from other wells in the immediate area in support of Yucca Mountain characterization activities, which include wells in Crater Flat on the west side of the mountain. For the most part, these withdrawals have been small. Exceptions were the relatively large volumes—up to 230,000 cubic meters (190 acre-feet) per year—that DOE pumped from the C-Well complex, also in Jackass Flats, as part of aquifer testing actions. Water from the C-Wells was reinjected as part of the testing. Table 3-16 of the Yucca Mountain FEIS summarized the quantities of water from J-12 and J-13 and from the C-Well complex for 1992 to 1997 and estimates for several years after 1997 (DIRS 155970-DOE 2002, p. 3-66). Since the completion of the Yucca Mountain FEIS, actual quantities of water pumped from Jackass Flats have dropped sharply. In 1997, the last year of record in Table 3-16 of the FEIS, about 420,000 cubic meters (340 acre-feet) of water were withdrawn from Jackass Flats. By 2000 and 2001, that number dropped to less than half the 1997 value to about 170,000 cubic meters (140 acre-feet) per year (DIRS 178692-La Camera et al. 2005, pp. 72 and 73; DIRS 181575-Wade 2000, all; DIRS 181576-Wade 2000, all; DIRS 181577-Wade 2000, all; DIRS 181578-Wade 2001, all; and DIRS 181580-Wade 2002, all). From 2002 to 2004, withdrawals dropped further, ranging from about 57,000 to 83,000 cubic meters (46 to 67 acre-feet) per year (DIRS 178692-La Camera et al. 2005, pp. 72 and 73; DIRS 178691-La Camera et al. 2006, p. 69; DIRS 181581-Wade 2003, all; DIRS 181582-Wade 2004, all; and DIRS 181583-Wade 2005, all). The large reductions in groundwater use are attributable to the reduction in water needs at the Yucca Mountain site as characterization activities ended and the project moved into licensing activities. Current water use at the site is only about 6,000 cubic meters (5 acre-feet) of water per year. (As noted above, the remaining groundwater withdrawals from Jackass Flats are attributable to Nevada Test Site needs.)

Table 3-17 of the Yucca Mountain FEIS summarized the results of long-term efforts by the U.S. Geological Survey to monitor changes in groundwater elevations in the vicinity of Yucca Mountain (DIRS 155970-DOE 2002, p. 3-67). The table listed water-level conditions in seven wells from 1992 to 1997 and compared them with median water levels in the same wells from measurements from 1985 to 1993 (DIRS 103283-La Camera et al. 1999, p. 84). Table 3-5 updates the data presented in the FEIS by including corresponding groundwater level monitoring results from 1998 through 2004. DOE used the same baseline water elevations it used on the Yucca Mountain FEIS to calculate the elevation differences. For example, the average groundwater elevation measured in well JF-1 during 2004 was 27 centimeters

Table 3-5. Differences between annual and baseline median groundwater elevations above sea level.

Baseline elevations[a]			Difference from baseline media (centimeters)[b]												
Well	Median (meters)[c]	Average deviation from median (centimeters)[b]	1992 to 1997[d]						1998 to 2004[e]						
JF-1	729.23	± 6	–3	0	–6	0	–6	–3	0	+6	+9	+15	+21	+24	+27
JF-2	729.11	± 9	+3	0	+3	+9	0	–3	0	+12	+18	+21	NA	+15	+18
JF-2a[f]	752.43	±12	0	+6	+12	+15	+21	+27	+43	+49	+67	+70	+70	+88	+85
J-13	728.47	± 6	–3	–3	–9	–6	–12	–12	–6	0	+6	+12	+12	+18	–3
J-11	732.19	± 3	0	0	+3	+6	+6	+12	+12	+6	+6	+12	+9	+12	+9
J-12	727.95	± 3	0	0	–3	–3	–9	–9	–9	0	+3	+6	+9	+15	+18
JF-3	727.95	± 3	NA	NA	–6	–6	–9	–9	–9	–3	+3	+6	+9	+15	+15

a. Source: DIRS 103283-La Camera et al. 1999, p. 84.
b. To convert centimeters to inches, multiply by 0.3937.
c. To convert meters to feet, multiply by 3.2808.
d. Source: DIRS 155970-DOE 2002, p. 3-67.
e. Source: DIRS 178691-La Camera et al. 2006, p. 71.
f. Well JF-2a is also known as UE-25 p#1, or P-1.
NA = Not available.

(11 inches) above the baseline elevation established for that well. Table 3-5 indicates a general increase in groundwater levels in all the wells beginning in 1998 to 1999. There were only a handful of instances in which the elevation in a well dropped below that reported in the previous year, so the increasing trend was relatively steady through the monitoring period from 1998 to 2004. This trend of increasing water levels probably is due either to the decrease in water use from the basin or to changes in recharge to the groundwater system (DIRS 178691-La Camera et al. 2006, p. 14), or a combination of both.

Saturated Zone Groundwater Quality. The groundwater sampling effort described in Section 3.1.4.2.1 included three groundwater wells in the vicinity of Yucca Mountain, which include production wells J-12 and J-13. As described in the Yucca Mountain FEIS, water samples from these three wells met primary drinking-water standards set at that time by the EPA for public drinking-water systems, but each well exceeded the secondary standard for fluoride and proposed primary standards for radon. Since the completion of the Yucca Mountain FEIS, the standard for radon is not yet in effect, but the EPA has lowered the primary drinking-water standard for arsenic to 0.01 milligram per liter. The reported values for the 1997 sampling of the three wells were 0.008, 0.009, and 0.011 milligrams per liter. The new standard for arsenic, effective January 23, 2006, requires treatment to less than 0.01 milligram per liter. DOE has installed and implemented an arsenic treatment system for the Yucca Mountain drinking-water system (DIRS 179878-BSC 2006, p. 7). Table 3-18 of the Yucca Mountain FEIS listed water chemistry data for groundwater in the volcanic and carbonate aquifers at Yucca Mountain (DIRS 155970-DOE 2002, p. 3-68). Water from the volcanic aquifer has a relatively dilute sodium-potassium-bicarbonate composition; water from the carbonate aquifer is quite different, with a more concentrated calcium-magnesium-bicarbonate composition. These characteristics are consistent with the different types of rock through which the water travels.

Table 3-19 of the Yucca Mountain FEIS listed radiological concentrations from sampling of groundwater in 1997 at and near Yucca Mountain (DIRS 155970-DOE 2002, p. 3-69). This sampling effort established a baseline for *radioactivity* in groundwater from the alluvial, volcanic, and carbonate aquifers. The radioactivity concentrations were below EPA *maximum contaminant levels* for public drinking-water systems, which include the value of 4 *millirem* per year set as the total body dose limit for beta- or gamma-emitting radionuclides. The discussion noted, however, that the groundwater would exceed proposed standards for radon. The information in Table 3-19 of the FEIS and the accompanying discussion are still valid and are incorporated here by reference. Table 3-19 of the FEIS listed sample results for total uranium, but indicated there was no associated drinking-water standard. Since the completion of the FEIS, EPA has established a maximum contaminant level of 30 micrograms (or 0.03 milligram) per liter for uranium in drinking water. The total uranium values in Table 3-19 of the FEIS are all below this level.

The Yucca Mountain FEIS discussed several studies on potential groundwater *contamination* from past nuclear weapons testing at the Nevada Test Site. DOE has detected radionuclide migration to groundwater. In general, the migration of tritium, a radionuclide that is transported in solution with water moving through the area, is limited to several kilometers. Less mobile radioactive constituents (generally those that do not go into solution or do not go into solution as completely and easily as tritium) have migrated no more than about 500 meters (1,600 feet). In one case, however, there is evidence of plutonium migration from a below-groundwater test at Pahute Mesa. Monitoring results indicate plutonium has moved at least 1.3 kilometers (0.8 mile) from the source in 28 years and might be due to the movement of very small particles called colloids. Area 25 of the Nevada Test Site, the location of Yucca Mountain and the proposed repository, was not an area of nuclear detonation testing, and DOE studies of contaminant migration from Nevada Test Site activities do not indicate that any contamination has reached the groundwater beneath Yucca Mountain. However, Pahute Mesa and Buckboard Mesa, which are areas where nuclear testing occurred (primarily at Pahute Mesa), are 40 kilometers (25 miles) and 30 kilometers (19 miles), respectively, north of Yucca Mountain. A single nuclear test with multiple detonations spaced in a row occurred in Area 30 of the Nevada Test Site (DIRS 101811-DOE 1996, p. 4-17) about 21 kilometers (13 miles) north of the repository site. The flow of groundwater from these areas could be to the south. Because of the distances, there is no reason to believe that contaminants could move as far as Yucca Mountain before repository-closure, with the possible exception of tritium. In addition, DOE modeling suggests that groundwater flow patterns from these test areas to the north skirt the Yucca Mountain area (DIRS 103021-DOE 1997, p. ES-28). This is similar to the conceptual model of groundwater flow from more recent U.S. Geological Survey efforts (Figure 3-8), which show that Pahute Mesa is in the dividing area between the Pahute Mesa-Oasis Valley Groundwater Basin and the Alkali Flat-Furnace Creek Groundwater Basin, the location of Yucca Mountain. The Survey model describes water from Pahute Mesa as contributing flow to the southwest through Oasis Valley (skirting Yucca Mountain) as well as to the south through the Fortymile Canyon Section (DIRS 173179-Belcher 2004, pp. 152 and 154). Chapter 8 of this Repository SEIS discusses the potential for long-term migration of radionuclides in the groundwater system to result in cumulative radiation impacts from nuclear testing and repository actions.

3.1.5 BIOLOGICAL RESOURCES AND SOILS

The region of influence for biological resources and soils is the area that contains all potential surface disturbances that would result from the Proposed Action and some additional area to evaluate local animal populations. This region is roughly equivalent to the analyzed land withdrawal area of about 600 square kilometers (150,000 acres). DOE has expanded the region of influence for biological resources and soils from that in the Yucca Mountain FEIS to include land proposed for an access road from U.S. Highway 95 and for construction of offsite facilities. This offsite area would include Bureau of Land Management lands between the southern boundary of the analyzed land withdrawal area and U.S. Highway 95 (Figure 3-1). The offsite area covers about 37 square kilometers (9,100 acres).

In the Yucca Mountain FEIS, DOE used available information and studies on plants and animals at the site of the proposed repository and the surrounding region to identify baseline conditions for biological resources. This information included land cover types, vegetation associations, and the distribution and abundance of plant and animal species in the region of influence and the broader region. The data suggested that the plants and animals in the Yucca Mountain region were typical of species in the Mojave and Great Basin deserts. As reported in the Yucca Mountain FEIS, DOE surveyed the region for naturally occurring wetlands and studied soil characteristics in the region, which included thickness, water-holding capacity, texture, and erosion hazard.

Beginning in 1982 with site investigation, DOE has conducted extensive field surveys to characterize the biological and soil resources in the vicinity of Yucca Mountain (DIRS 104593-CRWMS M&O 1999, all; DIRS 104592-CRWMS M&O 1999, all). DOE used the results of these studies to assess the impacts of site characterization in the Yucca Mountain FEIS analysis to understand and predict possible impacts from similar activities that would occur during repository construction and operations. For this Repository SEIS, DOE analyzed the results of field surveys and habitat data that have become available since completion of the Yucca Mountain FEIS. This Repository SEIS includes information from more recent lists of and surveys for special-status species and the results of a new land cover mapping effort.

3.1.5.1 Biological Resources

3.1.5.1.1 *Vegetation*

In the Yucca Mountain FEIS, DOE used data from two sources to describe land cover types in the analyzed land withdrawal area: a statewide classification and a detailed, field-validated classification of the area around the Yucca Mountain site. DOE has reassessed land cover in the region of influence using data from the *Southwest Regional Gap Analysis Project* (DIRS 174324-NatureServe 2004, all), which were not available at the completion of the FEIS and which describe land cover at a finer level of detail than previous land cover mapping efforts. In addition, the species composition results of field studies DOE performed in and near the analyzed land withdrawal area (conducted after the FEIS was completed, and as summarized in the *Rail Alignment* EIS) are consistent with the results in the Yucca Mountain FEIS and the results of subsequent analyses of Southwest Regional Gap Analysis Project land cover data.

Using previously defined *ecoregions* in the southwestern United States that are based on physical and biological similarities, the Southwest Regional Gap Analysis Project developed *mapping zones* to facilitate land cover delineation. By analyzing satellite imagery and field data, the Southwest Regional Gap Analysis Project classified geographic areas in each mapping zone based on land cover types and generated maps of land cover type occurrence. The project classified naturally vegetated land cover with an ecological systems classification and developed and described land cover types based on dominant vegetation, physical characteristics of the land, hydrology, and climate (DIRS 176369-Lowry et al. 2005, all; DIRS 173051-Comer et al. 2003, all). Ecological systems are recurring groups of biological communities in similar physical environments with similar dynamic ecological processes, such as fire or flooding. To identify land cover types in the region of influence, the project overlaid digital maps of the types in the mapping zones with a digital map of the repository region of influence.

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.

Ecoregion:
A relatively discrete set of ecosystems characterized by certain plant communities or assemblages.

Mapping zones:
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.

The analyzed land withdrawal area is in the Mojave Desert ecoregion but, because it is near the southern boundary of the Great Basin Desert ecoregion, land cover types common to both deserts occur in the area. Whereas most of the analyzed land withdrawal area and all of the offsite area to the south are in the Mojave mapping zone, the northern portion of the analyzed land withdrawal area is in the Nellis mapping zone, which reflects the transition between the Mojave and Great Basin deserts. DOE identified 19 land cover types in the region of influence (Table 3-6). Plant communities at lower elevations are typical of the Mojave Desert, and communities at higher elevations, generally at the northern end of the analyzed land withdrawal area, are typical of the transition zone between the Mojave Desert and the cooler Great

Table 3-6. Land cover types in the region of influence.

Land cover type	Percent of region of influence	Description
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	57	Occurs in broad valleys, lower washes, and low hills. Creosote bush (*Larrea tridendata*) and white bursage (*Ambrosia dumosa*) are typical dominants.
Mojave Mid-Elevation Mixed Desert Scrub	27	Common on lower foothill slopes in the transition zone into the southern Great Basin. Dominant species include blackbrush (*Coleogyne ramosissima*), Eastern Mojave (California) buckwheat (*Eriogonum fasciculatum*), Nevada jointfir (*Ephedra nevadensis*), spiny hopsage (*Grayia spinosa*), spiny menodora (*Menodora spinescens*), buck-horn cholla (*Cylindropuntia acanthocarpa*), big galleta (*Pleuraphis rigida*), Mexican bladdersage (*Salazaria mexicana*), Joshua tree (*Yucca brevifolia*), or Mojave yucca (*Yucca schidigera*).
Inter-Mountain Basins Semi-Desert Shrub Steppe	8.0	Occurs on alluvial fans and flats with moderate to deep soils. Common grasses include Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), saltgrass (*Distichlis spicata*), needle and thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), Sandberg bluegrass (*Poa secunda*), and alkali sacaton (*Sporobolus airoides*). Common shrubs include fourwing saltbush (*Atriplex canescens*), big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* and *Ericameria* spp.), jointfir, broom snakeweed (*Gutierrezia sarothrae*), and winterfat (*Krascheninnikovia lanata*).
Sonora-Mojave mixed salt desert scrub	2.0	Occurs in saline basins in the Mojave Desert, often around playas. Typical vegetation includes saltbush species such as fourwing saltbush or cattle saltbush (*Atriplex polycarpa*) and other salt-tolerant species.
North American Warm Desert Volcanic Rockland	1.6	Restricted to barren and sparsely vegetated volcanic ground such as basalt lava and tuff. Scattered creosote bush, saltbush, or other desert shrubs are typical.
Great Basin Xeric Mixed Sagebrush Shrubland	1.4	Occurs on dry flats, alluvial fans, rolling hills, rocky hill slopes, saddles, and ridges of the Great Basin. Dominated by black sagebrush (*Artemisia nova*) or little sagebrush (*Artemisia arbuscula*), and can be accompanied by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) or yellow rabbitbrush (*Chrysothamnus viscidiflorus*).
North American Warm Desert Bedrock Cliff and Outcrop	1.1	Occurs in foothills, includes barren to sparsely vegetated landscapes of steep cliff faces, narrow canyons, and smaller rock outcrops, including unstable scree and talus slopes typically below cliff faces. Species include desert and succulent species such as teddybear cholla (*Cylindropuntia bigelovii*).

Table 3-6. Land cover types in the region of influence (continued).

Land cover type	Percent of region of influence	Description
Inter-Mountain Basins Mixed Salt Desert Scrub	0.63	Occurs in saline desert basins and alluvial slopes. Vegetation includes one or more saltbush species such as shadscale saltbush (*Atriplex confertifolia*), fourwing saltbrush, or cattle saltbrush, accompanied by species such as Wyoming big sagebrush, yellow rabbitbrush, rubber rabbitbrush (*Ericameria nauseosa*), Nevada jointfir, spiny hopsage, winterfat, pale wolfberry (*Lycium pallidum*), or horsebrush (*Tetradymia* spp.).
Inter-Mountain Basins Cliff and Canyon	0.61	Occurs in foothills, includes barren and sparsely vegetated landscapes of steep cliff faces, narrow canyons, and smaller rock outcrops, including unstable scree and talus slopes typically below cliff faces. Widely scattered trees and shrubs include limber pine (*Pinus flexilis*), singleleaf pinyon (*Pinus monophylla*), juniper (*Juniperus* spp.), big sagebrush, antelope bitterbrush (*Purshia tridentata*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), jointfir, and other species often common in adjacent plant communities.
Inter-Mountain Basins Big Sagebrush Shrubland	0.57	Occurs in broad basins between mountain ranges and in foothills. Dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), Wyoming big sagebrush, or both.
Great Basin Pinyon-Juniper Woodland	0.33	Occurs on warm dry sites on mountain slopes, mesas, plateaus, and ridges. Dominated by single leaf pinyon and Utah juniper (*Juniperus osteosperma*), or both.
North American Warm Desert Active and Stabilized Dune	0.23	Consists of unvegetated to sparsely vegetated sand dunes.
Inter-Mountain Basins Semi-Desert Grassland	Less than 0.1	Occurs on dry plains and mesas. Vegetation consists of very drought-resistant grasses and shrubs.
Inter-Mountain Basins Greasewood Flat	Less than 0.1	Occurs near drainages or in rings around playas. Dominated or at least accompanied by greasewood (*Sarcobatus vermiculatus*).
North American Warm Desert Playa	Less than 0.1	Consists of barren and sparsely vegetated playas. Vegetation is very salt-tolerant when present.
Invasive Annual Grassland	Less than 0.1	Consists of invasive grasses including red brome (*Bromus rubens*).
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	Less than 0.1	Occurs in riparian corridors along perennial and seasonally intermittent streams. Vegetation is a mix of riparian trees and shrubs.
Inter-Mountain Basins Montane Sagebrush Steppe	Less than 0.1	Occurs on ridges and mountain slopes. Vegetation is typically dominated by sagebrush species.
North American Warm Desert Wash	Less than 0.1	Restricted to intermittently flooded washes. Vegetation composition is highly variable.

Sources: DIRS 174324-NatureServe 2004, all; DIRS 179926-SWReGAP n.d., all.

Basin Desert. Table 3-6 lists the *native species* of plants that are typical components of these land cover types.

In addition to shrubs and grasses, biological soil crusts are an important component to the Mojave and Great Basin *ecosystems*. Biological crusts consist of multiple species of lichen, moss, cyanobacteria, and algae that live on top of the soil surface, binding with soil particles and forming a cohesive mat or crust on the surface of dry landscapes (DIRS 181866-Belnap 2006, p. 1). Cyanobacteria are the dominant component of crusts in the Mojave Desert, while soil lichen and moss species tend to be limited. Biological crusts (if present) could play an important role in maintaining the health of some of the desert vegetation communities listed in Table 3-6, including but not limited to facilitating water infiltration, retaining soil moisture, and reducing soil loss from wind and water erosion (DIRS 181957-Kaltenecker and Wicklow-Howard 1994, pp. 3 to 8). Biological crusts are highly sensitive to surface disturbance and are easily destroyed. They probably occur in the region of influence in some areas where there has been no surface disturbance.

PLANT TERMS

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 (Executive Order 13112).

Nonnative species:
A species found in an area where it has not historically been found.

Invasive species:
An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112).

Noxious weeds:
Any species of plant which is, or is likely to be, detrimental or destructive and difficult to control or eradicate (Nevada Revised Statutes 555.005).

About six *invasive species* commonly occur in the region of influence. These species are so prevalent and opportunistic that it is no longer practical or possible to eliminate them from the environment, although it is possible to control their spread into new areas. Some species often colonize areas that construction or traffic have disturbed. The most common include red brome (*Bromus rubens*), Russian thistle (*Salsola* spp.), tumble mustard (*Sisymbrium altissimum*), halogeton (*Halogeton glomeratus*), redstem stork's bill (*Erodium cicutarium*), and Arabian schismus (*Schismus arabicus*). Red brome is the most abundant *nonnative species* in the region of influence and the surrounding area. Approximately 20 other nonnative, invasive species could be present to a lesser degree; in many cases, these species have been or might have been eliminated in particular areas. None of these species is on the State of Nevada's *Noxious Weed* List (DIRS 174543-NDOA 2005, all).

3.1.5.1.2 *Wildlife*

This section summarizes, incorporates by reference, and updates Section 3.1.5.1.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-72) for wildlife occurrence in the analyzed land withdrawal area and presents new information from studies and investigations that continued after completion of the Yucca Mountain FEIS. Thirty-six species of mammals are known to occur in and around Yucca Mountain. Rodents are the most abundant mammals, with 17 documented species. The most common rodents at Yucca Mountain are Merriam's kangaroo rats (*Dipodomys merriami*) and pocket mice, with long-tailed pocket mice (*Chaetodipus formosus*) at middle and higher elevations and little pocket mice (*Perognathus longimembris*) at lower elevations.

Other wildlife that occurs in the area includes:

- Three species of rabbit—desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*Sylvilagus nuttallii*), and black-tailed jackrabbits (*Lepus californicus*);

- Seven carnivores—kit foxes (*Vulpes macrotis*) (formerly combined with *Vulpes velox*) and coyotes (*Canis latrans*) (the most common), long-tailed weasels (*Mustela frenata*), badgers (*Taxidea taxus*), western spotted skunks (*Spilogale gracilis*), bobcats (*Lynx rufus*), and mountain lions (*Puma concolor*);

- Two ungulates—mule deer (*Odocoileus hemionus*) and wild burros (*Equus asinus*); and

- Several species of bats.

There are no known wild horses at or near Yucca Mountain. As defined by Nevada Administrative Code 503.020 and 503.025, four species of game mammals occur in the analyzed land withdrawal area—desert cottontail, mountain cottontail, mule deer, and mountain lions—and there are two known species of furbearers—kit foxes and bobcats.

Twenty-seven known species of reptiles, including 12 species of lizards, 14 species of snakes, and the desert tortoise (*Gopherus agassizii*), occur at and near Yucca Mountain. The most abundant lizards are the side-blotched lizard (*Uta stansburiana*) and the western whiptail (*Cnemidophorus tigris*), and the most abundant snakes are the coachwhip (*Masticophis flagellum*) and the long-nosed snake (*Rhinocheilus lecontei*). The common chuckwalla (*Sauromalus ater*) (formerly *Sauromalus obesus*), the largest nonvenomous lizard in the United States, is locally common in some rocky areas in the region of influence. There are no known amphibians at Yucca Mountain.

Investigators have recorded more than 120 species of birds at Yucca Mountain and in the surrounding region, including 22 species that are believed to nest regularly in the area and 15 species of raptors (DIRS 104593-CRWMS M&O 1999, p. 3-10). Three species of game birds (Nevada Administrative Code 503.045) have been seen in the analyzed land withdrawal area: Gambel's quail (*Callipepla gambelii*), chukar (*Alectoris chukar*), and mourning dove (*Zenaida macroura*).

Because most of the habitat in the offsite area to the south is similar to the lower elevation portions of the analyzed land withdrawal area, many of the same species are likely to occur there, especially rodents, rabbits, and reptiles. In addition, the Bureau of Land Management has designated land in the Striped Hills near the eastern edge of this offsite area as winter habitat for desert bighorn sheep (*Ovis canadensis nelsoni*) (DIRS 103079-BLM 1998, Map 3-7).

3.1.5.1.3 *Special-Status Species*

This Repository SEIS considers the following special-status animal and plant species: (1) species that the U.S. Fish and Wildlife Service lists or proposes to list as endangered or threatened under the *Endangered Species Act*, as amended (16 U.S.C. 1531 et seq.) or species the Service has designated as species of concern under the Act; (2) species the Bureau of Land Management considers sensitive as designated by the Bureau's State Director in Nevada (DIRS 172900-BLM 2003, all); (3) flora the State of Nevada classifies as fully protected (Nevada Administrative Code 527); and (4) wild mammals, birds, fish, reptiles, and amphibians that the State of Nevada classifies as endangered, threatened, or sensitive (Nevada Administrative Code 503). This section summarizes, incorporates by reference, and updates Section 3.1.5.1.3 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-73 and 3-74).

SPECIAL-STATUS SPECIES

Endangered Species Act:

The Act classifies an **endangered species** as being in danger of extinction throughout all or a significant part of its range.

The Act classifies a **threatened species** as likely to become endangered in the foreseeable future.

The Secretary of the Interior designates **proposed species** for inclusion in the lists of threatened and endangered species.

Nevada Administrative Code 503 and 527:

The state designates special-status animal species as endangered, threatened, protected, and sensitive under Nevada Administrative Code 503. Fully protected plants that are declared to be critically endangered and threatened with extinction are protected under Nevada Administrative Code 527.

Bureau of Land Management:

The Bureau's State Director for Nevada designates **sensitive species**, which are in addition to the above special-status species.

One animal species at Yucca Mountain, the Mojave population of the desert tortoise, is a *threatened species* under the *Endangered Species Act*. Yucca Mountain is at the northern edge of the range of the desert tortoise, and the abundance of tortoises at Yucca Mountain is low or very low in comparison with other portions of its range (DIRS 155970-DOE 2002, p. 3-73). Since the completion of the Yucca Mountain FEIS, additional surveys covering approximately 1.3 square kilometers (320 acres) for desert tortoises and other special-status species have occurred in the Yucca Mountain area (DIRS 181672-Morton 2007, p. 1). Most of those surveys were in Midway Valley within about 2 kilometers (1.2 miles) of the Exploratory Studies Facility. Neither those surveys nor other work at Yucca Mountain have resulted in observations of other special-status species.

Since completion of the Yucca Mountain FEIS, DOE has examined an updated version of the Nevada Natural Heritage Program's element occurrence database to identify any previously undocumented observations of special-status species within the region of influence. Table 3-7 lists the documented special-status species within the region of influence and the authorities that protect them. The State of Nevada classifies all migratory birds as protected. In addition to these species, individual bald eagles (*Haliaeetus leucocephalus*) occasionally migrate through the region; this species is classified as endangered by the State of Nevada, and although recently removed from listing under the *Endangered Species Act*, the species is still protected under the federal *Bald and Golden Eagle Protection Act* and has been seen once at the Nevada Test Site (DIRS 155970-DOE 2002, p. 3-73). Bald eagles are rare in the region and have not been seen at Yucca Mountain.

3.1.5.1.4 *Wetlands*

This section summarizes, incorporates by reference, and updates Section 3.1.5.1.4 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-74). As the FEIS reported, there are at present no naturally occurring wetlands at Yucca Mountain that would require regulation under Section 404 of the *Clean Water Act*, as amended (33 U.S.C. 1344 et seq.) (DIRS 155970-DOE 2002, p. 3-74). One manmade well

Table 3-7. Special-status species observed in the region of influence.

Common name (scientific name)	Status	Evaluation of potential for occurrence at Yucca Mountain[a]
	Birds[b]	
Golden eagle (*Aguila chrysaetos*)	BLM Sensitive	Present
Short-eared owl (*Asio flammeus*)	BLM Sensitive	Present
Long-eared owl (*Asio otus*)	BLM Sensitive	Present
Western burrowing owl *(Athene cunicularia hypugaea)*	BLM Sensitive	Present
Ferruginous hawk (*Buteo regalis*)	BLM Sensitive	Present
Swainson's hawk (*Buteo swainsoni*)	BLM Sensitive	Present
Prairie falcon (*Falco mexicanus*)	BLM Sensitive	Present
Loggerhead shrike *(Lanius ludovicianus)*	Nevada, BLM Sensitive	Present
Long-billed curlew (*Numenius americanus*)	BLM Sensitive	Rare
LeConte's thrasher (*Toxostoma lecontei)*	BLM Sensitive	Present
	Mammals	
Pallid bat (*Antrozous pallidus*)	Nevada Protected, BLM Sensitive	Common
Hoary bat (*Lasiurus cinereus*)	BLM Sensitive	Rare
California myotis (*Myotis californicus*) or Small-footed myotis (*Myotis ciliolabrum)*	BLM Sensitive	Common (The two species could not be confidently distinguished in the field.)
Fringed myotis (*Myotis thysanodes*)	Nevada Protected, BLM Sensitive	Rare
Long-legged myotis (*Myotis volans*)	BLM Sensitive	Rare
Western pipistrelle (*Pipistrellus hesperus)*	BLM Sensitive	Common
Brazilian free-tailed bat (*Tadarida brasiliensis*)	Nevada Protected, BLM Sensitive	Rare
	Reptiles	
Desert tortoise (*Gopherus agassizii)*	Federal Threatened, Nevada Threatened	Present
Western red-tailed skink (*Eumeces gilberti rubricaudatus*)	BLM Sensitive	Rare
Common chuckwalla (*Sauromalus ater*) (formerly *Sauromalus obesus*)	BLM Sensitive	Present
	Invertebrates	
Giuliani's dune scarab (*Pseudocotalpa giulianii*)	BLM Sensitive	Present, only in dune habitat south of Yucca Mountain.

Source: DIRS 181672-Morton 2007, p.1.

a. Common = known to be common in the region of influence; present = known to occur in the region of influence but at low abundance; rare = potentially occurs in the region of influence but very limited number of documented sightings.

b. The State of Nevada classifies all migratory birds as protected.

BLM = Bureau of Land Management.

pond in the analyzed land withdrawal area has riparian vegetation. Fortymile Wash and some of its tributaries could be classified as waters of the United States under the Act. In June 2007, the EPA and the U.S. Army Corps of Engineers released interim guidance that addresses the jurisdiction over waters of the United States in light of recent Supreme Court decisions (72 FR 31824, June 8, 2007). Based on this new guidance, it is less likely that the ephemeral washes and riverbeds in this area would be considered waters of the United States. For the proposed construction actions in these washes, the Corps of Engineers would have to determine the limits of jurisdiction under Section 404 of the *Clean Water Act*.

3.1.5.2 Soils

This section summarizes, incorporates by reference, and updates Section 3.1.5.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-74 to 3-76). DOE performed a soil survey in an 18-square-kilometer (4,400-acre) area around Midway Valley, which includes most of the areas where soil disturbances for the Proposed Action would occur, and performed a more general survey over the entire Yucca Mountain region (DIRS 104592-CRWMS M&O 1999, all). Both surveys identified only two *soil orders*, and the Midway Valley survey identified 17 *soil series* and seven *soil map units* (Table 3-8).

SOIL TERMS

Duripan:
A subsurface layer held together (cemented) by silica, usually containing other accessory cements.

Hydric:
Describes soils that are characterized by the presence of considerable moisture.

Indurated:
Hardened, as in a subsurface layer that has become hardened.

Petrocalcic:
A subsurface layer in which calcium carbonate or other carbonates have accumulated to the extent that the layer is cemented or indurated.

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 (Farmland Protection Policy Act, as amended; 7 U.S.C. 4201 et seq.).

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.

None of these soils is *prime farmland*, and there are no *hydric* soils at Yucca Mountain. None of the soils at Yucca Mountain qualifies for groups one or two of the Natural Resources Conservation Service's wind erodibility classification, which means that these soils are not highly susceptible to wind erosion.

Yucca Mountain soils derive from underlying volcanic rocks and mixed alluvium that is mostly of volcanic origin, and in general have low water-holding capacities. DOE has sampled and analyzed

Table 3-8. Soil mapping units at Yucca Mountain.

Map unit	Percent	Geographic setting	Soil characteristics
Upspring-Zalda	11	Mountain tops and ridges. Soils on smooth, gently sloping ridge tops and shoulders and on nearly flat mesa tops. Rhyolite and tuffs are parent materials for both soil types.	Typically shallow (10 to 51 cm[a]) to bedrock or thin duripan over bedrock. Well to excessively drained, low available water-holding capacity, medium to rapid runoff potential, and slight erosion hazard.
Gabbvally-Downeyville-Talus	8	North-facing mountain side slopes. Talus (stone-sized rock) random throughout unit in long, narrow, vertically oriented accumulations.	Shallow (10 to 36 cm[a]) to bedrock. Permeability moderate to moderately rapid. Moderate to rapid runoff potential, well-drained, low available water-holding capacity, and moderate erosion hazard.
Upspring-Zalda-Longjim	27	Mountain side slopes. Soils on south, east, and west slopes, and on moderately sloping alluvial deposits below side slopes.	Shallow (10 to 51 cm[a]) to bedrock or thin duripan over bedrock. Well to excessively drained, moderately rapid to rapid permeability and runoff potential, very low available water-holding capacity, and slight erosion hazard.
Skelon-Aymate	22	Alluvial fan remnants. Soils on gently to strongly sloping summits and upper side slopes.	Moderately deep (51 to 102 cm[a]) to indurated duripan or petrocalcic layer with low to very low available water-holding capacity, moderately rapid permeability, slow runoff potential, and slight erosion hazard.
Strozi variant-Yermo-Bullfor	7	Alluvial fan remnants. Soils on gently to moderately sloping alluvial fan remnants and stream terraces adjacent to large drainages.	Moderately deep (51 to 102 cm[a]) to deep (102 cm). Well drained, rapid permeability, very low available water-holding capacity, slow runoff potential, and slight erosion hazard.
Jonnic variant-Strozi-Arizo	12	Dissected alluvial fan remnants. Soils formed in alluvium from mixed volcanic sources on fan summits, moderately sloping fan side slopes, and inset fans.	Moderately deep (36 to 43 cm[a]) to deep (more than 102 cm), sometimes over strongly cemented duripan. Slow or rapid permeability, slow or moderate runoff potential, very low available water-holding capacity, and slight erosion hazard.
Yermo-Arizo-Pinez	13	Inset fans and low alluvial side slopes in mountain canyons and drainages between fan remnants. Soils on moderately to strongly sloping inset fans near drainages, adjacent to lower fan remnants, and below foothills.	Deep (more than 102 cm[a]), sometimes over indurated duripan. Well drained, very low available water holding-capacity, moderately slow to rapid permeability, slow to medium runoff potential, and slight erosion hazard.

Source: DIRS 155970-DOE 2002, p. 3-75.
a. To convert cm to inches, multiply by 0.3937.
cm = centimeter.

surface soils for radiological constituents. The Department has maintained records of spills or releases of nonradioactive materials both to meet regulatory requirements and to provide a baseline for the Proposed Action. DOE's *Distribution of Natural and Man-Made Radionuclides in Soil and Biota at Yucca Mountain, Nevada* summarizes existing radiological conditions in soils from 98 surface samples from within 16 kilometers (9.9 miles) of the Exploratory Studies Facility (DIRS 146183-CRWMS M&O 1996, all). The results of that analysis, in comparison with other parts of the world, indicate average levels of naturally occurring uranium-238 decay products and above-average levels of naturally occurring potassium-40 and thorium-232 decay products. The higher-than-average values could be due to the origin of the soil at the site from tuffaceous igneous rocks. In addition, the studies detected small concentrations of strontium-90, cesium-137, and plutonium-239 from worldwide nuclear weapons testing.

3.1.6 CULTURAL RESOURCES

The region of influence for cultural resources includes the analyzed land withdrawal area, land that DOE has proposed for an access road from U.S. Highway 95, and land where DOE would construct offsite facilities. The Department would construct a portion of the proposed access road from U.S. Highway 95 on Bureau of Land Management land that Nye County currently controls. The analysis for this Repository SEIS assumed a location on Bureau of Land Management land near Gate 510 of the Nevada Test Site for construction of the offsite facilities. Federal agencies manage most of the land in the region. This section summarizes, incorporates by reference, and updates Section 3.1.6 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-76 to 3-82). In addition, these sections present environmental data that have become available since DOE completed the Yucca Mountain FEIS and that are pertinent to cultural resources and the associated impact analysis.

3.1.6.1 Archaeological and Historic Resources

The Yucca Mountain FEIS reported approximately 830 archaeological sites in the analyzed land withdrawal area, based on archaeological site file searches at the Desert Research Institute in Las Vegas and Reno, Nevada, and at the Harry Reid Center for Environmental Studies at the University of Nevada, Las Vegas. Most of these archaeological sites are small scatters of lithic (stone) artifacts that usually comprise fewer than 50 artifacts with few formal tools and no temporally or culturally diagnostic artifacts in the inventory. Temporally and culturally diagnostic artifacts can include projectile points and ceramic artifacts that can reference specific periods or cultural groups.

Since DOE completed the Yucca Mountain FEIS, it has refined the number of sites in the analyzed land withdrawal area to approximately 532 archaeological sites and 553 isolated artifacts (DIRS 172306-Rhode 2004, all). The change in number is due to the combination of some of the sites with the gathering of additional information that showed the sites were part of the same artifact complex. In addition, the revised number reflects the archaeological resources that recent investigations for the U.S. Highway 95 access road recorded. These 1,085 archaeological sites and isolated artifacts strictly pertain to the analyzed land withdrawal area of the Proposed Action. None of the archaeological sites has been listed on the *National Register of Historic Places*; DOE, in consultation with the Nevada State Historic Preservation Office, has determined that the large majority of sites and isolated artifacts are not eligible for inclusion in the *National Register.* The Department, in consultation with the Nevada State Historic Preservation Office, has recommended 232 archaeological sites for inclusion in the *National Register* and manages these sites accordingly. The site types in the analyzed land withdrawal area are temporary camps, extractive localities, processing localities, caches, stone tool manufacture stations, and historic sites.

Since the completion of the Yucca Mountain FEIS, there have been intensive surveys, assessments, and periodic monitoring to identify, characterize, and better evaluate cultural resources in the analyzed land withdrawal area. A draft programmatic agreement among DOE, the Advisory Council on Historic Preservation, and the Nevada State Historic Preservation Office 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 Section 106 of the *National Historic Preservation Act of 1966* (16 U.S.C. 470) process.

3.1.6.2 American Indian Interests

3.1.6.2.1 *Yucca Mountain Project Native American Interaction Program*

In the Yucca Mountain FEIS, DOE discussed its program to consult and interact with tribes and organizations on the characterization of the Yucca Mountain site and the possible construction and operation of a repository. The Native American Interaction Program concentrates on the protection of cultural resources at Yucca Mountain and promotes a government-to-government relationship with tribes and organizations. Within this program, 17 tribes and organizations have formed the Consolidated Group of Tribes and Organizations, which consists of appointed tribal representatives who are responsible for presentation of their respective tribal concerns and perspectives to DOE. The Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone people from Arizona, California, Nevada, and Utah have cultural and historic ties to the Yucca Mountain area.

DOE held Tribal Update Meetings for members of the Consolidated Group of Tribes and Organizations between October 2004 and January 2005 (DIRS 174205-Kane et al. 2005, all). The Consolidated Group recommended additional studies to address eight issues of concern related to potential adverse impacts to the American Indian landscape. Additional recommendations involved increasing and ensuring consistent and effective communication between DOE and the Consolidated Group.

3.1.6.2.2 *American Indian Views of the Affected Environment*

The Yucca Mountain FEIS summarized American Indian views of the affected environment. In general, American Indians believe they are the original inhabitants of their homelands since the beginning of time. They assign meanings to places involved with their creation as a people, religious stories, burials, and important secular events. The traditional stories of the Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone peoples identify such places, including the Yucca Mountain region. The American Indian people believe cultural resources are not limited to the remains of native ancestors but include all natural resources and geologic formations in the region, such as plants and animals and natural landforms. Equally important are water resources and minerals. According to American Indian people, the Yucca Mountain region is part of the lands of the Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone peoples.

3.1.7 SOCIOECONOMICS

To define the existing conditions for the socioeconomic environment in the Yucca Mountain area for this Repository SEIS, DOE determined that it should base the region of influence on the distribution of potential residences of employees. At present, few Yucca Mountain Project employees work at the Yucca Mountain site. The Department would transfer most offsite Project positions to the Yucca Mountain site as the construction and operation of the repository began. Therefore, for this Repository SEIS, DOE used historical, rather than current, data to forecast the future residential distribution of Yucca Mountain

Project workers. This section summarizes, incorporates by reference, and updates Section 3.1.7 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-82 to 3-93) and provides new information, as applicable, from studies and investigations that continued after DOE completed the FEIS.

In 1994, when the total Yucca Mountain site employment was approximately 1,600 workers, about 98 percent of the workers, including those assigned to the Nevada Test Site location, lived in Clark and Nye counties. Since late 1995, Yucca Mountain site employment numbers have dropped significantly. DOE assumed that the historical pattern of residential distribution of onsite workers in 1994 reflects the projected residential distribution for the Proposed Action because 1994 is the most recent year in which onsite employment most nearly reflects expected employment for the Proposed Action. The migration patterns of Yucca Mountain Project workers who moved to Nevada from 1986 to March 2005 reinforce this expected pattern. Of the 3,866 individuals (1,740 workers and 2,126 dependents) who moved to Nevada as a direct result of Project employment, 3,808 chose to live in Clark County and 56 chose to live in Nye County, primarily in Pahrump and Mercury (DIRS 180788-BSC 2005, pp. 3-20 and 3-21). Therefore, DOE selected Clark and Nye counties as the region of influence for socioeconomic resources for this Repository SEIS (Figure 3-14). The Yucca Mountain FEIS included Lincoln County although less than 1 percent of the workforce lived in Lincoln County. Lincoln County is not a part of the Repository SEIS region of influence because so few Yucca Mountain Project workers lived there in 1994 and so few recent project migrants chose to live there. DOE recognizes that historical trends might not reflect future patterns and therefore presents an alternative residential distribution pattern in Appendix A of this Repository SEIS.

Clark County contains the cities of Las Vegas, Boulder City, Henderson, Mesquite, North Las Vegas, and other communities (DIRS 181749-Nevada State Demographer n.d., all). Based on a count of workers in a 1994 data report, 79 percent of the Yucca Mountain site workers lived in Clark County, and approximately 19 percent lived in Nye County (Table 3-9).

DOE used the Regional Economic Models, Inc. (REMI), economic-demographic forecasting computer model, *Policy Insight*®, Version 9 to estimate the baselines for population, employment, and three economic measures: Gross Regional Product, real disposable personal income, and state and local government spending. For this Repository SEIS, the REMI model projected the baselines from 2005 to 2067 for the two counties in the region of influence and for the State of Nevada. Table 3-10 lists the baseline information for the counties in the region of influence and for Nevada.

The version of the REMI model that DOE used for the Yucca Mountain FEIS contained historical data through 1997. DOE developed the baseline data for this Repository SEIS using REMI *Policy Insight* Version 9.0, which uses historical data through 2004 and updates DOE received from local and state sources. Employment and population estimates and projections incorporate data from the Nevada State Demographer's Office, Nevada Department of Employment, Training, and Rehabilitation, and the University of Nevada, Las Vegas Center for Business and Economic Research.

This section cites information, when available, from the Nevada State Demographer's Office and updates gathered by the U.S. Bureau of the Census. DOE developed the baselines with input from the State of Nevada and local sources. The Department used the baselines to project impacts to socioeconomic parameters, which include population and employment.

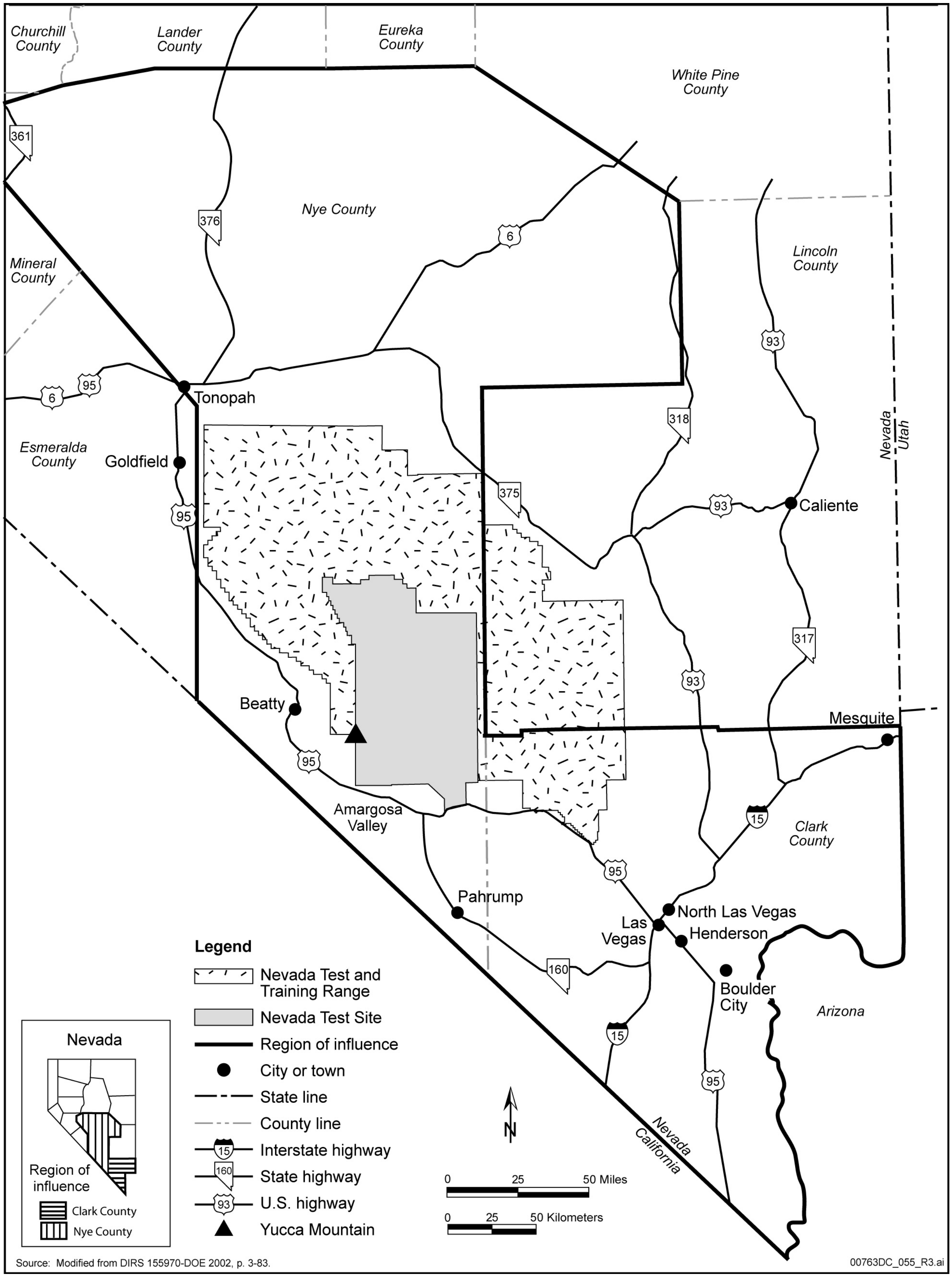

Figure 3-14. Socioeconomic region of influence for this Repository SEIS.

Table 3-9. Distribution by place of residence of Yucca Mountain site employees.

Place of residence	Onsite workers	Percent of total
Clark County	1,268	79
Nye County	308	19
Total region of influence	1,576	98
Outside region of influence	36	2
Total workers	1,612	100

Source: DIRS 104957-DOE 1994, p. 2-9.

Notes: Onsite Yucca Mountain Project employees worked either at the Yucca Mountain Repository or on the Nevada Test Site. All onsite workers were employed in Nye County.

3.1.7.1 Population

From 1990 to 2000, Nevada had a total growth of 64 percent (DIRS 174418-Nevada State Demographer n.d., all); the overall growth of the United States (DIRS 181012-Bureau of the Census 1990, all) was 13 percent. The population of the region of influence grew by 81 percent from 1990 to 2000, an average of almost 64,000 new residents annually. In 2000, the estimated population of the region of influence was about 1.43 million (DIRS 174418-Nevada State Demographer n.d., all).

In 2000, the population of Clark County was about 1.4 million people, which indicates an 81-percent growth rate during the 1990s (DIRS 174418-Nevada State Demographer n.d., all). Las Vegas, the county seat, is by far the largest population base, with about 480,000 residents in 2000. Boulder City had approximately 15,000 residents, Henderson had about 180,000 residents, Mesquite had 10,000 residents, and North Las Vegas had about 120,000 residents in the same year. By 2005, Las Vegas had a population of 570,000, Boulder City had 15,200, Henderson had 241,000, Mesquite had 16,000, and North Las Vegas had a population of 180,000.

In 2000, the population of Nye County was 33,000. As in Clark County, Nye County experienced 81-percent growth during the 1990s (DIRS 174418-Nevada State Demographer n.d., all). Today, Pahrump, the county's largest population center, is experiencing explosive growth, due primarily to in-migrating retirees and its proximity to Las Vegas. Pahrump had a population of about 24,000 people in 2000 and more than 33,000 in 2005. The county seat of Tonopah had about 2,900 residents in 2000.

Although the annual growth rate in the region of influence has slowed in the last 5 years from the extraordinary pace of the 1990s, the population should continue to grow at a rate greater than 4.6 percent a year, about four times the national average, in this decade (DIRS 178610-Bland 2007, all). Clark County will continue to lead the population growth in the foreseeable future in the region of influence.

The region of influence includes a number of incorporated cities and towns as well as unincorporated communities (Table 3-11). Clark County has five incorporated cities and numerous unincorporated but recognized communities. Nye County has no incorporated cities; the largest community is Pahrump.

Communities in Nye County are widely separated and often surrounded by lands that are federally owned or held in trust; these communities, therefore, tend to have economies that are distinct from one another. Clark County has a population density of about 67 persons per square kilometer (170 per square mile) (DIRS 173533-Bureau of the Census 2005, all) and Nye County about 0.69 person per square kilometer (1.8 per square mile) (DIRS 172310-Bureau of the Census 2004, all). Nevada has about 7.0 persons, on average, per square kilometer (18 per square mile). As reflected in the sparse population density for Nye

Table 3-10. Baseline values for population, employment, and economic variables, 2005 to 2067.

Variable	2005	2010	2015	2025	2035	2045	2067
Clark County							
Total population	1,820,000	2,260,000	2,650,000	3,170,000	3,540,000	3,950,000	5,000,000
Total employment	1,070,000	1,240,000	1,330,000	1,450,000	1,600,000	1,780,000	2,230,000
Spending by state and local governments (in billions of dollars)	6.5	8.5	11	13	16	18	23
Real disposable personal income (in billions of dollars)	55	69	80	100	125	157	208
Total Gross Regional Product (in billions of dollars)	87	110	132	173	225	291	394
Nye County							
Total population	41,000	52,000	61,000	73,000	84,000	97,000	131,000
Total employment	17,000	19,000	21,000	23,000	25,000	28,000	37,000
Spending by state and local governments (in billions of dollars)	0.16	0.20	0.25	0.32	0.39	0.47	0.64
Real disposable personal income (in billions of dollars)	1.0	1.3	1.4	1.8	2.2	2.8	4.0
Total Gross Regional Product (in billions of dollars)	1.1	1.3	1.6	2.1	2.7	3.5	5.0
All Nevada							
Total population	2,540,000	3,060,000	3,540,000	4,19,000	4,680,000	5,220,000	6,650,000
Total employment	1,520,000	1,720,000	1,830,000	2,000,000	2,180,000	2,410,000	3,030,000
Spending by state and local governments (in billions of dollars)	9.7	12	15	19	22	25	32
Real disposable personal income (in billions of dollars)	77	96	110	140	170	210	280
Total Gross Regional Product (in billions of dollars)	118	147	177	233	301	389	527

Source: DIRS 178610-Bland 2007, all.
Note: Values are in 2006 dollars.

Table 3-11. Population of incorporated Clark County cities and selected unincorporated towns in Nye County, 1991 to 2005.

Jurisdiction	1991	1995	2000	2005
Clark County				
Boulder City	13,000	14,100	14,900	15,200
Henderson	77,500	115,000	179,000	241,000
Las Vegas	290,000	367,000	482,000	570,000
Mesquite	2,520	5,170	10,100	16,400
North Las Vegas	53,500	78,300	118,000	180,000
Nye County				
Amargosa Valley	920	1,200	1,170	1,380
Beatty	1,800	1,900	1,150	1,000
Pahrump	8,800	15,000	24,200	33,200
Tonopah	3,600	3,400	2,830	2,610

Source: DIRS 180794-Nevada State Demographer's Office 2006, all
Note: Population numbers have been rounded to three significant figures.

County, the region of influence consists of a metropolitan concentration in the Las Vegas area, with spotty occupancy in the remainder of the region. The Federal Government manages more than 85 percent of the land in Nevada (DIRS 181638-NDCNR n.d., all). Cities in metropolitan Clark County are well connected via established road systems and proximity to one another, but major population centers in Nye County, such as Pahrump and Tonopah, are almost 270 kilometers (170 miles) apart. Transportation systems must often weave around federally held lands with restricted access.

The population growth in the State of Nevada and Clark County should exceed average national trends through 2067. The population growth in Clark County should grow more moderately through this decade and then slow to about 1.4 percent annually through 2067 (DIRS 178610-Bland 2007, all). Clark County will continue to house approximately 97 percent of the population in the region of influence. Nye County should grow at an accelerated rate, with an average annual increase of approximately 2 percent (DIRS 178610-Bland 2007, all) through 2067. Figure 3-15 shows estimated populations for the region of influence and the State of Nevada, projected to 2065.

3.1.7.2 Employment

In the region of influence, Clark County has the larger economy. In 2006, the estimated employment was 920,000; this constituted 98 percent of the regional employment and about 71 percent of the state employment. During the same year, Nye County had an employment base of approximately 13,000 (DIRS 178610-Bland 2007, all). Clark County should continue to lead employment growth in the region of influence (DIRS 180734-NDETR 2007, all). The Leisure and Hospitality sector, which includes casinos, hotels, gaming, eating and drinking establishments, and amusement and recreation facilities, is the largest employment sector in Clark County, with 30 percent of the employment in June 2006 (DIRS 180712-NDETR 2006, all). The Professional and Business sector and Leisure and Hospitality sector are the largest employment sectors in the Nye County economy. In June 2006, these services comprised 40 percent of Nye County's employment. Retail trade made up an additional 14 percent (DIRS 180712-NDETR 2006, all).

Las Vegas, in Clark County, has one of the fastest growing economies in the country. The Leisure and Hospitality industry drives this rapid growth. For each new hotel room, an employment multiplier effect creates an estimated 2.5 direct and indirect (composite) jobs. Despite an inventory of more than

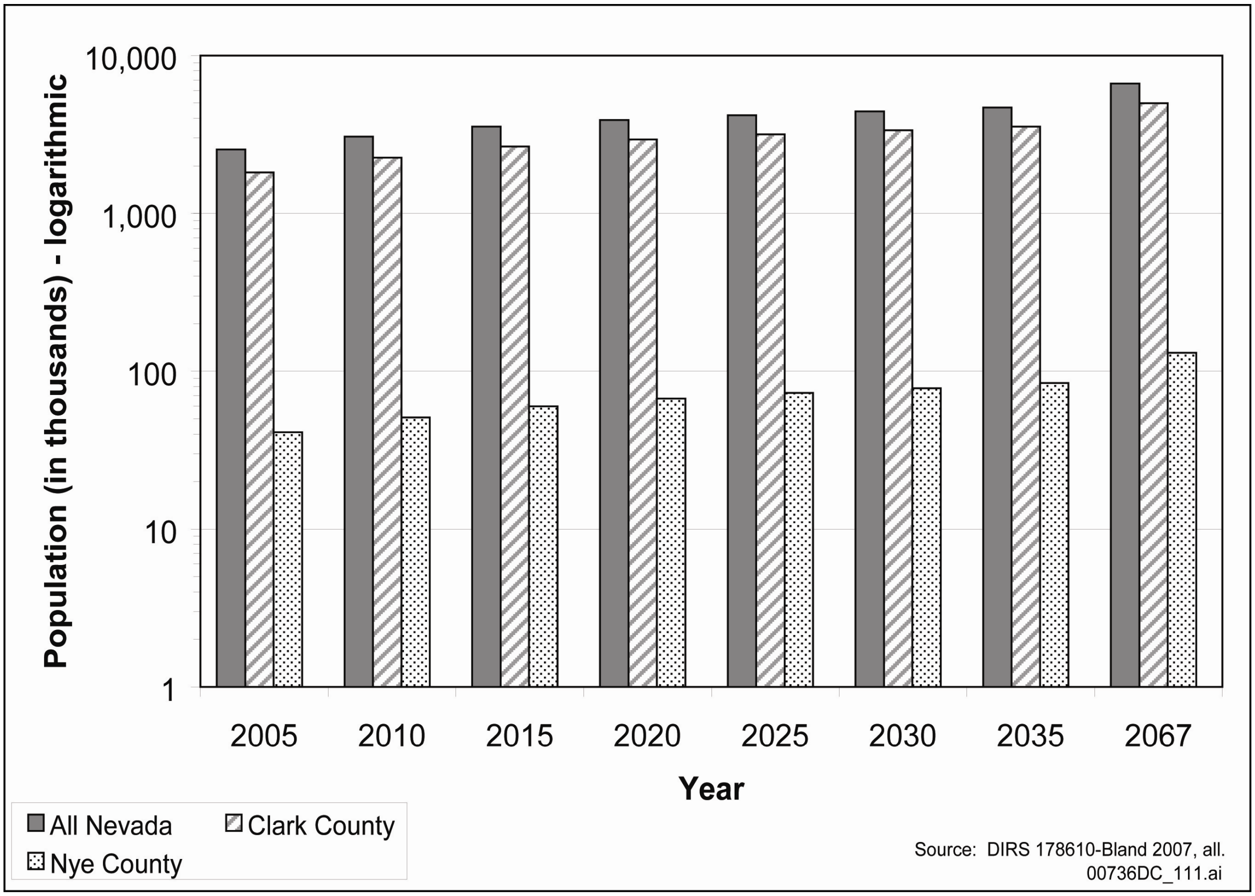

Figure 3-15. Estimated populations for the counties in the region of influence and the State of Nevada, projected to 2067.

130,000 rooms in December 2006, hotels consistently operate at 90-percent occupancy, reaching 95 percent on weekends (DIRS 180713-LVCVA 2006, all).

Hundreds of new jobs are added to the regional economy each month, and many job seekers have come to the area (primarily Clark County). Clark County has maintained a low unemployment rate near state and national averages. In January 2007, Clark County and Nye County had unemployment rates of 4.7 and 6.9 percent, respectively. The average in the State of Nevada was about 4.9 percent; the nationwide unemployment rate for the same period was about 4.6 percent (DIRS 180734-NDETR 2007, all).

In March 2005, an average of about 2,200 workers (210 on the site and 2,000 off) worked on the Yucca Mountain Project. By early 2007, the average number of onsite workers had fallen to fewer than 50. Most offsite workers, those primarily involved with engineering, licensing, project support, safety analysis, and related project support functions, worked in the Las Vegas area (DIRS 180788-BSC 2005, p. 3-12).

Projected employment in the region of influence broadly reflects population trends. The number of jobs in Clark County should reach approximately 2.2 million in 2067 (DIRS 178610-Bland 2007, all), up from 1.1 million in 2005. Clark County will host 98 percent of the employment opportunities in the region of influence. Nye County will add approximately 20,000 additional jobs by 2067 to the base of 17,000 in 2005 (DIRS 178610-Bland 2007, all).

In 2006, Clark County had 19 employers that maintained a payroll with at least 3,500 workers; the Clark County School District led with 30,000 to 39,999 workers, and the Clark County government was second with 10,000 to 19,999 workers. Many casinos in the county employed more than 3,500 workers. In the private sector, Bechtel Nevada Corporation led employers in Nye County with 1,000 to 1,499 workers, Nye County School District employed 900 to 999, and Round Mountain Gold Corporation employed at least 700 workers (DIRS 181180-NDETR 2006, all).

The 2005 per-capita income in Clark County was approximately $34,980, which is near the state's average of about $35,744. The per-capita income in Nye County was $28,761 (DIRS 180951-BEA 2007, all). The United States average per-capita income for the same period was $34,471 (DIRS 180952-BEA 2007, all).

3.1.7.3 Payments-Equal-to-Taxes Provision

An issue of interest is the DOE Payments-Equal-to-Taxes specified by the *Nuclear Waste Policy Act*, as amended (NWPA) (42 U.S.C. 10101 et seq.). DOE acquired data from the Yucca Mountain Project organizations that purchase or acquire property for use in Nevada, have employees in Nevada, or use property in Nevada. These organizations include federal agencies, national laboratories, and private firms. Not all of these organizations have a federal exemption, so they pay the appropriate taxes. The purchases (sales and use tax), employees (business tax), and property (property or possessory use taxes) of the Project organizations that exercise a federal exemption are subject to the Payments-Equal-To-Taxes provision (DIRS 156763-YMP 2001, all).

At present, DOE makes Payments-Equal-to-Taxes to the State of Nevada, Nye County, and Clark County. The amounts paid to the state and to Clark County are formula-driven, but DOE and Nye County periodically negotiate (DIRS 181181-TischlerBise 2005, all) (Table 3-12). In Nye County, Payments-Equal-to-Taxes from the Yucca Mountain Project are a major revenue source. In 2005, Nye County had budgeted expenditures of approximately $28.29 million. In the same year, Payments-Equal-to-Taxes payments to the county totaled $10.5 million. These payments do not automatically increase with growth.

Table 3-12. DOE Payments-Equal-To-Taxes for the Yucca Mountain Project, 2004 through 2007 (in dollars).

Jurisdiction	2004	2005	2006	2007	Total
State of Nevada	860,000	960,000	743,000	718,000	3,281,000
Nye County	10,250,000	10,500,000	10,750,000	11,000,000	42,500,000
Clark County	152,000	134,000	122,000	65,000	473,000
Total	11,262,000	11,594,000	11,615,000	11,783,000	46,254,000

Source: DIRS 181001-Lupton 2007, all.

3.1.7.4 Housing

As in much of the nation, the sale of new and existing homes in the Las Vegas area slowed in early 2007 and prices dropped. The greater Las Vegas area should experience a decline in home prices of almost 9 percent in the next year (DIRS 180999-Money 2007, all). New home sales were down 44 percent in the first quarter of 2007 in comparison with the first quarter of 2006 (DIRS 181013-SNHBA 2007, all).

The housing inventory in Clark County in 2005 was about 720,000 units, which consisted of 440,000 single-family units, 240,000 multifamily units, and 35,000 mobile homes or other units. The occupancy rate was 89 percent during 2005. The average household size was 2.7 persons (DIRS 180738-Bureau of the Census 2005, all). The median value of a Clark County house or condominium in 2005 was $289,000, up from $140,000 in 2000. The median value of a house or condominium in the State of Nevada was nearly the same in 2005, $283,000.

In 2006, 36,000 new homes and 42,000 existing homes were sold (DIRS 180955-Smith 2007, all). In 2006, the median price of a new home was about $330,000, and the median price of an existing home was about $290,000 (DIRS 181013-SNHBA 2007, all). These sale prices are above the national median prices of $250,000 and $220,000 for new and existing homes, respectively (DIRS 181014-NAHB 2007, all).

The housing inventory in Nye County in 2000 was about 16,000 units, which consisted of 6,400 single-family units, 1,000 multifamily units, and 8,500 mobile homes or other units. The occupancy rate was 84 percent during 2000. The median value of houses and condominiums was about $122,100, or about 88 percent of the median value of a house in Clark County. Median rents in Nye County were $541 per month, about 76 percent of the median rent in Clark County. The average household size was 2.4 persons. The 2000 housing inventory in Pahrump was about 12,000 housing units of which 5,000 were single-family units, 6,200 were multifamily units, and 480 were mobile homes or other units (DIRS 181016-City-Data 2007, all). Nye County is attractive to home buyers because it is within commuting distance to metropolitan Las Vegas and has less expensive housing. Pahrump should be attractive to new workers because of its proximity to the Yucca Mountain site. The 2005 median value of a house or condominium in Pahrump was $117,000 (DIRS 181016-City-Data 2007, all). New home prices in Nye County continue to escalate as build-to-suit land with water rights becomes increasingly scarce. Although unincorporated, Pahrump is in the Pahrump Regional Planning District, which has adopted a land use plan and zoning regulations to guide future development. However, existing *infrastructure* systems are strained and inadequate. Rental unit vacancy rates are approaching zero.

Nye County purchased almost 61 acres near the current Gate 510 access road to the Nevada Test Site from the Bureau of Land Management to develop a science and technology business park. The park is the first phase of a proposed master development that will encourage a live-work community lifestyle in the town of Amargosa Valley.

The Pahrump Regional Planning District, which includes Nye County, Pahrump, and portions of the Nye County School District, has determined that the county's current revenue structure cannot adequately provide the current level of services to current residents. Current assessments on residential land uses are not paying their way and generate net deficits to the county. New residents would cause additional net deficits under the existing revenue structure (DIRS 181181-TischlerBise 2005, all).

3.1.7.5 Public Services

3.1.7.5.1 *Education*

In the 2005–2006 school year, the region of influence comprised approximately 270 public elementary and middle schools, 46 public high schools, and 31 alternative and special education schools (DIRS 181156-MGT 2006, p. 11-3; DIRS 181158-NDE n.d., all; DIRS 181159-NDE n.d., all). The Clark County School District expects to build about 180 new schools by 2018 to accommodate population growth (DIRS 181156-MGT 2006, p. 5-10). The average pupil-to-teacher ratio in the 2005–2006 school year was about 26 to 1 in kindergarten and 22 to 1 in all grades first to eighth; the national pupil-to-teacher ratio was about 19 to 1 for elementary schools and 15 to 1 for secondary schools (DIRS 181160-NDE n.d., all). During the 2005–2006 school year, Clark County had about 320 schools and nearly 294,000 students (Table 3-13). Enrollment in Clark County schools tends to be very large, with several high schools serving more than 3,000 students each. During the same period, Nye County had approximately 6,200 students in 17 schools spread over about 47,000 square kilometers (18,000 square miles), which vary in size from an enrollment of 10 students in Duckwater Elementary school to nearly 1,300 students in Pahrump High School (DIRS 181161-NDE n.d., all). Nye County school officials report that all schools in the county are at capacity and that those in Pahrump exceed design capacity. A new elementary school is scheduled to open in fall 2008, and a new high school within 2 years of that in Pahrump. The balance of the county has opted to use modular units to accommodate the growth (DIRS 181182-Nye County School District 2007, all).

Table 3-13. Enrollment by school district and grade level, for the 1996–1997 through 2005–2006 school years.

Jurisdiction	1996–1997[a,b]	2000–2001[a,c]	2005–2006[d]
Clark County			
Prekindergarten	1,100	1,100	1,880
Kindergarten	15,000	19,000	22,343
Elementary (grades 1 to 6)	90,000	120,000	141,429
Secondary (grades 7 to 12)	73,000	94,000	127,943
District totals[e]	179,000	232,000	293,961[f]
Nye County			
Prekindergarten	43	54	101
Kindergarten	370	360	403
Elementary (grades 1 to 6)	2,300	2,500	2,849
Secondary (grades 7 to 12)	2,200	2,300	2,870
District totals[e]	4,970	5,290	6,223 [f]

a. Enrollment numbers by category rounded to two significant figures and district totals rounded to three significant figures for the 1996–1997 and 2000–2001 school years.
b. Source: DIRS 157146-NDE 2001, all.
c. Source: DIRS 155820-NDE 2001, all.
d. Source: DIRS 181169-NDE 2007, all.
e. Totals might differ from sums due to rounding.
f. Figures include students in ungraded situations.

3.1.7.5.2 *Health Care*

Most health care services in the region of influence are in Clark County, particularly in the Las Vegas area. In January 2007, Clark County had 13 accredited general medical and surgical hospitals (DIRS 181162-AHA 2006, all) and several specialized care facilities. Several major health care providers have proposed new hospitals or expansions of existing facilities and are awaiting various governmental approval processes. Although Nye County has one unaffiliated (that is, with the American Hospital Association or Joint Commission on Accreditation of Healthcare Organizations) accredited hospital in Tonopah, most people in the southern part of the county use local clinics or go to hospitals in metropolitan Las Vegas. The very recently opened 24-bed critical care Desert View Medical Center in Pahrump has emergency room service available 24 hours a day, 7 days a week (DIRS 181162-AHA 2006, all). Table 3-14 lists hospital use in the region of influence.

Table 3-14. Hospital use by county in the region of influence, 1995 to 2006.

Jurisdiction	1995[a]	2000[b]	2006[c]
Clark County			
Population	1,000,000	1,380,000	1,900,000
Average number of beds	2,100	2,600	3,100
Beds per 1,000 residents	2.2	1.9	1.6
Patient days	530,000	NA	NA
Nye County			
Population	24,000	32,000	43,600
Average number of beds	21	42	44[d]
Beds per 1,000 residents	0.86	1.3	1.0
Patient days	1,900	NA	NA

a. Source: DIRS 103451-Rodefer et al. n.d., pp. 214 to 216.
b. Source: DIRS 155872-Bureau of the Census 2000, County totals.
c. Source: DIRS 181162-AHA 2006, all.
d. Does not include the 24-bed Desert View Hospital, which opened in April 2006.
NA = Not available.

Medical services are available at the Nevada Test Site for Yucca Mountain Project personnel; Section 3.1.7.5 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 3-92) describes these services.

3.1.7.5.3 *Law Enforcement*

The Las Vegas Metropolitan Police Department is responsible for law enforcement in Clark County, with the exceptions of the cities of North Las Vegas, Henderson, Boulder City, and Mesquite, which have their own departments. The Las Vegas police department is the largest law enforcement agency in Nevada; in the 2004 to 2005 reporting period, the department had approximately 3,400 employees, including 2,250 commissioned officers—a ratio of 1.7 commissioned officers per 1,000 residents (DIRS 181163-LVMPD 2006, all). In 2005, the Nye County Sheriff's office had 141 employees, including 102 commissioned officers—a ratio of 2.5 commissioned officers per 1,000 residents. In comparison, the national officer-to-population ratio is 3.0 commissioned officers per 1,000 residents (DIRS 181167-FBI 2006, all; DIRS 181168-FBI 2005, all).

3.1.7.5.4 *Fire Protection*

A combination of fire departments that use career, part-time, and volunteer personnel provides protection in the region of influence; these include the Clark County, Las Vegas, and North Las Vegas fire departments and several other city, county, and military departments. No single state or national agency gathers and categorizes information about fire suppression activities, services, and personnel in the region of influence. In January 2007, the Clark County Fire Department had about 685 paid and 350 volunteer firefighters (DIRS 181170-CCFD 2006, all). The department responded to about 111,000 incidents in 2006 from 20 stations (DIRS 181186-Nevada State Fire Marshal 2006, all). The Las Vegas Fire Department had about 560 employees reported in 2005 (DIRS 185193-USFA 2008, all). The department responded to about 78,500 calls in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all) from 16 stations (DIRS 181646-CCFD 2005, all). In January 2006, the North Las Vegas Fire Department had 147 employees (DIRS 181171-Las Vegas Sun 2006, all) and answered 20,100 calls from seven stations (DIRS 181646-CCFD 2005, all). The Henderson Fire Department responded to 21,500 calls (DIRS 181186-Nevada State Fire Marshal 2006, all) from nine stations (DIRS 181646-CCFD 2005, all). Information for the Boulder City Fire Department was not available. The national average is 3.8 firefighters (paid and volunteer) per 1,000 residents (DIRS 181176-NFPA 2005, all).

In 2007, Clark County met fire suppression needs primarily with career firefighters. According to the U.S. Fire Administration, the Clark County Fire Department had about 614 career and 350 volunteer firefighters (DIRS 185193-USFA 2008, all). Indian Springs, a part of the Clark County Fire Department, had 21 volunteers and 2 stations. The Clark County Fire Department responded to about 111,000 incidents in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all) from about 25 stations (DIRS 185193-USFA 2008, all). The Las Vegas Fire Department had about 550 career firefighters (DIRS 185193-USFA 2008, all). The department responded to about 78,500 calls in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all) from 16 stations (DIRS 185193-USFA 2008, all). In 2007, the North Las Vegas Fire Department had 141 career firefighters and responded from 7 stations (DIRS 185193-USFA 2008, all). In 2006, the department answered 20,100 calls (DIRS 181646-CCFD 2005, all). In 2006, the Henderson Fire Department responded to 21,500 calls (DIRS 181186-Nevada State Fire Marshal 2006, all). In 2007, the department had 185 career firefighters responding from 9 stations (DIRS 185193-USFA 2008, all). The Boulder City Fire Department had 18 career firefighters responding from 1 station in 2007. The Nellis Air Force Base had 105 firefighters operating from 4 stations (DIRS 185193-USFA 2008, all). The national average is 3.8 firefighters (paid and volunteer) per 1,000 residents (DIRS 181176-NFPA 2005, all).

In 2007, Nye County met fire suppression needs primarily with volunteers from the communities in the county. The Pahrump Valley Fire Department has career, part-time, and volunteer personnel. The department answered 155 calls in 2006 (DIRS 181186-Nevada State Fire Marshal 2006, all). The Nevada Test Site reported 26 fire calls. None of the eight all-volunteer departments reported calls to the State Fire Marshall in 2006, although the Nye County Fire Protection District Department responded to 31 calls. Nye County is hampered by its rural nature and size; assistance from mutual aid departments is often an hour away. Many conventional developed neighborhoods in the county lack fire hydrants. Most of the Town of Pahrump is outside the nationally recommended radius of 5 kilometers (3 miles) to achieve a 4- to 5-minute response time (DIRS 181184-Pahrump Valley Fire Rescue Service 2004, p. 6). DOE did not determine conventional resident-to-firefighter ratios because the large geographical area of the two counties distorts meaningful mutual aid and response time comparisons.

3.1.8 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

The public health and safety region of influence consists of members of the public who reside within an 84-kilometer (52-mile) radius of the geologic repository operations area. The region of influence includes parts of Nye, Clark, Lincoln, and Esmeralda counties in Nevada and Inyo County in California. DOE estimated the baseline population in this area in 2003 as 33,000 (DIRS 181663-Morton 2007, all); the population is mostly in small communities in the southern and western portions of the 84-kilometer radius (Figure 3-16). The baselines in this Repository SEIS incorporate population estimates and projections from the Nevada State Demographer's Office and the Center for Business and Economic Research at the University of Nevada, Las Vegas. The occupational health and safety region of influence includes workers at the repository and potentially affected workers at nearby Nevada Test Site facilities. This section summarizes, incorporates by reference, and updates Section 3.1.8 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-93 to 3-101).

In the Draft Repository SEIS, this region of influence was referred to as having an 80-kilometer (50-mile) radius. Because of the actual alignment of the concentric rings on the grid in Figure 3-16, the distance from the proposed repository location to the outer ring is 84 kilometers (52 miles). For this Final

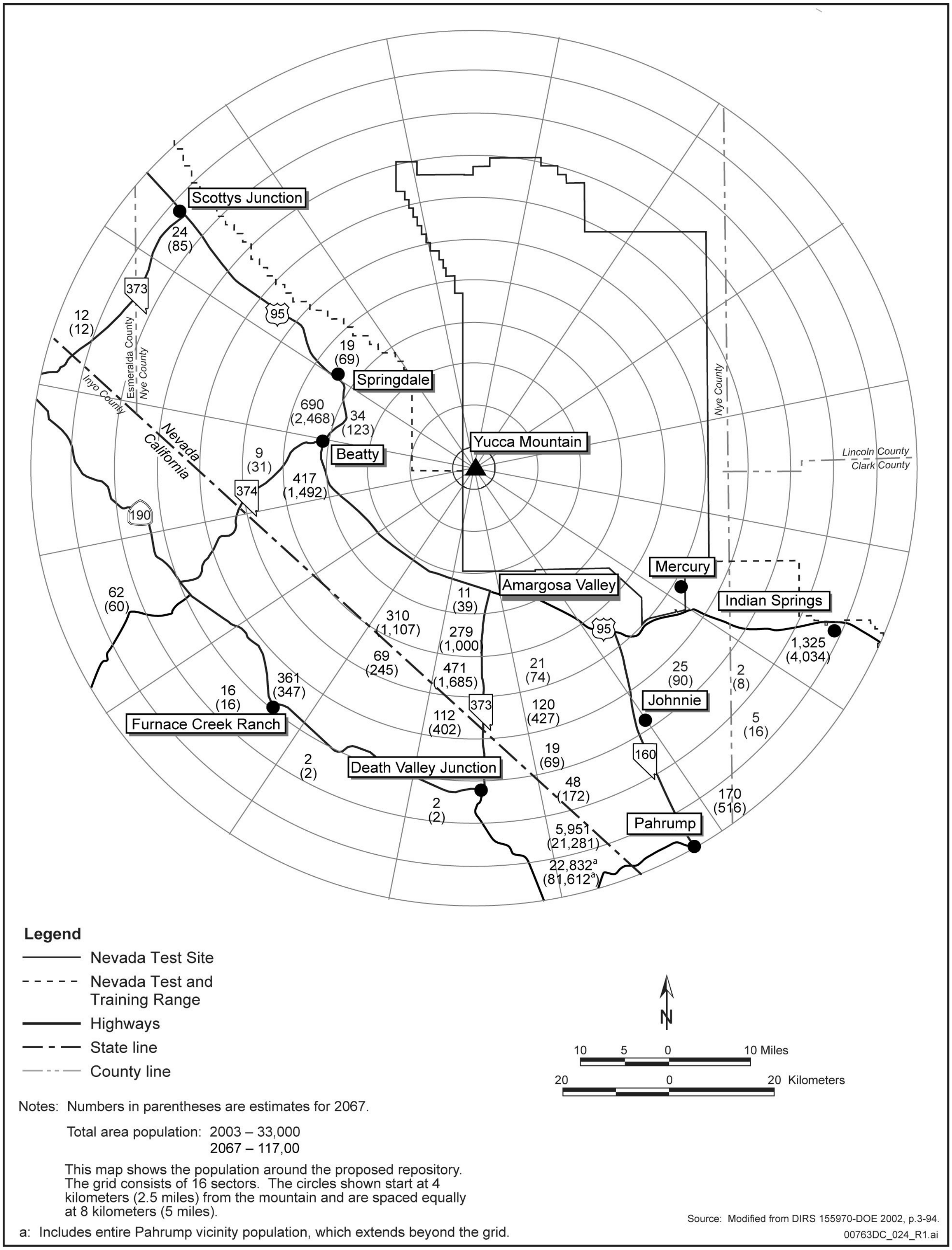

Figure 3-16. Population distribution within 84 kilometers (52 miles) of the proposed repository, 2003 estimations (2067 projections).

Repository SEIS, the region of influence is referred to as an 84-kilometer radius. The estimated population within each grid cell has not changed from the Draft Repository SEIS.

3.1.8.1 Radiation Sources in the Environment

Radiation levels from background sources in the environment provide a basis for comparison with radiation from manmade sources. Background radiation derives from cosmic and cosmogenic sources, external terrestrial sources, radon in homes, and internally deposited radionuclides. The Yucca Mountain FEIS contains more detail about types of radiation.

The effect of radiation on people depends on the kind of radiation exposure (*alpha* and *beta particles*, and *x-rays* and *gamma rays*), the total amount of exposed tissue, and the duration of the exposure. The representative annual external doses for the region of influence range from a low of about 100 millirem at the town of Amargosa Valley to a high of 150 millirem at Beatty from terrestrial sources and cosmic and cosmogenic radiation. Internally deposited radionuclides contribute an additional 40 millirem per year, mainly from potassium-40, and doses from radon and its short-lived progeny add another 200 millirem per year. Therefore, the total dose from all background sources in the region of influence ranges from 340 to 390 millirem per year. This background dose varies by location and is slightly higher than the U.S. average, which is about 300 millirem per year.

Radiation can cause a variety of adverse health effects in people. The following discussion is an overview of a common method for estimation of the effects of radiation exposure; Appendix D of this Repository SEIS contains more detailed information. At low doses, the most important adverse health effect for estimation of the consequences of environmental and occupational radiation exposures (which typically are low) is the potential inducement of *cancers* that can lead to death in later years. This effect is referred to as latent because the cancer might not be the cause of death and because cancer can take years to develop.

The collective dose to an exposed population is the sum of the estimated doses to each member of the exposed population. This is referred to as a *population dose,* which is measured in person-rem. For example, if 1,000 people each received a dose of 0.001 *rem,* the population dose would be 1 person-rem (1,000 persons multiplied by 0.001 rem equals 1 person-rem). The same population dose (1 person-rem) would result if 500 people each received a dose of 0.002 rem (500 persons multiplied by 0.002 rem equals 1 person-rem).

As recommended by the Interagency Steering Committee on Radiation Standards, this Repository SEIS uses a conversion factor of 0.0006 *latent cancer fatality* per person-rem, for both workers and the public, to estimate the radiological impacts of repository operations (DIRS 174559-Lawrence 2002, p. 2). The factor is higher than those the Yucca Mountain FEIS used, which were 0.0004 and 0.0005 latent cancer fatality per person-rem for workers and the public, respectively (DIRS 155970-DOE 2002, p. 3-97).

As stated in the Yucca Mountain FEIS, these concepts can be used to estimate the effects of exposure to radiation. For example, if 100,000 people each were exposed only to background radiation (0.3 rem per year), an estimated 18 latent cancer fatalities could occur as a result of 1 year of exposure (100,000 persons multiplied by 0.3 rem per year multiplied by 0.0006 latent cancer fatality per person-rem equals 18 latent cancer fatalities).

TERMS USED IN RADIATION DOSE ASSESSMENT

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.

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.

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.)

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.)

Millirem:
One one-thousandth (0.001) of a rem.

Total effective dose equivalent:
Often generically referred to simply as dose, it is an expression of the radiation dose received by an individual from external radiation and from radionuclides internally deposited in the body. All doses presented in this Repository SEIS are in terms of total effective dose equivalent.

Latent cancer fatality:
A death that results from cancer that exposure to ionizing radiation caused. There typically is a latent period between the time of the radiation exposure and the time the cancer cells become active.

Solid cancer:
Solid cancers include all malignant neoplasms other than those of the lymphatic and hematopoietic tissue (DIRS 181250-National Research Council 2006, p. 377).

Calculations of the number of latent cancer fatalities due to radiation exposure do not normally yield whole numbers and, especially in environmental applications, can yield numbers less than 1. For example, if 100,000 people each were exposed to a total dose of only 1 millirem (0.001 rem), the population dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.06 (100,000 persons multiplied by 0.001 rem multiplied by 0.0006 latent cancer fatality per person-rem equals 0.06 latent cancer fatality).

The estimated average number of deaths that could result if many different groups of 100,000 people received the same exposure is 0.06. In most groups, nobody (zero people) would incur a latent cancer fatality from the 1-millirem dose each member received. In a small fraction of the groups, 1 latent cancer fatality would result; in exceptionally few groups, 2 or more latent cancer fatalities would occur. The average number of deaths over all the groups would be 0.06 latent cancer fatality per 100,000 (just as the average of 0, 0, 0, and 1 is 0.25). The most likely outcome is no latent cancer fatalities in any of the different groups.

To aid in decisionmaking, DOE has applied these same concepts to estimate the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The probability of a latent cancer fatality that corresponds to a single individual's exposure to 0.3 rem per year over a (presumed) 70-year lifetime is:

Probability of a latent cancer fatality = 1 person × 0.3 rem per year × 70 years × 0.0006 latent cancer fatality per person-rem
= 0.013 probability of a latent cancer fatality

This is a statistical average; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.3-percent chance that the individual would incur a latent cancer fatality. For comparison purposes, statistics from the Centers for Disease Control and Prevention indicate that 24 percent of all deaths in the State of Nevada during 1998 were attributable to cancer from all causes (DIRS 153066-Murphy 2000, p. 83).

3.1.8.2 Radiation Environment at the Yucca Mountain Site

Environmental radiation at the Yucca Mountain site consists of natural background radiation from cosmic and terrestrial sources, past nuclear testing activities, and radon releases from activities at the Exploratory Studies Facility. The Yucca Mountain FEIS detailed the radiation exposure rates from these sources and the existing radiological environments in the region of influence. Table 3-15 summarizes major radiation sources and associated doses.

Table 3-15. Major sources of radiation exposure at Yucca Mountain.

Sources of exposure	Dose rate (per year)
Natural background radiation	
Cosmic and terrestrial radiation at Yucca Mountain ridge	160 millirem
ESF operations	
Median external dose rate to ESF workers	40 millirem
Average inhalation dose rate to ESF workers from radon and decay products	40 millirem
Annual dose to an individual 20 kilometers (12 miles) south of the ESF from exposure to ESF radon releases	< 0.1 millirem
Annual dose to the population within 84 kilometers (52 miles) of the repository from exposure to ESF radon releases	10 person-rem
Radiation doses from past nuclear testing activities at Nevada Test Site	
Maximum annual dose to an individual in Springdale, Nevada, 14 kilometers (9 miles) north of Beatty	0.12 millirem
Annual dose to the population within 84 kilometers of the Nevada Test Site	0.38 person-rem

Source: DIRS 155970-DOE 2002, pp. 3-98 to 3-100.
ESF = Exploratory Studies Facility.

3.1.8.3 Health-Related Mineral Issues Identified During Site Characterization

Certain minerals known to present a potential risk to worker health are present in the volcanic rocks at Yucca Mountain. The risks generally are related to potential exposure caused by inhalation of airborne particulates (dust). These minerals include crystalline silica (silica dioxide) and *erionite* and have been determined by the International Agency for Research on Cancer to be known human *carcinogens*. The National Institute of Health, U.S. Department of Human Services, has included silica and erionite on its list of "Known to be Human Carcinogens" report that was provided to Congress (DIRS 176678-DOE 2006, p. 6-12). Crystalline silica comes in several forms that include quartz, tridymite, and cristobalite. Prolonged exposure to silica dust can result in the formation of scar tissue in the lungs. This scar tissue can reduce overall lung capacity. DOE performs evaluations of airborne crystalline silica at Yucca Mountain during routine operations and tunneling. The repository host rock has cristobalite content that ranges from 18 to 28 percent (DIRS 104523-CRWMS M&O 1999, p. 4-81). The American Conference of Governmental Industrial Hygienists has established *threshold limit values* for various forms of crystalline silica. Further, the World Health Organization has listed crystalline silica as a carcinogen.

Underground mechanical excavation produces dust when the rock is broken loose. Dust is also generated when the broken rock is transferred to railcars, conveyors, or a storage pile, and can also be generated by wind erosion of excavated rock storage piles. Excavation activities during past activities at Yucca Mountain have resulted in some exceedences of crystalline silica threshold limit values at specific work locations. In these cases, workers at these locations are required to wear respirators to mitigate occupational exposures.

Erionite is an uncommon zeolite mineral that forms wool-like fibrous masses. The International Agency for Research on Cancer recognized erionite as a human carcinogen in 1987 (DIRS 103278-IARC 1987, all). Even at low concentrations, erionite is believed to be a potent carcinogen, capable of causing mesothelioma, a form of lung cancer. As a result of its apparent carcinogenicity, erionite may pose a risk if encountered in quantity during underground construction. However, based on geologic studies to characterize the repository horizon, erionite appears to be absent or rare at the proposed repository depth and location, so most operations have not been affected. During excavation activities, DOE performs continuous monitoring of the geologic strata. If erionite is encountered, the area is sealed off and remediated. During the initial tunneling operations in the mid-1990s, one vein of erionite was encountered. This vein was only a few millimeters wide and was in the far south region of the exhaust tunnel and not in the main repository horizon. In subsequent studies, only minor traces of erionite have been found in the repository horizon (DIRS 176678-DOE 2006, p. 6-12).

A number of other minerals present at Yucca Mountain might have associated health risks if prolonged exposures occur. These minerals include the zeolite group minerals mordenite (which is fibrous), clinoptilolite, heulandite, and phillipsite. Even though these are not classified as known human carcinogens, the measures implemented to mitigate occupational risk from silica (including dust suppression, air filters, and personal protective gear) also protect workers from exposure to other minerals.

In January 2004, DOE announced a Silicosis Medical Screening Program for Yucca Mountain tunnel workers who were involved in tunneling and underground operations between 1992 and 2004. The DOE Office of Civilian Radioactive Waste Management and the University of Cincinnati mailed 6,228 informative letters, postcards, and invitations to affected individuals to participate in the screening program. A total of 978 persons responded to the mailings, 551 completed a work history interview, and 414 of those interviewed underwent a medical examination. The final report from the University of Cincinnati diagnosed two cases of silicosis. Both cases were found in the screening examination, although one case previously had been diagnosed and reported as medical history. These cases of silicosis cannot be attributed solely to exposure at Yucca Mountain because both workers had a long history of working in occupations that were dusty and likely to contain silica dust. The average age of the two confirmed silicosis cases was 70 years, the average time working in mining or tunneling occupations was 30 years, and the average time working at Yucca Mountain was 5 years (DIRS 181251-OCRWM 2007, all). Compensation coverage for DOE employees exposed to silica is defined in the *Energy Employees Occupational Illness Compensation Program Act*, which is administered by the U.S. Department of Labor.

3.1.8.4 Industrial Health and Safety Impacts During Past Construction Activities

During past activities related to construction at Yucca Mountain, health and safety impacts to workers resulted from common industrial hazards (such as tripping and falling). The categories of worker impacts include *recordable incidents*, lost workdays, and fatalities. Recordable incidents or cases are 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); and (3) incidents that result in the transfer of a worker to another job, termination of employment, medical treatment, loss of consciousness, or restriction of motion during work activities.

To date, activities at Yucca Mountain have had no *involved worker* fatalities. DOE has compiled statistics for the other types of health and safety impacts in accordance with the regulations of the Occupational Safety and Health Administration (29 CFR Part 1904). These statistics cover the 30-month period from the fourth quarter of 1994 through the first quarter of 1997. DOE selected this period because there was high onsite work activity during which the tunnel boring machine was in operation in the Exploratory Studies Facility. Table 3-16 lists the industrial health and safety loss statistics for industry, general construction, general mining, and Yucca Mountain for the construction period for the Exploratory Studies Facility. The table also lists current industrial health and safety loss statistics. DOE expects these statistics to be representative for the types of activities that would occur during the construction of the surface facilities and the development of the emplacement drifts.

Table 3-16. Health and safety statistics for total industry, general construction, general mining, and Yucca Mountain, 1997 and 2005.[a]

Rates	Total industry	General construction	General mining	Yucca Mountain experience for involved workers
1997 total recordable cases	7.1[b]	9.5[b]	5.9[b]	6.8
2005 total recordable cases	4.6[c]	6.3[c]	4.1[c]	0
1997 lost workday cases	3.3[b]	4.4[b]	3.7[b]	4.8
2005 lost workday cases	2.4[c]	3.4[c]	2.7[c]	0

a. Based on 100 full-time equivalent worker years or 200,000 worker hours.
b. Data for 1997 for the period of excavation of the Exploratory Studies Facility (DIRS 148091-BLS 1998, all).
c. Data for 2005 (DIRS 179131-BLS 2006, all).

3.1.9 NOISE AND VIBRATION

The region of influence for noise and vibration includes the Yucca Mountain site and existing and future residences to the south in the town of Amargosa Valley. This section discusses the affected environment in terms of noise sources and levels, regulatory standards, and vibration, and it summarizes and incorporates by reference Section 3.1.9 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-101 to 3-104).

3.1.9.1 Noise Sources and Levels

Yucca Mountain is in a quiet desert environment where natural phenomena such as wind, rain, and wildlife account for most background noise. Average day-night sound-level values range from 22 *A-weighted decibels (dBA)* on calm days to 38 dBA on windy days. Manmade noise levels at the Yucca Mountain Exploratory Studies Facility were consistent with noise levels near industrial operations, which range from 44 to 72 dBA. The nearest housing to Yucca Mountain is in the town of Amargosa Valley about 22 kilometers (14 miles) to the south. The estimated sound level in the town of Amargosa Valley ranges from 45 to 55 dBA.

NOISE AND VIBRATION TERMS

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.

Day-night average sound level:
The energy average of the A-weighted 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.

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.

3.1.9.2 Regulatory Standards

With the exception of prohibitions of nuisance noise, neither the State of Nevada nor local governments have established numerical noise standards. Nevertheless, many federal agencies use *day-night average sound levels* as guidelines for land use compatibility and to assess the impacts of noise on people. As required, DOE has a hearing protection program in place that includes monitoring of noise levels in worker areas. Engineering controls are the primary methods of noise suppression, and the plan requires supplemental hearing protection when noise levels exceed safe levels.

Sound levels that cause annoyance vary greatly by individual and background conditions. The threshold for hearing hazard, which depends on the frequency of the sound, ranges from around 65 *decibels* at a frequency of 4,000 hertz to about 88 decibels at 125 and 8,000 hertz. These threshold levels assume continuous exposure for periods of hours. High risk for hearing loss occurs at 120 dBA and can result from exposures as brief as seconds to minutes.

3.1.9.3 Vibration

Many natural phenomena such as wave action on beaches, strong winds, and earthquakes, as well as human activities such as construction, transportation, and military activities, cause ground vibration. Background vibration almost always exists to some degree, and levels are generally higher in large cities than in rural communities.

A typical background level of ground vibration is 52 *vibration velocity decibels* (VdB) with respect to 1 microinch per second, and the human threshold for the perception of ground vibration is 65 VdB. There are three ground vibration impacts of general concern: human annoyance, damage to buildings, and interference with vibration-sensitive activities.

Background levels for ground vibration at the Yucca Mountain site are low. Other than site maintenance activities, there is a lack of the classic manmade sources of ground vibration.

3.1.10 AESTHETICS

Visual resources, with nighttime darkness as a component, include the natural and manmade physical features that give a particular landscape its character and value as an environmental factor. 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. This section summarizes, incorporates by reference, and updates Section 3.1.10 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-104 to 3-106).

The Yucca Mountain region consists of unpopulated to sparsely populated desert and rural lands. Because much of Yucca Mountain is on the Nevada Test Site and the Nevada Test and Training Range, both with restricted public access, the public can see Yucca Mountain only from portions of U.S. Highway 95 near the intersection of State Route 373.

The Bureau of Land Management assigns visual resource values to lands that it manages. The Bureau classification of visual resource values involves assessment of visual resources and assignment of one of four *visual resource management classes* based on three factors: scenic quality, visual sensitivity, and distance from travel routes or observation points. Class I represents the highest visual values, and Class IV represents the lowest. Each visual resource class has an associated management objective that defines permissible land uses and developments. Table 3-17 describes the Bureau of Land Management objectives for visual resource classes.

The Bureau of Land Management has classified a portion of the analyzed land withdrawal area, with characteristics fairly common to the region, as Class IV and the remainder as Class III. The land to the west of the site consists of Class III and Class IV lands. The lands south of the analyzed land withdrawal area boundary, where DOE would construct the access road from U.S. Highway 95, the Marshalling Yard and Warehouse, Sample Management Facility, Offsite Training Facility, and temporary accommodations for construction workers, are Class III. Land on the Nevada Test Site is not under Bureau of Land Management jurisdiction but, using the Bureau's methods, DOE has assigned these lands as Class IV. Figure 3-17 shows the visual resource classifications.

Nighttime darkness in the Yucca Mountain region is a valued component of the solitude experience many people seek and greatly enhances astronomy and stargazing activities. Existing or potential sources of nighttime light in this area include the towns of Beatty and Amargosa Valley between Death Valley National Park and the Yucca Mountain site, the community of Pahrump slightly east of the park, and particularly Las Vegas farther to the east. Current lighting at the Yucca Mountain site is similar to or less than lighting at other work areas on the Nevada Test Site and represents a minor contribution to the area's sources of nighttime lighting.

Table 3-17. 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 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.

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

3.1.11 UTILITIES, ENERGY, AND SITE SERVICES

The region of influence for potential impacts to utilities, energy supplies, and site services comprises those public and private resources on which DOE would draw to support the Proposed Action. These resources are in Nye, Clark, and Lincoln counties in Nevada. Utilities include water and sewer services, energy supplies include electric power and fossil fuel, and site services include security, medical, and fire protection. This section summarizes, incorporates by reference, and updates Section 3.1.11 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-106 to 3-110) and presents new information DOE has accumulated since it completed the FEIS.

3.1.11.1 Utilities

The Proposed Action could affect water and sewer utilities through project-related increases in population and the associated increases in water demand and sewage production. Based on historical residency patterns, DOE anticipates that the majority of project-related increases in population would occur in Clark and Nye counties (DIRS 155970-DOE 2002, p. 3-82).

3.1.11.1.1 *Water*

The Southern Nevada Water Authority is a cooperative agency that was formed in 1991 to address southern Nevada's regional water needs. It is the wholesale water provider to municipal water agencies in the Las Vegas Valley and Boulder City. It supplies water to the communities of Boulder City, Henderson, Las Vegas, North Las Vegas, Laughlin, and portions of unincorporated Clark County (DIRS 181261-SNWA n.d., p. v). Southern Nevada gets nearly 90 percent of its water supply from the Colorado River and the remaining 10 percent from groundwater. To meet growing water demands, the Southern

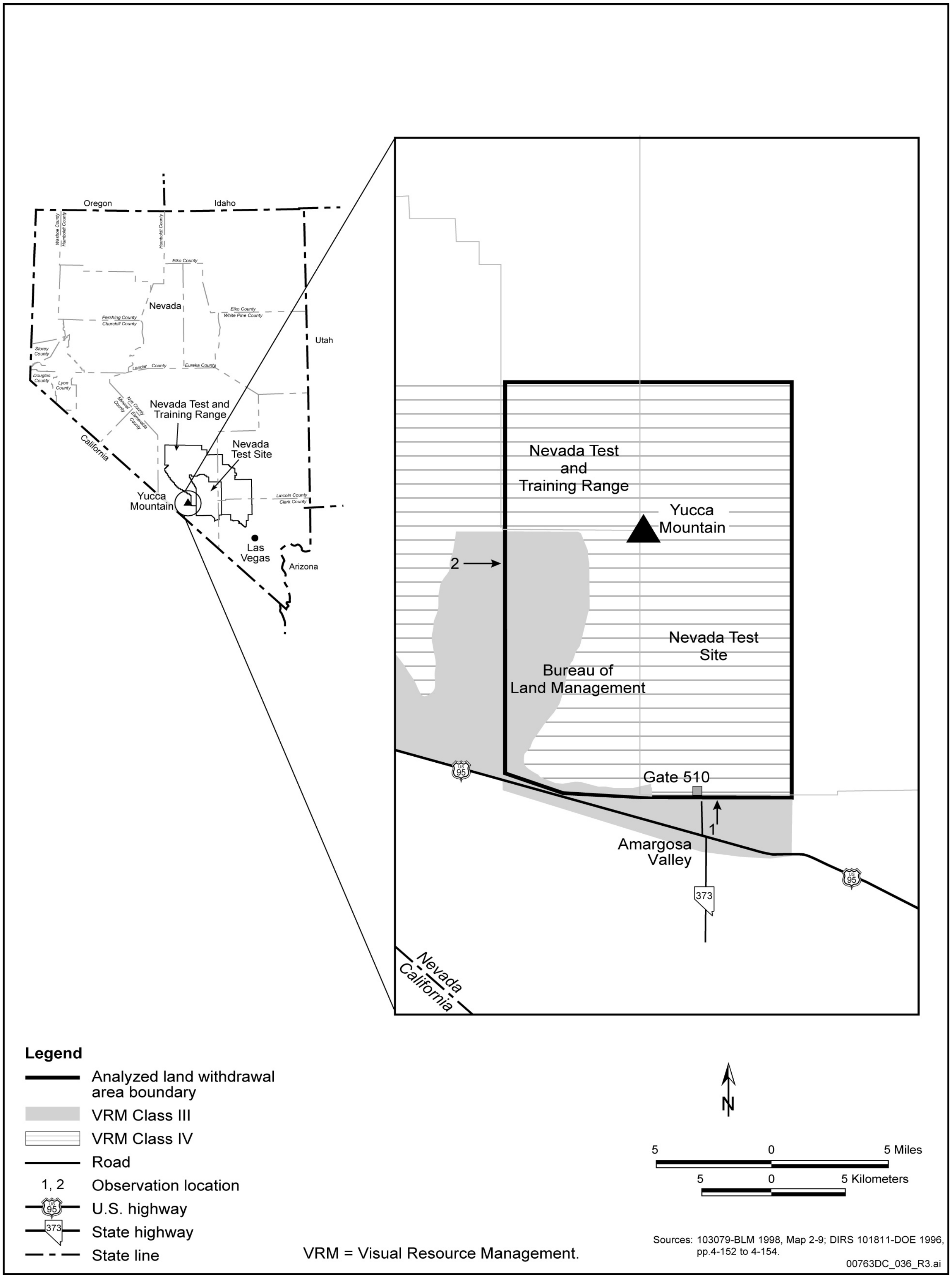

Figure 3-17. Visual Resource Management classifications near Yucca Mountain.

Nevada Water Authority is upgrading current facilities and installing new facilities. In 2002, the Authority completed a second water intake system at Lake Mead; and it has scheduled a third for completion in 2011. The Southern Nevada Water Authority is identifying new water resources and developing a portfolio of resource options to help meet potential future demands. The portfolio includes both Colorado River water options (such as apportionments, water banks, and water exchanges) and in-state, non-Colorado River water options (such as Las Vegas Valley groundwater rights, shallow groundwater, surface-water rights, and groundwater rights in other portions of Clark County as well as Lincoln, White Pine, and Nye counties) (DIRS 181261-SNWA n.d., pp. v and vi).

In southern Nye County, the location of the proposed repository, groundwater is the only source of water. Total groundwater use in Nye County in 2000 was approximately 125 million cubic meters (101,000 acre-feet) (DIRS 173226-Buqo 2004, p. 47). Historically, nearly 80 percent of Nye County's annual groundwater withdrawal is for agricultural irrigation and only 7 percent is for domestic purposes (including public supplies). Mining uses an additional 9 percent, public use and losses use 2 percent, livestock use 1 percent, and commercial activities use 1 percent (DIRS 173226-Buqo 2004, p. 41).

Since completion of the Yucca Mountain FEIS, a new water supply and demand evaluation has become available for Nye County (DIRS 173226-Buqo 2004, all). The evaluation indicated that Beatty (Oasis Valley Hydrographic Area) has adequate water rights and wells to meet projected future demands. A water connection moratorium that was in effect in 1996 ended after another well (the former Barrick Gold Well EW-4) came on line. The only significant water issues in Beatty are the naturally occurring levels of arsenic and fluoride in the groundwater and the water treatment that could be necessary to reduce those levels (DIRS 173226-Buqo 2004, p. 85). In the Amargosa Desert Hydrographic Area, the existing groundwater rights of 31 million cubic meters (25,000 acre-feet) (DIRS 182821-Converse Consultants 2005, p. 100) exceed the published perennial yield of 30 million cubic meters (24,000 acre-feet). However, actual water use in the basin is far less and has not exceeded 20 million cubic meters (16,000 acre-feet). Existing groundwater sources would be adequate for anticipated needs (DIRS 173226-Buqo 2004, pp. 80 to 83). Although activities at Yucca Mountain would not require the use of water from the Pahrump Valley Hydrographic Area, project-related population increases could cause increased water use in the hydrographic area. The total groundwater that was pumped from the Pahrump Valley Hydrographic Area in 2000 was about 28 million cubic meters (23,000 acre-feet), which was the lowest demand since 1993 because of a decrease in water pumped for irrigation. This is about 21 percent higher than the upper end of estimates of the perennial yield of that hydrographic area, which ranges from 15 million to 23 million cubic meters (12,000 to 19,000 acre-feet). Water consumption in the Pahrump Valley results from approximately 8,700 domestic water wells; nearly 300 irrigation wells; and 254 municipal, commercial, and industrial wells (DIRS 173226-Buqo 2004, p. 89). Drilling continues at a rate of over 400 wells a year. With projected population increases, the annual demand for water could be about 99 million cubic meters (80,000 acre-feet) by 2050 (DIRS 173226-Buqo 2004, p. 95). Possible alternatives for meeting the projected future water shortfalls in the Pahrump Valley include a managed overdraft of the basin by optimizing the locations of new wells, development of the carbonate aquifer that underlies the basin, importation of water from other basins, and administrative actions such as conservation (DIRS 173226-Buqo 2004, pp. 57 to 59). In 2007, the Nevada Legislature passed a measure enacting the Nye County Water District. The District is empowered to manage water within the boundaries of Nye County in a manner similar to that of the Southern Nevada Water Authority in Clark County.

3.1.11.1.2 *Sewer*

Wastewater treatment in the Las Vegas Valley occurs in facilities of the City of Las Vegas (which also serves the City of North Las Vegas), Boulder City, Henderson, and the Clark County Water Reclamation District (DIRS 181261-SNWA n.d., p. v). The District serves portions of unincorporated Clark County and the communities of Blue Diamond, Indian Springs, Laughlin, Overton, and Searchlight (DIRS 181264-CCWRD n.d., all). Although other small wastewater treatment facilities might service parts of Clark County outside the populous areas of the Las Vegas Valley, septic systems provide the primary means of treatment in these outlying areas, particularly for private residences.

Most communities in southern Nye County rely primarily on septic systems or small communal wastewater treatment systems, with the exception of Beatty, which has municipal sewer service. Pahrump has no communitywide wastewater treatment system, although the formation of a sanitary district in the Pahrump area has been investigated to provide an area-wide solution for sanitary sewer service (DIRS 181265-Tri-Core Engineering 2005, all). Nye County is developing a service plan for the Pahrump Regional Planning District, which is the first required step in the formation of a sanitary sewer district.

3.1.11.2 Energy

3.1.11.2.1 *Electric Power*

The Yucca Mountain FEIS described the distributors that supply electric power in the region of influence: Nevada Power Company, Valley Electric Association, and Lincoln County Power District No. 1.

Nevada Power Company supplies electricity to southern Nevada in a corridor from southern Clark County that includes Las Vegas, North Las Vegas, Henderson, and Laughlin, to the Nevada Test Site in Nye County. The power sources were approximately 39 percent company-generated and 61 percent purchased power in 2005. In 2005, Nevada Power Company sold 21 million megawatt-hours to its 770,000 customers, and the peak load was the highest ever at just under 5,600 megawatts. The company has an annual customer growth rate of approximately 6 percent, the highest of any electric utility in the country (DIRS 172302-Nevada Power Company 2004, all). It forecasts a 2.1-percent average rate of growth in peak demand from 2007 through 2026, when it should reach an anticipated level of about 9,400 megawatts (DIRS 185100-Gecol 2007, p. 33). To keep pace with demands for electricity, Nevada Power Company must build more substations and transmission and distribution facilities each year. It added a 1,160-megawatt generating station and a 75-megawatt unit in early 2006 (DIRS 181270-Nevada Power Company 2006, all). The completion of several other projects, which include the first two phases of the Centennial project (a transmission line and substation construction project) and the ongoing construction at existing power plants, should ensure an adequate supply of electric power for the next several years (DIRS 173383-Nevada State Office of Energy 2005, p. 34). A projected shortfall between demand and available resources could occur after 2011, which will require the future addition of resources to maintain resource adequacy and ensure system reliability (DIRS 185100-Gecol 2007, pp. 34 to 38).

The Valley Electric Association distributes power to southern Nye County, which includes Pahrump, Amargosa Valley, Beatty, and the Nevada Test Site. The Western Area Power Administration allocates Valley Electric Association a portion of the lower-cost hydroelectric power from the Colorado River dams. However, the combination of increased demand and low water levels has decreased the hydroelectric power share to only 20 percent of Valley Electric Association's total electricity resources. The private market supplements power to meet the demands of association members. The costs of purchased power represent 62 percent of the total expenses of the cooperative. The amount of energy that Valley Electric Association sells annually to its members almost tripled in the 11 years from 1985 through 1995. The annual sales of energy increased by another 100 million kilowatt-hours between 1995 and 2005. In 2005, Valley Electric Association sold approximately 400 million kilowatt-hours to its 19,000 members. The association invested more than $4.3 million in 2005 in new plant facilities and system improvements to ensure continued reliable service to its members (DIRS 181273-VEA n.d., all).

Lincoln County Power District No. 1 is a general-improvement district with headquarters in Caselton, Nevada, that serves approximately 820 customers. It supplies more than 72,000 megawatt-hours per year (DIRS 173383-Nevada State Office of Energy 2005, p. 40).

The Nevada Test Site power grid provides transmission of electric power for ongoing operations at Yucca Mountain. At present, two commercial utility companies own transmission lines that supply electricity to the Nevada Test Site (Figure 3-18). The description of the existing Test Site power supply incorporates by reference Section 3.1.11.2 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, p. 108).

Table 3-18 lists the historical electricity use (partially estimated) for ongoing Yucca Mountain operations for 1995 through 2000. Annual power use and peak demand declined and stabilized at a level lower than the 1997 values due to the decline of site activity after 1997. From 1995 through 1997, Yucca Mountain ongoing operations accounted for about 15 to 20 percent of the electric power the Nevada Test Site used.

3.1.11.2.2 *Fossil Fuel*

Tanker trucks deliver fossil fuels (heating oil, propane, diesel, gasoline, and kerosene) to the Nevada Test Site and the Yucca Mountain site from readily available supplies in southern Nevada. Since 2002, when Congress and the President designated the site as suitable for a repository, consumption of fossil fuels by the Yucca Mountain Project has declined in step with the reduction in site characterization activities.

The fossil-fuel system in the region of influence, the State of Nevada, has sufficient capacity to meet normal Nevada demands. However, the isolation of Nevada cities and the limited number of pipelines that provide service to the state can make the system marginally reliable (DIRS 173383-Nevada State Office of Energy 2005, p. 69).

3.1.11.3 Site Services

DOE has established a support infrastructure to provide emergency services to the Yucca Mountain Project. The *Yucca Mountain Project Emergency Management Plan* describes emergency planning, preparedness, and response (DIRS 167254-DOE 2003, all). The Yucca Mountain Project cooperates with the Nevada Test Site in such areas as training, emergency drills, and exercises to provide full emergency preparedness capability. In addition, the Yucca Mountain Project trains and maintains an underground rescue team. The Nevada Test Site provides support for the Yucca Mountain security program, fire protection, and medical services. The Nye County Sheriff's Department provides traffic enforcement and has authority for civil disturbances. The Yucca Mountain Project has access to a Flight for Life helicopter that can transport two victims to a trauma center in Las Vegas, Nevada.

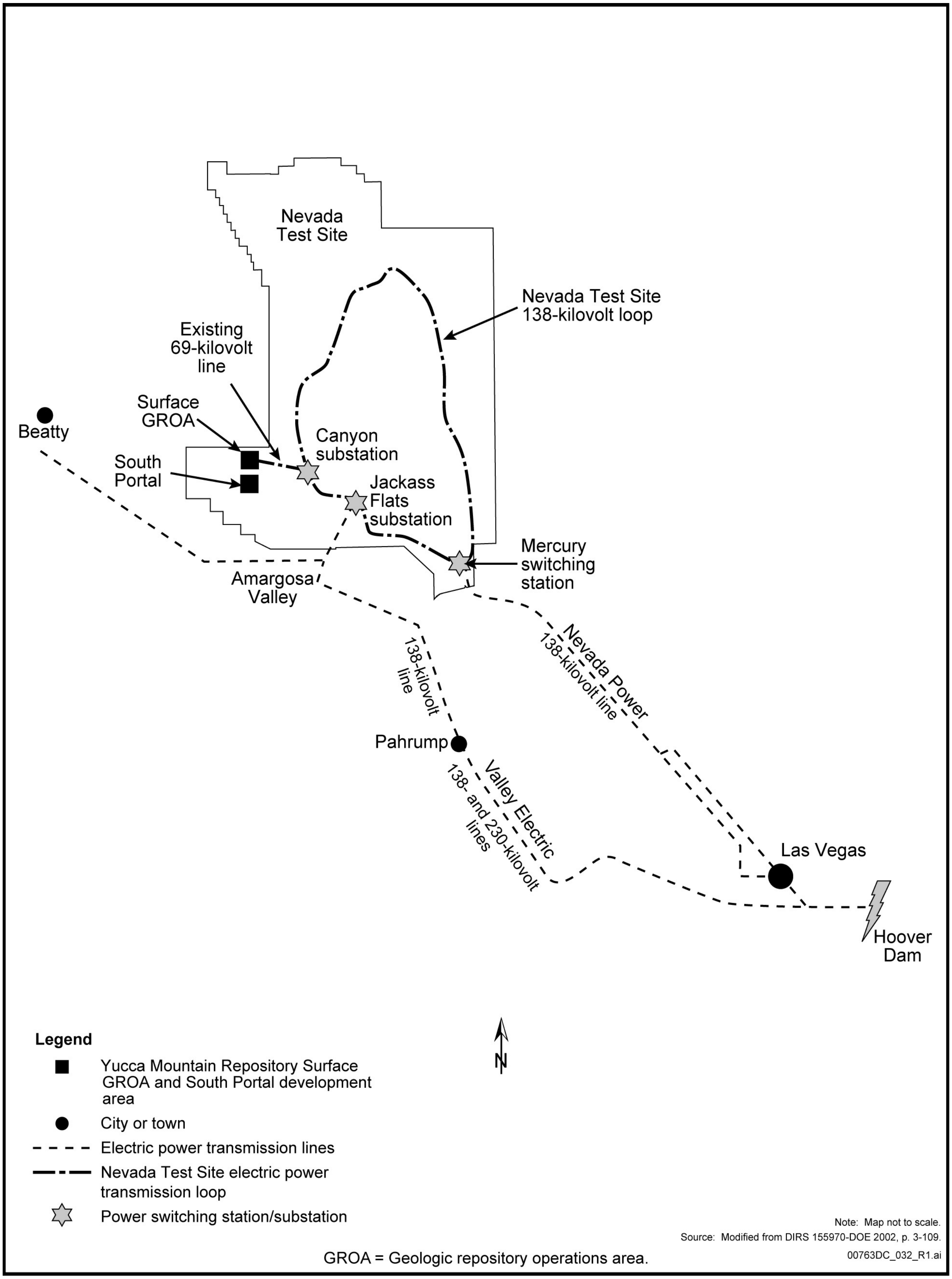

Figure 3-18. Existing Nevada Test Site electric power supply.

Table 3-18. Electric power use for the Exploratory Studies Facility and Field Operations Center.

Fiscal year[a]	Consumption (megawatt-hours)	Peak (megawatts)
1995	9,800	3.5
1996	19,000	4.9
1997	23,000	5.3
1998[b]	21,000[b]	4.2[b]
1999[b]	17,000[b]	4.2[b]
2000[b]	8,700[b]	4.2[b]

Source: DIRS 155970-DOE 2002, p. 108.
a. Before 1995, Yucca Mountain Project power was not separately metered.
b. Estimated.

3.1.12 WASTE AND HAZARDOUS MATERIALS

This section summarizes, incorporates by reference, and updates as appropriate Section 3.1.12 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-110 to 3-312). This section discusses changes in the plans for treatment and disposal of waste and the management of hazardous materials at the proposed repository since the completion of the Yucca Mountain FEIS, and it reevaluates the capacities of regional facilities that could receive waste from Yucca Mountain.

The region of influence for waste and hazardous materials consists of on- and offsite areas, including landfills and hazardous and radioactive waste processing and disposal sites, in which DOE would dispose of waste it generated under the Proposed Action. At present, the types of waste the Yucca Mountain Project generates are *solid waste* and construction debris, oil-contaminated debris, hazardous waste, *sanitary sewage*, and wastewater.

3.1.12.1 Solid Waste

DOE disposes of solid waste from the Yucca Mountain Project in landfills on the Nevada Test Site in Areas 23 and 9. Both landfill capacities and their estimated operational life spans have not changed since the completion of the Yucca Mountain FEIS. Although DOE currently disposes of solid waste at the Nevada Test Site, it could send such waste to other locations on the Test Site or in the analyzed land withdrawal area, or to nearby municipal solid waste landfills. In addition to the landfills on the Test Site, there are 20 operating municipal solid waste landfills including four *industrial waste* landfills in Nevada (DIRS 184969-NDEP 2007, Appendix 3). Since 2002, the total capacity of landfills in Nevada has increased from 150 million cubic meters (200 million cubic yards) to 1.1 billion cubic meters (1.4 billion cubic yards).

Although DOE could dispose of solid waste throughout the state, the landfills that would be the most likely to receive waste from Yucca Mountain are those in Nye, Lincoln, Clark, and Esmeralda counties. Of those landfills, the Apex Regional landfill in Clark County is the largest municipal landfill and receives over half of the waste disposed of in Nevada, averaging over 10,000 metric tons (11,000 tons) of solid waste per day. Based on current waste disposal rates and remaining lifespan estimates from the Nevada Division of Environmental Protection, the Apex Regional landfill has a total of approximately 144 remaining life years left and a total capacity of about 661 million cubic meters (865 million cubic yards).

In addition, DOE transports recyclable materials from site maintenance activities off the site for recycling. Recyclable materials include paper, cardboard, aluminum cans, scrap metal, used oil, used antifreeze, and lead-acid batteries.

3.1.12.2 Hazardous Waste Disposal Facilities

> **HAZARDOUS WASTE**
>
> Waste designated as hazardous by Environmental Protection Agency (EPA) 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.

DOE currently contracts with permitted hazardous waste vendors to ship hazardous waste from the Yucca Mountain site to offsite treatment, storage, and disposal facilities that handle waste under the provisions of the *Resource Conservation and Recovery Act*, as amended (42 U.S.C. 6901 et seq.). Although commercial companies that collect hazardous waste for processing and disposal could use facilities throughout the country, DOE considered only the currently available hazardous waste facilities in the western United States. Estimates for the western states place the hazardous waste disposal capacity as high as 50 times the demand for landfills and seven times the demand for incineration until at least 2013. There are currently three hazardous waste treatment, storage, and disposal facilities in Nevada. The American Ecology Treatment and Disposal Site in the town of Beatty treats and disposes of hazardous wastes, nonhazardous industrial wastes, and wastes that contain polychlorinated biphenyls. Safety-Kleen Systems operates a hazardous waste treatment, storage, and disposal facility in North Las Vegas and Phillip Services Corporation operates a similar facility in the City of Fernley.

DOE sends recyclable hazardous wastes, such as solvents, corrosives, and fuels, to appropriate facilities for recycling.

3.1.12.3 Wastewater

DOE uses a septic system to treat and dispose of sanitary sewage at the Yucca Mountain site. The system design can handle a daily flow of about 76 cubic meters (20,000 gallons) (DIRS 102599-CRWMS M&O 1998, p. 64).

3.1.12.4 Existing Low-Level Radioactive Waste Disposal Facilities

> **AGREEMENT STATE**
>
> A state that reaches an agreement with the Nuclear Regulatory Commission to assume regulatory authority to license and regulate radioactive materials.

At present, the Yucca Mountain Project does not generate *low-level radioactive waste*, but it would during repository operations. This section describes only those facilities that currently receive low-level radioactive waste in the United States, but DOE has not committed to a disposal location for such waste. Low-level radioactive waste disposal occurs at a DOE low-level waste disposal site, sites in *Agreement States*, or NRC-licensed sites. The Nevada Test Site is one of the nation's approved sites for the disposal of low-level waste. Only DOE and U.S. Department of Defense generators may ship waste for disposal at the

Test Site. The Radioactive Waste Acceptance Program at the Nevada Test Site ensures safe disposal operation by requiring waste generators to meet strict waste acceptance criteria before *shipment* and disposal (DIRS 181748-DOE 2006, all).

In addition to the Nevada Test Site, there are three existing commercial low-level radioactive waste disposal facilities in the United States: EnergySolutions Barnwell Operations in Barnwell, South Carolina; U.S. Ecology in Richland, Washington; and EnergySolutions Clive Operations in Clive, Utah. These facilities are in Agreement States and accept waste from all or parts of the nation. The NRC evaluates Agreement State programs every 2 to 4 years to ensure consistency in the nation's materials and safety programs. There are current or anticipated limitations associated with these three commercial disposal sites. EnergySolutions Barnwell Operations is scheduled to be closed to out-of-state waste in 2008; U.S. Ecology generally accepts waste only from sites in the regional compact that includes the State of Washington; and EnergySolutions Clive Operations is licensed to accept only Class A wastes. The regional compact that includes Washington has a contract for receiving low-level waste from the regional compact that includes Nevada but, if Barnwell closes, the U.S. Ecology facility would be the only licensed commercial facility available for disposal of Class B and C low-level waste.

3.1.12.5 Materials Management

DOE has programs and procedures in place for the Yucca Mountain Project to procure and manage hazardous and nonhazardous materials (DIRS 104842-YMP 1996, all). By using these programs, DOE minimizes health and environmental hazards of hazardous materials at the Yucca Mountain site. DOE would continue the use of the programs throughout repository operations.

The *Nevada Combined Agency Hazardous Material Facility Report* (DIRS 181526-Spence 2007, all) from the Nevada State Fire Marshal's Office lists the hazardous materials that meet or exceed the thresholds for storage of hazardous materials that the state and the federal *Emergency Planning and Community Right-to-Know Act*, as amended (42 U.S.C. 1001 et seq.) have established.

3.1.13 ENVIRONMENTAL JUSTICE

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs federal agencies to "promote nondiscrimination in Federal programs substantially affecting human health and the environment, and provide *minority* and low-income communities access to public information on, and an opportunity for public participation in, matters relating to human health or the environment." Executive Order 12898 also directs agencies to identify and consider disproportionately high and adverse human health or environmental impacts of their actions on minority and low-income communities and American Indian tribes, as well as provide opportunities for community input to the *National Environmental Policy Act*, as amended (NEPA; 42 U.S.C. 4321 et seq.) process, which includes input on potential effects and *mitigation* measures. Executive Order 12898 and its associated implementing guidance establish the framework for characterization of the affected environment for

ENVIRONMENTAL JUSTICE TERMS

Minority:
Hispanic, Black, Asian/Pacific Islander, American Indian/Eskimo, Aleut, and other nonwhite person.

Low income:
Below the poverty level as defined by the U.S. Bureau of the Census.

environmental justice. Section 3.1.6.2 of this Repository SEIS discusses the ties of American Indians to cultural characteristics or historic resources in the area.

This section summarizes and incorporates by reference Section 3.1.13 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-112 to 3-118) and describes the minority and low-income populations in the region of influence for the Yucca Mountain Repository that could experience disproportionately high and adverse human health or environmental effects from the Proposed Action. The analysis considered minority and poverty data in relation to the smallest census areas for which information was available. The analysis used block data for identification of minority areas and block group data for low-income areas.

The regions of influence for environmental justice in this Repository SEIS vary with resource area and correspond to the region of influence for each resource area. DOE analyzed U.S. Bureau of the Census block data for minority populations and block group data for low-income populations partly or completely within the regions of influence where the percentages of minority or low-income residents were meaningfully greater than average.

On August 24, 2004, the NRC issued the *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040-52048, August 24, 2004). The policy statement recommends examination of an 80-kilometer (50-mile) radius for licensing and regulatory actions involving power *reactors*. After identification of the impacted area, the policy statement recommends identification of potentially affected low-income and minority communities. Under current NRC staff guidance, an agency identifies a minority or low-income community by comparing the percentage of minority or low-income population in the county (or parish) and the state. If the percentage in the impacted area significantly exceeds the state or county percentage for either the minority or low-income population, the policy calls for consideration of environmental justice in greater detail. NRC staff guidance defines "significantly" to be 20 percentage points. As an alternative, if either the minority or low-income population percentage in the impacted area exceeds 50 percent, the policy calls for consideration of environmental justice matters in greater detail. DOE employed the NRC policy for this Repository SEIS.

3.1.13.1 State of Nevada

This Repository SEIS uses minority and poverty data from the 2000 Census, which indicates that minority persons comprised 35 percent of the population in Nevada. Figure 3-19 shows the 2000 Census blocks in which the minority population equaled or exceeded 50 percent within the 80-kilometer (50-mile)-radius around Yucca Mountain. About 11 percent of the people of Nevada were living in poverty. The poverty threshold in the 2000 Census for a family of four was a 1999 income of $17,603.

3.1.13.2 Clark County

In 2000, the minority population of Clark County was approximately 40 percent of the total population. Several census blocks in the region of influence had minority populations equal to or greater than 50 percent. In Clark County, 11 percent of the population was living in poverty. There were four block groups in Clark County within or intersected by the 80-kilometer (50-mile)-radius around Yucca Mountain. Block group poverty levels ranged from 0 to approximately 11 percent. No block group exceeded 31 percent.

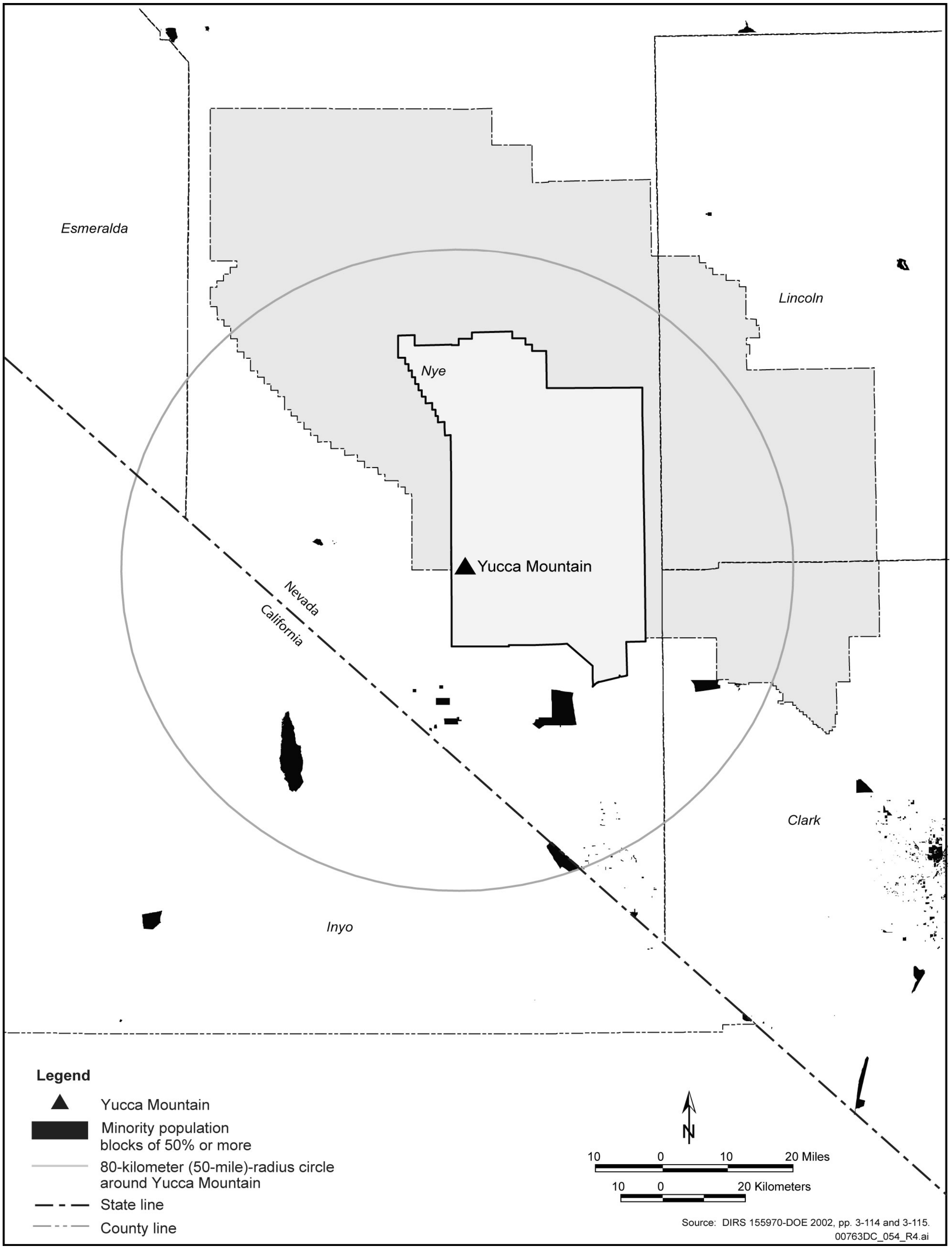

Figure 3-19. 2000 Census blocks with minority populations of 50 percent or more within the 80-kilometer (50-mile)-radius circle.

3.1.13.3 Nye County

Based on the 2000 Census, the minority population of Nye County was approximately 15 percent. Several census blocks in the region of influence had a minority population of 50 percent or more. Approximately 11 percent of the Nye County population was living in poverty. Fifteen block groups in Nye County were within or intersected the 80-kilometer (50-mile)-radius around Yucca Mountain. Block-group poverty levels ranged from approximately 1 to 20 percent. No block group exceeded 31 percent.

3.1.13.4 Inyo County, California

In 2000, the minority population of California was approximately 40 percent. The minority population of Inyo County was approximately 20 percent. Several census blocks within the 80-kilometer (50-mile) radius have a minority population of 50 percent or more. About 14 percent of the people of California were living in poverty. One block group near Stewart Valley lies partly within the affected area. Approximately 13 percent of the Inyo County block groups were low-income. The percentage of low-income residents would have to be 34 percent in the Inyo County block group to be meaningfully greater than average.

3.2 Affected Environment Related to Transportation

To assess the potential impacts of its transportation-related activities, DOE must characterize baseline environmental conditions. Section 3.2.1 provides baseline information about national transportation, and it summarizes, incorporates by reference, and updates Section 3.2.1 of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-119 to 3-121). Section 3.2.2 incorporates Chapter 3, Sections 3.2 and 3.3 of the Rail Alignment EIS for baseline conditions for construction and operation of a railroad in Nevada. Section 3.2.3 reports recent data on traffic conditions in the Yucca Mountain region.

3.2.1 NATIONAL TRANSPORTATION

The loading and shipping of spent nuclear fuel and high-level radioactive waste would occur at 72 commercial and 4 DOE sites in 34 states. DOE would transport most of these materials to the Yucca Mountain site by rail and the remainder by *overweight trucks*. Trains would travel on existing *railroads* to a point in Nevada from which DOE would construct a new railroad to Yucca Mountain, as the Rail Alignment EIS explains. Trucks would travel on existing highways. DOE would use *heavy-haul trucks* for short-distance transport of spent nuclear fuel from some generator sites to nearby railheads.

The national transportation of spent nuclear fuel and high-level radioactive waste (which would include transportation in Nevada to a point of departure for the Caliente or Mina rail corridor) would use existing highways and railroads and would represent a small fraction of the existing national highway (0.0002 percent of truck miles per year) and railroad traffic (0.006 percent of railcar miles per year) (DIRS 181280-DOT 2006, all; DIRS 181282-AAR 2006, all). Because there would be no new land acquisition or construction to accommodate national transportation, this Repository SEIS focuses on potential impacts to human health and safety and the potential for *accidents* along the national transportation routes.

The region of influence for public health and safety along existing transportation routes is 800 meters (0.5 mile) from the centerline of the transportation rights-of-way and from the boundary of railyards for *incident-free* (nonaccident) conditions. The region of influence extends to 80 kilometers (50 miles) to address potential human health and safety impacts from accident scenarios.

For this Repository SEIS, DOE used the TRAGIS computer program (DIRS 181276-Johnson and Michelhaugh 2003, all) to derive representative highway and rail routes for transportation of spent nuclear fuel and high-level radioactive waste for use in the analysis of health and safety impacts. TRAGIS based the estimated population densities along routes on the 2000 Census. TRAGIS identified highway routes from commercial and DOE generator sites to the proposed repository that would meet U.S. Department of Transportation regulations; no corresponding federal regulations constrain the routing of rail shipments. The analysis used population densities along the highway and rail routes to estimate human health impacts and consequences of transportation. Except in Nevada, the analysis based projected growth in populations along routes on Bureau of the Census forecasts of state populations to 2067. For routes in Nevada, DOE used 2000 Census data to develop an initial estimate of the populations within 800 meters (0.5 mile) along highways, commercial rail lines, and the potential rail *alignments* in the Caliente and Mina rail corridors. The analysis accounted for growth in populations along Nevada routes by using forecasts of population growth in Nevada counties from the REMI computer program. The analysis used population growth forecasts from Clark County, Nye County, and the Nevada State Demographer and data for each county from the 2000 Census to estimate populations in Nevada in 2067.

Appendix G describes the representative routes that DOE used for analysis in this Repository SEIS. The Department would make actual transportation mode and routing decisions on a route-specific basis during the transportation planning process, if there was a decision to build a repository at Yucca Mountain. The following sections discuss transportation routes for rail, legal-weight highway, and heavy-haul highway shipments from generator sites.

3.2.1.1 Rail Transportation Routes

In most cases, rail transportation of spent nuclear fuel and high-level radioactive waste would originate with shortline rail carriers that provide service to the commercial and DOE sites. At rail yards near the sites, dedicated rail shipments would switch from shortline carriers to national mainline railroads. Figure 2-11 in Chapter 2 shows the representative rail routes that DOE analyzed and could use for shipments to Nevada. This network has about 230,000 kilometers (140,000 miles) of track that link the nation's major population centers and industrial, agricultural, energy, and mineral resources (DIRS 181282-AAR 2006, p. 3). With the exception of shortline regional railroads that serve the commercial and DOE sites, cross-country shipments would move on mainline railroads. Appendix G describes the representative rail routes.

3.2.1.2 Highway Transportation Routes

Highway transportation of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain site would use local highways near the commercial and DOE sites and near Yucca Mountain, Interstate Highways, Interstate bypasses around metropolitan areas, and preferred routes designated by state routing agencies where applicable. Figure 2-12 in Chapter 2 shows the representative truck routes that DOE analyzed and could use for shipments to Nevada. DOE calculated population density distributions along the routes to support calculations of risk to human health.

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.

3.2.1.3 Heavy-Haul Truck Routes

For generator sites that do not have direct rail service, DOE would transport spent nuclear fuel on heavy-haul trucks to nearby railheads. Heavy-haul trucks would use local highways to carry the spent nuclear fuel to a nearby railhead for transfer to railcars for transport to Nevada.

3.2.2 TRANSPORTATION IN NEVADA

Chapter 3, Sections 3.2 and 3.3, of the Rail Alignment EIS present information about the affected environment related to the construction and operation of a railroad in Nevada. This Repository SEIS incorporates by reference Sections 3.2 and 3.3 of the Rail Alignment EIS.

3.2.3 TRAFFIC IN THE YUCCA MOUNTAIN REGION

Main roads near Yucca Mountain are generally two-lane highways with very little daily traffic. Table 3-19 lists average daily traffic volumes along primary roads in the region of influence in 2005 (DIRS 178749-NDOT n.d., all). These traffic volumes indicate that roadways near the Yucca Mountain site rarely experience congestion. The *Highway Capacity Manual 2000* defines the levels of service, which is an industry standard for traffic engineering (DIRS 176524-Transportation Research Board 2001, all). The manual defines six levels of service that reflect the level of traffic congestion and qualify the operating conditions of a roadway. The six levels range from A to F, as best (free flow, little delay) to worst (congestion, long delays). Factors that influence the operation of a roadway or intersection include speed, delay, travel time, freedom to maneuver, traffic interruptions, comfort, convenience, and safety.

The Highway Capacity Manual describes the levels of service as follows:

- Level of service A describes completely free-flow conditions. Individual drivers are virtually unaffected by the presence of other vehicles in the traffic stream.

Table 3-19. Average daily traffic counts in southern Nevada, 2005.

Roadway and location of traffic count station	Vehicles per day	Level of service
U.S. Highway 95, 0.3 kilometer (0.19 mile) north of State Route 373 (Nye County)	2,600	B
U.S. Highway 95, 2.4 kilometers (1.5 miles) south of State Route 373 (Nye County)	2,900	B
State Route 373, 0.8 kilometer (0.5 mile) south of U.S. Highway 95 (Nye County)	560	A
U.S. Highway 95, 6.4 kilometers (4.0 miles) north of the Mercury interchange (Nye County)	3,200	B
State Route 160, 0.2 kilometer (0.1 mile) south of U.S. Highway 95 (Nye County)	990	A

Source: DIRS 178749-NDOT n.d., all.

- Level of service B also indicates free flow, but the presence of other vehicles becomes more noticeable. Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver within the traffic stream from level of service A.

- Level of service C is in the range of stable flow, but marks the beginning of the range of flow in which operation of individual drivers becomes significantly affected by interactions with others in the traffic stream. The selection of speed is now affected by others and maneuvering requires substantial vigilance on the part of the driver.

- Level of service D represents high density but stable flow. Speed and freedom to maneuver are severely restricted, and the driver experiences a generally poor level of comfort and convenience.

- Level of service E represents operating conditions at or near capacity. All speeds are reduced to a low but relatively uniform value.

- Level of service F indicates a breakdown of traffic flow or stop-and-go traffic. This condition exists wherever the amount of traffic approaching a point exceeds the amount that can cross the point. Backups form behind such locations. Operations within the backups are characterized by stop-and-go waves, and they are extremely unstable.

The Manual generally considers levels of service A, B, and C to be good operating conditions in which motorists experience minor or tolerable delays of service. As Table 3-19 indicates, the roads in the vicinity of Yucca Mountain are level of service A or B.

Most roads in metropolitan Clark County have levels of service that reflect congestion. The most congested area is the U.S. 93, U.S. 95, I-515, and I-15 interchanges, which are known locally as the "Spaghetti Bowl." The Spaghetti Bowl area is at level of service F during peak hours (DIRS 155779-DOE 1999, p. 3-1).

3.3 Affected Environment at Commercial and DOE Sites

DOE analyzed the impacts for the *No-Action Alternative* of not constructing and operating a geologic repository at Yucca Mountain. The Department assumed that spent nuclear fuel and high-level radioactive waste would remain at commercial and DOE sites throughout the United States. Because neither the No-Action Alternative nor the environmental baseline conditions at the generator sites have changed significantly, DOE has neither updated the affected environment nor reanalyzed the No-Action Alternative for this Repository SEIS. This section summarizes and incorporates by reference Section 3.3

of the Yucca Mountain FEIS (DIRS 155970-DOE 2002, pp. 3-183 to 3-194), which included baseline environmental factors at commercial and DOE sites such as land use requirements, radiological effluents, worker and offsite populations, and occupational and public radiation doses. These factors provided a basis for comparison of impacts between the Proposed Action and the No-Action Alternative in the Yucca Mountain FEIS.

3.3.1 SITE ENVIRONMENTAL FACTORS

3.3.1.1 Commercial Sites

The Yucca Mountain FEIS presented general site environmental factors for the 72 commercial nuclear power plant sites in the contiguous United States. Nuclear power plants typically are on flat to rolling countryside in wooded or agricultural areas. Site areas range from 0.34 to 120 square kilometers (0.13 to 46 square miles).

The average permanent staff at a nuclear power plant ranges from 800 to 2,400 workers. In addition, many temporary workers are necessary for tasks that occur during refueling and maintenance outages. In rural communities, this temporary employment can have a substantial effect on the local economy. Nuclear power plants represent investments of several billion dollars each, which generates tax revenue and often enables higher quality and more extensive public services.

Nuclear power plants release small amounts of radioactive materials to the environment through atmospheric and aquatic pathways. Releases to the atmosphere consist of noble gases, tritium, isotopes of iodine, and cesium. Radioactive effluents that sites release to aquatic pathways consist primarily of *fission* and activation products such as isotopes of cesium and cobalt. Sites monitor these materials carefully before and during effluent releases to comply with the licensed release limits.

Commercial sites routinely report worker occupational radiation exposures. The data indicate most of the radiation dose to workers is from external radiation rather than internal exposure to inhaled or ingested radioactive material from the operation of the *nuclear reactor*. In 1999, the total collective occupational dose for all operating commercial reactors was almost 14,000 person-rem. DOE based this collective dose on data from 114,000 monitored personnel. Of these monitored workers, about half had no measurable dose.

The Yucca Mountain FEIS listed and discussed radiation exposures to the public at commercial sites. In 1992, the estimated total population doses for populations living within 80 kilometers (50 miles) of operating nuclear power reactors were 32 person-rem by waterborne pathways and 15 person-rem by airborne pathways. Estimated population dose commitments from both pathways varied widely among the sites.

3.3.1.2 DOE Sites

The Yucca Mountain FEIS presented general site environmental factors for five DOE sites at which spent nuclear fuel and high-level radioactive waste exist. The environmental factors were land use, socioeconomics, and occupational radiation exposure. Large expanses of federally owned land surround and buffer the public from potential effects at three DOE sites—the Hanford Site, Idaho National Laboratory, and Savannah River Site. The Fort St. Vrain Independent Spent Nuclear Fuel Installation in

Colorado and the West Valley Demonstration Project in New York are on much smaller tracts with nearby lands having low density and mostly agricultural and residential land uses.

Based on their large employment bases, the Hanford Site, Idaho National Laboratory, and Savannah River Site represent a substantial portion of local workforces. In addition to base employment, DOE sites contribute to the local economy through the creation of *indirect employment* and through the local purchase of goods and services.

The Yucca Mountain FEIS discussed occupational radiation exposures for workers at the DOE sites. For the five DOE sites, the 1999 total collective dose for workers was about 380 person-rem. There were almost 6,000 individuals with measurable doses, and the average annual dose was about 60 millirem per person. The Fort St. Vrain site reported no measurable doses for 1999. In the Yucca Mountain FEIS, DOE estimated the collective doses for populations who lived within 80 kilometers (50 miles) of the five DOE sites. In 1999, the total estimated offsite population dose was about 7.1 person-rem. About 2.5 million people received this dose; the average was about 0.003 millirem per person, which is a very small fraction of the annual dose from natural background radiation of about 300 millirem in the United States.

3.3.2 REGIONAL ENVIRONMENTAL FACTORS

DOE used a regional approach that divided the continental United States into five regions (Figure 3-20) to analyze the No-Action Alternative in the Yucca Mountain FEIS. The affected environment for each region includes the inventory of spent nuclear fuel and high-level radioactive waste in the region, climatic parameters, groundwater flow times, affected waterways (rivers), river flow, and the identification of populations that depend on drinking water from those waterways. The use of these regional environmental factors resulted in representative values that are not susceptible to short-term or frequent fluctuations but instead evolve over long periods (decades). As a consequence, the regional factors would not be different from those in the Yucca Mountain FEIS. Tables 3-20 through 3-23 provide the regional environmental factors from the FEIS that DOE used in the No-Action Alternative analyses.

Precipitation, rain days, wet days, and temperature are important climatic parameters to material degradation times and rates of release. Table 3-21 lists the regional values for each parameter along with precipitation chemistry (pH, chloride anions, and sulfate anions). Most of the radioactivity and metals from degraded material would seep into the groundwater and flow with it to surface outcrops, rivers, or streams. Table 3-22 lists the ranges of groundwater flow times in each region. The analysis calculated these ranges as the estimated times in years that it takes for groundwater, and separately for contaminants in the groundwater, to reach the surface-water resource nearest to each site at which people could obtain drinking water. The range is the shortest and longest flow time, depending on the site. Most of the estimated population dose for the No-Action Alternative would be a result of drinking contaminated surface water. Table 3-23 lists the number of people who would use the public drinking water systems that degradation of radioactive materials could affect.

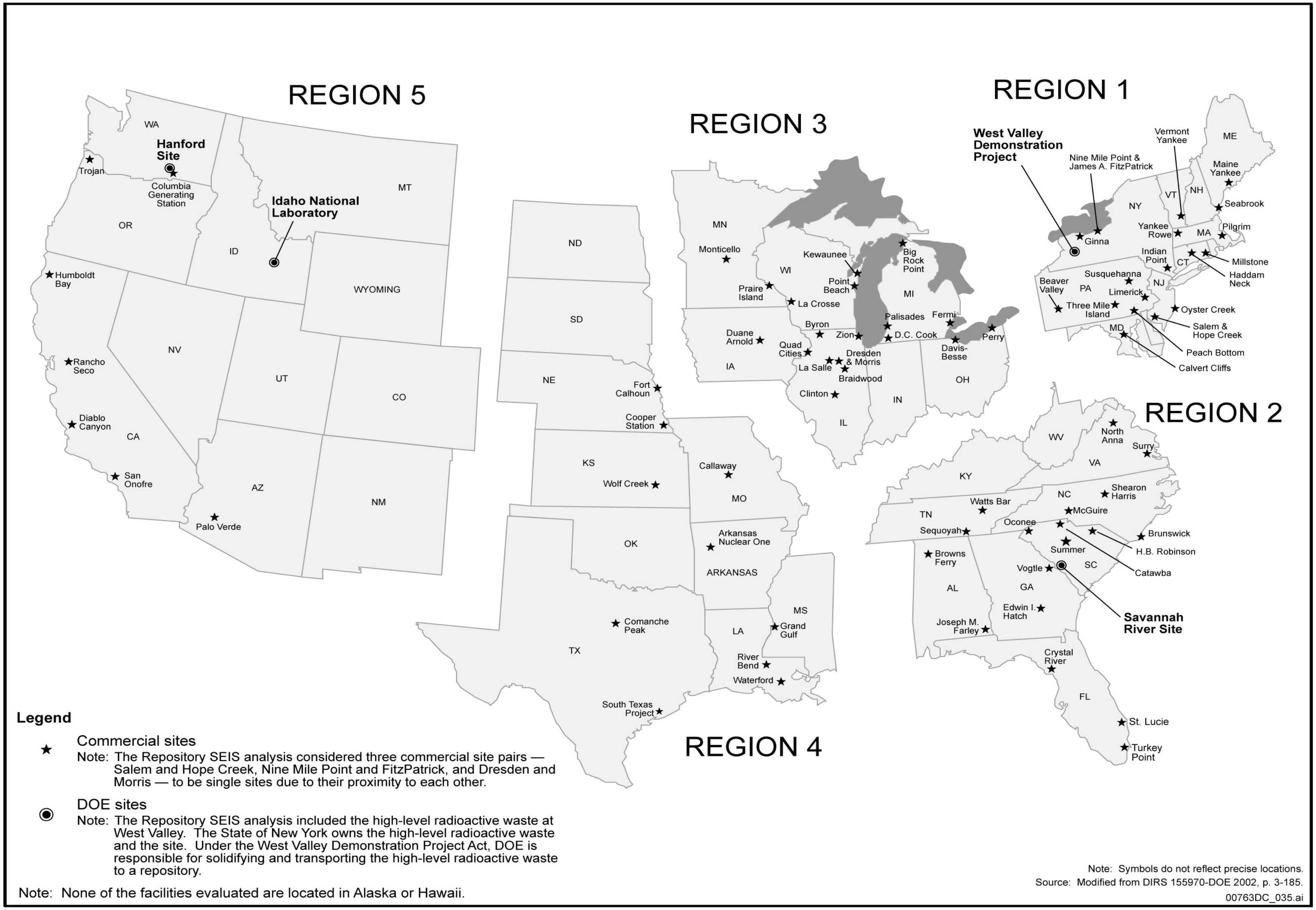

Figure 3-20. Commercial and DOE sites in each No-Action Alternative analysis region.

Table 3-20. Proposed Action quantities of spent nuclear fuel (*metric tons of heavy metal*) and canisters of high-level radioactive waste in each geographic region.[a]

Region	Commercial spent nuclear fuel	DOE spent nuclear fuel	High-level radioactive waste
1	16,800	0	300
2	18,900	30	6,000
3	14,700	0	0
4	7,200	0	0
5	5,400	2,300	2,000
Totals	63,000	2,300	8,300

Source: DIRS 155970-DOE 2002, p. 3-191.
a. Totals might differ from sums due to rounding.

Table 3-21. Regional environmental parameters.

Region	Precipitation rate (centimeters per year)[a]	Percent rain days (per year)	Percent wet days (per year)	pH	Precipitation chemistry: Chloride anions (weight percent)	Precipitation chemistry: Sulfate anions (weight percent)	Average temperature (°C)[b]
1	110	30	31	4.4	6.9×10^{-5}	1.5×10^{-4}	11
2	130	29	54	4.7	3.9×10^{-5}	9.0×10^{-5}	17
3	80	33	42	4.7	1.6×10^{-5}	2.4×10^{-4}	10
4	110	31	49	4.6	3.5×10^{-5}	1.1×10^{-4}	17
5	30	24	24	5.3	2.1×10^{-5}	2.5×10^{-5}	13

Source: DIRS 155970-DOE 2002, p. 3-192.
a. To convert centimeters to inches, multiply by 0.3937.
b. To convert °C to °F, add 17.78 and then multiply by 1.8.
°C = degrees Celsius. °F = degrees Fahrenheit.

Table 3-22. Ranges of flow time (years) for groundwater and contaminants in the unsaturated and saturated zones in each region.

Region	Contaminant K_d[a,b] (milliliters per gram)	Unsaturated zone: Water flow time	Unsaturated zone: Contaminant flow time	Saturated zone: Groundwater flow time	Saturated zone: Contaminant flow time	Total contaminant flow time
1	0 – 100	0.7 – 4.4	0.4 – 2,100	0.3 – 56	10 – 5,000	10 – 6,000
2	10 – 250	0.6 – 10	35 – 5,000	3.3 – 250	11 – 310,000	460 – 310,000
3	10 – 250	0.5 – 14	32 – 1,500	1.3 – 410	9 – 44,000	65 – 45,000
4	10 – 100	0.2 – 7.1	110 – 2,300	3.9 – 960	300 – 520,000	460 – 520,000
5	0 – 10	0.9 – 73	14 – 4,700	1.7 – 170	0 – 25,000	200 – 26,000

Source: DIRS 155970-DOE 2002, p. 3-192.
a. K_d = equilibrium adsorption coefficient.
b. The K_d would be 0 if there were no soil at the site.

Table 3-23. Public drinking water systems and the populations that use them in the five regions.

Region	Drinking water systems	Population
1	85	10,000,000
2	150	5,600,000
3	150	12,000,000
4	95	600,000
5	6	2,800,000
Totals	486	31,000,000

Source: DIRS 155970-DOE 2002, p. 3-194.

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