APPENDIX F

FLOODPLAINS AND WETLANDS ASSESSMENT

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ACRONYMS AND ABBREVIATIONS

BLM	Bureau of Land Management
CFR	Code of Federal Regulations
DIRS	Document Input Reference System
DOE	U.S. Department of Energy
EIS	environmental impact statement
FEIS	final environmental impact statement
FEMA	Federal Emergency Management Agency
NEPA	National Environmental Policy Act

APPENDIX F

FLOODPLAIN AND WETLANDS ASSESSMENT

F.1 Introduction

Pursuant to Executive Order 11988, *Floodplain Management*, each federal agency is required, when conducting activities in a floodplain, to take actions to reduce the risk of flood damage; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Pursuant to Executive Order 11990, *Protection of Wetlands*, each Federal agency is to avoid, to the extent practicable, the destruction or modification of wetlands, and to avoid direct or indirect support of new construction in wetlands if a practicable alternative exists. The U.S. Department of Energy (DOE or the Department) issued regulations that implement these Executive Orders (10 Code of Federal Regulations [CFR] 1022, *Compliance with Floodplain/Wetlands Environmental Review Requirements*). In accordance with the terms of this regulation, specifically 10 CFR 1022.11(d), DOE must prepare a floodplain assessment for proposed actions that would take place in floodplains and a wetlands assessment for any proposed actions that would occur in wetlands. The purpose of this appendix is to meet both of these requirements.

In February 2002, DOE published *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* (hereinafter referred to as the Yucca Mountain FEIS) (DIRS 155970-DOE 2002, all). As part of that environmental impact statement (EIS) process, DOE prepared a floodplain/wetlands assessment in accordance with 10 CFR Part 1022, and published the assessment as Appendix L of the Yucca Mountain FEIS. The assessment examined the effects of repository construction and operation and potential construction of a rail line on (1) floodplains near the Yucca Mountain site and (2) floodplains and areas that may have wetlands along potential rail alignments.

Because DOE chose rail as the preferred mode of transporting spent nuclear fuel, high-level radioactive waste, and other materials to the repository site, the Rail Alignment EIS evaluates the potential effects of the construction and operation of the rail line (its common segments, alternative segments, and associated facilities) on floodplains and wetlands along the proposed rail alignment. The EIS also evaluates potential impacts to floodplains and wetlands from the implementation of the Shared-Use Option.

In accordance with 10 CFR 1022.13, this Floodplain and Wetlands Assessment includes a Project Description (see Section F.2), an analysis of floodplain and wetland impacts (see Section F.3), and a discussion of alternatives (see Section F.4).

F.2 Project Description

Chapter 2 of the Rail Alignment EIS contains a detailed description for the Proposed Action and two implementing alternatives (the Caliente Implementing Alternative and the Mina Implementing Alternative, each with a Shared-Use Option). Sections 3.2.5 and 3.3.5 of the Rail Alignment EIS describe the existing environment for surface-water resources along the Caliente and Mina rail alignments; this appendix does not repeat that information. This section of the Floodplain and Wetlands Assessment provides additional information on floodplains and wetlands associated with the Caliente and Mina rail alignments. Section F.3 provides additional data regarding potential impacts to floodplains and wetlands to support the floodplain and wetlands assessment.

F.2.1 FLOODPLAIN DATA REVIEW

Title 10 CFR Part 1022.11 lists four sources of information that must be reviewed to determine whether a proposed action would be located within a floodplain. These sources include the following:

- Flood Insurance Rate Maps or Flood Hazard Boundary Maps prepared by the Federal Emergency Management Agency (FEMA)
- Information from a land-administering agency or from other government agencies with floodplain determination expertise
- Information in safety basis documents as defined in 10 CFR Part 830 (*Nuclear Safety Management*)
- DOE environmental documents

DOE collected and analyzed floodplain data, which are provided in Section F.2.1.1 for the Caliente rail alignment and in Section F.2.1.2 for the Mina rail alignment.

For actions that would be located in a floodplain, DOE is required to describe the nature and extent of the flood hazard. DOE must determine if an action would be located within either a base-action floodplain or a critical-action floodplain, using the most authoritative information available about site conditions. The base floodplain is, at a minimum, the area inundated by a flood having a 1-percent chance of occurring in any given year (referred to as the 100-year floodplain). The critical-action floodplain is the area inundated by a flood having an 0.2-percent chance of occurring in any given year (referred to as the 500-year floodplain).

Critical action is defined as any activity for which even a slight chance of flooding would be too great. Such actions could include the storage of highly volatile, toxic, or water-reactive materials. DOE considered the critical action floodplain (500-year floodplain) in this assessment because petroleum, oil, lubricants, and other hazardous materials could be used during the construction and operation of the proposed railroad and because spent nuclear fuel and high-level radioactive waste would be transported on the rail line.

The spent nuclear fuel and high-level radioactive waste that DOE would transport to a repository at Yucca Mountain would be considered highly toxic, but when in transit or temporarily positioned at an associated facility, this material would be managed in shipping casks that meet U.S. Nuclear Regulatory Commission regulations. Commission regulations (10 CFR Part 71) are intended to ensure that the public will be protected both during normal transportation activities and in the event a shipment is involved in a transportation accident. These regulations state that each shipping cask must meet certain containment, radiation control, and criticality control requirements when it is subjected to specified normal transportation conditions and hypothetical accident conditions. The test conditions include a 9-meter (30-foot) free drop; a puncture test allowing the container to free fall 1 meter (3.3 feet) onto a steel rod 15 centimeters (6 inches) in diameter; a 30-minute, all-engulfing fire at 800°C (1,500°F); and an 8-hour immersion under 0.9 meter (3 feet) of water. Further, an undamaged package must be subjected to 1-hour immersion under 200 meters (655 feet) of water. These regulations define radiological criteria (that is, radioactivity release and radiation levels external to the cask) that must be achieved. These criteria require the cask structural integrity to be effectively unimpaired.

Shipping casks would never be opened during the transportation process and the potential for a release during any accident or flooding scenario would be extremely remote (DIRS 104774-Fischer et al 1987, pp. 9-1 to 9-15). Hazardous materials that would be most susceptible to accidental spills and releases would be the fuels and other petroleum products required to support power and equipment needs during the railroad construction and operations phases. Storage of these materials would be according to normal environmental regulatory requirements (within secondary containment) and, as practicable, would be stored outside of floodplains.

F.2.1.1 Caliente Rail Alignment

DOE analyzed floodplain data in accordance with 10 CFR Part 1022 for the Caliente rail alignment; the analysis is here and documented in the *Hydrologic and Drainage Evaluation Report for the Caliente Rail Corridor* (DIRS 182755-PBS&J 2007, pp. 8 to 12).

FEMA has mapped floodplains on Flood Insurance Rate Maps for areas of Lincoln, Nye, and Clark Counties. In Lincoln County, applicable flood-map coverage was only available for the City of Caliente. FEMA provides these maps for use in community planning and development to adequately prepare for potential flood events. FEMA has mapped 500-year floodplains only within the city limits of Caliente. The FEMA flood map coverage is shown on Figure F-1 and described in detail in Sections F.3.2.1 through F.3.2.12.

Overlaying the Caliente rail alignment on the FEMA maps allows for estimates of crossing distances (that is, the length of the rail alignment within the various floodplains). Table F-1 lists the floodplains identified along the Caliente rail alignment by alternative segments and common segments. Sections F.3.2.1 through F.3.2.12 describe the floodplains, where information is available, that would be encountered by each of the rail line segments.

In addition to the FEMA flood maps, DOE used two studies completed in support of the Rail Alignment EIS to provide additional information related to discharge rates and flood hazards. The *Hydrologic and Drainage Evaluation Report for the Caliente Rail Corridor* (DIRS 182755-PBS&J 2007, all) included field reconnaissance of every drainage feature along the entire Caliente rail alignment and a review of all available streamflow and precipitation data sources. Also, an earlier study completed by Kennedy, Jenks, and Chilton in 1990 (DIRS 176903-De Leuw, Cather and Company 1992, Appendix H) provides approximate design discharge flow rates for portions of the alignment with drainage areas greater than 2.6 square kilometers (1 square mile) in size. The study also identifies locations along the Caliente rail alignment with significant and unusual flooding hazards, including sections of the alignment affected by alluvial fans, closed-basin lakes, extremely high peak discharges, and wide shallow flow. Sections F.3.2.1 through F.3.2.12 summarize these studies.

DOE also contacted Bureau of Land Management (BLM) field offices having jurisdiction over the federally owned lands along the Caliente rail alignment to determine if they were aware of any floodplain data beyond that available from FEMA. None of the offices DOE contacted provided any floodplain data (DIRS 176303-Ong 2005, all; DIRS 176304-Ong 2005, all).

F.2.1.2 Mina Rail Alignment

DOE analyzed floodplain data in accordance with 10 CFR Part 1022 for the Mina rail alignment. The analysis is summarized here and documented in the *Phase I Hydrologic and Drainage Evaluation Report for the Mina Rail Corridor* (DIRS 180885-Parsons Brinckerhoff 2007, pp. 8 to 11).

FEMA has mapped floodplains on Flood Insurance Rate Maps for areas of Lyon, Mineral, and Nye Counties. In Lyon County, applicable flood-map coverage is available for most of the county, which includes areas north and west of the Mason Valley Wildlife Management Area, and approximately 20 percent of Nye County. FEMA has mapped floodplains only in the southernmost section of Walker Lake.

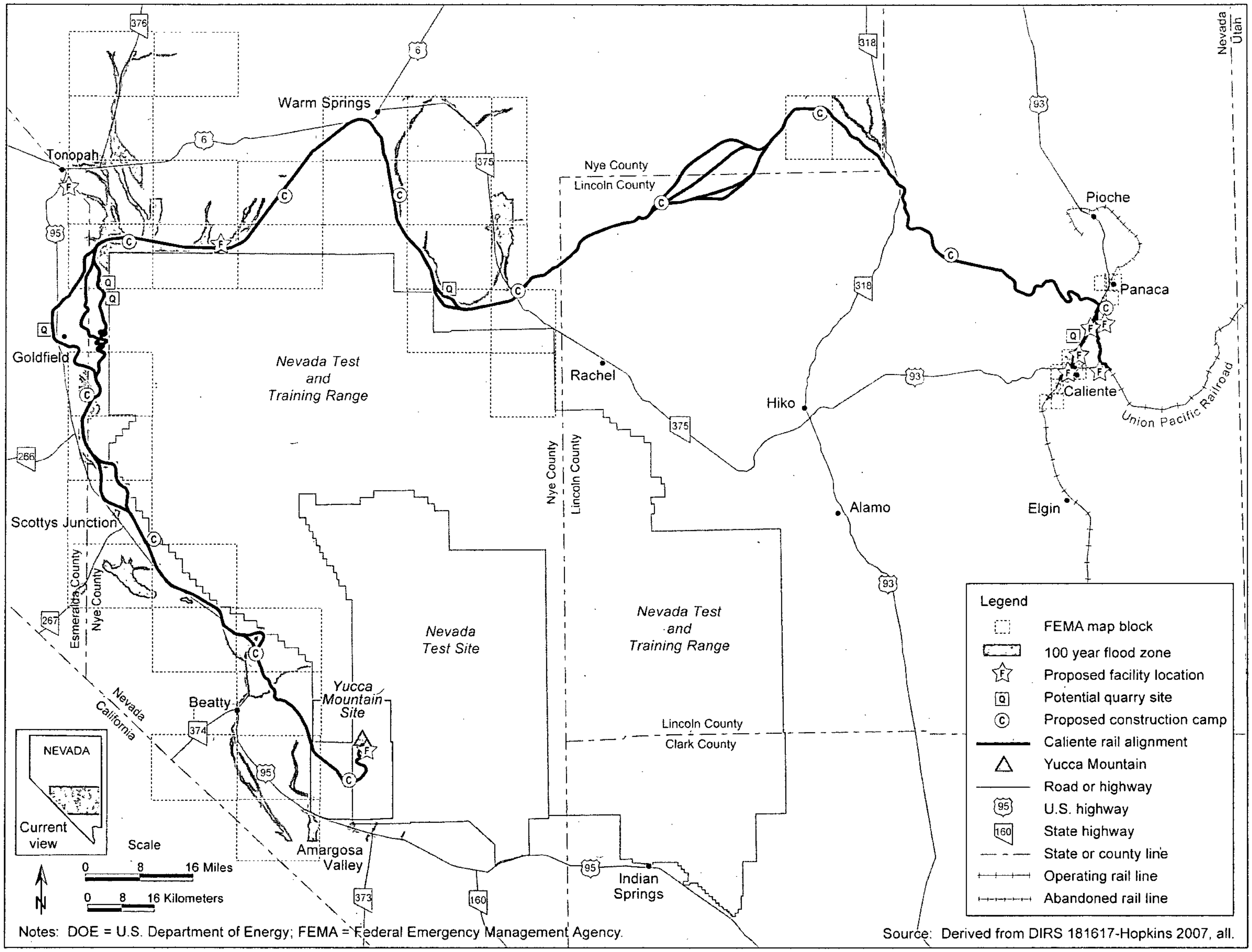


Figure F-1. FEMA floodplain map coverage for the Caliente rail alignment.

Table F-1. Floodplains the Caliente rail alignment would cross (page 1 of 2).

Rail line segment	Portion covered by FEMA[a] maps (percent)	Floodplain crossing distance (kilometers)[b] Mapped	Additional estimated	Description of feature that would be crossed
Caliente alternative segment	28	2.6	2.5	Starting from the southern end of the alignment with the Clover Creek Floodplain to its junction with the Meadow Valley Wash Floodplain and up the alignment approximately 4 kilometers (2.5 miles). No FEMA map available above Caliente city limit. Additional floodplain estimated by using shaded relief map and extending flood plain. Crossing distance for Meadow Valley Wash is based on the width of the flood zones farther south where there is flood map coverage.
Eccles alternative segment	0	0	1.0	FEMA map coverage is not available for the Eccles alternative segment. Crossing distance is estimated from the width of the 100-year flood zone along Clover Creek near its confluence with Meadow Valley Wash where there is flood zone map coverage.
Common segment 1	14	0	2	No floodplains identified.
Garden Valley alternative segment 1	0	0	3.9	No FEMA map coverage; floodplain estimated as area adjacent to Coal Valley Playa.
Garden Valley alternative segment 2	0	0	9.5	No FEMA map coverage; floodplain estimated as area adjacent to Coal Valley Playa.
Garden Valley alternative segment 3	0	0	3.9	No FEMA map coverage; floodplain estimated as area adjacent to Coal Valley Playa.
Garden Valley alternative segment 8	0	0	9.5	No FEMA map coverage; floodplain estimated as area adjacent to Coal Valley Playa.
Common segment 2	26	0	0	No floodplains identified.
South Reveille alternative segment 2	100	23.1	0	Reveille Valley braided wash floodplain extending from Railroad Valley around southern tip of Reveille Range.
South Reveille alternative segment 3	100	0	0	No floodplains identified.
Goldfield alternative segment 1	58	1	0	Floodplains from Mud Lake Playa and Stonewall Flat extending up Mud Lake Playa minor tributaries and Jackson Wash and China Wash, respectively.

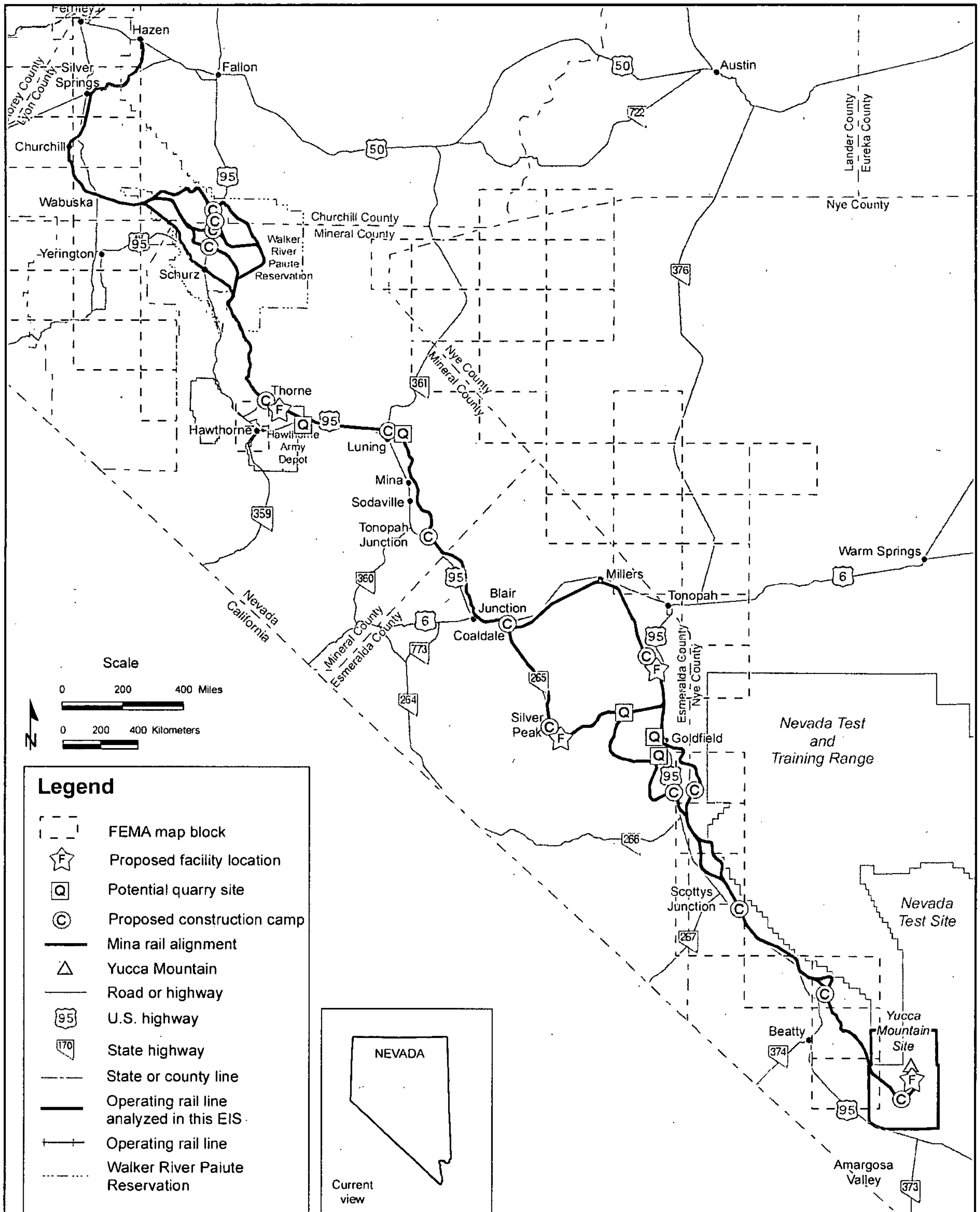
Table F-1. Floodplains the Caliente rail alignment would cross (page 2 of 2).

Rail line segment	Portion covered by FEMA[a] maps (percent)	Floodplain crossing distance (kilometers)[b] Mapped	Additional estimated	Description of feature that would be crossed
Goldfield alternative segment 3 (continued)	55	1	0	Floodplains from Mud Lake Playa and Stonewall Flat extending up Mud Lake Playa minor tributaries and Jackson Wash and China Wash, respectively.
Goldfield alternative segment 4	43	1.5	0	Floodplains from Mud Lake Playa, Alkali Lake Playa, and Stonewall Flat extending up Mud Lake Playa minor tributaries, Big Wash tributaries, and Jackson Wash and China Wash tributaries, respectively. Alkali Lake Playa floodplain not mapped by FEMA.
Common segment 4	100	1.3	0	Floodplain extends downgradient of Stonewall Flat Playa to the Lida Valley Alkali Flat Playa.
Bonnie Claire alternative segment 2	30	0	0	No floodplains identified.
Bonnie Claire alternative segment 3	78	1.9	0	Floodplains extending up tributaries of the Lida Valley Alkali Flat Playa and up the Stonewall Pass wash from the Bonnie Claire Flat area of Sarcobatus Flat.
Common segment 5	74	0.3	0	Floodplain extending from Sarcobatus Flat up to Tolicha Wash.
Oasis Valley alternative segment 1	100	1.1	0	Floodplain of the Amargosa River within Thirsty Canyon.
Oasis Valley alternative segment 3	100	0.4	0	Floodplain of the Amargosa River within Thirsty Canyon.
Common segment 6	55	0.1	0	Beatty Wash Floodplain extending from Amargosa River Floodplain.
		0.23[c]		Busted Butte Wash draining east side of Yucca Mountain to Fortymile Wash (wash and tributaries crossed).

a. FEMA = Federal Emergency Management Agency.
b. To convert kilometers to miles, multiply by 0.62137.
c. There are no FEMA maps covering Busted Butte Wash on the eastern slope of Yucca Mountain. Estimates of flood zone crossings in this area are from DOE 2002 flood mapping efforts (DIRS 155970-DOE 2002, Figure 3-12).

There are no FEMA flood maps for any part of Esmeralda County. The FEMA flood map coverage is shown on Figure F-2 and described in detail in Sections F.3.3.1 through F.3.3.12.

In the areas FEMA has mapped, flood insurance studies have been completed that include a hydraulic analysis and a computation of the floodway and/or flood zones. FEMA defines the floodway as "the



Note: FEMA = Federal Emergency Management Agency.
Source: Derived from DIRS 181617-Hopkins 2007, all.

Figure F-2. FEMA floodplain map coverage for the Mina rail alignment.

channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights." Minimum federal standards limit such increases to 0.3 meter (1 foot). The area of the floodplain between the floodway and the outer limit of the 100-year flood limit is defined as the floodway fringe. The floodway is identified to assist the community in management of the floodplains detailed in the flood insurance study.

In addition to the FEMA flood maps, DOE used three studies completed in support of the Rail Alignment EIS to provide additional information related to discharge rates and flood hazards. The *Phase I Hydrologic and Drainage Evaluation Report for the Mina Corridor* (DIRS 180885-Parsons Brinckerhoff 2007, all) and the *Hydrologic and Drainage Evaluation Report for the Caliente Corridor* (DIRS 182755-PBS&J 2007, all) included field reconnaissance of every drainage feature along the entire Mina rail alignment and a review of all available streamflow and precipitation data sources. Also, an earlier study completed by Kennedy, Jenks, and Chilton in 1990 (DIRS 176903-De Leuw, Cather and Company 1992, Appendix H) provides approximate design discharge flow rates for portions of the alignment. The study also identifies locations along the Mina rail alignment with significant and unusual flooding hazards, including sections of the alignment affected by alluvial fans, closed-basin lakes, extremely high peak discharges, and wide shallow flow. Sections F.3.3.1 through F.3.3.12 summarize these studies.

Overlaying the Mina rail alignment on the FEMA maps allows for estimates of crossing distances (that is, the length of the rail alignment within the various floodplains). Table F-2 lists the floodplains identified along the Mina rail alignment by alternative segments and common segments. Sections F.3.3.1 through F.3.3.12 discuss the floodplains, where information is available, that would be encountered by each of the rail line segments.

DOE also contacted BLM field offices with jurisdiction over the federally owned lands along the Mina rail alignment to determine if they were aware of any floodplain data beyond that available from FEMA. None of the offices DOE contacted provided any floodplain data (DIRS 176303-Ong 2005, all; DIRS 176304-Ong 2005, all).

Table F-2. Floodplains the Mina rail alignment would cross (page 1 of 2).

Rail line segment	Portion covered by FEMA[a] maps (percent)	Floodplain crossing distance (kilometers)[b]		Description of feature that would be crossed
		Mapped	Additional estimated	
Union Pacific Hazen Branchline	-	-	-	-
Department of Defense Branchline North	-	-	-	-
Schurz alternative segment 1	0	0	-	No floodplains mapped.
Schurz alternative segment 4	0	0	-	No floodplains mapped.
Schurz alternative segment 5	0	0	-	No floodplains mapped.
Schurz alternative segment 6	0	0	-	No floodplains mapped.
Department of Defense Branchline South	-	-	-	-

Table F-2. Floodplains the Mina rail alignment would cross (page 2 of 2).

Rail line segment	Portion covered by FEMA[a] maps (percent)	Floodplain crossing distance (kilometers)[b] Mapped	Additional estimated	Description of feature that would be crossed
Common segment 1	0	0	0	No floodplains identified.
Montezuma alternative segment 1	0.10	0.0 10	0	Floodplain from Jackson Wash and Jackson Wash tributaries, respectively. Alkali Lake Playa floodplain not mapped by FEMA.
Montezuma alternative segment 2	10	2.0	0	The floodplain is located between Stonewall Mountains and Cuprite Hills and is associated with Stonewall Flat.
Montezuma alternative segment 3	0.10	0.0 10	0	The very southern end of Montezuma 3 would cross a very small section of FEMA floodplains just before it joins with common segment 2.
Common segment 2	100	1.3	0	Floodplain extends downgradient of Stonewall Flat Playa to the Lida Valley Alkali Flat Playa.
Bonnie Claire alternative segment 2	30	0	0	No floodplains identified.
Bonnie Claire alternative segment 3	78	1.9	0	Floodplains extending up tributaries of the Lida Valley Alkali Flat Playa and up the Stonewall Pass wash from the Bonnie Claire Flat area of Sarcobatus Flat.
Common segment 5	74	0.3	0	Floodplain extending from Sarcobatus Flat up to Tolicha Wash.
Oasis Valley alternative segment 1	100	1.1	0	Floodplain of the Amargosa River within Thirsty Canyon.
Oasis Valley alternative segment 3	100	0.4	0	Floodplain of the Amargosa River within Thirsty Canyon.
Common segment 6	55	0.1	0	Beatty Wash Floodplain extending from Amargosa River Floodplain.
		0.23[c]		Busted Butte Wash draining east side of Yucca Mountain to Fortymile Wash (wash and tributaries crossed).

a. FEMA = Federal Emergency Management Agency.
b. To convert kilometers to miles, multiply by 0.62137.
c. There are no FEMA maps covering Busted Butte Wash on the eastern slope of Yucca Mountain. Estimates of flood zone crossings in this area are from DOE flood mapping efforts (DIRS 155970-DOE 2002, Figure 3-12).

F.2.2 WETLAND DATA REVIEW

Title 10 CFR 1022.11 requires DOE to examine the following information to determine whether a proposed action would be located in a wetland, consistent with the most authoritative information available about site conditions:

- U.S. Army Corps of Engineers, *Wetlands Delineation Manual*
- U.S. Fish and Wildlife Service National Wetlands Inventory
- U.S. Department of Agriculture, Natural Resources Conservation Service local identification maps
- U.S. Geological Survey topographic maps
- DOE environmental documents

DOE used these data sources to support the delineation of wetlands along the Caliente and Mina rail alignments. The Department identified and delineated all wetlands within 0.40 kilometer (0.25 mile) of the Caliente and Mina rail alignments, except for the southern portion of the Caliente alternative segment. The evaluation corridor was restricted to a 61-meter (200-foot) width in this area due to the presence of private property and the fact that DOE would construct the alignment within an area narrower than the 61-meter delineation corridor. Wetlands typically must exhibit three general characteristics, including wetland hydrology, hydrophytic vegetation, and hydric soils, and there generally must be a positive indicator of each of these characteristics for a site to be classified as a wetland (DIRS 180914-PBS&J 2006, all; DIRS 180889-PBS&J 2007, all).

Sections F.3.2.1 through F.3.2.12 describe the wetland delineation for the Caliente rail alignment. Sections F.3.3.1 through F.3.3.12 describe the wetland delineation for the Mina rail alignment.

F.3 Floodplain and Wetland Impacts

In accordance with 10 CFR 1022.12(a)(2), a floodplain assessment must discuss the positive and negative, direct and indirect, and long- and short-term effects of a proposed action on floodplains and wetlands. In addition, the effects on lives and property, and on natural and beneficial values of floodplains, must be evaluated. For actions taken in wetlands, the assessment should evaluate the effects of the proposed action on the survival, quality, and natural and beneficial values of the wetlands. If DOE could find no practicable alternative to locating railroad construction and operations activities in floodplains or wetlands, the Department would design or modify its actions to minimize potential harm to or in the floodplains and wetlands.

For the purpose of assessing direct impacts to floodplains and wetlands, the region of influence for these resources is limited in most cases to the area of disturbance. DOE has defined the area of construction as the area within 150 meters (500 feet) on either side of the centerlines of the rail alignments (called the nominal width of the rail line construction right-of-way; see Section 2.2 of the Rail Alignment EIS). The goal of conceptual design and engineering is to limit impacts to this area to the maximum extent practicable. The area of disturbance would be limited to a smaller area along sections of the alignment where there are wetlands or private property; in areas requiring deep cuts or high fills, the area of disturbance could extend beyond the nominal width of the construction right-of-way.

The region of influence for surface-water resources would be limited in most cases to the nominal width of the rail line construction right-of-way. In places where surface-water flow patterns (including floodwaters) could be modified or surface-water drainage could carry eroded soil, sediment, or spills downstream, the region of influence extends beyond the construction right-of-way. Within the region of influence, there could be impacts to floodwaters such that they would back up on the upstream side of the rail line, while there could be impacts to water quality if pollutants traveled downstream during a storm event without precipitating out (soils from erosion) or becoming too dilute (petroleum-based lubricants or fuels) to detect.

DOE evaluated potential impacts to floodplains and wetlands based on a series of criteria, as listed in Table F-3. There would be an impact if railroad construction and operations would cause any of the conditions listed in Table F-3. To avoid or limit adverse impacts to floodplains and wetlands, the Department would comply with applicable laws, regulations, policies, standards, and directives, and implement best management practices (see Chapter 7). Most importantly, careful pre-planning of construction and operations activities will allow the Department to assess and minimize potential impacts before they occur (see Section 2.1 in the Rail Alignment EIS).

Table F-3. Impact assessment standards.

Resource criteria	Basis for assessing adverse impact
Wetlands	• Cause filling of wetlands or otherwise alter drainage patterns such that wetlands or waters are adversely affected.
Floodplains	• Alter floodway or floodplain or otherwise impede or redirect flows such that human health, the environment, or personal property is adversely impacted. • Conflict with applicable flood management plans or ordinances.

The areas where surface-water impacts would be greatest and where DOE would implement direct controls (such as erosion and sedimentation controls) would be within the construction right-of-way. DOE would reduce impacts to floodplains and wetlands by avoiding these resources where practicable and reducing the footprint of impact where the alignment would cross floodplains or wetlands. The Department would minimize the filling of wetlands and in some cases would reduce the width of the construction footprint in areas where the rail line would intersect or abut wetlands to reduce adverse impacts to wetlands in these areas. Impacts are addressed in this section in relation to the impact assessment standards listed in Table F-3, including construction in floodplains, alterations to floodwater discharge, construction in wetlands, and water-quality degradation.

The presence of floodplains or wetlands in the areas of the Caliente and Mina rail alignments depends in large part on the meteorology and hydrology of the area. Central and southern Nevada is characterized by low precipitation and high annual evaporation rates typical of desert climates, as described in Sections 3.2.5 and 3.3.5 of the Rail Alignment EIS. Because of the climate and topography (which is mostly north-south trending, parallel mountain ranges with broad, intervening valleys) in this area, internal drainage is the predominant hydrologic feature. Important characteristics of this hydrologic system include ephemeral streams and playas. Ephemeral streams might be dry over multiple seasons or years during periods of drought, but could have multiple periods of flow or standing water during wet periods, as happened during the winter of 2004-2005.

Runoff in the area is the result of snowmelt and seasonal precipitation that occurs most commonly in winter and occasionally in fall and spring. Localized thunderstorms also occur in this area, primarily in the summer. Thunderstorms can be intense, creating runoff in one wash while an adjacent wash receives little or no rain. In rare cases, however, storm and runoff conditions can be extensive enough to result in flow being present throughout the drainage systems. Although flow in most washes is rare, the area is subject to flash flooding from intense summer thunderstorms or sustained winter precipitation. When it occurs, intense flooding can include mud and debris flows in addition to runoff. Much of the runoff quickly infiltrates into rock fractures or into the dry soils, some is carried down alluvial fans in arroyos, and some drains onto dry lakebeds where it might stand for weeks as a lake (DIRS 180885-Parsons Brinckerhoff 2007, p. 17).

Washes in the areas of the Caliente and Mina rail alignments typically terminate in playas and flats within enclosed basins, typical of the Great Basin hydrologic regime (DIRS 174207-NDWR [n.d.], Part 1, p. 4-1). The exception is Meadow Valley Wash at the eastern end of the Caliente rail alignment, which is part of the Colorado River drainage system. The Amargosa River drainage system terminates within an enclosed basin, but in this case, outside of the Nevada state boundary into the Death Valley area of California. Sections 3.2.5 and 3.3.5 of the Rail Alignment EIS includes a detailed discussion of all of the mapped surface-water features along the Caliente and Mina rail alignments, respectively.

The proposed rail alignments pass through numerous valleys and over or around numerous ranges, as described in Sections 3.2.5 and 3.3.5 of this EIS. Physical limitations on the design of a rail line (for example, the need for relatively gentle gradients and wide turns) require that the alignments follow valley floors to go around ranges or parallel the mountain ranges in transition zones to gradually change elevation to reach, or descend from, passes. In the valley floors, the alignments parallel predominant drainage channels and cross through or near flats and playas. Closer to ranges, the alignments are laid out at a right angle to the predominant drainage (from topographic highs to inland basins). As a result, the proposed rail alignments would encounter a wide variety of surface drainage features.

> **50-year flood** is a flood that has a 2-percent chance of being equaled or exceeded in any given year.
>
> **100-year flood** is a flood that has a 1-percent chance of being equaled or exceeded in any given year. A base flood may also be referred to as a 100-year storm and the area inundated during the base flood is sometimes called the 100-year floodplain.
>
> **500-year flood** is a flood that has a 0.2-percent chance of being equaled or exceeded in any given year.

F.3.1 COMMON IMPACTS

F.3.1.1 Construction in Floodplains

Many of the floodplains that would be encountered by the proposed rail line are associated with internally draining basins with few, if any, inhabitants or facilities, and where the floodwaters end up in playa areas. The floodplains assessed herein are primarily those areas of normally dry washes that are temporarily and infrequently inundated from runoff during 100-year or 500-year floods. The proposed rail alignments are in a region where flash flooding events are the primary concern. Although such flooding can be violent and hazardous, it is generally focused in its extent and duration, limiting the potential for extensive impacts associated with the proposed rail line; that is, any damage would be expected to be confined to a small portion of the rail line.

Construction of a rail line along the Caliente rail alignment or the Mina rail alignment would affect floodplains, either through direct alteration of the stream channel cross section that would affect the flow pattern of the stream, or through indirect changes in the amount of impervious surfaces and additional water volume added to the floodplain. In most of the areas along the proposed rail alignment, construction in a floodplain would not increase the risk of future flood damage or increase the impact of floods on human health and safety because there are very few human activities or facilities in the areas adjacent to the proposed alignments, with a few exceptions, such as the City of Caliente along the Caliente rail alignment and town of Mina along the Mina rail alignment. DOE expects that adverse impacts along the proposed rail alignments would be minimized because construction activities would adhere to design standards that limit the degree to which floodwaters would be allowed to rise. DOE would incorporate hydraulic modeling into the engineering design process to ensure that all crossings are designed in a manner that limits adverse impacts to nearby populations and resources; therefore, DOE expects that impacts associated with construction in floodplains would be small.

> **Subgrade elevation** of the rail line is the elevation of the top of the ***subballast***.
>
> **Subballast** is a layer of crushed gravel that is used to separate the ***ballast*** and roadbed for the purpose of load distribution and drainage.
>
> **Ballast** is crushed stone used to support the railroad ties and provide drainage.

Except in areas where drainage structures cross a Federal Emergency Management Agency-designated 100-year floodplain, hydraulic design would be based upon typical Class 1 freight railroad standard design criteria. Class 1 freight railroad standard criteria require that the ***50-year flood*** should not come into contact with the top (crown) of the culvert or the lowest point of the bridge, whichever is applicable. For the ***100-year flood***, these criteria require that the floodwaters should not rise above the ***subgrade elevation*** at the structure. To conform to these standards, DOE would use circular culverts where flow rates would be small (less than 4 cubic meters per second [140 cubic feet per second]). For larger flows (up to 28 cubic meters per second

[1,000 cubic feet per second]), DOE would use box culverts. The Department would construct bridges where flows were larger and where the rail surface would not be tall enough to accommodate a sufficiently sized culvert, and would install the culverts with ***riprap*** around the exposed ends to protect the fill material from erosion (DIRS 176166-Nevada Rail Partners 2006, p ii). Bridge abutments and piers would be similarly protected. In some places, training dikes or ***berms*** would be required to redirect flow and ensure that the flow would be conveyed through the structure. In places, channel improvements might be necessary for a short distance upstream and downstream of the rail line to intercept and effectively redirect flows through drainage structures.

DOE would analyze crossings on a case-by-case basis and propose culverts whenever feasible. Where there would be very wide and shallow depths of flow during a 100-year flood, or the flow would be divided into multiple natural channels that would cross the rail line, the Department would use a series of multiple culverts, potentially in concert with small bridges to span the main flow channel. In locations where there were very high fill conditions, it would be more economical to use multiple culverts than to construct a bridge (DIRS 176166-Nevada Rail Partners 2006, p ii). Because DOE would design stormwater conveyance systems to safely convey design floods (50-year and 100-year) and would minimize concentration of flow to the greatest extent practicable, impacts associated with construction of the rail line on stormwater conveyance would be small.

Although DOE would generally design rail line features to accommodate 100-year floods, based on typical Class 1 freight railroad standard design criteria as described above, the final design process could also consider a range of flood frequencies and include a cost-benefit analysis in the selection of a design frequency in accordance with standard rail line design guidelines and practices (DIRS 106860-AREA 1997, Volume 1, Section 3.3.2.2c). In areas where drainage structures cross a Federal Emergency Management Agency-designated 100-year floodplain, the bridge would be designed to comply with Agency standards and appropriate county regulations. Federal Emergency Management Agency standards require that floodway surcharge (the difference between the 100-year flood elevation and the actual flood surface elevation) not exceed 0.3 meter (1 foot) at any location. These standards are designed to limit the impacts of floodwater impacts to structures built in or adjacent to floodplains (DIRS 176166-Nevada Rail Partners 2006, p. ii). By adhering to these standards, the Department would substantially limit the potential for adverse impacts to the population and resources located adjacent to floodplains.

The placement of a bridge typically involves encroachment into the floodplain by the bridge abutments. This encroachment can have some impact on the height of floodwaters upstream of the bridge. Excessive encroachment can also result in increased scour potential at the abutments, piers, and the stream bottom, and through the bridge opening, due to increases in flow velocities. Based on the conceptual design for the proposed alternative segments, encroachments up to 30 percent of the floodplain width would be possible, which could result in an increase of 0.3 meter (1 foot) in the height of floodwaters at the upstream side of the proposed bridge where the floodplain is wide and shallow (DIRS 180918-Nevada Rail Partners 2007, p. ii).

DOE would reduce impacts to floodplains and the resources close to the floodplains by adhering to the design standards that limit the degree to which floodwaters would be allowed to rise. DOE would incorporate hydraulic modeling into the engineering design process to ensure that all crossings were designed to limit impacts to nearby populations and resources.

In general, construction-related impacts associated with the floodplains would be similar to those that could occur in any other identified drainage areas (in other words, the alteration of natural drainage patterns and possible changes in erosion and sedimentation rates or locations). Construction in washes or other flood-prone areas may reduce the area through which floodwaters naturally flow, which could cause water levels to rise at the upstream side of crossings. Sedimentation would be likely to occur on the upstream side of crossings in these areas where the flow of water is restricted to the point where ponding occurs. DOE would manage sedimentation of this type under a regular maintenance program (DIRS 155970-DOE 2002, pp. 6 to 79). Impacts to floodplains resulting from restrictions in flow and resulting sedimentation are expected to be small due to the regular maintenance DOE would perform.

F.3.1.2 Alterations to Floodwater Discharge

Alterations to natural drainage, sedimentation, and erosion would be unlikely to increase future flood damage, increase the effect of floods on human health and safety, or cause significant harm to the natural and beneficial values of the floodplains. This is because of the relatively limited size of the disturbance that would be necessary to construct a rail line and because the rail line design would include appropriate water-conveyance structures or devices to accommodate flood flows.

Alterations to floodplains (such as cuts and fills) due to rail line construction could cause the alteration of natural drainage patterns and runoff rates that could affect downgradient resources. Construction activities that could alter surface drainage temporarily include moving large amounts of soil and rock to develop the track platform (or subgrade) and constructing temporary access roads to reach construction initiation points and major structures, such as bridges, and to allow movement of equipment to the construction initiation points. Permanent alterations to drainage would be limited to engineered drainage structures and grading and excavation activities. DOE would not expect alterations to floodplain drainage to adversely impact people and property downstream because DOE would use best management practices and standard engineering design and construction practices to minimize adverse impacts.

Depending on site-specific conditions, construction grading may be used to channel a number of minor drainage channels into a single culvert or under a single bridge, which would result in water flowing from a single location on the downstream side rather than across a broader area. As a result, some localized changes in drainage patterns would occur. However, these changes would be limited to areas where natural drainage channels were small; therefore, DOE would expect adverse impacts associated with altered drainage patterns to be small. The Department does not expect that any increase in the velocity of floodwaters caused from rechanneling or regrading would result in adverse impacts to downgradient resources because alterations to drainage would be limited to the area of construction and the associated facility locations.

F.3.1.3 Construction in Wetlands

Direct impacts to wetlands associated with the rail alignment would result from temporary or permanent filling or draining of these resources. Indirect impacts would include potential water-quality degradation resulting from actions in and around these resources. Wetland areas would be filled or disturbed as a result of construction of the proposed rail line.

Wetlands improve water quality by acting as filters and slowing seasonal floodwater as it moves around wetland vegetation. It acts similar to a sponge by storing water and then slowly releasing water downslope (DIRS 178594-EPA 2006, all). Wetlands also filter water-borne sediments out of the water column when seasonal floodwaters come in contact with vegetation and other debris such as rocks and logs. Plant roots and microorganisms on plant stems and roots function in transforming pollutants into a less mobile form and play an important role in the atmospheric nitrogen cycle.

DOE would minimize filling of wetlands by incorporating avoidance into engineering and design of the rail line to the maximum extent practicable. DOE would use a minimum-width footprint when possible.

This would be accomplished by increasing the slope of the roadbed or bridging across wetlands and not constructing access roads in wetlands.

F.3.1.4 Water-Quality Degradation

Construction and operation activities associated with the Proposed Action would have the potential to degrade water quality and cause negative impacts to floodplains and wetlands due to the potential release and spread of contaminants (that is, materials potentially harmful to human health or the environment), which could be released through an accidental spill or discharge. These types of releases could be localized (in the event of a small spill) or widespread (in the case where precipitation or intermittent runoff carried contaminants away from the site of the spill). Sections 4.2.12 and 4.3.12 of the Rail Alignment EIS discuss hazardous materials in more detail, including petroleum products (such as fuels and lubricants) and coolants (such as antifreeze) for equipment operation. Other contaminants could include solvents used in cleaning or degreasing actions. The construction camps and some of the railroad operations support facilities would include some bulk storage of hazardous materials, and supply trucks would routinely bring new materials and remove used materials and wastes (such as lubricants and coolants) from the construction sites (see Section 4.2.12 of the Rail Alignment EIS). These activities would present some potential for accidental spills and releases, the significance of which would greatly depend on the nature and volume of the material spilled and its location. A release or spill of contaminants to a stream or wash, or carrying of contaminants to such receptors by stormwater runoff, would have the greatest potential for adverse environmental impact.

The potential for such impacts would be reduced because of the arid environment and lack of flowing water along either rail alignment. Also, construction contractors would be required to comply with regulatory requirements on spill prevention measures, reporting and remediating spills, and properly disposing or recycling used materials. Employees responsible for railroad operations would also be required to comply with any regulatory requirements and best management practices applicable to the proper storage and use of hazardous materials. Common stormwater pollution control practices mandate that hazardous materials be stored inside facilities, or have secondary containment or other protective devices, and that spill control and containment equipment be stationed close to hazardous material (such as fuel) storage areas. Thus, the potential for an accidental release that would not be localized or contained would be very small. During construction activities, water sprayed to control dust and achieve soil compaction criteria would not be used in quantities large enough to support surface-water flow and possible contaminant transport for any distance.

During operation of the rail line, it would be extremely unlikely that a railcar carrying spent nuclear fuel or high-level radioactive waste would derail in a floodplain or wetland, or in one of the washes crossed by the proposed rail alignment that drains to a floodplain or wetland. If a railcar transporting a shipping cask containing radioactive waste were to derail, the chances of a radiation release would be remote. As described in Section F.2.1, the shipping casks are designed to withstand accident conditions and are subject to very stringent design and testing standards to ensure their structural integrity. Impacts to wetlands and floodplains resulting from a release of hazardous materials of any type would be expected to be very small because of the precautions that would be taken to avoid and respond to spills. Further, shipping casks would never be opened during the transportation process and the potential for a release to occur during any accident or flooding scenario is extremely remote (DIRS 104774-Fischer et al. 1987, pp. 9-1 to 9-15).

Increased sediment loading as a result of soil disturbance actions during construction would be the most likely adverse impact associated with the Proposed Action. DOE would be required to identify the appropriate and applicable steps that would be taken during construction to minimize sediment loading. These steps most likely would be actions to reduce potential for increased erosion and subsequent sedimentation and to ensure that any downstream water did not experience increases in sediment loading or turbidity that would threaten the beneficial use of that water. DOE would not expect adverse impacts to surface waters along the proposed rail alignment that would interfere with any beneficial use of the water, which is a primary criterion applied by the State of Nevada environmental standards (Nevada Administrative Code 445A.121).

F.3.2 SEGMENT-SPECIFIC IMPACTS FOR THE CALIENTE RAIL ALIGNMENT

F.3.2.1 Interface with the Union Pacific Railroad Mainline – Caliente and Eccles Alternative Segments

Two alternative segments (Caliente and Eccles alternative segments) are under consideration for connecting to the existing Union Pacific Railroad Mainline. Facilities at the Interface with the Union Pacific Railroad Mainline include the Interchange Yard, the Staging Yard, a Satellite Maintenance-of-Way Facility, train crew facilities, and possibly the Nevada Railroad Control Center and National Transportation Operations Center.

F.3.2.1.1 Caliente Alternative Segment

FEMA has mapped flood zones only for the very southern portion of the Caliente alternative segment, as shown in Figures F-3 and F-4. From its starting point on the southern bank of Clover Creek, the alignment would cross 100-year and 500-year flood zones associated with both Clover Creek and Meadow Valley Wash. The Interchange Yard would be within 100-year and 500-year flood zones associated with Clover Creek. The alignment would remain in the 100-year floodplain associated with Meadow Valley Wash as it traveled north and left the area mapped by FEMA. Based on an analysis of the FEMA flood mapping and topographic contour data for the alignment, it appears that the Caliente alternative segment would be in a floodplain associated with Meadow Valley Wash from the time it left Caliente until it turned west just before joining Caliente common segment 1.

As listed in Table F-1, the alignment would cross a total of 2.6 kilometers (1.6 miles) of FEMA-mapped floodplains and approximately 2.6 kilometers of additional floodplains that FEMA has not mapped. It should be noted that the Caliente rail alignment would follow an existing abandoned Union Pacific rail bed from where it originates in Caliente for most of its length before joining common segment 1. Therefore, most rail line construction activities (except for operations support facilities) would be confined to the existing railbed.

The Interchange Yard on the Caliente alternative segment would be in the City of Caliente, directly across from the former Union Pacific Railroad Caliente Station within the area of the former Union Pacific Railroad yards. FEMA floodplain maps for this area show that a 240-meter (790-foot) section of the Interchange Yard would be in a 100-year floodplain and the remainder would be in a 500-year floodplain. Floodwaters from Meadow Valley Wash flow through the center of Caliente to the south where they merge with the runoff from three dry washes that flow to the southwest. In the area where the Interchange Yard would intersect the 100-year floodplain, the floodwater depth was calculated to be 0.90 meter (3 feet) during the 100-year storm event (DIRS 176806-FEMA 1985, all). Because the interchange tracks would be in an area already occupied by an existing Union Pacific siding, the Interchange Yard would not be likely to obstruct the flow of floodwaters to the point that floodwater depths would increase.

Two of the three alternative locations being considered for the Staging Yard are along the Caliente alternative segment (Indian Cove and Upland). The southern portion of the Indian Cove Staging Yard would be constructed in the 100-year floodplain mapped by FEMA along Meadow Valley Wash. Based on the elevation of the meadow in which the Staging Yard would be constructed, it appears that the

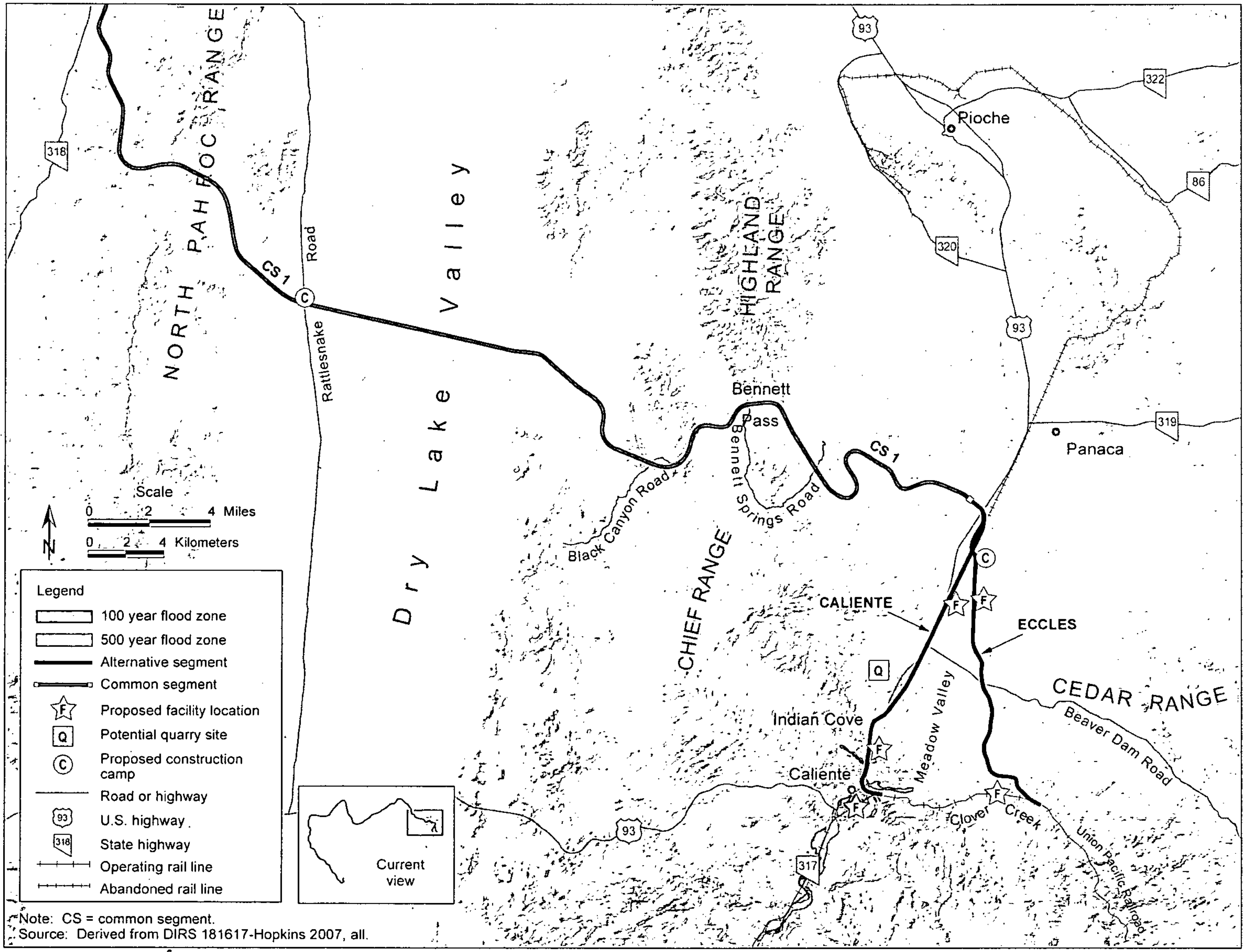


Figure F-3. FEMA floodplain map for map area 1 of the Caliente rail alignment.

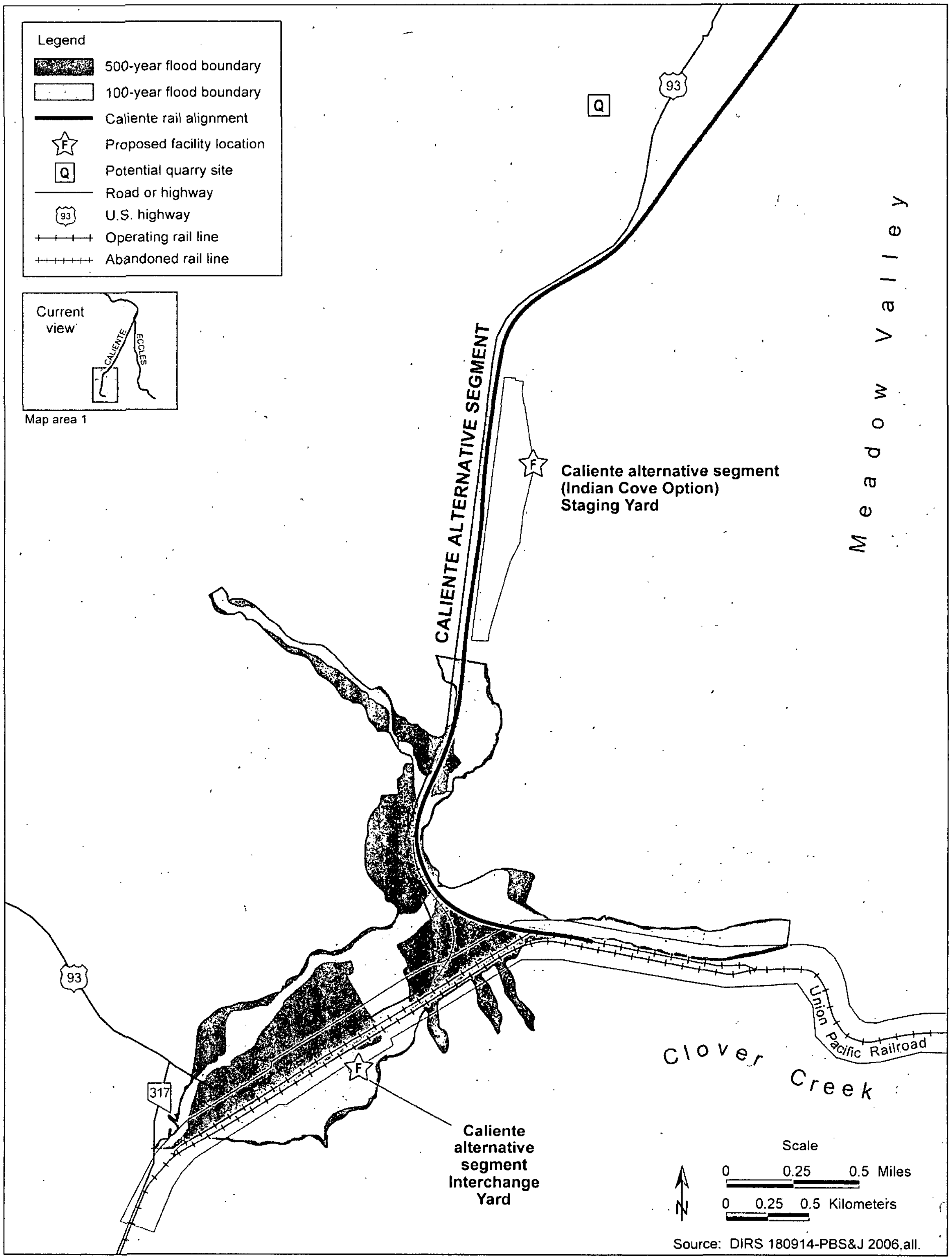


Figure F-4. FEMA floodplain map for the Caliente alternative segment.

entire meadow could be considered floodplain. The Caliente-Upland optional location for the Staging Yard is also susceptible to flooding from Meadow Valley Wash; however, FEMA has not mapped floodplains in this area. One of the construction camps would be about 2.5 kilometers (1.6 miles) south of the Caliente alternative segment junction with Caliente common segment 1. This construction camp would not intersect floodplains or wetlands. Section F.3.1 addresses the common impacts to floodplains the Caliente alternative segment and its associated facilities would cross.

DOE delineated wetlands within 30 meters (100 feet) of the Caliente alternative segment (see Figures F-5 and F-6) in a field survey completed in support of the Rail Alignment EIS (DIRS 180914-PBS&J 2006, Figures 4A to 4RT). Some larger wetland areas extend beyond the area delineated. Field investigations for wetlands along the Caliente alternative segment determined wetlands are primarily vegetated by herbaceous plants, but contain scattered clusters of scrub/shrub plant communities, pools of open water, and drainages (DIRS 180914-PBS&J 2006, Table 6). Most wetlands along the Caliente alternative segment contain dense communities of persistent herbaceous wetland plants that cause water-borne sediments to precipitate out of the seasonal sheet flow and slow the velocity of surface water flowing over the landscape. The root structure of herbaceous plants also functions in binding and retaining soil sediments. Persistent herbaceous vegetation along the rail alignment can provide a high magnitude of water-quality functions. Persistent vegetation is characterized as plants that retain their above-ground biomass during the nongrowing season (DIRS 178728-Bartoldus, Garbisch, and Kraus 1994, pp. 6 to 14) and contribute to sediment stabilization and flood flow attenuation functions. Nonpersistent vegetation decomposes during the nongrowing season, and therefore provides a lower magnitude of sediment retention functions.

Some wetlands along the Caliente alternative segment have a moderately complex wildlife habitat structure, as evidenced by the presence of trees and shrubs, and pools of open water or streams with flowing water. These wetlands function as important breeding sites, provide habitat for larval development, and serve as a primary food source for adults. Insects, spiders, snails, worms, and small fish living in wetlands are prey for certain amphibians. Wetlands also function as reproductive and nursery habitat for a variety of reptiles (DIRS 178594-EPA 2006, p. 3). Left undisturbed, these wetlands would continue to provide a variety of commonly recognized ecological functions such as wildlife habitat, sediment stabilization, nitrogen and nutrient cycling, flood attenuation, and water-quality benefits. These wetlands could play a more significant role in maintaining water quality and wildlife habitat during rail line construction. For example, undisturbed wetlands would intercept and cause the precipitation of sediments carried by ephemeral water. In addition, wetland vegetation could transform, relocate, and volatize small amounts of pollutants accidentally released into the environment.

The magnitude and quality of functions provided by undisturbed wetlands depends on the size of wetlands. Generally, large contiguous wetlands provide a suite of functions and higher ecological functional capacity. For example, a moderate- to large-sized wetland could provide the food, shelter, and reproductive requirements for wildlife, provide flood reduction capabilities, and filter sediments. Smaller wetlands might only provide limited habitat for transient wildlife, have little or no flood storage capacities, or depending on its position within the landscape, could easily be overwhelmed by a sudden influx of sediments and lose its capacity to effectively filter sediments.

Construction along the Caliente alternative segment would result in the permanent loss of some wetland habitat. Removal of the persistent wetland vegetation would result in short-term exposure to erosion by wind or water and desiccation by the warm climate. Undisturbed wetlands would continue to perform water-quality functions by filtering potential unconsolidated sediments; however, the flood flow attenuation capacity would be slightly reduced, and could result in some minor localized flooding and erosion during seasonal precipitation events. Wetlands could also be affected by increased sedimentation

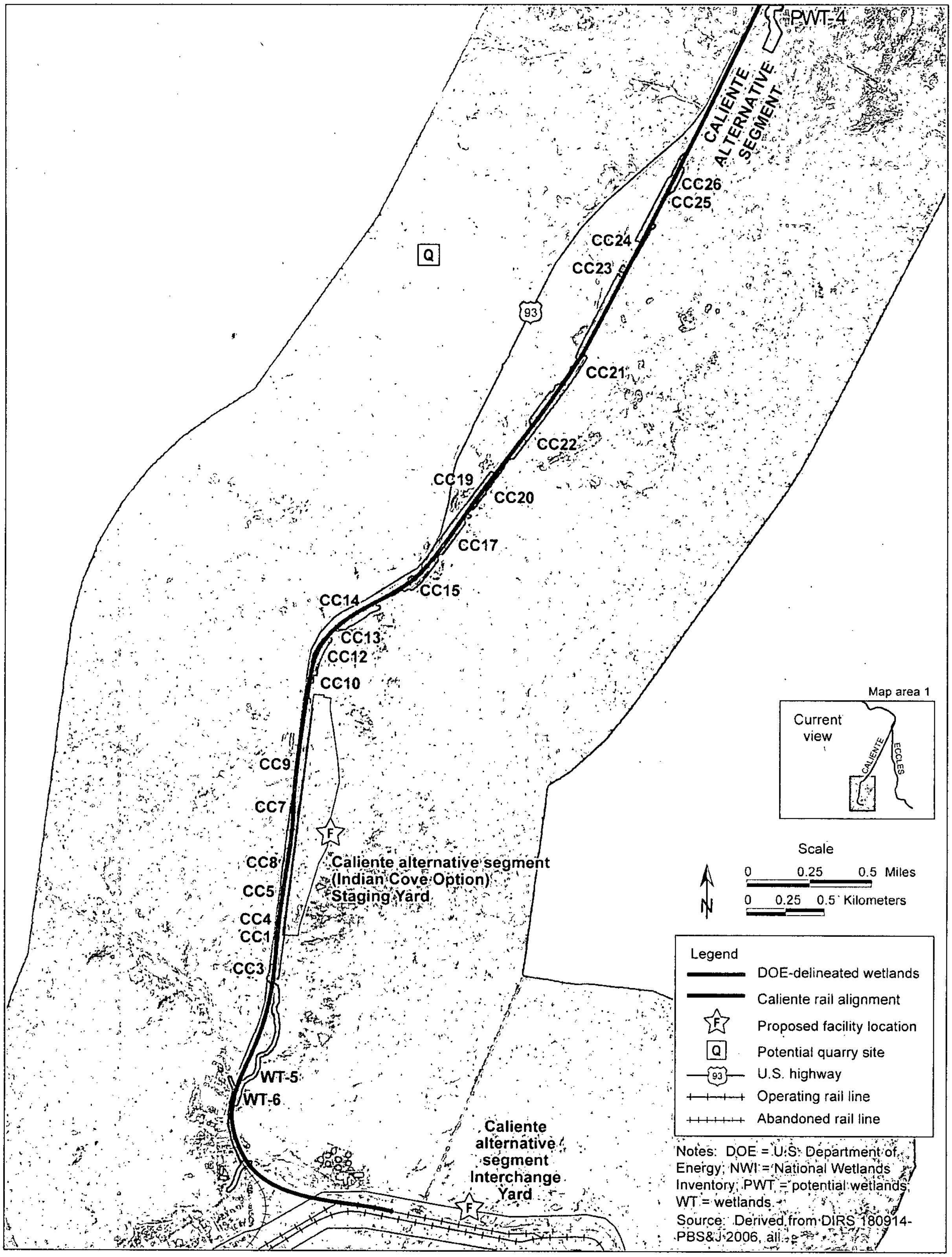


Figure F-5. Wetlands along southern portion of the Caliente alternative segment.

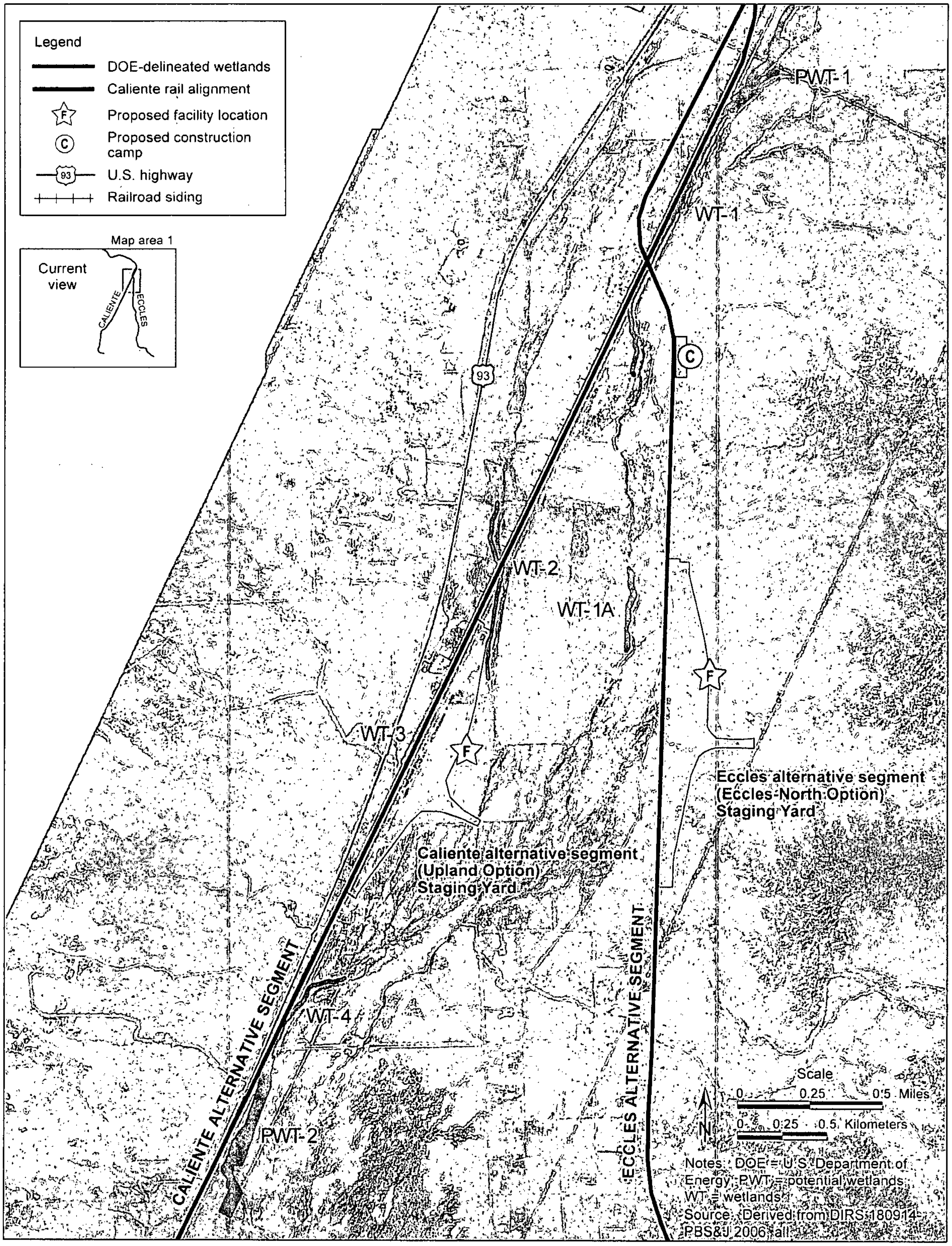


Figure F-6. Wetlands along northern portion of the Caliente alternative segment.

resulting from construction-related activities. Implementing best management practices such as constructing sediment ponds and installing hay bales or silt fences would minimize potential impacts. Wildlife utilizing wetlands in the proposed disturbance areas would be temporarily displaced, but would probably use nearby wetlands. DOE would minimize impacts to wetlands, which in turn, would minimize adverse impacts to herpetofauna (amphibians and reptiles) using these water resources. Where feasible, affected areas would be restored to the maximum extent practicable.

Removal of vegetation along the Caliente rail alignment would reduce the flood alteration capacity, and result in the loss of wildlife and increased sedimentation, particularly during rain events. In some areas, an influx of sediments related to disturbances could produce an accreting environment on the streambed and result in decreased flood storage capacities. Wildlife affected by the Caliente alternative segment would be temporarily displaced and would utilize nearby habitats. Over time, some wildlife species would return to affected areas, especially if lost habitat was reestablished.

The total area of wetlands delineated within 30 meters (100 feet) of the Caliente alternative segment is 0.28 square kilometer (68 acres). DOE would minimize impacts to wetlands in this area by reducing the width of the construction footprint to approximately 21 meters (70 feet), which would reduce the area of wetlands to be filled to 0.05 square kilometer (12 acres). Although DOE evaluated the use of vertical retaining walls and other methods to further reduce the construction footprint and the amount of wetlands that would be filled, the Department found that those methods would be impracticable due to cost (DIRS 180916-Nevada Rail Partners 2007, Appendix F-1). DOE could modify the final design of the alignment to avoid additional wetlands, such as those adjacent to the old rail roadbed along Meadow Valley Wash, by using a slightly narrower construction footprint; however, this would only slightly reduce the area of wetlands that would be filled.

DOE is considering two optional locations for the Staging Yard along the Caliente alternative segment (Indian Cove and Upland), as shown on Figures F-5 and F-6. The Indian Cove Staging Yard would be constructed in a wetland. Construction of the Staging Yard in Indian Cove would require the wetland meadow area to be drained and built up above the level of the floodplain. It might also require an active drainage system and a channel around the site to keep the area dry and in a stable condition. Meadow Valley Wash drainage through the site is from north to south toward the City of Caliente. Drainage of the site would be accomplished by constructing a channel along the eastern edge of the facility. The channel around the site would be approximately 1,680 meters (5,500 feet) long. The Department would determine final channel dimensions during final design of the Staging Yard. It is very likely that a system of drains would have to be constructed under the Staging Yard tracks. Fill could be needed to elevate portions of the site out of the floodplain. These actions would require permits from the U.S. Army Corps of Engineers, as well as compliance with Section 404 of the Clean Water Act for stormwater runoff control measures. Assuming that the entire meadow is wetlands, the Staging Yard at Indian Cove would require up to 0.19 square kilometer (47 acres) of wetlands to be filled.

One of the proposed quarry locations (and its associated siding) is also along the Caliente alternative segment. The railroad siding for this quarry would be constructed on the west side of the alignment in the vicinity of the quarry. Since the wetland delineation did not extend into this area, the amount of wetlands that would be filled must be estimated based on the wetlands that were delineated along the alignment. The total area of the siding is 0.18 square kilometer (44 acres) and a conservative assumption that half of this area is wetlands that would be filled would mean that 0.09 square kilometer (22 acres) of wetlands would be filled to construct the quarry siding.

The construction of the Caliente alternative segment would require the filling of wetlands associated with Meadow Valley Wash. In addition, if the Caliente quarry and/or the Indian Cove Staging Yard are selected, a significant portion of additional wetlands would be filled. In order to mitigate the loss of wetlands that must be filled, DOE would enhance adjacent wetlands. By minimizing the footprint of the rail roadbed within wetlands and mitigating the loss of wetlands that are filled, DOE would minimize adverse impacts to these wetlands (and the functions served by wetlands); therefore, direct impacts to wetlands left intact are expected to be localized and small. Indirect impacts, such as disruption of water flow, will be avoided by constructing the rail line on an existing berm and constructing bridges and culverts in areas where water crosses the rail line; therefore, indirect impacts from the construction of the rail line would be small. The filling of up to 0.19 square kilometer (47 acres) of wetlands in Indian Cove for the Staging Yard would greatly impact the wetland functions served by the wet meadow, such as its ability to support wildlife, retain flood flows, and filter water; therefore, this is considered a large impact.

F.3.2.1.2 Eccles Alternative Segment

There are no FEMA flood maps for the area of the Eccles alternative segment; however, it is reasonable to assume that the floodplain mapped for Clover Creek in the area of Caliente extends to the east, upstream to the starting point of this alternative segment (see Figure F-3). Clover Creek is a tributary of Meadow Valley Wash. The place where the Eccles alternative segment would cross Meadow Valley Wash is also a likely floodplain. Section F.3.1 addresses the common impacts to floodplains that would be crossed by and adjacent to the Eccles alternative segment.

DOE delineated one wetland area in an incised channel along Meadow Valley Wash that would be crossed by the Eccles alternative segment approximately 1.5 kilometers (0.93 mile) south of the junction with common segment 1. A bridge would be used to cross Meadow Valley Wash and its associated wetlands in this area. The wetlands in this area are about 7.6 meters (25 feet) wide. Since a bridge will be used to cross this area, the fill estimate is based on the assumption that one pier would be constructed in the wetlands encompassing an area of 1.9 square meters (20 square feet).

Five other areas with wetlands (see Figure F-7) were identified near the proposed location of the Eccles Interchange Yard in Clover Creek (DIRS 180914-PBS&J 2006, Figure 4B). Three of those wetlands (WT-9, WT-10, and WT-11) are in Clover Creek about 30 to 180 meters (100 to 600 feet) north of the proposed Interchange Yard and would not be disturbed during construction. These three wetlands could be indirectly impacted by the construction of the Staging Yard. The existing railroad embankment would be expanded by filling and grading to match the mainline elevation, which would require fill along and within the confines of Clover Creek. The fill would extend approximately 15 meters (50 feet) into the creek for approximately 1,400 meters (4,600 feet) along the creek. For construction of the interchange siding, the fill would extend approximately 7.5 meters (25 feet) into the creek for approximately 900 meters (3,000 feet) on the east end and 600 meters (2,000 feet) on the west end of the interchange tracks. Based on these assumptions, the total amount of fill required for the Interchange Yard would be approximately 0.033 square kilometer (8.2 acres). Appropriate protection measures (for example, lining the fill with riprap and gabions) would be used along the entire length of the Interchange Yard to stabilize and protect the structure from the floodwaters.

Filling a long section of a stream bank has the potential to create greater adverse impacts than simply crossing a stream, because the structure of the stream itself would be modified to a much greater extent as opposed to a bridge crossing or culvert that would have less of a presence within the stream. It is likely that fill required to construct the Interchange Yard could result in the permanent alteration of the localized hydraulic conditions. Such alterations to the hydraulic conditions of the stream would have the potential to increase flow velocity and result in a higher potential for erosion during high flow (flood) events. Indirect impacts to the wetlands within Clover Creek could result from the increased flow rates during flood events. Clover Creek and its associated floodplain, which encompasses Dutch Flat, ranges in width from 130 to 400 meters (430 to 1,300 feet). Since the Staging Yard would only extend about 15 meters (50 feet) into Clover Creek and its associated floodplain, impacts to the wetlands within Clover Creek

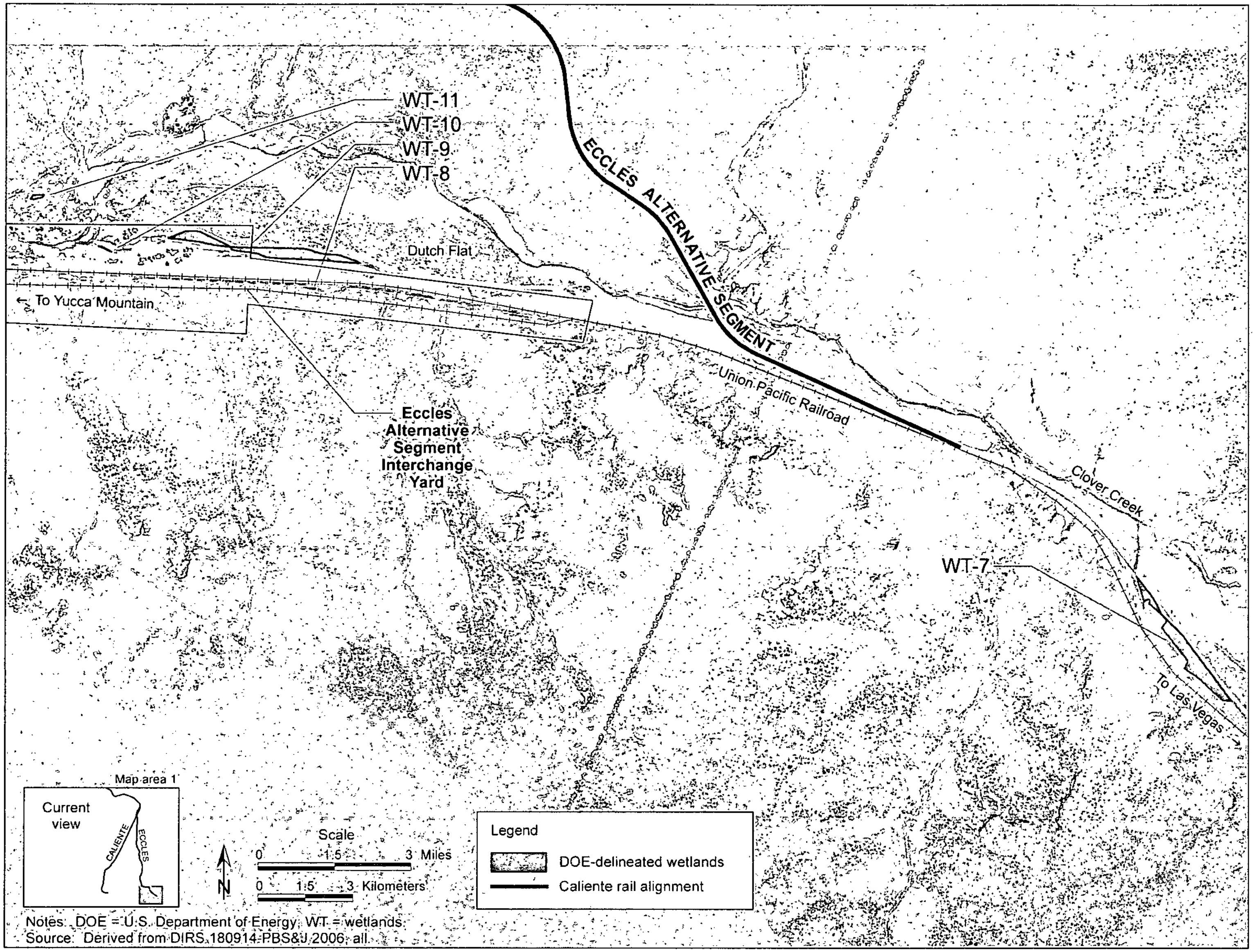


Figure F-7. Wetlands in vicinity of Eccles Interchange Yard.

from increased flow rates are expected to be small. DOE would minimize these impacts through the use of erosion control practices and hydraulic design. The other two areas with wetlands (WT-7 and WT-8) are on the opposite side of the existing Union Pacific tracks from the proposed Interchange Yard and would not be filled for construction of that yard. DOE would maintain all surface-water connections from those two wetlands to Clover Creek by constructing bridges or culverts at connecting drainage features. DOE would flag or fence all wetlands within the area of construction to protect them during construction activities; therefore, no direct impacts are expected to these wetlands during construction.

F.3.2.2 Caliente Common Segment 1

FEMA has published only one flood map that covers a small section of the area crossed by Caliente common segment 1. This flood map covers a portion of land in White River Valley and the adjacent north end of the Seaman Range, as shown in Figure F-8. Common segment 1 would not cross any FEMA floodplains shown in the area on this single map. Common segment 1 would run 1.4 kilometers (0.87 mile) north of an unnamed playa that is 47 square kilometers (18 square miles) in size when crossing Dry Lake Valley. During periods of heavy rainfall, runoff from the Highland, Chief, North Pahroc, and Seaman Ranges can produce ephemeral lakes in these playas. One construction camp would be located along the common segment, but it would not intersect floodplains or wetlands. Common impacts to nearby playas and their associated floodplains are addressed in Section F.3.1.

In the North Pahroc Range pass (between White River Valley to the west and Dry Lake Valley to the east), Caliente common segment 1 would pass within 600 meters (2,000 feet) of a small group of three isolated wetlands (see Figure F-9). These isolated, nonjurisdictional (not regulated under Section 404 of the Clean Water Act) wetlands were delineated during the field survey conducted in support of the Rail Alignment EIS (DIRS 180914-PBS&J 2006, Figure 4S). These wetlands are labeled WT-12, WT-13, and WT-14 and are associated with an unnamed spring. A lack of wildlife habitat was observed in this area. The shoreline of the ponds lacks the vegetation that would provide food, shelter, or reproductive habitat for a variety of species (DIRS 180914-PBS&J 2006, Photos 50 and 51, pp. B-25 and B-26). Using the Cowardin (DIRS 178724-Cowardin et al. 1979, all) classification scheme, the stock watering pond (WT-12) is classified as a palustrine emergent/rock bottom/unconsolidated bottom wetland and the other areas (WT-13 and WT-14) as emergent wetlands (DIRS 180914-PBS&J 2006, p. 19).

The unnamed spring appears to have been created by excavating (or blasting) a hole into the soil and excavating a channel to convey water into a basin used as a stock watering pond. The spring head and excavated channel (WT-13) and the stock pond (WT-12) occupy less than 0.0081 square kilometer (2 acres). The channel was flowing from the spring head through the channel to the stock pond at the time of the field survey (DIRS 180914-PBS&J 2006, p. 13). No direct impacts are anticipated to these wetlands since they are uphill of and outside the rail line construction right-of-way; therefore, there would be no direct or indirect impacts to these wetlands as a result of the construction or operation of the proposed rail line.

F.3.2.3 Garden Valley Alternative Segments

FEMA flood maps do not cover any of the Garden Valley alternative segments. However, it is likely that some areas in the valley experience periodic flooding. Garden Valley alternative segment 2 would cross three of the same intermittent creeks and washes and the drainage feature designated as Water Gap, which is characterized as a topographically constricted area through which several small drainage channels run. Although the area is normally dry, Water Gap must be considered a suspect area for flooding issues. Garden Valley alternative segment 2 would also skirt (within 1 kilometer [0.6 mile]) the Coal Valley

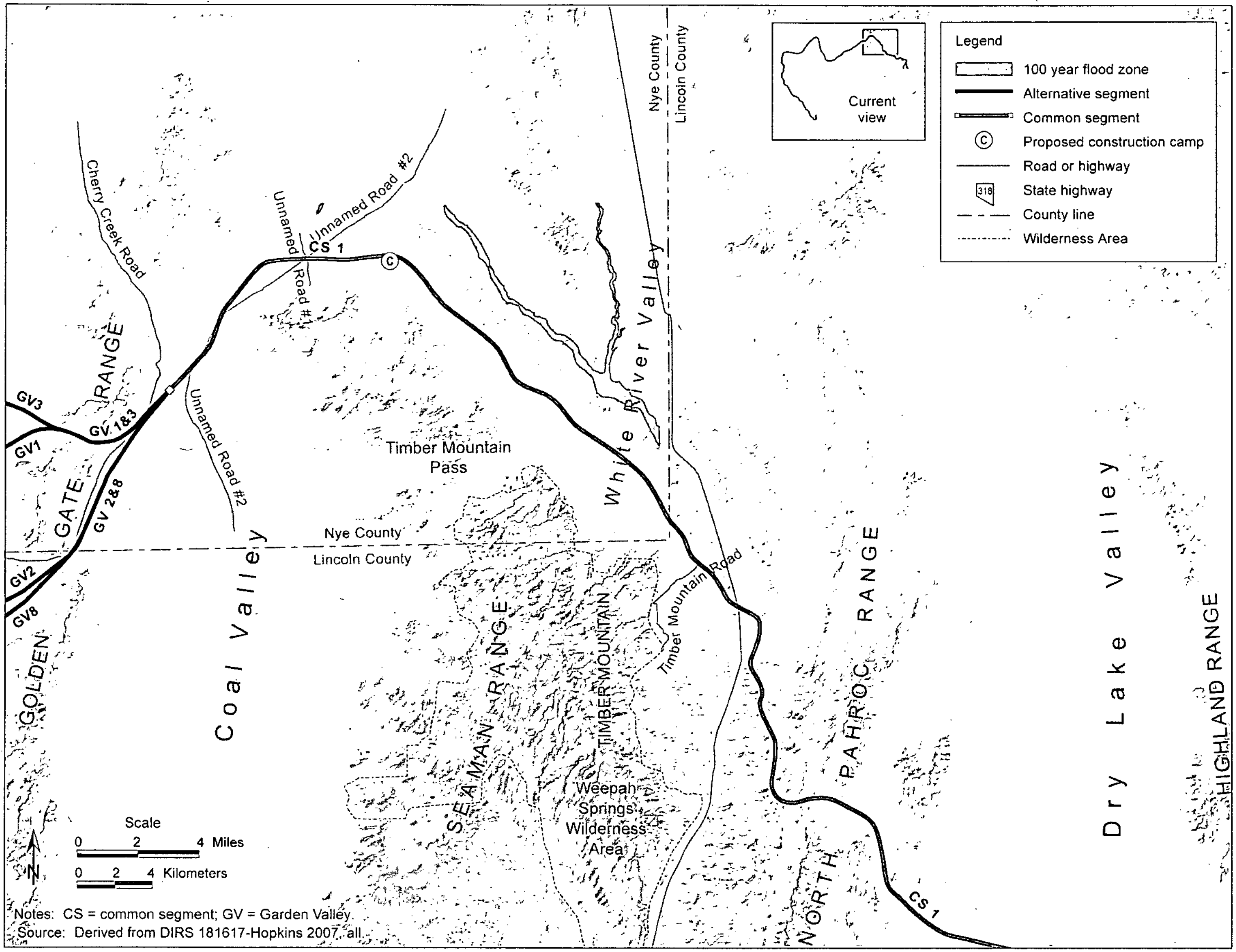


Figure F-8. FEMA floodplain map for map area 2 of the Caliente rail alignment.

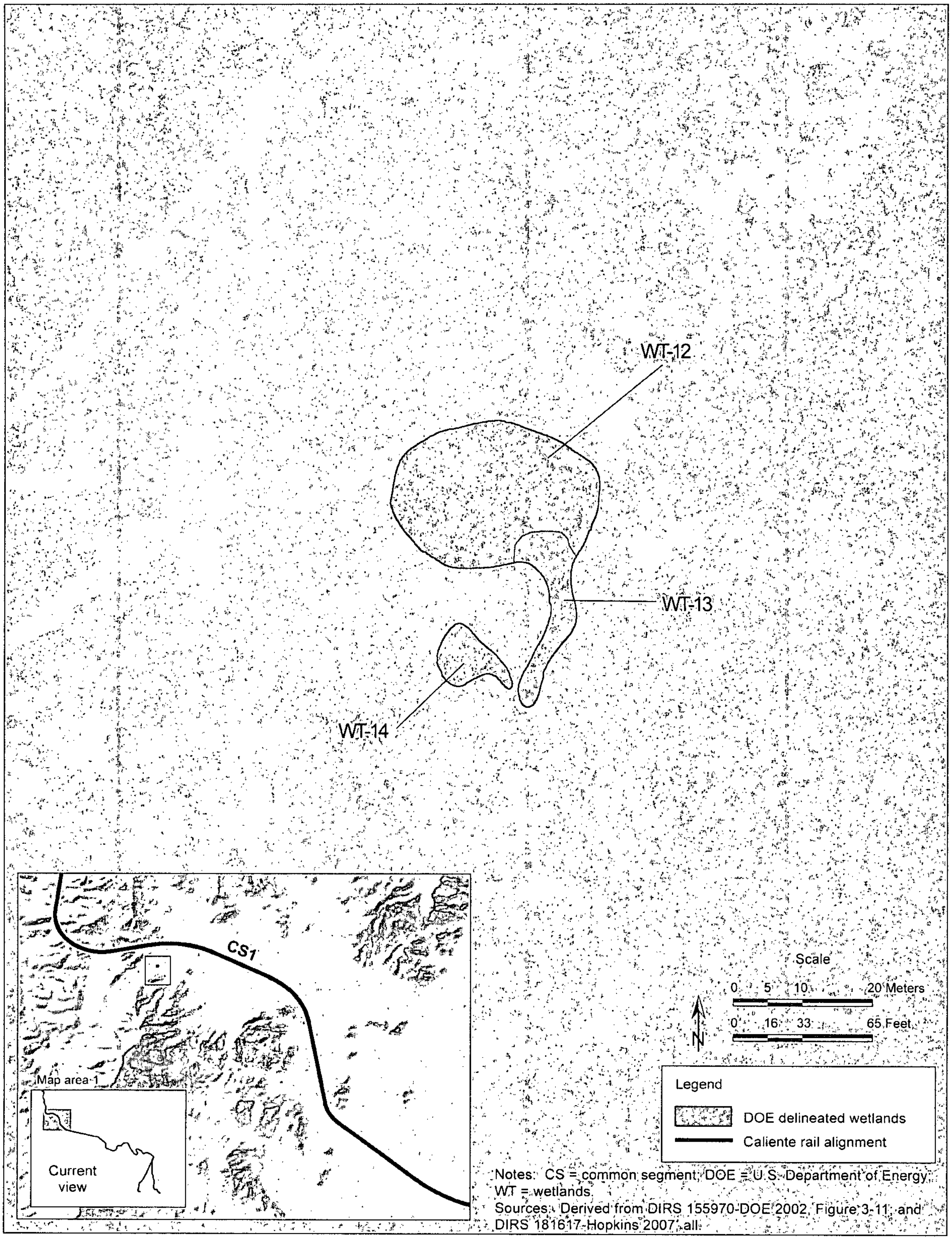


Figure F-9. Isolated wetlands south of Caliente common segment 1.

playa, another area expected to be susceptible to flooding and standing water. Each alternative segment would have a construction camp located about 6 kilometers (3.7 miles) east of the junction with Caliente common segment 2. None of these three locations intersect floodplains. Common impacts to nearby floodplains are addressed in Section F.3.1.

Although the National Wetlands Inventory dataset identifies the Coal Valley playa as a lacustrine littoral unconsolidated shore wetland, DOE field studies in support of the Rail Alignment EIS confirmed that there are no hydric soils, plant species indicative of wetlands, or other indicators of wetlands on or adjacent to the playa near the alignment (DIRS 180696-PHE 2007, p. 3). No wetlands were identified along any of the Garden Valley alternative segments.

F.3.2.4 Caliente Common Segment 2

The only portion of Caliente common segment 2 covered by FEMA flood maps is the west end in Railroad and Reveille Valleys, but common segment 2 would not cross any floodplains in this limited area, as shown in Figure F-10. Two washes in this area have associated floodplains. One of these washes originates in Reveille Valley and runs adjacent to the proposed rail alignment and the other originates in the hills to the south and would be crossed by the rail alignment. Both of these washes terminate in the Railroad Valley playa north of the rail alignment. The floodplain for the adjacent wash does not extend laterally as far as the proposed rail alignment and the floodplain associated with the wash that would be crossed does not extend as far south as the proposed rail alignment. In the eastern portion of common segment 2, where there is no flood map coverage, the proposed rail alignment would cross drainage features, including Davis Creek and Quinn Canyon Wash, both of which have the potential to be associated with floodplains that have not been mapped. Two construction camps would be located along common segment 2; however, neither intersects floodplains. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to Caliente common segment 2.

There are no wetlands identified along Caliente common segment 2 or its associated facilities.

F.3.2.5 South Reveille Alternative Segments

FEMA flood maps encompassing the area of these two short alternative segments are shown in Figure F-10. South Reveille alternative segment 2 would cross a 3.1-kilometer (1.9-mile) stretch of the 100-year floodplain associated with five tributaries draining to the well-defined, unnamed braided wash. Two potential quarry sites are located near the origination of the alternative segments. The proposed sites for the quarry plants that would support quarry NN-9A are located within the same floodplain that South Reveille alternative segment 2 would cross. South Reveille alternative segment 3 lies farther away from the wash and would not cross any 100-year floodplains. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to the South Reveille alternative segments.

There are no wetlands identified along the South Reveille alternative segments or their associated facilities.

F.3.2.6 Caliente Common Segment 3

Most of Caliente common segment 3 would cross land that has FEMA flood map coverage. According to the FEMA maps, the common segment would not cross 100-year floodplains until it nears the vicinity of Mud Lake Playa and its tributaries where the flood boundaries are fairly extensive, as shown in Figures F-10 and F-11. From the east, the rail alignment would first encounter floodplains associated with Stone Cabin Creek and Saulsbury Wash as they converge on Mud Lake Playa. The proposed rail alignment would then cross the floodplain of a wash draining the central Ralston Valley before it would

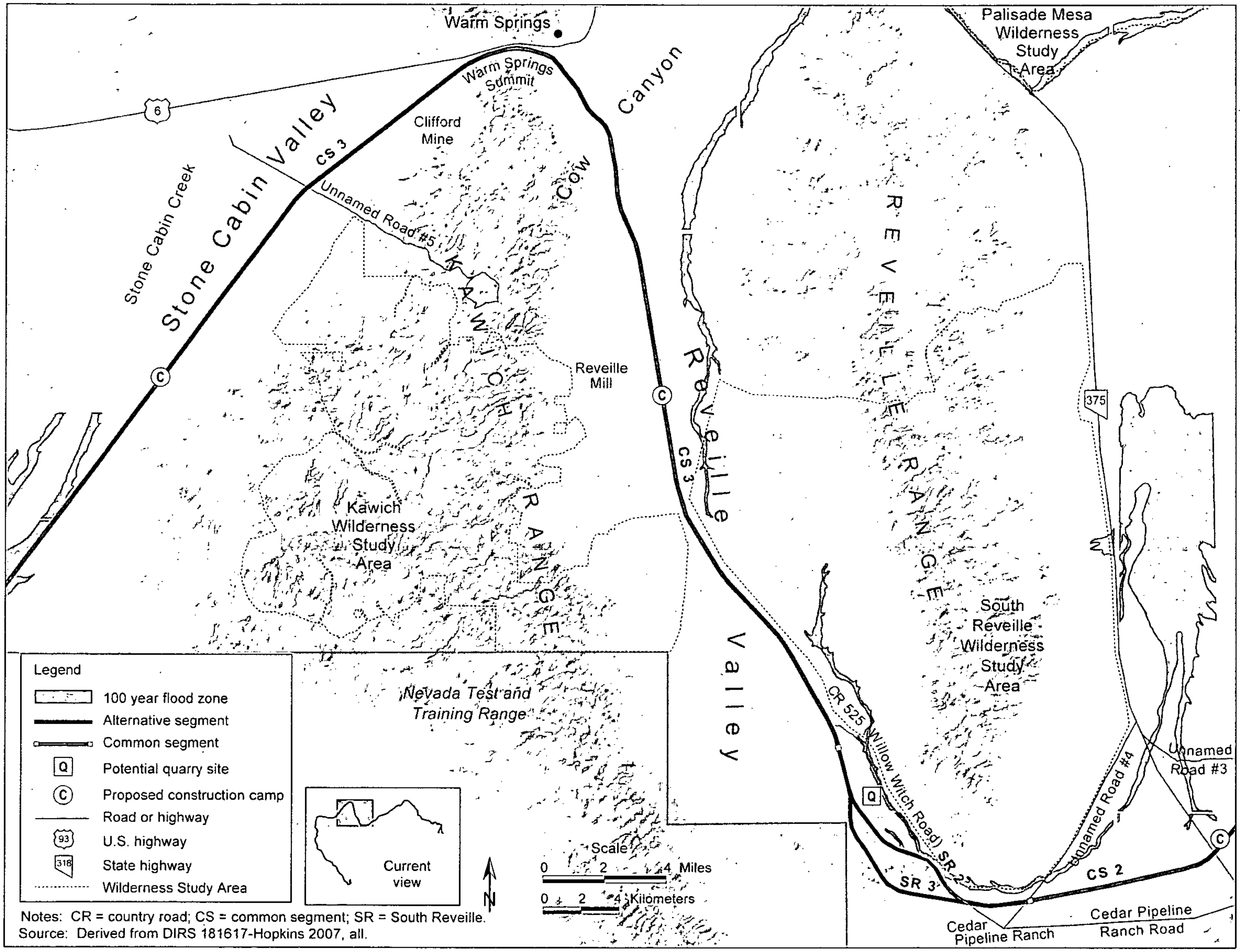


Figure F-10. FEMA floodplain map for map area 4 of the Caliente rail alignment.

cross through two legs of a drainage system draining the western Ralston Valley. The Mud Lake Playa area has by far the most extensive area of 100-year floodplains. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to Caliente common segment 3.

Three construction camps would be located along Caliente common segment 3 (see Figures F-10 and F-11), one of which would be constructed within a floodplain associated with Mud Lake Playa. DOE would construct the Maintenance-of-Way Trackside Facility (see Section 2.2.4.1.2.1) in the southwestern portion of Stone Cabin Valley (see Figure F-11) in floodplains associated with Stone Cabin Creek. Common impacts to floodplains in which these facilities would be constructed are addressed in Section F.3.1.

There are no wetlands identified along Caliente common segment 3 or its associated facilities.

F.3.2.7 Goldfield Alternative Segments

FEMA flood maps cover the northern and southern portions of the Goldfield alternative segments, but not the central area that includes Goldfield, as shown on Figure F-11. According to FEMA flood maps, the alternative segments would cross a small portion of the floodplain associated with Mud Lake Playa, and each segment would cross a small portion of the floodplain associated with the drainage channel leading to Stonewall Flat Playa. There are three proposed quarry sites along the Goldfield alternative segments, two along Goldfield alternative segment 3, and one that would be accessible from Goldfield alternative segment 4; however, none of them intersect floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by or adjacent to the Goldfield alternative segments..

There are no wetlands identified along the Goldfield alternative segments.

F.3.2.8 Caliente Common Segment 4

The FEMA flood maps provide coverage for almost all of Caliente common segment 4. The proposed rail alignment segment would skirt within 0.5 kilometer (0.31 mile) of Stonewall Flat Playa to the east and Alkali Flat Playa to the southwest and cross over the drainage path that connects the two areas. As shown in Figure F-11, the rail alignment would cross a 1.3-kilometer (0.81-mile) portion of the 100-year floodplain associated with the drainage between Stonewall Flat Playa and Alkali Flat Playa in Lida Valley. One construction camp would be located along common segment 4; however, it would not intersect any floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to Caliente common segment 4.

Although the segment would not cross any mapped wetlands, Stonewall Flat Playa is classified by the National Wetlands Inventory dataset as a lacustrine littoral unconsolidated shore (L2US) wetland system. DOE field studies in support of the Rail Alignment EIS confirmed that there are no hydric soils, plant species indicative of wetlands, or other indicators of wetlands on or adjacent to the playa near the alignment (DIRS 180696-PHE 2007, p. 6).

There are no wetlands within the region of influence for Caliente common segment 4.

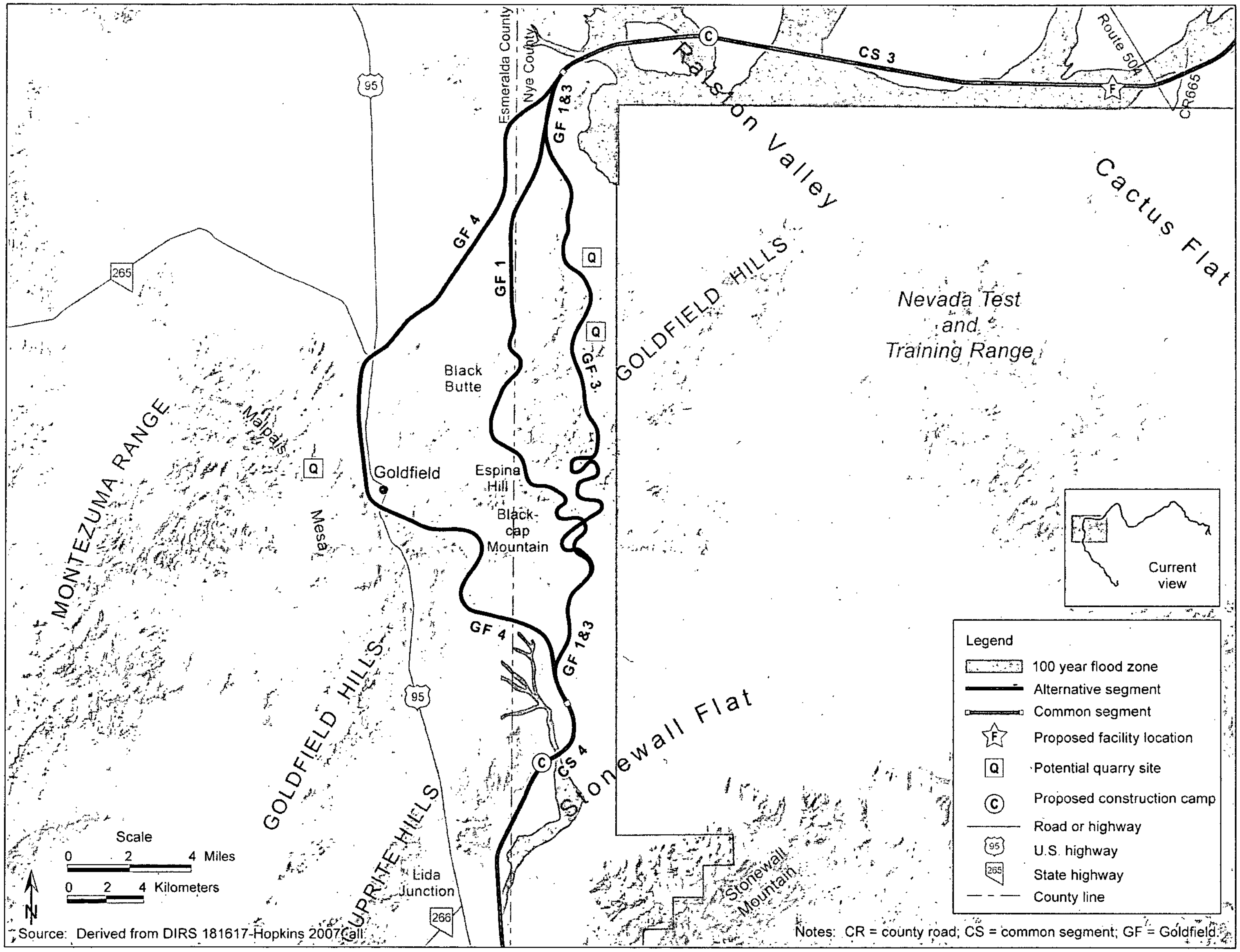


Figure F-11. FEMA floodplain map for map area 5 of the Caliente rail alignment.

F.3.2.9 Bonnie Claire Alternative Segments

FEMA flood maps cover most of the Bonnie Claire alternative segments, but do not include land east of the segments, which are shown on maps as an old boundary of the Nevada Test and Training Range. Consequently, there is no floodplain mapping east of this boundary. Bonnie Claire alternative segment 3, the western alternative segment, has more extensive flood map coverage than Bonnie Claire alternative segment 2. As shown in Figure F-12, the northwest end of Bonnie Claire alternative segment 3 would cross a 100-year floodplain associated with the Alkali Flat playa. The flood maps also show a floodplain for an unnamed drainage channel from Pahute Mesa. This floodplain ends just south of Bonnie Claire alternative segment 3 at one of the old Test and Training Range boundaries.

The floodplain is sufficiently close to Bonnie Claire alternative segment 3 to assume it could have a similar width if floodplain mapping were extended upslope to where it would be crossed by Bonnie Claire alternative segment 3. It is possible this floodplain would extend far enough northeast to be encountered by Bonnie Claire alternative segment 2; however, the distance is too far to support such an assumption. In addition, Bonnie Claire alternative segment 2 would occur at higher elevations in the foothills where the wash would encounter fewer tributaries. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to the Bonnie Claire alternative segments.

There are no wetlands identified along the Bonnie Claire alternative segments.

F.3.2.10 Common Segment 5

FEMA flood maps provide coverage for almost all of common segment 5 (see Figures F-12 and F-13) and indicate the proposed rail alignment would cross a 100-year floodplain associated with Tolicha Wash as it drains toward Sarcobatus Flat. FEMA has also identified a 100-year floodplain approximately 2 kilometers (1.2 miles) southwest of the alignment. This small floodplain is associated with two minor playas in Sarcobatus Flat. One construction camp would be located along common segment 5; however, it would not intersect floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to common segment 5.

There are no wetlands identified along common segment 5.

F.3.2.11 Oasis Valley Alternative Segments

FEMA flood maps provide complete coverage for the Oasis Valley alternative segments, as shown in Figure F-13. The maps show both alternative segments would cross the Amargosa River 100-year floodplain. The linear distance required to cross the Amargosa River in Oasis Valley would be less for Oasis Valley alternative segment 3 because there are fewer braided channels upstream than there are downstream. One construction camp would be located along the alternative segments; however, it would not intersect floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to the Oasis Valley alternative segments.

DOE field surveys identified a small isolated wetland, WT-15, (74 square meters [0.018 acre]) just outside the construction right-of-way, approximately 160 meters (530 feet) north of Oasis Valley alternative segment 1 (see Figure F-14). This wetland does not have a connection to interstate commerce, and would be regarded as isolated, and thus considered nonjurisdictional. The wetland occurs within a slight topographic depression (DIRS 180914-PBS&J 2006, Table 6 and Figure 4T). This wetland can be characterized as a shrub-shrub/emergent wetland complex with a moderately complex wildlife habitat structure (DIRS 180914-PBS&J 2006, Photos 52 and 53). There would be no direct impacts to this wetland during rail line construction because it is outside the construction right-of-way and it would be

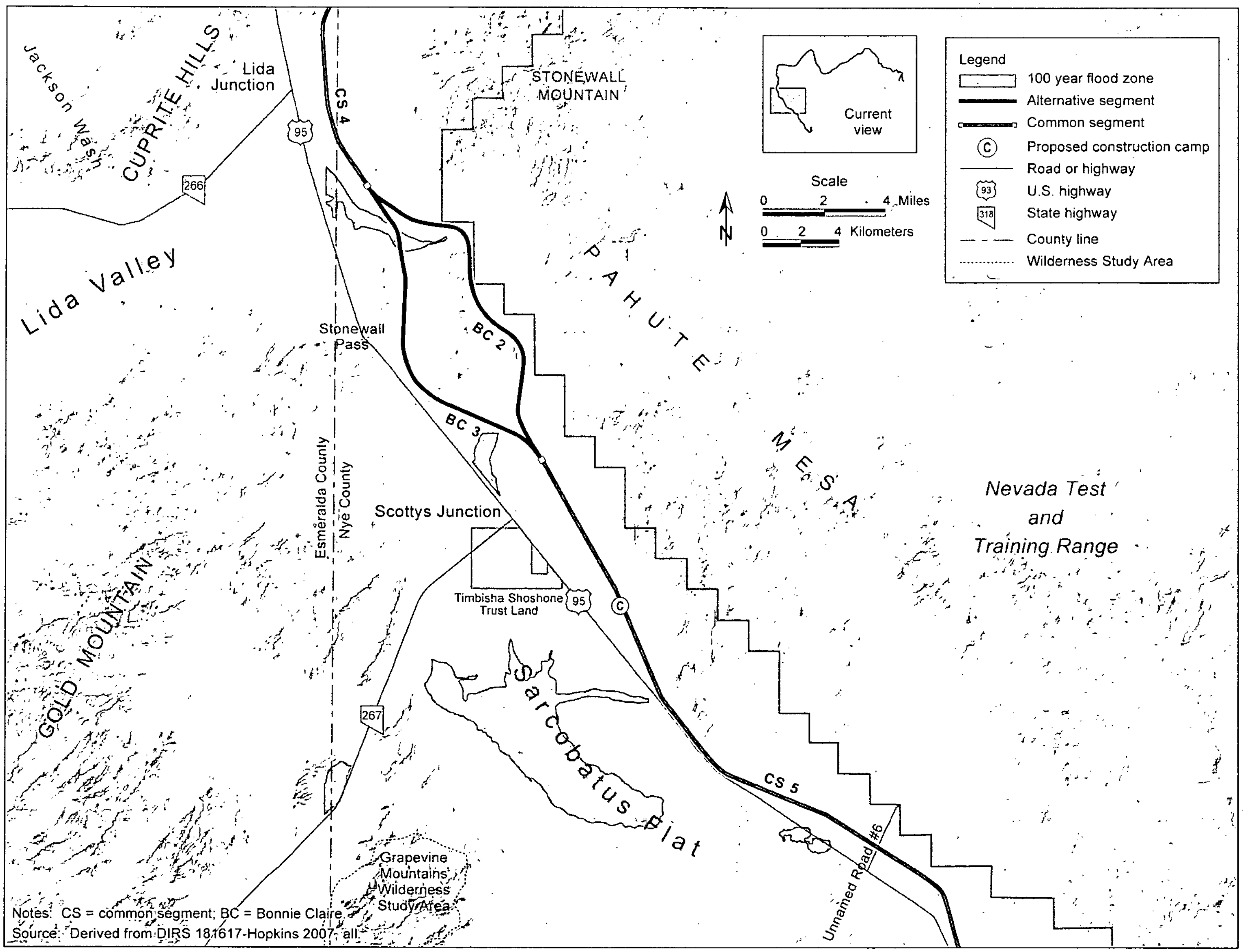


Figure F-12. FEMA floodplain map for map area 6 of the Caliente rail alignment.

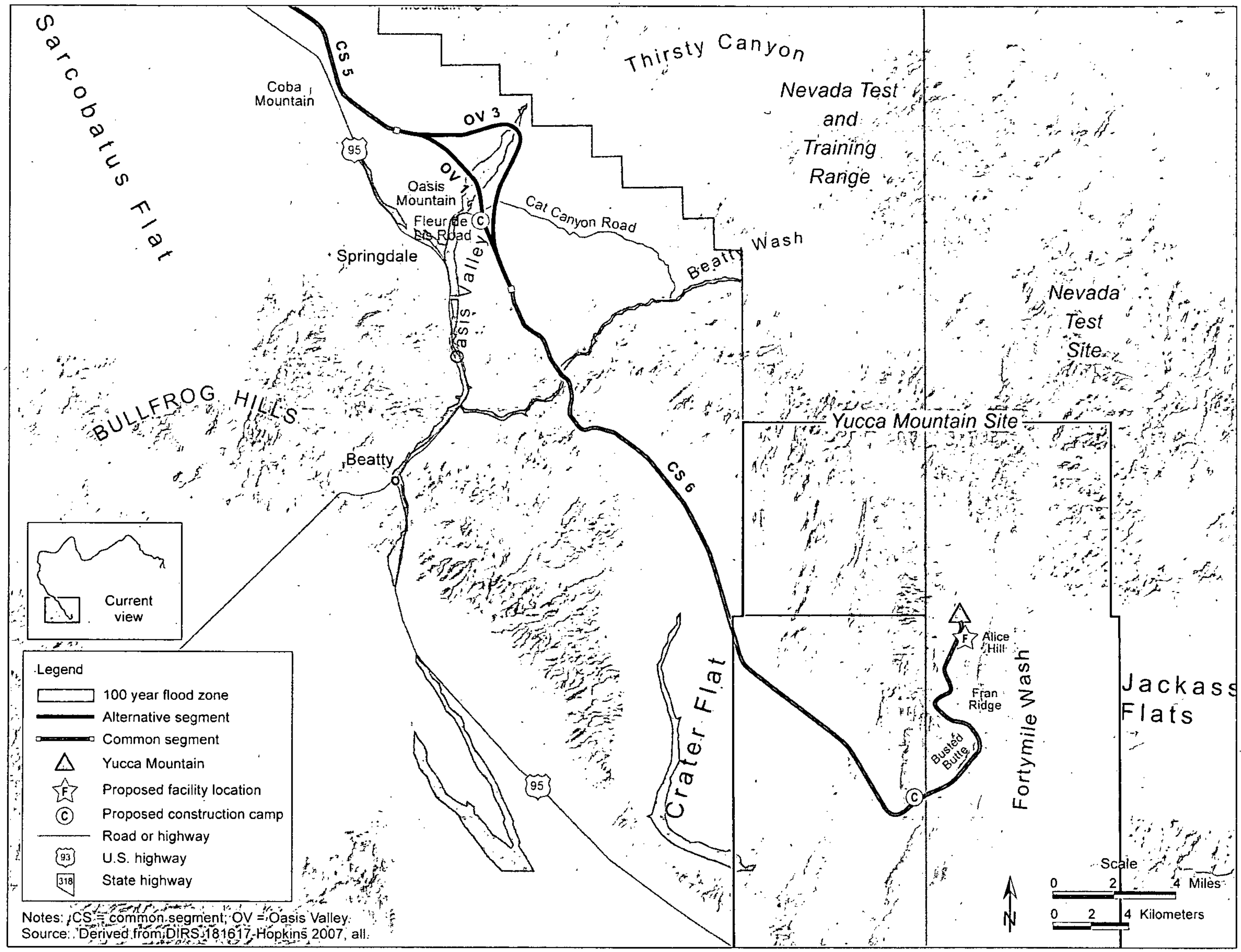


Figure F-13. FEMA floodplain map for map area 7 of the Caliente rail alignment.

Figure F-14. Isolated wetland near Oasis Valley alternative segment 3.

fenced or flagged. Indirect impacts such as sedimentation, erosion, and incidental spills would still be possible and are addressed in Section F.3.1.

F.3.2.12 Common Segment 6

Slightly more than half of common segment 6 has coverage on FEMA flood maps. The coverage terminates at about the point where the proposed rail alignment reaches the repository land withdrawal area (see Figure F-13). Although the flood maps do not provide coverage for the area of the repository on the eastern side of Yucca Mountain, DOE has performed flood studies on several washes in that area, as addressed in the Yucca Mountain FEIS. An overlay of the proposed rail alignment with the Yucca Mountain FEIS (see Figure-15) indicates that common segment 6 would cross short stretches of 100-year floodplains associated with Busted Butte Wash (also known as Dune Wash) and Drill Hole Wash (DIRS 155970-DOE 2002, pp. 3-38 and 3-39, and Figure 3-11). As shown in Table F-1, common segment 6 would cross a 0.10-kilometer (0.062-mile) section of the Beatty Wash floodplain. The FEMA flood maps also show a floodplain associated with an unnamed wash in Crater Flat; however, the floodplain does not extend upstream to the point where it would be crossed by the proposed rail alignment.

Table F-4 lists peak discharges for estimated floods along the main washes at Yucca Mountain, including a value for the estimated regional maximum flood. In addition to the flood estimates listed in the table, DOE used another estimating method, the probable maximum flood methodology (based on American National Standards Institute and American Nuclear Society Standards for Nuclear Facilities) to generate another maximum flood value for washes adjacent to the existing facilities and operations at the repository north and south portals. The flood value this method generates, which includes a bulking factor to account for mud and debris (including boulder-size materials), is the most severe reasonably possible for the location under evaluation and is larger than the regional maximum flood. DOE used the probable maximum flood values to predict the areal extent of flooding in the area of the repository and to determine if facilities and operations at the repository could be at risk for flood damage.

Table F-4. Estimated peak discharge along washes at the Yucca Mountain Repository.[a]

Name	Drainage area, square kilometers (square miles)	Peak discharge 100-yr flood, cubic meters per second (cubic feet per second)	Peak discharge 500-yr flood, cubic meters per second (cubic feet per second)	Regional maximum flood, cubic meters per second (cubic feet per second)
Fortymile Wash	810 (310)	340 (12,000)	1,600 (56,800)	15,000 (530,000)
Busted Butte Wash	17 (6.6)	40 (1,400)	180 (6,400)	1,200 (42,000)
Drill Hole Wash	40 (15)	65 (2300)	280 (9,900)	2,400 (85,000)
Yucca Wash	43 (17)	68 (2,400)	310 (11,000)	2,600 (92,000)

a. Source: DIRS 155970-DOE 2002, Table 3-9.

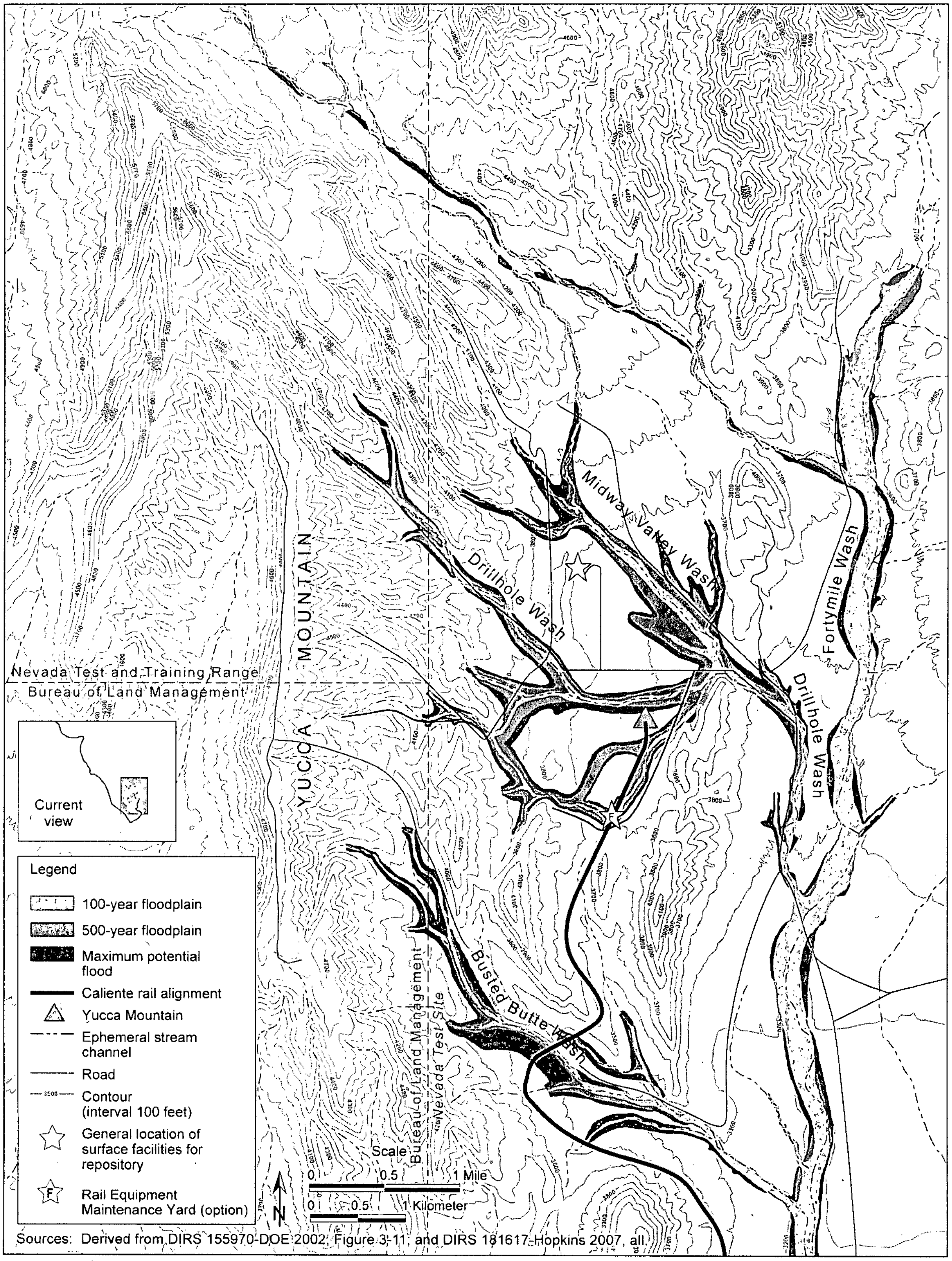


Figure F-15. DOE floodplain map for repository area.

During 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. During the 1995 event, the peak flow near the location where the existing Yucca Mountain access road crosses Fortymile Wash was reported as approximately 85 cubic meters per second (3,000 cubic feet per second) (DIRS 182755-Parsons Brinckerhoff 2007, p. 13). The 1995 event was brought about by relatively short-term precipitation events at higher altitudes near Yucca Mountain; the 1998 flood was characterized by sustained regional precipitation over several days (DIRS 159895-Tanko and Glancy 2001, p. 3). One construction camp would be located along common segment 6; however, it would not intersect floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to common segment 6.

No wetlands were identified along common segment 6.

F.3.3 SEGMENT-SPECIFIC IMPACTS FOR THE MINA RAIL ALIGNMENT

F.3.3.1 Interface with the Union Pacific Railroad Hazen Branchline (Hazen to Wabuska)

DOE would not perform any construction activities along this portion of the Mina rail alignment. Therefore, there would be no impacts to floodplains or wetlands along the existing Union Pacific Railroad Hazen Branchline.

F.3.3.2 Department of Defense Branchline North (Wabuska to the boundary of the Walker River Paiute Reservation)

DOE would not perform any construction activities along this portion of the Mina rail alignment. Therefore, there would be no impacts to floodplains or wetlands along the existing Department of Defense Branchline North (see Figure F-16).

F.3.3.3 Department of Defense Branchline through Schurz

DOE would not perform any new construction activities along this portion of the Mina rail alignment. Therefore, there would be no impacts to floodplains or wetlands along the existing Department of Defense Branchline through Schurz (see Figure F-16).

F.3.3.4 Schurz Alternative Segments

As shown in Figure F-2, FEMA flood maps do not cover any of the Schurz alternative segments. However, it is reasonable to assume that the floodplain mapped for the very southern portion of Walker Lake extends upstream to where the Schurz alternative segments would cross over the Walker River. Because the alternative segments would follow valley floors, utilize mountain gaps, and cross unnamed ephemeral playas, it is feasible that floodplains could exist in low-lying areas along the alternative segments. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to the Schurz alternative segments.

A survey for wetlands along the Mina rail alignment conducted by DOE in support of the Rail Alignment EIS identified emergent wetlands (WRN-1, WRN-2, WRN-3, and WRN-4) that would be crossed by the Schurz alternative segments (see Figure F-17). The total surface area for these wetlands is 0.065 square kilometer (16 acres). Emergent and scrub-shrub wetlands continue north and south beyond the region of influence.

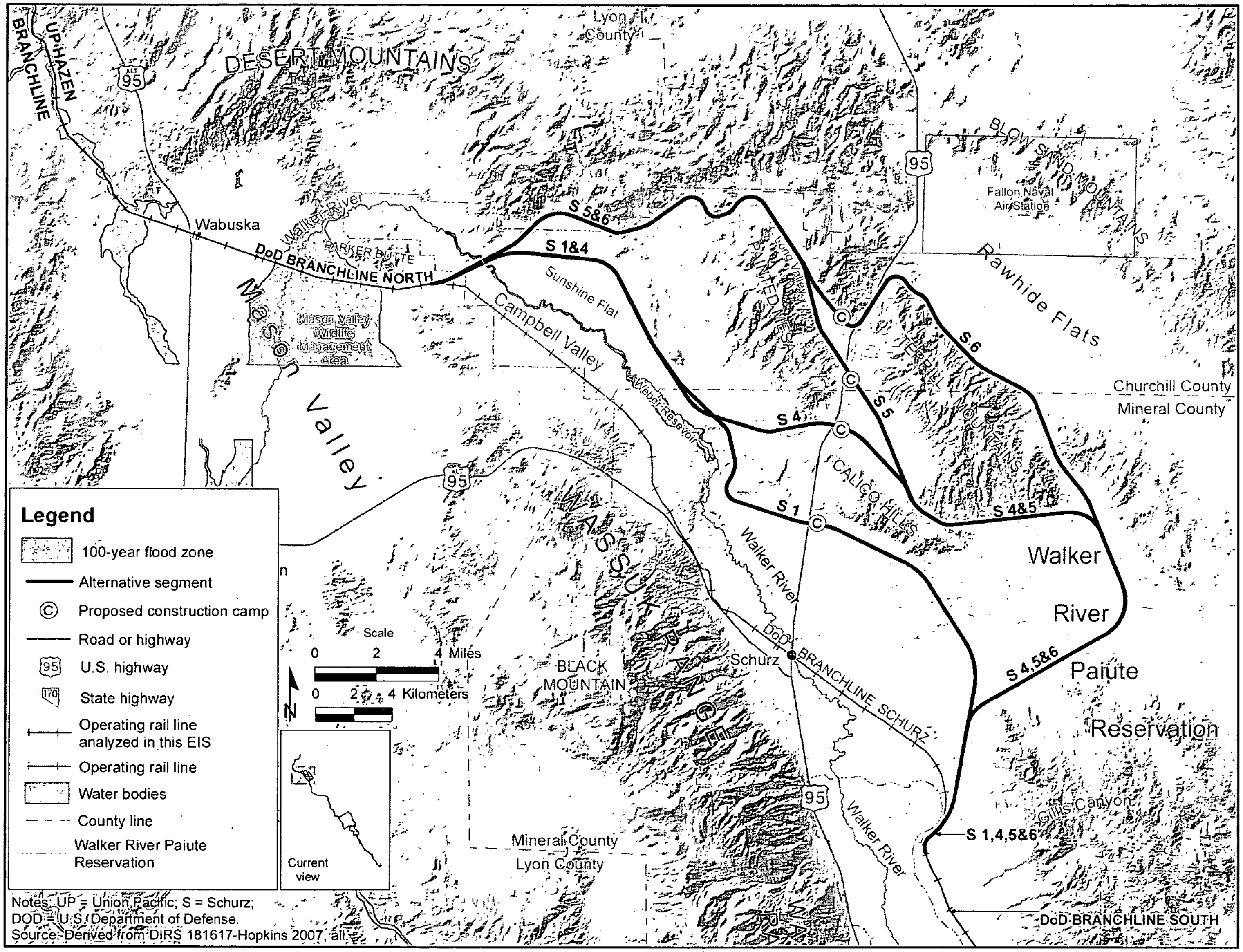


Figure F-16. FEMA floodplain map for map area 1 of the Mina rail alignment.

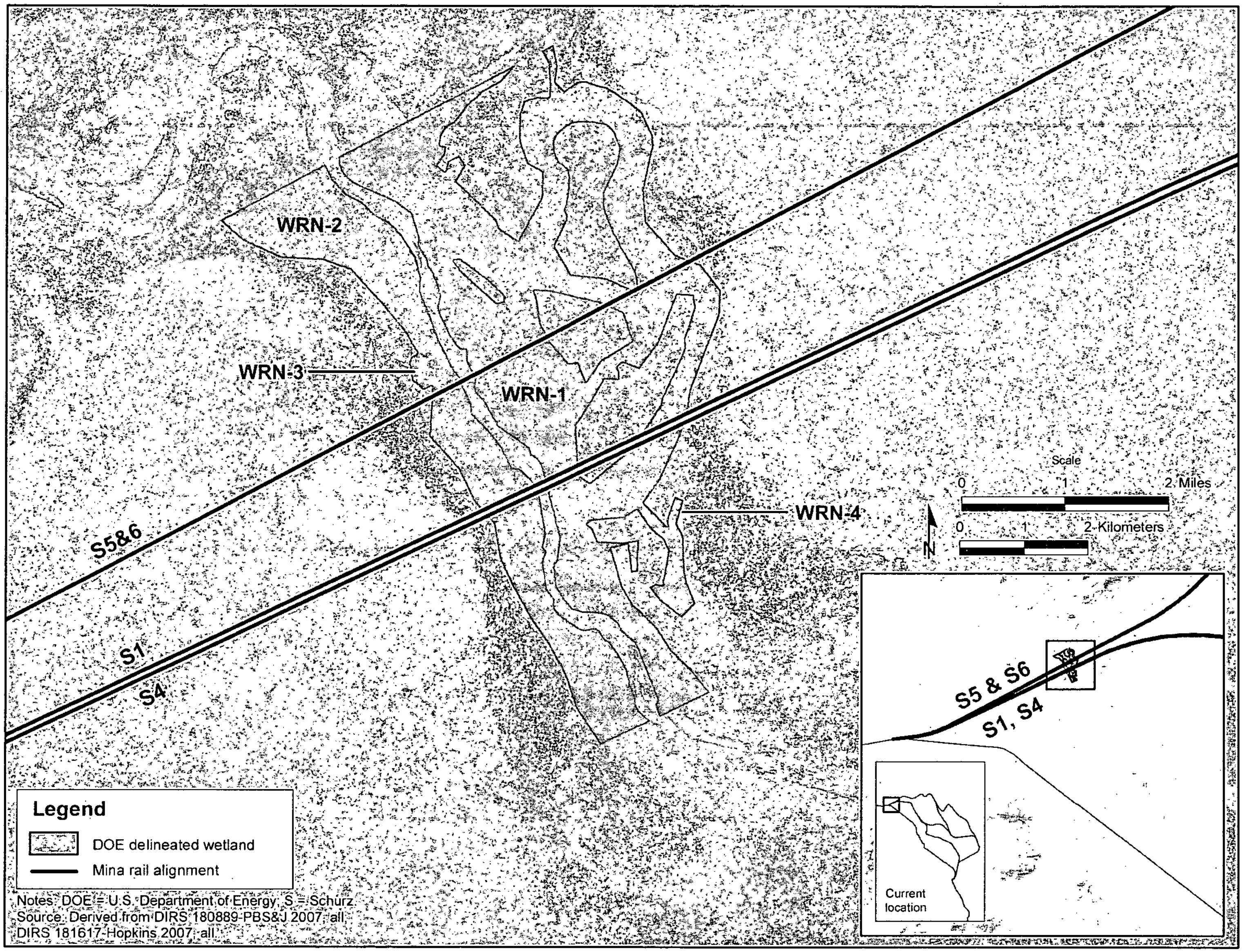


Figure F-17. Wetlands along Walker River (shows WRN-1 through WRN-4).

Placement of piers and construction of the bridge in the active stream would occur during low flow (generally September through April). To provide access for cranes and other heavy equipment to the stream channel, which is about 12 meters (40 feet) wide in this area, heavy mats made of wood or other solid material would be sunk into the stream. There would be sufficient gaps between the mats to allow flow of water. No sand, gravel, or other loose fill will be placed in the stream channel. The mats would be removed from the channel after the bridge pilings are driven into ground and the concrete bridge sections are erected over the channel.

The double-cell bridge would be about 300 meters (1,000 feet) long with 12-meter (40-foot) pier spacing. The only permanent fill will be the concrete pilings required to support the bridge piers. Using these methods, the only permanent fill or loss of wetlands would be a total of about 20 square meters (0.005 acre) for emplacement of about 10 piers in wetlands for Schurz alternative segments 1 and 4, or 28 square meters (0.007 acre) for emplacement of about 14 piers for Schurz alternative segments 5 and 6.

Construction of the Schurz alternative segments would result in the permanent loss of wetland habitat. Wildlife migration corridors would be fragmented, and result in a localized loss of shelter and concealment for some wildlife species. Shading provided by the riparian vegetation would be lost in the areas of disturbance, which would result in localized increased surface-water temperatures. The removal of vegetation could also result in the permanent loss of fisheries habitat, sediment stabilization and retention, and flood flow attenuation functions.

Removal of the persistent wetland vegetation in temporarily impacted areas would result in short-term exposure to wind erosion and enhanced desiccation by the summer sun heat, loss of shade to the Walker River shoreline, and loss of fish and wildlife habitat. Freshly disturbed areas would provide an opportunity for non-native invasive species, such as salt cedar, to colonize new areas and further decrease the quality of the wetland habitat.

Undisturbed wetlands would continue to perform water-quality functions by filtering potential unconsolidated sediments. The flood flow attenuation capacity would be slightly reduced, and could result in some minor localized flooding and erosion during seasonal precipitation events. The remaining undisturbed wetlands would continue to provide commonly recognized functions. For example, Baltic rush and salt grass would filter water-borne sediments from draining into Walker River from the surrounding terrestrial environment and would provide nesting habitat for water-dependant wildlife species. The remaining woody vegetation would continue to provide flood flow attenuation functions and provide wildlife habitat.

DOE would minimize impacts by constructing a bridge over the Walker River and its associated wetlands. Of the 0.065 square kilometer (16 acres) crossed in this area, only 28 square meters (300 square feet) would be permanently filled to facilitate the construction of the bridge. By maximizing avoidance in this way, DOE would minimize permanent impacts to the maximum extent practicable. DOE would also implement best management practices such as constructing sediment ponds and installing hay bales or silt fences, which would minimize potential impacts during construction. Wildlife utilizing wetlands in the proposed disturbance areas would be temporarily displaced, but would continue to use the undisturbed adjacent areas; therefore, impacts to the wetlands in this area from the construction of the rail alignment are expected to be small.

F.3.3.5 Department of Defense Branchline South (Hawthorne to Mina Common Segment 1)

Although Department of Defense Branchline South represents an existing railway, DOE would develop construction camp 17 on the southern portion of this rail alignment. The construction camp would not overlie any floodplains or wetlands. Aside from construction of this camp, DOE does not anticipate any other surface disturbances along this portion of the Mina rail alignment (see Figure F-18).

F.3.3.6 Mina Common Segment 1 (Gillis Canyon to Blair Junction)

FEMA flood maps do not cover any part of Mina common segment 1. Because the proposed segment would follow valley floors, cross unnamed ephemeral washes and playas, or utilize mountain gaps, it is feasible that a floodplain could exist in low-lying areas along the common segment, especially in low-lying areas receiving seasonal water from ephemeral washes. The Staging Yard at Hawthorne, four construction camps, and two potential quarry sites would be located along common segment 1; however, none of these facilities intersect with floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to Mina common segment 1.

Although the National Wetlands Inventory dataset indicates Mina common segment 1 would cross through wetlands within Soda Springs Valley, field investigations conducted by DOE in support of this EIS determined that surface water shown by the NWI dataset are absent from the region of influence (DIRS 180889-PBS&J 2007, Figures 5A and 5B, Photos 16 to 22). These areas are mostly unvegetated, barren landscapes that are more representative of ephemeral playas. A review of existing data indicates that areas shown as NWI wetlands actually correspond to unnamed ephemeral playas as identified by the National Hydrologic Dataset. No wetlands were identified along Mina common segment 1.

F.3.3.7 Montezuma Alternative Segments

FEMA flood maps only cover a small portion of the Montezuma alternative segments, near their southern termination. Because the proposed alternative segments would follow valley floors, cross unnamed ephemeral washes and playas, or utilize mountain gaps, it is feasible that a floodplain could exist in low-lying areas along the alternative segments, especially in low-lying areas receiving seasonal water from ephemeral washes. As shown in Figure F-19, Montezuma alternative segment 2 would cross approximately 2 kilometers (1.2 miles) of floodplains associated with a drainage in Lida Valley and the Stonewall Flat playa. Two alternative locations for the Maintenance-of-Way Facility (Klondike option and Silver Peak option) would also be located along the alternative segments, as well as four proposed construction camp sites and three quarry sites. None of these facilities would intersect floodplains or wetlands. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to the Montezuma alternative segments.

For Montezuma alternative segment 1, the National Wetland Inventory dataset identifies an unnamed pond in the private area near the Town of Silver Peak as wetlands; however, DOE field studies in support of the Rail Alignment EIS determined there are no wetlands in this area. For Montezuma alternative segments 2 and 3, the National Wetland Inventory dataset classifies the large playas in Big Smoky Valley and Stonewall Flat as wetlands; however, DOE field studies in support of this EIS confirmed no wetlands exist within the region of influence (DIRS 180889-PBS&J 2007, Figure 5C, Photos 23 and 24). No wetlands were identified along the Montezuma alternative segments.

F.3.3.8 Mina Common Segment 2

As shown in Figure F-19, FEMA flood maps provide coverage for the entire length of Mina common segment 2; however, no floodplains are crossed by the segment. Because the proposed segment would follow valley floors, cross unnamed ephemeral washes and playas, or utilize mountain gaps, it is feasible that a floodplain could exist in low-lying areas along common segment 2, especially in low-lying areas receiving seasonal water from ephemeral washes. Section F.3.1 addresses common impacts to floodplains that would be crossed by and adjacent to Mina common segment 2.

No wetlands were identified along Mina common segment 2.

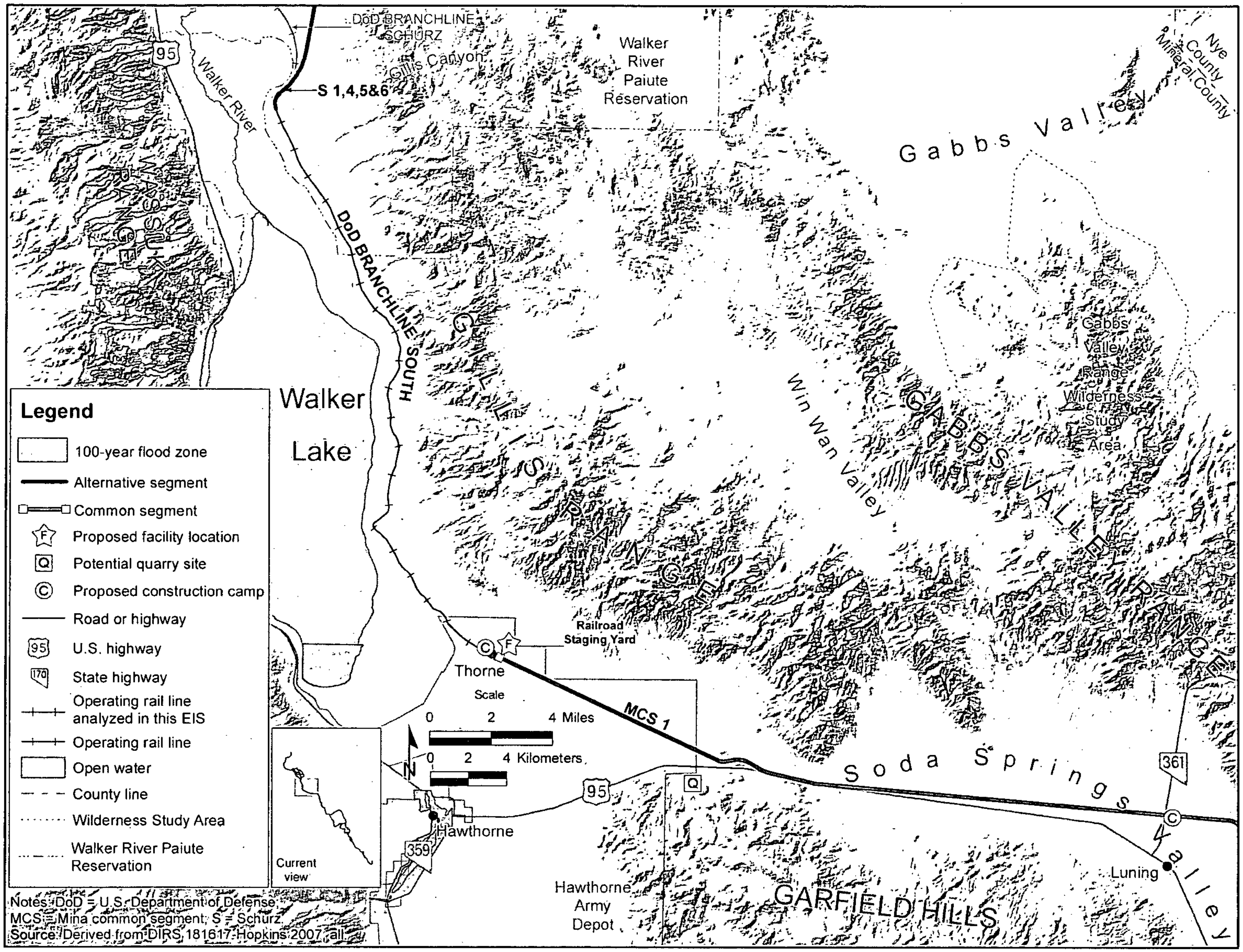


Figure F-18. FEMA floodplain map for map area 2 of the Mina rail alignment.

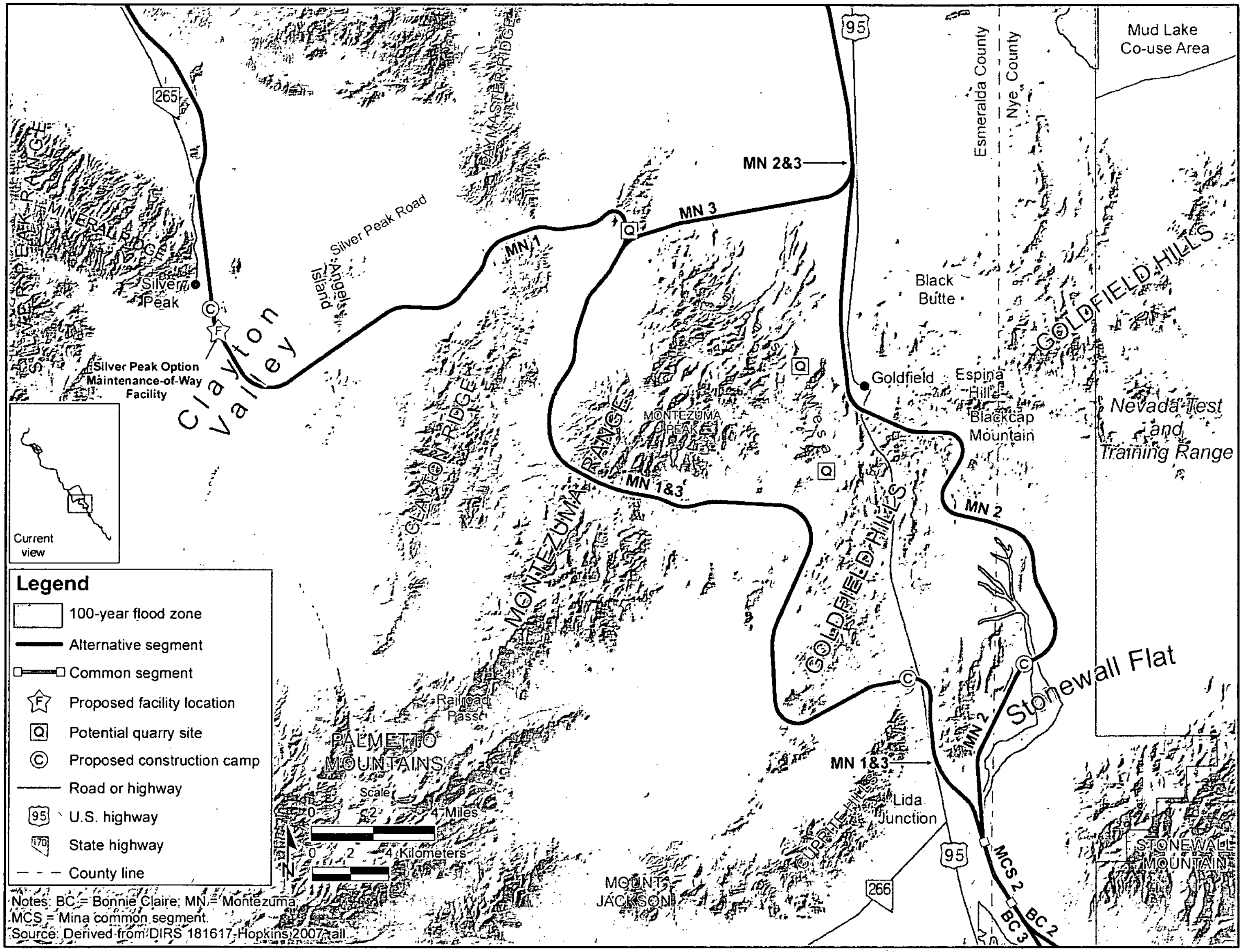


Figure F-19. FEMA floodplain map for map area 5 of the Mina rail alignment.

F.3.3.9 Bonnie Claire Alternative Segments

Refer to Section F.3.2.9.

F.3.3.10 Common Segment 5 (Sarcobatus Flat Area)

Refer to Section F.3.2.10.

F.3.3.11 Oasis Valley Alternative Segments

Refer to Section F.3.2.11.

F.3.3.12 Common Segment 6 (Yucca Mountain Approach)

Refer to Section F.3.2.12.

F.4 Alternatives

In accordance with 10 CFR 1022.13(a)(3), DOE must consider alternatives to the Proposed Action that would avoid adverse impacts and incompatible development in the floodplain or wetland, including alternative sites, alternative actions, and no action. Further, DOE must evaluate measures that mitigate the adverse impacts of actions in a floodplain or wetland including, but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas.

As shown in Figure F-20, the Proposed Action includes two implementing alternatives, each with a ***Shared-Use Option***.

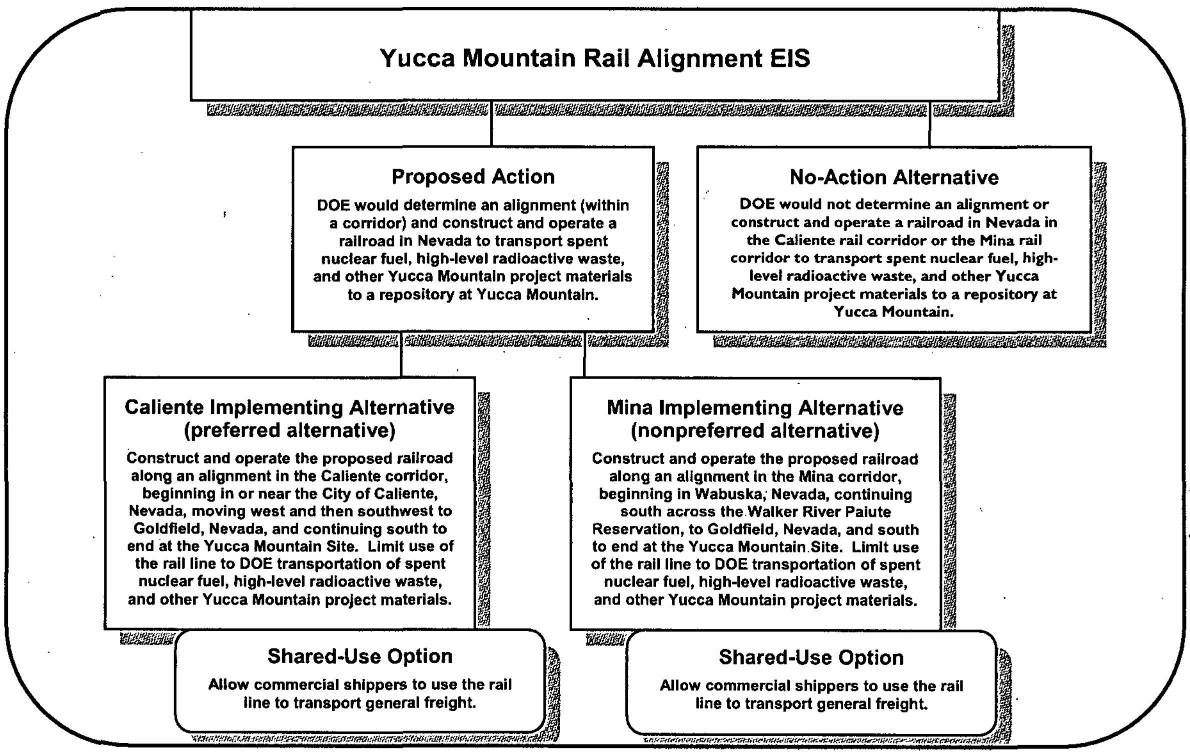


Figure F-20. Alternatives analyzed in the Rail Alignment EIS.

Under the Proposed Action Caliente Implementing Alternative, DOE would determine a rail alignment within the Caliente rail corridor and would construct and operate a railroad for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials within Nevada. The proposed railroad would run from a site in or near the City of Caliente, Lincoln County, Nevada, to a geologic repository at Yucca Mountain, Nye County, Nevada. The Caliente Implementing Alternative is the DOE preferred alternative.

Under the Proposed Action Mina Implementing Alternative, DOE would determine a rail alignment within the Mina rail corridor and would construct and operate a railroad for the shipment of spent nuclear fuel, high-level radioactive waste, and other materials within Nevada. The proposed railroad would run from Wabuska, Lyon County, Nevada, to a geologic repository at Yucca Mountain, Nye County, Nevada. The Mina Implementing Alternative is the DOE nonpreferred alternative.

Along each of the rail alignments, DOE considered a range of alternative segments and a series of common segments, and eliminated some of the alternative segments from detailed analysis. Appendix C, Evolution of Common Segments and Alternative Segments, describes the elimination process.

Under either Proposed Action implementing alternative, the Shared-Use Option would allow commercial shippers to use the rail line. Under the Shared-Use Option, other organizations could construct commercial sidings and additional facilities that would allow commercial commodities (such as nonmetallic minerals or stone) to be transported on the rail line.

Under the ***No-Action Alternative***, DOE would not determine a rail alignment or construct and operate the proposed railroad within the Caliente rail corridor or the Mina rail corridor. As such, the No-Action Alternative provides a basis for comparison with the Proposed Action.

Section F.4.1 summarizes the process DOE used to define and select the two implementing alternatives. It also addresses the more recent selection of the preferred alignment.

F.4.1 PROPOSED ACTION

F.4.1.1 Alternative Evaluations under the Proposed Action

Appendix C describes the process DOE used to evaluate and determine the range of alternative segments for the Caliente and Mina rail alignments considered in the Rail Alignment EIS, and the results of that process.

F.4.1.2 Preferred Alignment

The Council on Environmental Quality NEPA implementing regulations require an agency to identify its preferred alternative, if one or more exists, in the Draft EIS (40 CFR 1502.14[e]). For the Rail Alignment EIS, the DOE preferred alternative is to construct and operate a railroad along the Caliente rail alignment and to implement the Shared-Use Option. DOE identified preferred alternative segments (Figure F-21) within the Caliente rail alignment based on analysis of environmental impacts, engineering and cost factors, and regulatory compliance issues, including permit requirements and challenges, stakeholder preference, land-use conflicts, and uncertainties (see Table 2-30 of the Rail Alignment EIS).

Appendix C provides a more detailed description of the evaluation process DOE used to screen the various alternative segments and select the proposed rail alignments (still with some alternative segments).

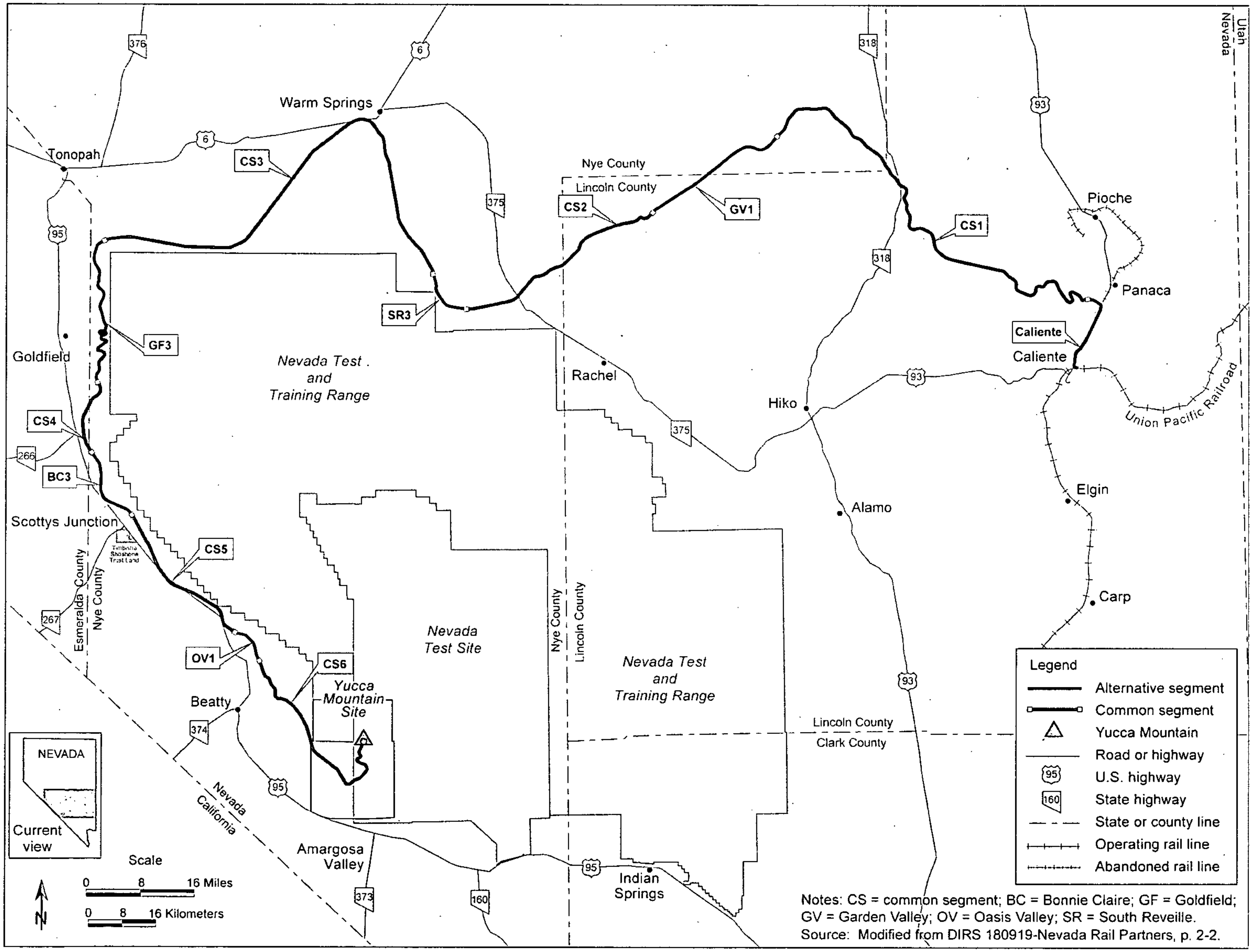


Figure F-21. Preferred Caliente rail alignment, combination of common segments and alternative segments.

F.4.2 SHARED-USE OPTION

The Shared-Use Option would involve the use of the DOE rail line for general freight such as mineral resources or oil that could be shipped by private companies. Construction-related impacts to floodplains and wetlands would be similar to those identified for the Proposed Action without shared use.

F.4.3 NO-ACTION ALTERNATIVE

Council on Environmental Quality regulations (40 CFR 1502.14) require that the alternatives analysis in an EIS include the alternative of no action. Under the No-Action Alternative in the Rail Alignment EIS, DOE would not select a rail alignment within the Caliente or Mina rail corridors for the construction and operation of a railroad. As such, the No-Action Alternative provides a basis for comparison with the Proposed Action.

In the event that DOE were not to select a rail alignment in the Caliente or Mina rail corridors, the future course that it would pursue to meet its obligations under the NWPA is uncertain. DOE recognizes that other possibilities could be pursued, including identifying and evaluating alignments in other corridors considered in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Chapter 6).

DOE would relinquish the public lands withdrawn from surface and mineral entry for purposes of evaluating the lands for the potential construction, operation, and maintenance of a railroad (70 *FR* 76854, December 28, 2005). These lands would then become available for other uses as determined by the BLM once it amended or revoked the withdrawal.

F.4.4 MITIGATION MEASURES

In accordance with 10 CFR 1022.12(a)(3), DOE must address measures to mitigate the adverse impacts of actions in a floodplain or wetlands, including but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas. Whenever possible, DOE would avoid disturbing floodplains and wetlands and would minimize impacts to the extent practicable, if avoidance was not possible. This section discusses the floodplain and wetland mitigation measures that would be considered in the vicinity of the proposed rail alignment and, where necessary and feasible, implemented during railroad construction, operations, and maintenance. In general, DOE would minimize impacts to floodplains and wetlands through the implementation of engineering design standards and best management practices.

DOE has identified several measures to help avoid, minimize, or mitigate potential adverse impacts to floodplains and wetlands under the Proposed Action and Shared-Use Option. DOE has designed the rail alignment segments to avoid direct and indirect impacts to water resources wherever practicable. Due to the nature of rail line design and the construction activities that would be required to implement the design, the rail line cannot avoid crossing floodplains and wetlands. The engineering design process would ensure that the engineered structures used to pass water runoff from one side of the rail line to the other would do so in a way that would minimize impacts to floodplains and wetlands. Such impacts would be limited mostly to the construction phase and would be subject to Clean Water Act regulations and permitting. In most cases DOE would minimize adverse impacts through the implementation of best management practices in concert with the permits and plans regulatory agencies would require.

F.4.4.1 Engineering Design Standards

Before any construction could begin, DOE would require pre-construction surveys to ensure that the work would minimize impacts to floodplains and wetlands. In addition, the site's reclamation potential would be determined during these surveys. If the surveys indicate that construction would threaten these resources, and modification or relocation of the proposed rail line and associated roads would not be reasonable, DOE would develop mitigation measures. DOE would incorporate mitigation measures developed during the pre-construction surveys into the final design of the proposed rail line and associated facilities.

DOE would minimize the disturbance of surface areas and vegetation and would maintain natural contours to the maximum extent feasible. DOE would expect to establish reclamation guidelines for site clearance, topsoil salvage, erosion and runoff control, recontouring, revegetation, siting of roads, and construction practices similar to that established for the repository (DIRS 102188-YMP 1995, pp. 2-1 to 2-14). DOE would stabilize slopes to minimize erosion and would avoid unnecessary off-road vehicle travel.

Although DOE would generally design rail line features to accommodate 100-year flows, the final design process may also consider a range of flood frequencies and include a cost-benefit analysis in the selection of a design frequency in accordance with standard rail line design guidelines and practices (DIRS 106860-AREA 1997, Volume 1, Section 3.3.2.2.c). DOE would analyze crossings on a case-by-case basis and propose culverts whenever feasible (DIRS 180918-Nevada Rail Partners 2007, p. ii). In areas where drainage structures would cross a FEMA Flood Zone A (such as a 100-year flood zone), DOE would design the bridge to comply with FEMA standards and appropriate county regulations. The FEMA standards require that floodway surcharge (the difference between the 100-year-flood elevation and the actual flood surface elevation) would not cause more than a 0.3-meter (1-foot) rise at any location. The FEMA standards have been designed to limit floodwater impacts to structures built in or adjacent to the floodplain (DIRS 180918-Nevada Rail Partners 2007, p. ii). By adhering to these standards, DOE would substantially limit the potential for adverse impacts to the population and resources located adjacent to floodplains.

Where very wide and shallow depths of flow occur during the 100-year event, or the flow is divided into multiple natural channels that would cross the alignment, DOE would use a series of multiple culverts, potentially in concert with small bridges, to span the main flow channel where practicable. In locations where there are very high fill conditions, multiple culverts would be more practical and economical than constructing a bridge (DIRS 180918-Nevada Rail Partners 2007, p. ii). DOE would install culverts with riprap around the exposed ends and use other measures, as necessary, to protect the fill material from erosion. DOE would take similar actions as needed for bridges to protect the structures and to ensure disturbed areas are not subject to increased erosion.

F.4.4.2 Best Management Practices

A National Pollutant Discharge Elimination System General Construction Permit would be required for construction activities. In accordance with this permit, construction contractors would be required to prepare and submit a Stormwater Pollution Prevention Plan. The Stormwater Pollution Prevention Plan would be prepared consistent with State of Nevada and federal standards for construction activities and would detail the best management practices DOE would employ to minimize soil loss and degradation to nearby water resources. DOE would base the design of the best management practices program on practices listed in the *Best Management Practices Handbook* developed by the Nevada Division of Environmental Protection and the Nevada Division of Conservation Districts (DIRS 176309-NDEP 1994, all) and the *Storm Water Quality Manuals Construction Site Best Management Practices Manual* developed by the Nevada Department of Transportation (DIRS 176307-NDOT 2004, all). Table F-5 lists many of the categories of best management practices that would be considered for the construction and operation of the proposed rail line.

Table F-5. Best management practices (page 1 of 2).

Practice	Description
Road and construction site practices	
Development site plan	A site plan identifies the physical features of the site, the location of proposed development, and the location of temporary and/or permanent best management practices. By utilizing a development site plan, the proposed development can be situated to minimize impact to natural resources and the land, and to enable water-quality protection measures and runoff conveyance measures to be properly located.
Grading seasons and practices	The grading season is determined by the local climate conditions. All grading, clearing, and excavation work should be conducted during this period to avoid climatic conditions that could increase the chances for erosion. Grading and construction activities should be coordinated such that bare and disturbed soil exposure is minimized during the winter snow and rainy seasons.
Erosion and sediment controls	
Erosion and sediment control structures	Properly designed, installed, and maintained, erosion and sediment control structures will effectively reduce the transport of sediments, minimize erosion and the degradation of water resources, and reduce negative impacts to natural resources (vegetation and wildlife).
Runoff interceptor trench or swale	Properly designed, installed, and maintained, a runoff interceptor trench or swale will effectively convey surface runoff, minimize soil erosion resulting from surface runoff, and reduce the degradation of receiving water resources.
Siltation or filter berms	Siltation or filter berms capture and retain runoff from construction sites and allow sediments to settle out, and direct runoff water through filter berms at outlets to stabilized drainage ways.
Filter or silt fence	Filter or silt fences are constructed to intercept and capture sediment by decreasing the velocity of surface runoff.
Sediment basins	Sediment basins are effective in reducing water pollution by trapping sediment originating from construction sites and by providing basins for deposition and storage of silt, sand, gravel, stone, and other debris.
Soil stabilization practices	
Rock and gravel mulches	The application of gravel or crushed rock as a mulch is used to stabilize soils during construction activities for erosion control on a variety of surface disturbance areas.
Wood chip, straw, and black mulches	Wood chips, straw, and bark mulches are used as mulch to protect the soil surface from raindrop and irrigation impacts, and decrease runoff.
Jute and synthetic netting	The primary purpose of nettings is to anchor mulch in place on varying topography or in wind-prone areas. Netting provides stability to surface disturbances and reduces the soil erosion potential.
Slope stabilization practices	
Slope shaping	Slope shaping is comprised of designing and modifying cut or fill slopes to reduce the soil erosion and runoff potential. Activities include predisturbance planning and design, terraces, benches, serrations, and steps.

Table F-5. Best management practices (page 2 of 2).

Practice	Description
Slope stabilization practices (continued)	
Retaining structures	Retaining structures are walls comprised of wood, rock, concrete, or other material, constructed at the toe of a slope in order to protect the slope face or toe from scour and erosion from storm runoff.
Rock riprap	Rock riprap is a layer of loose rock placed over an erodible soil or surface disturbance in order to protect the soil surface, to provide for slope stabilization on steep slopes, and to reduce soil erosion within a project area.
Infiltration systems	
Infiltration trench or basin	A shallow rock- or gravel-filled trench located at the drip line of roofs or adjacent to other impervious surfaces such as paved driveways and parking areas can percolate runoff from impervious surfaces and prevent erosion.
Watershed management	
Stream protection and stabilization	Stabilization of stream channels and stream banks is an effective treatment to reduce sediment loading and control erosion and land damage.
Floodwater retarding structure	Floodwater retarding structures are installed to reduce flood damage downstream by controlling the release rate from flood flows of predetermined frequencies.
Floodwater diversion	Floodwater diversions will protect the land, surface improvements, and the watershed by reducing erosion and sediment delivery to receiving waters.
Mining (quarries)	
Excavation stabilization	Excavation stabilization of mined surfaces may prevent erosion, sedimentation, and the degradation of surface and ground water quality through the discharge of sediments or other pollutants into stream channels, drainage ways, or waters of the state.
Surface runoff management	Stormwater runoff management practices when designed, installed, and maintained properly, are effective methods to treat nonpoint source pollution and minimize impacts to surface and ground water quality.
Urban resource management	
Street runoff collection	Street runoff collection prevents erosion of roadside shoulders and adjacent roadway slopes from surface runoff.
Storm drainage structures	Storm drainage structures include pipes, channels, drop inlets, slotted drains, grease and oil traps, or other facilities used to collect and/or convey surface runoff. Their effectiveness depends on keeping them free from debris or filled with sediment.
Landscaping	Proper landscaping can stabilize disturbed sites in a manner that controls surface drainage and soil erosion.

Best management practices are structural and nonstructural controls that are used to control ***nonpoint source pollution*** such as sedimentation and stormwater runoff. Structural controls are best management practices that need to be constructed (such as detention or retention basins). Nonstructural controls refer to best management practices that typically do not require construction, such as planning, education, revegetation, or other similar measures. Sedimentation and stormwater runoff are typically addressed through the use of temporary and permanent best management practices. These include techniques such as grading that would induce positive drainage, installation of silt fences, and revegetation to minimize or prevent soil exposed during construction from becoming sediment to be carried offsite. DOE would implement, inspect, and maintain best management practices to minimize the potential for adversely affecting downstream water quality. Therefore, DOE expects impacts from erosion and sediment runoff associated with construction efforts to be small.

During large flood events, when water is held on the upstream side of the structure, it is possible that sediment could accumulate on the upstream side of the crossings. DOE would remove this material periodically so that future floods would have sufficient space to accumulate, rather than overflow the structures during successively smaller floods. Sediment removed from these areas would be removed by truck and disposed of appropriately or, depending on the location of the drainage channel, simply moved out of the drainage channel and left at the site. Under natural conditions this sediment would have continued downstream and been deposited as the floodwaters dispersed. Compared to the total amount of sediment that is moved by floodwater along the entire length of a wash, the amount deposited behind a crossing would be minor.

Storage of hazardous materials during the construction and operations periods would be in accordance with normal environmental regulatory requirements (for example, within secondary containment) and best management practices. As practicable, DOE would store hazardous materials outside of floodplains. Hazardous materials that would be most susceptible to accidental spills and releases would be the fuels and other petroleum products that would be required to support power and equipment needs for the construction and operation of the proposed rail line.

F.4.4.3 Regulatory Mitigation

If it is determined that the potential wetland areas along Meadow Valley Wash do qualify as jurisdictional wetlands, mitigation for their loss would be determined with the appropriate state and federal agencies. This might involve the enhancement of remaining wetlands or the development of replacement wetlands in other areas along Meadow Valley Wash or elsewhere in Nevada.

For surface-water resources, there are several actions DOE would take in accordance with regulatory requirements that would define mitigation measures during implementation of either the Proposed Action or the Shared-Use Option. These actions would include preparing plans and acquiring permits, as identified as follows in Sections F.4.4.3.1 through F.4.4.3.4.

F.4.4.3.1 Stormwater Discharge

Sediment is the primary pollutant generated at construction sites. Runoff from construction and industrial activities has the potential to generate large quantities of sediment and other contaminants if not properly addressed. In response to this common cause of water-quality impairment, the Environmental Protection Agency promulgated regulations requiring the permitting of stormwater-generated pollution under the National Pollutant Discharge Elimination System (Section 402 of the Clean Water Act). The Nevada Division of Environmental Protection has been delegated the authority to administer these federal regulations and has adopted state regulations to administer a National Pollutant Discharge Elimination System Stormwater program. A National Pollutant Discharge Elimination System General Construction

Permit would be required for construction activities associated with the Proposed Action or Shared-Use Option. In accordance with the National Pollutant Discharge Elimination System, DOE must do the following:

- Prepare a Stormwater Pollution Prevention Plan or plans to address construction of the proposed rail line, including (but not limited to) quarry sites, borrow pits, associated facilities, and labor camps.
- Obtain stormwater National Pollutant Discharge Elimination System permit(s) from the Nevada Bureau of Water Pollution Control, which may involve general and individual permits.
- As part of the National Pollutant Discharge Elimination System permit application, identify proposed measures, including best management practices, to control pollutants in stormwater discharges during and after construction, such as diversion, detention, erosion control, sediment traps, gravel construction entrances, covered storage, spill response, and good housekeeping.

F.4.4.3.2 Discharge of Dredged or Fill Materials

Jurisdictional waters of the United States, subject to regulation under Section 404 of the Clean Water Act, include interstate waters, intrastate waters with a nexus to interstate commerce, tributaries to such waters, and wetlands that are adjacent to waters of the United States. For purposes of this floodplain and wetlands assessment, DOE treated all wetlands equally whether or not they were jurisdictional or nonjurisdictional wetlands. Direct impacts to wetlands associated with the proposed rail alignment would result from temporary or permanent filling or draining of these resources. Indirect impacts would include potential degradation of water quality resulting from actions in and around these resources. Section 404 of the Clean Water Act established a program to regulate the discharge of dredged or fill material into jurisdictional waters, including wetlands. Construction activities, such as those proposed for the development of the rail alignment, that impact jurisdictional wetlands are regulated under this program.

DOE is considering complying with Section 404(r) of the Clean Water Act, which states that the discharge of dredged or fill material as part of the construction of a federal project specifically authorized by Congress is not prohibited or subject to regulation under Section 404 of the Clean Water Act so long as certain conditions are met. One of those conditions is to publish EIS information on the effects of such discharge, including an analysis of alternatives as required by Section 404(b)(1) of the Clean Water Act. The analysis in Sections 4.2.5 and 4.3.5 of the Rail Alignment EIS describes the effects of discharges to wetlands and other waters of the United States. If DOE determines that it will comply with Section 404(r), an alternatives analysis that meets the requirements of Sections 404(b)(1) and 404(r) will be published in the final Rail Alignment EIS. Otherwise, DOE would apply to the Army Corps of Engineers for a permit to fill jurisdictional waters.

DOE would minimize filling of wetlands by incorporating avoidance into engineering and design of the rail line to the maximum extent practicable. DOE would use a minimum-width footprint when practicable, which DOE would accomplish by increasing the slope of the roadbed or bridging across wetlands and not constructing access roads in wetlands. In the areas where wetlands could not be avoided altogether (such as the areas along the Caliente alternative segment), DOE would reduce the width of the construction right-of-way from 300 meters (1,000 feet) to 21 meters (70 feet) at a minimum. By incorporating avoidance of these resources into the engineering and design of the rail line, DOE would minimize adverse impacts to wetlands (and the functions served by wetlands).

F.4.4.3.3 Working in Waterways

According to Nevada Revised Statutes 445A.465, which discusses the prohibition on discharging pollutants into waters of the state without a permit, DOE would have to obtain a permit from the Nevada Division of Environmental Protection, Bureau of Water Pollution Control, to work in waterways. The application for this permit would have to include a description of best management practices DOE would propose to use in and along waterways to protect water quality; control erosion and sedimentation; protect and restore riparian areas; stabilize, protect, and rehabilitate stream banks; and control water pollution. In addition, DOE would have to perform construction activities when streambeds were at low flows or preferably dry, and preserve and restore existing drainage patterns to the extent practicable.

F.4.4.3.4 Flood Hazard Control

In areas where drainage structures would cross a FEMA Flood Zone A (that is, a 100-year flood zone), DOE would design the bridge to comply with FEMA standards and appropriate county regulations. The FEMA standards require that floodway surcharge (that is, the difference between the 100-year flood elevation and the actual flood surface elevation) not exceed 0.3 meter (1 foot) at any location. The FEMA standards have been designed to limit floodwater impacts to structures built in or adjacent to the floodplain (DIRS 180918-Nevada Rail Partners 2007, p. ii). By adhering to these standards, DOE would substantially limit the potential for adverse impacts to the population and resources located adjacent to floodplains. Other practices DOE would use to minimize impacts to floodplains include:

- Construct the proposed rail line in such a way as to maintain current drainage patterns to the extent practicable and not result in new drainage of wetland areas.
- Inspect all drainages, bridges, and culverts semi-annually, or more frequently, as seasonal flows dictate, for debris accumulation.
- Remove debris from drainage structures and properly dispose of debris in an upland area.
- Coordinate with the local floodplain administrators to ensure that new project-related stream and floodplain crossings were appropriately designed to minimize impacts.

F.5 Glossary

100-year flood	A flood event of such magnitude that it occurs, on average, every 100 years; this equates to a 1-percent chance of its occurring in a given year. A base flood may also be referred to as a 100-year storm. The area inundated during the base flood is sometimes called the 100-year floodplain.
50-year flood	A flood event of such magnitude that it occurs, on average, every 50 years; this equates to a 2-percent chance of its occurring in a given year.
accessible environment	For this ***environmental impact statement*** (EIS), all points on Earth outside the surface and subsurface area controlled over the long term for the ***repository***, including the atmosphere above the controlled area.
accident	An unplanned sequence of events that results in undesirable consequences. Examples in this Rail Alignment EIS include an inadvertent release of radiation from the casks or hazardous materials from their containers; train derailments; vehicular accidents; and construction-related accidents that could affect workers.
air quality	A measure of the concentrations of pollutants, measured individually, in the air.
alpha particle	A positively charged particle ejected spontaneously from the nuclei of some ***radioactive*** elements. It is identical to a helium nucleus and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). See ***ionizing radiation.***
alternative	One of two or more actions, processes, or propositions, from which a decisionmaker will determine the course to be followed. The National Environmental Policy Act, as amended, states that in preparing an EIS, an agency "shall ... (s)tudy, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" [42 U.S.C. 4321, Title I, Section 102(E)]. The regulations of the Council on Environmental Quality that implement the National Environmental Policy Act indicate that the alternatives section is "the heart of the environmental impact statement (40 CFR 1502.14), and include rules for presentation of the alternatives, including no action, and their estimated impacts. The Nevada Rail Corridor SEIS analyzes one alternative to the ***Proposed Action***, the ***No-Action Alternative***. Under the Nevada Rail Corridor SEIS No-Action Alternative, the U.S. Department of Energy (DOE or the Department) would not select a rail alignment within the Mina rail corridor for the construction and operation of a railroad. As such, the No-Action Alternative provides a basis for comparison to the Proposed Action. The Rail Alignment EIS analyzes one alternative to the Proposed Action – the No-Action Alternative – and two implementing alternatives under the Proposed Action – the Caliente Implementing Alternative and the Mina Implementing Alternative – for constructing, operating, and possibly abandoning a ***railroad*** for the shipment of ***spent nuclear fuel*** and ***high-level radioactive waste*** for long-term ***disposal*** in a ***geologic repository*** at Yucca Mountain. Under the No-Action Alternative, DOE would not construct the proposed railroad along the Caliente ***rail alignment*** or the Mina rail alignment.

alternative segments	Geographic region of the ***rail alignment*** for which multiple routes for the ***rail line*** have been identified. In this Rail Alignment EIS, there are different alignments identified within the Caliente ***rail corridor*** and the Mina rail corridor that could minimize or avoid environmental ***impacts*** and reduce construction complexities.
atomic mass	The mass of a neutral atom, based on a relative scale, usually expressed in atomic mass units. See ***atomic weight.***
atomic nucleus	See ***nucleus***.
atomic number	The number of ***protons*** in an atom's ***nucleus***.
atomic weight	The relative mass of an atom based on a scale in which a specific carbon atom (carbon-12) is assigned a mass value of 12. Also known as relative ***atomic mass***.
ballast	The coarse rock that is placed under the ***railroad*** tracks to support the railroad ties and improve drainage along the ***rail line***.
barrier	Any material, structure, or condition (as a thermal barrier) that prevents or substantially delays the movement of water or ***radionuclides***.
berm	A mound or wall of earth.
beta particle	A negatively charged ***electron*** or positively charged positron emitted from a ***nucleus*** during ***decay***. Beta decay usually refers to a radioactive transformation of a ***nuclide*** by electron emission, in which the ***atomic number*** increases by 1 and the mass number remains unchanged. In positron emission, the atomic number decreases by 1 and the mass number remains unchanged. See ***ionizing radiation.***
boiling-water reactor (BWR)	A ***nuclear reactor*** that uses boiling water to produce steam to drive a turbine.
canister	An unshielded metal container used as: (1) a pour mold in which molten vitrified ***high-level radioactive waste*** can solidify and cool; (2) the container in which DOE and electric utilities place intact ***spent nuclear fuel***, loose rods, or nonfuel components for shipping or ***storage***; or (3) in general, a container used to provide ***radionuclide confinement***. Canisters are used in combination with specialized overpacks that provide structural support, ***shielding*** or confinement for storage, transportation, and ***emplacement***. Overpacks used for transportation are usually referred to as transportation ***casks***; those used for emplacement in a ***repository*** are referred to as ***waste packages***.
cask	A heavily shielded container that meets applicable regulatory requirements used to ship ***spent nuclear fuel*** or ***high-level radioactive waste***.
common segment	Geographic region of the ***rail alignments*** for which a single route for the ***rail line*** has been identified.
confinement	As it pertains to ***radioactivity***, the retention of ***radioactive*** material within some specified bounds. Confinement differs from containment in that there is no absolute physical ***barrier*** in the former.
decay (radioactive)	The process in which one ***radionuclide*** spontaneously transforms into one or more different radionuclides called decay products.
disposal (of spent nuclear fuel and high-level radioactive waste)	The ***emplacement*** in a ***repository*** of ***spent nuclear fuel***, ***high-level radioactive waste***, or other highly ***radioactive*** material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste, and the ***isolation*** of such waste from the ***accessible environment***.

dose (radioactive)	The amount of ***radioactive*** energy taken into (absorbed by) living tissues. See ***effective dose equivalent***.
effective dose equivalent	Often 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.
electron	A stable elementary particle that is the negatively charged constituent of ordinary matter.
environment	(1) Includes water, air, and land and all plants and humans and other animals living therein, and the interrelationship existing among these. (2) The sum of all external conditions affecting the life, development, and survival of an organism.
emplacement	The placement and positioning of ***waste packages*** in the ***repository***.
environmental impact statement (EIS)	A detailed written statement that describes: "...the environmental impact of the ***proposed action***; any adverse environmental effects which cannot be avoided should the proposal be implemented; ***alternatives*** to the proposed action; the relationship between local short-term uses of man's ***environment*** and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." Preparation of an EIS requires a public process that includes public meetings, reviews, and comments, as well as agency responses to the public comments.
exposure (to radiation)	The condition of being subject to the effects of or potentially acquiring a ***dose*** of ***radiation***. The incidence of radiation on living or inanimate material by ***accident*** or intent. Background exposure is the exposure to natural ionizing radiation. Occupational exposure is the exposure to ionizing radiation that occurs during a person's working hours. Population exposure is the exposure to a number of persons who inhabit an area.
fission	The splitting of a ***nucleus*** into at least two other nuclei, resulting in the release of two or three ***neutrons*** and a relatively large amount of energy.
fission products	***Radioactive*** or nonradioactive atoms produced by the ***fission*** of heavy atoms, such as uranium.
fuel assembly	A number of fuel elements held together by structural materials, used in a ***nuclear reactor***; sometimes called a fuel bundle.
gamma ray	The most penetrating type of radiant nuclear energy. It does not contain particles and can be stopped by dense materials such as concrete or lead. See ***ionizing radiation.***
geologic repository	A system for the ***disposal*** of ***radioactive*** waste in excavated geologic media, including surface and subsurface areas of operation, and the adjacent part of the geologic setting that provides ***isolation*** of the radioactive waste in a controlled area.
high-level radioactive waste	(1) The highly ***radioactive*** material that resulted from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing, and any solid material derived from such liquid waste that contains ***fission products*** in sufficient concentrations.
impact	For an EIS, the positive or negative effect of an action (past, present, or future) on the natural ***environment*** (land use, ***air quality***, water resources, geological resources, ecological resources, aesthetic and scenic resources) and the human environment (***infrastructure***, economics, social, and cultural).

infrastructure	Basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communication systems.
ionizing radiation	(1) ***Alpha particles***, ***beta particles***, ***gamma rays***, ***X-rays***, ***neutrons***, high-speed ***electrons***, high-speed ***protons***, and other particles capable of producing ions. (2) Any ***radiation*** capable of displacing electrons from an atom or molecule, thereby producing ions.
irradiation	***Exposure*** to ***radiation***.
isolation	Inhibiting the transport of ***radioactive*** material so that the amounts and concentrations of this material entering the ***accessible environment*** stay within prescribed limits.
neutron	An atomic particle with no charge and an ***atomic mass*** of 1; a component of all atoms except hydrogen; frequently released as ***radiation***.
No-Action Alternative	Under the No-Action Alternative in the Nevada Rail Corridor SEIS, DOE would not construct and operate a railroad within the Mina rail corridor from Wabuska to Yucca Mountain. Under the No-Action Alternative the Rail Alignment ***EIS***, DOE would not implement the ***Proposed Action*** in the Caliente rail corridor or the Mina rail corridor.
nonpoint source pollution	Pollution does not come from a single source but from many unidentifiable sources. An example of nonpoint source pollution would be urban runoff of items like oil, fertilizers, and lawn chemicals. As rainfall or snowmelt moves over and through the ground, it picks up and carries away natural and human-made pollutants. These pollutants are eventually deposited into natural bodies of water, such as lakes, rivers, wetlands, coastal waters, and underground sources of drinking water.
nuclear reactor	A device in which a nuclear fission chain reaction can be initiated, sustained, and controlled to generate heat or to produce useful ***radiation***.
nucleus	The central, positively charged, dense portion of an atom. Also known as ***atomic nucleus***.
nuclide	An atomic ***nucleus*** specified by its ***atomic weight***, ***atomic number***, and energy state; a ***radionuclide*** is a ***radioactive*** nuclide.
pressurized-water reactor (PWR)	A nuclear power ***reactor*** that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.
Proposed Action	The activity proposed to accomplish a federal agency's purpose and need. An EIS analyzes the environmental ***impacts*** of a proposed action, which includes the project and its related support activities. The Proposed Action in the Nevada Rail Corridor SEIS, is to construct and operate a railroad to connect the Yucca Mountain repository to an existing rail line near Wabuska, Nevada (the Mina rail corridor). The Proposed Action in the Rail Alignment EIS, is to determine an alignment (within a corridor) and construct and operate 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.
proton	An elementary particle that is the positively charged component of ordinary matter and, together with the ***neutron***, is a building block of all atomic nuclei.

radiation	Energy traveling through space. Radiation can be non-ionizing, like radio waves, ultraviolet radiation, or visible light, or ionizing, depending on its effect on atomic matter. As used in this Rail Alignment EIS "radiation" refers to ***ionizing radiation***. Ionizing radiation has enough energy to ionize atoms or molecules while non-ionizing radiation does not. Radioactive material is a physical material that emits ionizing radiation.
radioactive	Emitting ***radioactivity***.
radioactivity	(1) The spontaneous transformation of unstable atomic nuclei, usually accompanied by the emission of ionizing ***radiation*** (e.g., such as ***alpha***, ***beta***, or ***gamma rays***). (2) The property of unstable nuclei in certain atoms (of elements such as uranium) to spontaneously emit ionizing radiation during nuclear transformations.
radionuclide	See ***nuclide***.
rail alignment	An engineered refinement of a ***rail corridor*** in which DOE would identify the location of a rail line. A rail alignment is comprised of ***common segments*** and ***alternative segments***.
rail corridor	As used in this Rail Alignment EIS, a strip of land, 400 meters (0.25 mile) wide through which DOE would identify an alignment (***rail alignment***) for the construction of a ***rail line*** in Nevada to a ***geologic repository*** at Yucca Mountain.
rail line	An engineered feature incorporating the track, ties, ***ballast***, and ***subballast*** at a specific location.
railroad	A transportation system incorporating the rail line, operations support facilities, railcars, locomotives, and other related property and infrastructure.
reactor	See ***nuclear reactor***.
repository	See ***geologic repository***.
riprap	Broken rocks or chunks of concrete used as foundation material or to protect embankments and gullies to control water flow or prevent erosion.
roadbed	The earthwork foundation upon which the track, ties, ***ballast***, and ***subballast*** of a ***rail line*** are lain.
Shared-Use Option	An option under the ***Proposed Action***. DOE would allow commercial and other shippers to use the ***rail line*** for general freight shipments. General freight would include stone and other nonmetallic minerals, petrochemicals, waste materials (nonradioactive), or other commodities that private companies would ship or receive.
shielding	Any material that provides ***radiation*** protection.
spent nuclear fuel	Fuel that has been withdrawn from a ***nuclear reactor*** following ***irradiation***, the component elements of which have not been separated by reprocessing. For this project, this refers to (1) intact, nondefective ***fuel assemblies***, (2) failed fuel assemblies in ***canisters***, (3) fuel assemblies in canisters, (4) consolidated fuel rods in canisters, (5) nonfuel assembly hardware inserted in ***pressurized-water reactor*** fuel assemblies, (6) fuel channels attached to ***boiling-water reactor*** fuel assemblies, and (7) nonfuel assembly hardware and structural parts of assemblies resulting from consolidation in canisters.
storage	The collection and containment of waste or ***spent nuclear fuel*** in a way that does not constitute ***disposal*** of the waste or spent nuclear fuel for the purposes of awaiting treatment or disposal capacity.

subballast	A layer of crushed gravel that is used to separate the ***ballast*** and ***roadbed*** for the purpose of load distribution and drainage.
subgrade elevation	The elevation of the top of the ***subballast*** in the ***rail line***.
waste packages	Two thick metal cylinders, one nested within the other. The inner cylinder would be made of stainless steel to provide structural strength. The outer cylinder would be made of a nickel alloy that is highly resistant to corrosion.
X-rays	Penetrating electromagnetic ***radiation*** having a wavelength much shorter than that of visible light. X-rays are identical to ***gamma rays*** but originate outside the ***nucleus***, either when the inner orbital ***electrons*** of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons.

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APPENDIX G

METHODOLOGY FOR ASSESSING IMPACTS TO GROUNDWATER

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ACRONYMS AND ABBREVIATIONS

DIRS	Document Input Reference System
DTN	Data Tracking Number
DOE	U.S. Department of Energy
DEIS	Draft Environmental Impact Statement
GIS	Geographic Information System
GNIS	Geographic Names Information System
NDWR	Nevada Division of Water Resources
NWIS	National Water Information System
USGS	U.S. Geological Survey

APPENDIX G

METHODOLOGY FOR ASSESSING IMPACTS TO GROUNDWATER

This appendix provides detailed information on the methods DOE used to assess potential impacts to groundwater provided in Sections 4.2.6 and 4.3.6 of the Rail Alignment EIS (DOE/EIS-0369).

Section G.3 defines terms shown in ***bold italics***.

This appendix describes:

- The general approach and assumptions the U.S. Department of Energy (DOE or the Department) used to identify existing groundwater resources and to assess potential impacts to those groundwater resources from the proposed groundwater withdrawal for construction and operation of the proposed rail line
- The methodology for determining the impact to the aquifer (at an existing groundwater resource feature) due to pumping at a specific well location or the location of a group of wells
- The aquifer types considered and the corresponding calculations employed for the proposed well locations where an assessment was performed

Section G.1 describes the methods DOE used to assess impacts to groundwater from railroad construction along either the Caliente rail alignment or the Mina rail alignment; Section G.1.3 describes the methods for determining potential impacts from railroad operations along either alignment. DOE used the same methods to assess potential impacts to groundwater resources under the Shared-Use Option for each alignment as described in Section G.2.

DOE performed calculations to quantitatively evaluate potential impacts to existing water wells and springs from withdrawing groundwater from proposed new wells that would support construction and operation of the proposed rail line. DOE has proposed many locations along the Caliente and Mina rail alignments for water wells. Each set of calculations evaluates impacts on the host aquifer from pumping of these wells. DOE has categorized wells into construction wells (Section G.1.2), which would be temporary, and operations wells (Section G.1.3), which would be permanent. DOE further categorized construction wells into: (1) construction water wells which would provide water during construction of the rail roadbed and to support water needs at construction camps (Section G.1.2.2), and to support water needs associated with construction of rail facilities (Section G.1.2.3); and (2) quarry wells (Section G.1.2.5), which would provide water to specific quarry sites. The evaluation of construction impacts includes a sensitivity analysis for locations along the Caliente rail alignment (Section G.1.2.4), which DOE conducted to identify favorable locations where increased productivity rates would not impact existing groundwater uses.

G.1 Construction Impacts Assessment

G.1.1 OVERVIEW OF GROUNDWATER ASSESSMENT METHODOLOGY AND ASSUMPTIONS

For assessing potential impacts to groundwater resources, DOE assumed the total duration of the construction phase would be 4 years, the shortest construction period being considered. Actual construction would occur during about the first 3 years, with the final year allocated to installation and testing of signal and communications equipment, and putting the rail line into service. DOE assumed this 4-year construction duration because it would require higher or the same groundwater withdrawal rates from the new proposed water wells than if a longer duration were assumed. This analysis approach is conservative and any impacts identified would include impacts under a longer (up to 10 years) construction duration.

DOE assumed that all of the water required for the Proposed Action would be obtained from the proposed new water wells. DOE also assumed that all of the groundwater required for rail roadbed construction activities within each hydrographic area that the Caliente rail alignment or Mina rail alignment would cross would be acquired within a 9-month period (DIRS 176189-Converse Consultants 2006, Section 2.1; DIRS 180888-Converse Consultants 2007, Section 2.1).

The construction impacts assessment involved calculating the approximate ***radius of influence*** of the ***cone of depression*** surrounding each proposed new water-supply well located in an area with existing wells or any known springs that could potentially be impacted. Section G.1.2.1 provides details regarding the approach that was used for identifying existing wells and known springs that could be located within the radius of influence of the cone of depression surrounding each proposed new water-supply well. The cone of depression generated by pumping groundwater from a well increases (approximately radially) in relation to its areal extent, and the magnitude of the drawdowns contained within it increase during the initial, transient period of operation. As the system approaches steady state, both the size of the cone of depression and the magnitude of drawdowns would be expected to expand to reach maximum (equilibrium) values within the specified pumping time frame (in this case, 9 months), unless there were barriers to flow that could affect the generally radial flow behavior surrounding a pumping well and these barriers were located within the radius of influence of that pumping well. The maximum impact of a well on the aquifer is achieved once steady-state conditions have developed. Therefore, DOE performed the impact evaluations using steady-state well formulae so that the likely maximum impacts could be assessed.

Vertical flow can also occur between aquifers. If a well is ***screened*** in a ***leaky aquifer***, part of the flow is derived from the horizontal flow in that aquifer, and part from the vertical flow from underlying or overlying aquifers, located below or above the aquifer in question. DOE neglected this phenomenon in the impact analyses because additional flow originating from other aquifers would decrease the calculated drawdown in the aquifer of interest. Therefore, DOE has conservatively estimated the impact of the well on the water-bearing zone.

DOE determined and evaluated a range of potential aquifer conditions. At several locations, DOE completed more than one calculation of the radius of influence to reflect different potential aquifer conditions (confined aquifer versus unconfined aquifer; alluvial aquifer versus fractured volcanic rock aquifer, etc.; see Section G.1.2.2) that might occur at the pumping location.

If a calculated radius of influence equaled or exceeded the distance separating the proposed well location and an existing well or spring, then DOE assumed there would be a hydrogeologic impact on that existing well or spring. The *Hydrogeologic DEIS Analysis Report, REV. 0, April 10, 2006* (DIRS 176189-

Converse Consultants 2006, all) describes the locations and characteristics of wells proposed for supplying water needed for rail roadbed earthwork compaction along the Caliente rail alignment. The *Hydrogeologic DEIS Analysis Report, REV. 0, April 27, 2007* (DIRS 180888-Converse Consultants 2007, all) describes the locations and characteristics of wells proposed for supplying water needed for rail roadbed earthwork compaction along the Mina rail alignment.

G.1.2 CONSTRUCTION WATER-SUPPLY WELLS

DOE performed calculations to evaluate the potential impacts of groundwater withdrawals from individual wells or groups of wells on nearby existing wells and springs. DOE varied the analytical methods used for the impacts analyses at the various locations to reflect the different aquifer conditions inferred to be present at each pumping site. The impacts analyses consisted of:

- Identifying the average and peak withdrawal rates of each proposed well or group of wells
- Identifying potential hydrogeologic conditions that could be present at each location and evaluating an appropriate calculation methodology for each potential condition
- Calculating the extent and magnitude of drawdowns that would be generated by the proposed well or an equivalent single well for a well cluster pumping at the specified average withdrawal rate (under the range of potential hydrogeologic conditions postulated)
- Identifying the location and characteristics of existing water wells and springs that might be impacted by the drawdown generated by the proposed groundwater withdrawals
- Estimating the potential reduction in well capacity or spring discharge, if any, that could occur as a result of the proposed groundwater withdrawals

G.1.2.1 Hydrogeologic Impacts Analysis Approach

DOE used the following approach to evaluate potential impacts on existing wells and springs from the proposed groundwater withdrawals from new water wells:

- Review the specified data regarding the proposed well locations, well construction details, estimated groundwater depths, and proposed groundwater withdrawal rates and timeframes. The references containing these data for the Caliente rail alignment include DIRS 176189-Converse Consultants 2006, all; DIRS 176168-Nevada Rail Partners 2006, Section 3.1.5; DIRS 180922-Nevada Rail Partners 2007, Section 3.1.5; DIRS 176172-Nevada Rail Partners 2006, Section 4.4; DIRS 180875-Nevada Rail Partners 2007, Section 4.4; and DIRS 180919-Nevada Rail Partners 2007, Section 3.1.5. The references containing these data for the Mina rail alignment include DIRS 180888-Converse Consultants 2007, all; DIRS 180873-Nevada Rail Partners 2007, Section 2.1.5; and DIRS 180875-Nevada Rail Partners 2007, Section 4.4.
- Identify all the existing wells and springs in proximity to the proposed pumping well locations and their characteristics, use category, and permit status using report information (such as DIRS 176600-Converse Consultants 2005, all; DIRS 180887-Converse Consultants 2007, all) and information from on-line sources, including the Nevada Division of Water Resources (NDWR) water-rights and well-log databases, the U.S. Department of the Interior, U.S. Geological Survey (USGS), and National Water Information System (NWIS) (DIRS 176325-USGS 2006, all). DOE used the following Geographic Information System (GIS) datasets in the analyses:
  - GNIS-Nevada Springs. Data Tracking Number (DTN) MO0605GOISGNISN.000 (DIRS 176979)
  - USGS Existing Wells Location Information for the State of Nevada. DTN MO0607USGSWNVD.000 (DIRS 177294)

- Nevada Division of Water Resources Well Data. DTN MO0607NDWRWELD.000 (DIRS 177292)
- Two New Existing Wells within Dry Lake Valley. DTN MO0607PWMAR06D.000 (DIRS 177293)
- National Hydrological Dataset Point Information for the State of Nevada 2006. DTN MO0607NHDPOINT.000 (DIRS 177712)
- National Hydrological Dataset Waterbody Information for the State of Nevada 2006. DTN MO0607NHDWBDYD.000 (DIRS 177710)
- Converse Consultants 2007 (DIRS 182759)
- NDWR (DIRS 182898)
- NDWR (DIRS 182899)

The (location) coordinates assumed for most of these existing wells are based on the center of the 40-acre Quarter Quarter Section description provided on well logs that were submitted to the NDWR. Therefore, these wells could actually be anywhere within each described 40-acre Quarter Quarter Section of land.

- For initial screening purposes, if DOE identified an existing well or a spring within a 1.6-kilometer (1-mile) radius (buffer distance) of a proposed new water well, DOE selected that proposed well location as a candidate for conducting a groundwater hydrogeologic impacts evaluation. If DOE found no spring or existing well within this initial search radius, it extended the search distance outward from the proposed well location to identify the nearest spring or existing well and determined its hydrogeologic and construction characteristics (for the existing wells). If the nearest existing well or spring was farther away than the initial search distance of 1.6 kilometers, an impacts analysis was still performed if one was deemed appropriate for that location, provided the nearest existing well was found to be within a distance of 2.4 kilometers (1.5 miles) of the proposed pumping well location. The analysis was done taking into account the withdrawal rate at the proposed new well location and the annual duty for the nearest existing well if it had a formal appropriated water right. DOE searched the NDWR water-rights database and well-log databases to confirm the identity, use, water-rights status, if any, and appropriated annual duty and diversion rate, if applicable, associated with each existing well (or spring) within the final searched buffer distance.
- Existing wells and known springs were deemed significant, even if there was not an active water right associated with the well (provided that the well has a use that is listed as being other than the uses listed immediately below) or the spring. In addition to possibly being a source of water for human use, springs provide a water source for wildlife and form unique habitats within the desert ecosystem.
- DOE did not analyze impacts on existing wells that were found to have no productive use based on use category or status (that is, were confirmed to be groundwater exploration or test wells, thermal gradient test wells, or were dry). For example, DOE excluded from the list of wells of potential concern several existing wells cataloged in the USGS NWIS database that were confirmed to be either monitoring wells, thermal gradient or oil and gas testing wells, or hydrogeologic investigation wells and that have no associated productive (beneficial) use other than their potential future use as monitoring wells.
- DOE included wells with a designation of Domestic. The State of Nevada does not require a water-rights application or permit (formal appropriation) to drill a well for domestic purposes. However, DOE considered domestic wells in the impacts analyses.
- DOE reviewed available geologic and hydrogeologic information for known and potential aquifers in areas where existing wells or springs near proposed new pumping wells indicated that a quantitative analysis of hydrogeologic impacts was warranted. Information and data reviewed included well-log data (total well depth, lithologic units, depth to groundwater, pumping-test data, appropriated duty

balance, and diversion rate data, if applicable) for existing wells near proposed new well locations, published geologic and hydrogeologic reports, and groundwater resource appraisal reports. DOE used this information to identify appropriate analytical methods for quantitatively evaluating the drawdown effects from the proposed groundwater withdrawals on the aquifer in which the wells would be installed. The following references containing available geologic and hydrogeologic information for the study area were reviewed:

Caliente Rail Alignment

- DIRS 177524-Anning and Konieczki 2005
- DIRS 173179-Belcher 2004
- DIRS 176851-Brothers, Bugo, and Tracy 1993
- DIRS 176883-Brothers, Katzer, and Johnson 1996
- DIRS 176852-Drici, Garey, and Bugo 1993
- DIRS 116801-Driscoll 1986
- DIRS 176818-Eakin 1962
- DIRS 181909-Fridrich et al. 2007, all
- DIRS 129721-Geldon et al. 1998
- DIRS 106094-Harrill, Gates, and Thomas 1988
- DIRS 180775-Lopes et al. 2006
- DIRS 106695-Malmberg and Eakin 1962
- DIRS 103136-Prudic, Harrill, and Burbey 1993
- DIRS 169384-Reiner et al. 2002
- DIRS 176519-Rowley and Shroba 1991
- DIRS 176947-Rowley et al. 1994
- DIRS 176502-Rush 1964
- DIRS 176849-Rush 1968
- DIRS 176950-Rush and Everett 1966
- DIRS 174643-Seaber, Kapinos, and Knapp 1994
- DIRS 173842-Shannon & Wilson 2005
- DIRS 175986-Shannon & Wilson 2005
- DIRS 150228-Slate et al. 2000
- DIRS 176488-State of Nevada 2006
- DIRS 147766-Thiel Engineering Consultants 1999
- DIRS 172905-USGS 1995
- DIRS 176325-USGS 2006
- DIRS 176848-Van Denburgh and Rush 1974

Mina Rail Alignment

- DIRS 180760-Albers and Stewart 1981
- DIRS 177524-Anning and Konieczki 2005
- DIRS 173179-Belcher 2004

- DIRS 181394-Everett and Rush 1967
- DIRS 181909-Fridrich et al. 2007, all
- DIRS 129721-Geldon et al. 1998
- DIRS 106094-Harrill, Gates and Thomas 1988
- DIRS 180697-Huxel and Harris 1969
- DIRS 180775-Lopes et al. 2006
- DIRS 106695-Malmberg and Eakin 1962
- DIRS 180777-Mauer et al. 2004
- DIRS 103136-Prudic, Harrill, and Burbey 1993
- DIRS 169384-Reiner et al. 2002
- DIRS 176849-Rush 1968
- DIRS 180754-Rush et al. 1971
- DIRS 174643-Seaber, Kapinos, and Knapp 1994
- DIRS 173842-Shannon & Wilson 2005
- DIRS 175986-Shannon & Wilson 2005
- DIRS 180881-Shannon & Wilson 2007
- DIRS 150228-Slate et al. 2000
- DIRS 176488-State of Nevada 2006
- DIRS 180975-Stewart, Carlson, and Johannessen 1982
- DIRS 181896-Stoller-Navarro 2005
- DIRS 147766-Thiel Engineering Consultants 1999
- DIRS 172905-USGS 1995
- DIRS 176325-USGS 2006
- DIRS 180759-Van Denburgh and Glancy 1970

- DOE completed quantitative analyses to calculate the estimated lateral extent of the drawdown cone of depression that would be induced in the aquifer surrounding each proposed new water-well location (or well cluster) during pumping at the water-well location(s) at the prescribed withdrawal rate. DOE performed quantitative analyses using one or more sets of analytical equations to correspond to one or more sets of assumptions. The analyses were designed to cover the range of possible aquifer conditions that might be encountered at the proposed well locations. For those proposed new well locations that were evaluated due to the presence of a nearby existing well with a water right, results of these analyses were combined with an analysis undertaken to quantitatively evaluate the radius of influence that might be induced by pumping at that existing well. DOE compared the results of the radius-of-influence calculations for both the proposed new location and the existing well to determine whether the drawdown cones of depression from the two well locations could contact each other. Analytical results demonstrated that such conditions (that is, that the radii of influence would intersect each other, based on the assumptions made for analysis) would occur only in a few cases. These cases of likely impact to existing groundwater were a result of high average groundwater withdrawal rates prescribed at a proposed new well location (see the sensitivity analysis cases described in Section G.1.2.4), unfavorable hydrogeologic conditions in the area, the proximity of the nearest existing well to the proposed well location, or a very large appropriated annual duty for the existing well. Sections G.1.2.2 and G.1.2.4 provide details regarding the calculation methods and assumptions.

Tables G-1 and G-2 list proposed new well locations for the Caliente and Mina rail alignments for which DOE performed hydrogeologic impacts analyses.

Table G-1. Proposed new well locations pumped at specified average (base-case) groundwater withdrawal rates for which DOE performed groundwater impacts analyses – Caliente rail alignment (page 1 of 2).

Proposed new well	Hydrographic area number	Hydrographic area name	Alternative segment/common segment
ClV1	204	Clover Valley	Eccles/common segment 1
ClV2	204	Clover Valley	Eccles/common segment 1
PanV1	203	Panaca Valley	Eccles/common segment 1
PanV4	203	Panaca Valley	Eccles/common segment 1
PanV23	203	Panaca Valley	Eccles/common segment 1
PanV2/PanV24	203	Panaca Valley	Eccles/common segment 1
PanV6/PanV3	203	Panaca Valley	Eccles/common segment 1
PanV25/PanV26	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
PanV7/PanV8	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
PanV9/PanV10/PanV11/PanV12	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
PanV13/PanV15	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
DLV3	181	Dry Lake Valley	Common segment 1
DLV4	181	Dry Lake Valley	Common segment 1
PahV1/PahV2/PahV3	208	Pahroc Valley	Common segment 1
PahV7/PahV8/PahV9	208	Pahroc Valley	Common segment 1
GV2	172	Garden Valley	Garden Valley 2
GV10	172	Garden Valley	Garden Valley 1
RrV5	173A	Railroad Valley South	Comment segment 2/South Reveille 3/common segment 3
RrV6/RrV11	173A	Railroad Valley South	Common segment 2/South Reveille 2/common segment 3 Common segment 2/South Reveille 3/common segment 3
RrV8	173A	Railroad Valley South	Common segment 2/South Reveille 3/common segment 3
HC4	156	Hot Creek Valley	Common segment 3
HC5/HC7	156	Hot Creek Valley	Common segment 3
SCV3	149	Stone Cabin Valley	Common segment 3
ASV6	142	Alkali Spring Valley	Goldfield 4
SaF1/SaF2	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5
SaF4	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5

Table G-1. Proposed new well locations pumped at specified average (base-case) groundwater withdrawal rates for which DOE performed groundwater impacts analyses – Caliente rail alignment (page 2 of 2).

Proposed new well	Hydrographic area number	Hydrographic area name	Alternative segment/common segment
SaF5/SaF9	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5 Bonnie Claire 2/common segment 5
SaF7/SaF11	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5 Bonnie Claire 2/common segment 5
OV9	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6
OV24/OV25/OV26	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6
OV12/OV18/OV19/OV20/OV21	228	Oasis Valley	Common segment 5/Oasis Valley 3/common segment 6
OV3/OV4/OV5/OV13	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6 Common segment 5/Oasis Valley 3/common segment 6
OV14/OV16/OV6/OV8	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6

Table G-2. Proposed new well locations pumped at the maximum groundwater withdrawal rates for which DOE performed groundwater impacts analyses – Mina rail alignment (page 1 of 2).

Proposed new well	Hydrographic area number	Hydrographic area name	Alternative segment/common segment
WLA-3a	110A	Walker Lake Valley	Department of Defense Branchline North/Schurz alternative segment 1/Department of Defense Branchline South
WLc-2a	110C	Walker Lake Valley	Department of Defense Branchline South/Mina common segment 1
CSM-2a	118	Columbus Salt Marsh	Mina common segment 1
CSM-3a	118	Columbus Salt Marsh	Mina common segment 1
SSa-2	121A	Soda Springs Valley East	Mina common segment 1
SSa-3	121A	Soda Springs Valley East	Mina common segment 1
SSa-4	121A	Soda Springs Valley East	Mina common segment 1
SSb-2	121B	Soda Springs Valley West	Mina common segment 1
BSa-1a	137A	Big Smoky Valley – Tonopah Flat	Mina common segment 1/Montezuma alternative segment 1; Mina common segment 1/Montezuma alternative segment 2
BSa-2a	137A	Big Smoky Valley – Tonopah Flat	Mina common segment 1/Montezuma alternative segment 2
BSa-3a	137A	Big Smoky Valley – Tonopah Flat	Mina common segment 1/Montezuma alternative segment 2
AS-1b	142	Alkali Spring Valley	Montezuma alternative segment 2

Table G-2. Proposed new well locations pumped at the maximum groundwater withdrawal rates for which DOE performed groundwater impacts analyses – Mina rail alignment (page 2 of 2).

Proposed new well	Hydrographic area number	Hydrographic area name	Alternative segment/common segment
AS-2b	142	Alkali Spring Valley	Montezuma alternative segment 2
ASV6	142	Alkali Spring Valley	Montezuma alternative segment 2
Cl-1a	143	Clayton Valley	Montezuma alternative segment 1
Cl-8a	143	Clayton Valley	Montezuma alternative segment 1
Cl-9a	143	Clayton Valley	Montezuma alternative segment 1
Li-3a	144	Lida Valley	Montezuma alternative segment 1
SaF4	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5
SaF5/SaF9	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5, Bonnie Claire 2/common segment 5
SaF7/SaF11	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5, Bonnie Claire 2/common segment 5
OV24/OV25/OV26	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6
OV12/OV18/OV19/OV20/OV21	228	Oasis Valley	Common segment 5/Oasis Valley 3/common segment 6
OV3/OV4/OV5/OV13	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6, common segment 5/Oasis Valley 3, common segment 6
OV9	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6
OV14/OV16/OV6/OV8	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6

G.1.2.2 Hydrogeologic Impacts Calculation Methods

DOE performed calculations using one or more sets of analytical equations reflecting one or more sets of assumptions made regarding the hydrogeologic conditions present at the analysis location. These calculations were designed to cover the range of possible aquifer conditions that might be encountered at the proposed new well locations. Applicable aquifer conditions varied according to well location, proposed well depth, and the available geologic and hydrogeologic information for each area. Types of aquifers considered for the various proposed locations included alluvial valley-fill aquifers, alluvial valley-fill aquifers with transecting faults, and faulted and/or fractured consolidated rock aquifers. Types of aquifer conditions assumed to exist at the various well locations for either the Caliente or the Mina rail alignment included:

- Infinite-extent unconfined aquifer
- Infinite-extent confined aquifer
- Semi-infinite-extent unconfined aquifer
- Semi-infinite-extent confined aquifer
- Carbonate and volcanic rock aquifers
- Limited-extent unconfined aquifer

A particular pumping well location could have calculations for more than one type of aquifer condition depending on the assumptions made due to varying geologic information from different reports. For these locations with more than one potential type of aquifer condition, the results from the calculations for the different types of aquifer conditions served to identify the range and extent of possible impacts to the aquifer as a result of pumping groundwater. Sections G.1.2.2.1 through G.1.2.2.6 describe the analytical methods DOE utilized.

Hydrogeologic impacts analysis calculations were generally performed for those proposed construction wells that are intended to supply water for rail roadbed construction; development and operation of construction camps; and development and operation of potential quarries. Water consumption rates during the period of use of construction camps during the peak output year have been estimated at approximately 76 liters (20 gallons) per minute, which is equivalent to approximately 110,000 liters (28,800 gallons) per day (DIRS 180888-Converse Consultants 2007, Table 2-4). Methodologies and approaches used for evaluating impacts from wells intended to support the first two of these activities are provided in Sections G.1.2.2.1 through G.1.2.2.6 and Section G.1.2.4. Section G.1.2.3 provides a discussion of the approach used for evaluating potential impacts from groundwater withdrawals for wells used to support construction of rail facilities. Section G.1.2.5 provides a discussion of the approach used for evaluating potential impacts from groundwater withdrawals for wells used to support development and operation of proposed quarries.

G.1.2.2.1 Infinite-Extent Unconfined Aquifer

For the case of an unconfined aquifer, the governing equation describing the relationship between the withdrawal rate of a well and the hydraulic head in the aquifer is (DIRS 105038-Bear 1979, eq. 8-24):

$$H_0^2 - h^2 = \frac{Q_w}{\pi K} \ln\left(\frac{R}{r}\right)$$

The terms are:

H_0 undisturbed saturated thickness, [Distance or Length (L)],

h saturated thickness at distance "r" from the well, [L],

K hydraulic conductivity, [Length/Time (L/T)], where T is time

Q_w withdrawal rate, [Volume (L^3)/T],

R radius of influence of the well, [L], and

r radial distance from the well, [L].

The saturated thickness (h) at distance "r" from the well, or h(r), is calculated as follows (DIRS 105038-Bear 1979, eq. 8-4 and Figure 8-4):

$$h(r) = \sqrt{H_0^2 - \frac{Q_w}{\pi K} \ln\left(\frac{R}{r}\right)}$$

The drawdown "s" at distance "r" from the well (DIRS 105038-Bear 1979, Figure 8-4), or s(r), is calculated using the expression for h(r),

$$s(r) = H_0 - h(r) = H_0 - \sqrt{H_0^2 - \frac{Q_w}{\pi K} \ln\left(\frac{R}{r}\right)}$$

When the hydraulic head at the face of the well is set to a given value ($h(r=r_w) = h_w$), the well capacity is obtained from the following relationship (DIRS 105038-Bear 1979, eq. 8-23):

$$H_0^2 - h_w^2 = \frac{Q_w}{\pi K}\ln\left(\frac{R}{r_w}\right) \qquad \text{or} \qquad Q_w = \frac{\pi K(H_0^2 - h_w^2)}{\ln\left(\frac{R}{r_w}\right)}$$

The drawdown "s_w" at the face of a well is a factor in both the capacity of the well and the extent of the well's radius of influence. This drawdown is generally not equal to the drawdown observed within the casing of the pumping well because of various head losses that take place near the well and within the well screened interval (perforated interval in well casing) and the sand pack (interval in the well bore annular space backfilled with sand). The magnitude of these losses depends mostly on the quality of well construction and characteristics of the water in the aquifer, and is difficult to estimate beforehand. Examples discussed in the literature (such as DIRS 116801-Driscoll, 1986, pp. 554 to 569) discuss aggregate well and head losses for typical wells resulting in effective well efficiencies from on the order of 50 to 85 percent. DOE assumed (conservatively) for these calculations that the useful drawdown, that is, the drawdown at the face of the well, would be equal to 85 percent of the maximum drawdown that could occur within the well casing. This assumption is based on engineering judgment. For an unconfined aquifer, the theoretical maximum drawdown within a well is equal to the undisturbed saturated thickness minus the length of the well screen ($s_{max} = H_0 - L$), assuming that the bottom of the screen is located at the bottom of the aquifer and that the screen is not exposed during well operation (these are typical practices when a well is screened in an unconfined aquifer). It is also assumed that the screen is long enough to accommodate the pump. The maximum useful drawdown (at the well face) is then:

$$s_w = 0.85\ (H_0 - L)$$

The radius of influence is defined as the distance from the well where the drawdown becomes insignificant and can be neglected. For wells deriving most of their groundwater flow from water from recharge in the area immediately surrounding the well, this radius of influence can be estimated based on mass balance considerations. However, this scenario is likely not applicable in much of the study area, where ***evapotranspiration*** rates generally exceed precipitation rates and/or recharge rates to aquifers are very low (in lower-elevation valley bottom areas) (DIRS 176502-Rush 1964, Table 10; DIRS 103136-Prudic, Harrill, and Burbey 1993, p. 2; DIRS 180759-Van Denburgh and Glancy 1970, p. 17 and Table 6; DIRS 169384-Reiner et al. 2002, Table 5). For wells assumed to derive most of their flow from the horizontal movement of water within the aquifer, as is typically the case in this analysis, empirical formulae were developed to estimate the radius of influence. Two such formulae are presented (DIRS 105038-Bear 1979, eqns. 8-11 and 8-12); note that units are meters and seconds and that s_w is the drawdown at the face of withdrawal well ($s_w = H_0 - h_w$):

$$R = 3{,}000\ s_w K^{1/2} \qquad \text{and} \qquad R = 575\ s_w (H_0 K)^{1/2}$$

DOE used the second of these two formulae in this analysis, because it is expressed in terms of aquifer transmissivity "$H_0 K$" and can be directly applied to cases involving both confined and unconfined aquifers. The first formula uses the hydraulic conductivity, which in the case of a confined aquifer, would have to be calculated by assuming a given thickness of the permeable zone, which may be unknown.

An example of a proposed water-supply area where DOE assumed an infinite-extent, unconfined alluvial aquifer case is well location SCV3 in the Stone Cabin Valley hydrographic area along proposed Caliente common segment 3. The SCV3 location lies in an area underlain by alluvial valley fill. The nearest mapped rock units are at least several miles from the proposed well site; therefore, an infinite-extent, alluvial aquifer is assumed.

Another example of a proposed water-supply well location where DOE assumed an infinite-extent unconfined aquifer is the proposed well location Cl-1A southwest of the community of Silver Peak in hydrographic area 143 (Clayton Valley) along the Mina rail alignment. This well location would be southwest of an existing well field that services Silver Peak. This well location and the corresponding analysis is a special case in that the proposed withdrawal rate at the Cl-1A well location is approximately 1,300 liters (350 gallons) per minute (gpm) or less. This withdrawal rate is higher than the anticipated withdrawal rate for other proposed new water-supply wells along the Mina rail alignment because groundwater underlying much of Clayton Valley is extremely brackish (DIRS 180760-Albers and Stewart 1972, p. 2) as a result of an existing mineral processing operation in the valley. Therefore, locations that could serve as sources of better-quality groundwater for use in rail roadbed construction and for supplying water for a proposed construction camp in this vicinity are very limited in this area.

G.1.2.2.2 *Infinite-Extent Confined Aquifer*

If the producing zone in the host aquifer occurs below a relatively thick, impermeable layer, such as a layer of clay, then the system could behave as a confined aquifer. For a confined aquifer, the relationship between the withdrawal rate of a well and the hydraulic head in the aquifer can be written as follows (DIRS 105038-Bear 1979, eq. 8-6):

$$s = \frac{Q_w}{2\pi T}\ln\left(\frac{R}{r}\right)$$

where the terms are:

T transmissivity T = H_0 K (undisturbed saturated thickness times the hydraulic conductivity) [L^2/T; where T is time].

s drawdown, [L],

Q_w withdrawal rate, [L^3/T],

R radius of influence of the well, [L], and

r radial distance from the well, [L].

For drawdown at the well face, the expression for well capacity becomes (DIRS 105038-Bear 1979, eq. 8-4):

$$Q_w = \frac{s_w 2\pi T}{\ln\left(\frac{R}{r_w}\right)}, \text{ where T is transmissivity}$$

The formula for the radius of influence used in these calculations for a confined aquifer is the same as that used for the unconfined case. As for the case of an unconfined aquifer, DOE assumed for these calculations that the useful drawdown (that is, the drawdown at the face of the well) would be equal to 85 percent of the maximum drawdown that could occur within the well casing. In the confined case, the theoretical maximum drawdown within the well is the distance between the static hydraulic head to the top of the permeable zone ($s_{max} = \varphi_0 - EL_{top}$). The maximum useful drawdown is then:

$$s_w = 0.85\ (\varphi_0 - EL_{top})$$

An example of a proposed water supply area where DOE assumed an infinite-extent confined alluvial aquifer case consists of the proposed set of new well locations HC5 and HC7 in the Hot Creek Valley hydrographic area along the Caliente rail alignment. The proposed well locations are considered infinite-extent confined because location HC5/HC7 is described as being mapped on alluvial valley-fill materials, the estimated total depth of the wells is 150 meters (500 feet), and it was considered possible that a relatively impermeable geologic layer, such as a clay unit, might be present above the targeted aquifer, which could lead to confined conditions.

G.1.2.2.3 Semi-Infinite-Extent Unconfined Aquifer

DOE assumed a semi-infinite-extent confined alluvial aquifer case for some proposed well locations where a single (linear) geologic boundary exists adjacent to the proposed well location(s) and assumed that this boundary might act as a no-groundwater-flow feature (flow barrier) that could affect groundwater flow characteristics in the aquifer surrounding the pumping well location(s). Geologic boundaries considered as representing potential no-flow boundaries include faults offsetting a geologic unit of likely low permeability (low hydraulic conductivity) from a geologic unit of likely higher permeability (higher hydraulic conductivity) or an unfaulted geologic contact between two such different geologic units. For these cases, the relationship between the withdrawal rate of a well and the hydraulic head in the aquifer can be calculated using the same formulae as for the infinite-extent unconfined aquifer described in Section G.1.2.2.1. However, in these cases, to account for this assumed adjacent no-flow boundary, the system is modeled by increasing the withdrawal rate in the pumping well by a factor of two to simulate the adjacent boundary. The "method of images" is used in this case to account for the possible no-flow boundary adjacent to the proposed well (DIRS 105038-Bear 1979, p. 356).

To simulate a no-flow boundary, an image pumping well is placed opposite the real pumping well on the other side of the boundary. The system simulating the pumping well and the boundary therefore consists of the real well and an image well, both equal in strength. Strictly speaking, a semi-infinite aquifer has two boundaries, and the far boundary should be treated in the same way. However, in most cases, this far boundary would be a great enough distance from the proposed well (in other words, the far boundary would lie beyond the radius of influence for the proposed pumping well) that the effects of this far boundary on the proposed pumping well would be negligible and can be ignored. Because the proposed well location is adjacent to one boundary and far enough away from the other boundary, a semi-infinite aquifer is considered. One can assume that in relation to the adjacent boundary, the proposed well is close enough to this no-flow boundary that the distance between it and its reflection (image well) across that boundary is negligible. Recall that the image well is equal in strength to the real well. Therefore, the system can be approximated by keeping only the real pumping well and increasing its extraction rate by a factor of two, which is the same as placing the image well right at the same location of the real well.

To solve for the radius of influence, the infinite-extent aquifer formula, unconfined in this case, can be used, but the pumping rate substituted in the equation must equal the actual pumping rate multiplied by two. Note that assuming an impervious boundary is conservative. In reality, geological boundaries would not be completely impervious and would provide some flow. This is especially true for cases where a fault occurs in alluvial valley-fill deposits. In such cases, the faulted zone/fault boundaries would not likely be completely impermeable to flow. This flow across the boundary would lessen the impact of the proposed well on the aquifer. Therefore, the assumption that such faults would act as completely impermeable barriers to flow is conservative; that is, this assumption would result in the determination of a greater amount of impact than might actually occur.

An example of a new well location where DOE assumed a semi-infinite-extent unconfined alluvial aquifer case is proposed new well location RrV8 (a quarry well) in the Railroad Valley South hydrographic area along the Caliente rail alignment. The proposed well location is situated in a valley-fill alluvial aquifer adjacent to mapped volcanic rock units. Section G.1.2.5 describes the methodology and approach used in the hydrogeologic impacts calculation performed for this location.

G.1.2.2.4 Semi-Infinite-Extent Confined Aquifer

DOE assumed a semi-infinite-extent confined alluvial aquifer case for some proposed new well locations where the same conditions occur that are described in Section G.1.2.2.3 except that the host aquifer is assumed to be confined rather than unconfined in nature. For the case of a semi-infinite-extent confined aquifer, the relationship between the withdrawal rate of a well and the hydraulic head in the aquifer can be calculated using the same formulae as for the infinite-extent confined aquifer described in Section G.1.2.2.2. However, as in the semi-infinite-extent unconfined aquifer case, DOE assumed that a (linear) no-flow boundary exists and that this no-groundwater flow feature lies adjacent to the proposed withdrawal well. To simulate the no-flow boundary, the "method of images" is used (DIRS 105038-Bear 1979, p. 356). Section G.1.2.2.3 provides a more detailed explanation concerning the use of "method of images" for a semi-infinite aquifer case. Because the no-flow boundary is adjacent to the pumping well location, the system is approximated by a real well and an image well, both at the same location and extracting groundwater at the same rate. Therefore, the formula for an infinite-extent confined aquifer is applicable, provided the pumping rate used in the formula is double the actual pumping rate (to account for the image well).

An example of a new well location where DOE assumed a semi-infinite-extent confined alluvial aquifer case is proposed new location PanV6/PanV3 in the Panaca Valley hydrographic area. The proposed well location is mapped in alluvial valley fill, and is adjacent to rock units variously characterized as "tuffaceous sedimentary rocks" or lakebed deposits (Panaca Formation). The lithologic makeup of these rock materials and available published information suggest that these rock materials might be either relatively permeable or relatively impermeable, depending on location. Based on this condition and the existing available hydrogeologic information for the area surrounding the proposed PanV6/PanV3 location, DOE assumed the host aquifer for well location PanV3/PanV6 to be a horizontal alluvial aquifer, semi-infinite in extent, and confined.

G.1.2.2.5 Carbonate and Volcanic Rock Aquifers

The hydrogeologic characteristics of carbonate rock aquifers and volcanic rock aquifers vary depending on their location within the areas that either the Caliente rail alignment or the Mina rail alignment would cross. Depending on factors such as the degree of fracturing or faulting, and degree of welding, volcanic rocks along the proposed rail alignments might be either relatively permeable to relatively impermeable, or even moderately permeable (transmissive) with respect to groundwater flow. Carbonate rock aquifers present within some areas of the proposed rail alignments are generally assumed to be relatively permeable due to fracturing and openings caused by dissolution (see DIRS 103136-Prudic, Harrill, and Burbey 1993, p. 13). In the hydrogeologic impact calculations, for those cases where the aquifer was assumed to be comprised of carbonate rock or permeable volcanic rock, DOE treated the aquifer as an equivalent porous media and used the same formulae as for the infinite-extent unconfined or confined aquifer cases (Sections G.1.2.2.1 and G.1.2.2.2 above).

DOE assumed a volcanic rock aquifer case at proposed new well location ASV6 in the Alkali Spring Valley hydrographic area. This proposed well location is in an area of mapped volcanic rock units and alluvial fan deposits with the target aquifer being a fractured volcanic rock unit, assumed to be overlain by a layer of alluvial fan materials (DIRS 176189-Converse Consultants 2006, Appendix B). An example of a new well location where DOE assumed a carbonate rock aquifer is proposed new location DLV4 for the Caliente rail alignment in the Dry Lake Valley hydrographic area. The proposed well location is in an area underlain by alluvial valley fill; however, a carbonate rock aquifer underlying the alluvial materials is assumed to be host aquifer for the well based on the characteristics of other wells installed in this area (DIRS 176189-Converse Consultants 2006, Appendix B).

G.1.2.2.6 Limited-Extent Unconfined Aquifer

DOE assumed a limited-extent unconfined aquifer case for some locations where multiple potential no-flow boundaries are located adjacent to the proposed new well location(s). A limited-extent aquifer case was assumed for proposed new well locations OV3, 4, 5, and 13 in the Oasis Valley hydrographic area (area 228). The Oasis Valley hydrographic area calculations assumed a wedge-shaped alluvial aquifer of limited extent because of the presence of different rock units along the sides of the wedge-shaped alluvium. In this case, it was assumed that the two lateral boundaries of the alluvial aquifer could represent geologic contacts with relatively impermeable volcanic rocks. At Oasis Valley, the source of water to Upper Oasis Valley Ranch Springs downgradient of the proposed well locations was assumed to be groundwater underflow derived from upgradient areas, possibly with some vertical inflow component.

DOE intended the approach taken in the limited-extent unconfined aquifer calculations to be very conservative, because the lateral boundaries likely are not true no-flow boundaries. Available information suggests that at both locations there is likely to be some hydraulic connection between the alluvium and adjacent rock units, which would support an assumption that at least some groundwater underflow from adjacent rock units to the alluvial aquifer would occur (see DIRS 169384-Reiner et al. 2002, pp. 8 to 10 for the case of the Oasis Valley calculations).

At Oasis Valley, DOE assumed an upper-bound limiting pumping rate at the proposed wells that would not affect discharge rates at existing springs downgradient of the proposed new well locations. To evaluate the potential impact of such pumping on existing spring discharges, two criteria must be considered: the radius of influence and the relative percentage of the withdrawal rate to total aquifer discharge. In this evaluation, DOE assumed the total discharge from springs to be similar to the aquifer discharge, which is a conservative assumption because the total spring discharge would represent the lowest possible aquifer discharge (given that evapotranspiration is a significant component of aquifer discharge). Because DOE assumed a limited-extent aquifer, it was necessary to establish an upper bound for the pumping rate to ensure that the proposed groundwater withdrawal would not impact aquifer conditions enough to alter water levels throughout the aquifer. In this calculation, DOE estimated that the maximum pumping rate at the proposed groundwater pumping wells should be at least an order of magnitude (a factor of 10) lower than the total discharge from the limited-extent aquifer (assumed to be the total discharge rate from the springs in the alluvium). With this constraint, DOE then calculated a radius of influence for each proposed new well location and compared these calculated radii of influence to the distances separating each proposed new well location and the nearest existing spring to show that these calculated radii of influence would be valid and representative indicators of the extent of impact at each proposed pumping location, and demonstrate that existing springs should not be affected by the proposed groundwater withdrawals.

G.1.2.2.7 Treatment of Faults and Major Fracture Systems

For a selected set of new groundwater withdrawal well locations, the proposed new well was determined to be located in the vicinity of one or more faults or extensive fracture systems or was found to be specifically targeted for installation directly within a major fault zone or an extensive fracture zone (DIRS 176189-Converse Consultants 2006, Appendix B). For such cases, additional evaluations of hydrogeologic data and/or additional analyses were performed.

In cases where a proposed well was determined to be oriented lateral to a mapped fault trace or fracture zone trace, the fault or fracture zone was treated as a potential no-flow barrier if it was located sufficiently close to the proposed new well to be within the region of influence from pumping at that well location. In such cases, the calculations included a specific method (method of images as described in Section G.1.2.2.3) to simulate the potential effects of the fault or fracture zone on groundwater flow behavior.

Hydraulic tests performed in faulted and fractured consolidated rock aquifers at a few wells in the region of the Nevada Test Site and Yucca Mountain indicate that high-permeability zones associated with faults are capable of acting as conduits for transmitting hydraulic responses from pumping wells over larger-scale (on the order of kilometers) distances if the pumping well draws its water from the fault zone. These effects have been observed for both faulted and fractured volcanic rock and faulted and fractured carbonate rock aquifers (DIRS 181896-Stoller-Navarro 2005, Section 2.0; DIRS 129721-Geldon et al. 1998, pp. 23 to 24 and p. 31). Results from pump tests conducted at these wells often indicate that very complex hydrogeologic conditions, including heterogeneous hydraulic rock properties, the presence of complex structural systems controlling flow, and other non-isotropic conditions, exist at these test sites. For these reasons, where a proposed new well was initially identified as targeting a specific fault or fracture system that might be capable of acting as a high-permeability conduit, DOE identified the locations of existing wells and springs up to 10 kilometers (6.2 miles) away from each such proposed well. In these cases, DOE reviewed available data on existing wells and springs and locations of known (mapped) fault and fracture zone traces within the 10-kilometer radius surrounding each new well location and compared these with the locations of the proposed well to estimate the likelihood of a hydraulic connection occurring between the proposed well and existing wells and springs beyond a distance of 2.4 kilometers (1.5 miles) but within the approximately 10-kilometer distance. If sufficient evidence was found that a proposed new well would likely intercept a fault/fault zone, and that an existing well or spring within the 10-kilometer search distance could likely be hydraulically connected to the proposed withdrawal well withdrawal zone, potential impacts to the nearest such well or spring caused as a result of the proposed withdrawal were assessed. Tables G-3 and G-4 summarize those proposed new well locations for the Caliente and Mina rail alignments, respectively, where a fault or fault zone was initially targeted as a potential water-bearing zone for a new well.

G.1.2.3 Groundwater Withdrawals for Construction of Rail Facilities and Sidings

Water needs and required groundwater well withdrawal rates associated with construction of rail facilities and sidings are small compared to the amount of water required to support construction of the rail line. Construction of the Cask Maintenance Facility would require approximately 4,400 cubic meters (approximately 3.6 acre-feet, or 1.176 million gallons) of water, with construction estimated to occur over approximately 2 years (DIRS 104508-CRWMS M&O 1999, Table III-2). The amount of water needed to construct the other facilities (Staging Yard, Maintenance-of-Way Facilities, and the Rail Equipment

Table G-3. Proposed new well locations where a fault or fault zone was initially identified as a targeted water-bearing zone – Caliente rail alignment.

Well location identification	Rail line segment
PanV14/PanV16	Common segment 1
DLV2, DLV3, DLV4, and DLV6	Common segment 1
PahV1 and PahV2	Common segment 1
PahV5 and PahV8	Common segment 1
StF10	Goldfield alternative segments
LV5/LV13	Goldfield alternative segments
LV8/LV19	Goldfield alternative segments
OV7/OV15	Common segment 6
OV22/OV23	Common segment 6

Table G-4. Proposed new well locations where a fault or fault zone was initially identified as a targeted water-bearing zone – Mina rail alignment.

Well location identification	Rail line segment
BSa-3a	Mina common segment 1/Montezuma alternative segments 2 and 3
WLa-1c	Department of Defense Branchline North/Schurz alternative segment 4/Department of Defense Branchline South
CSM-2a	Mina common segment 1
As-2a and AS-3a	Montezuma alternative segment 1
OV7/OV15	Common segment 6
OV22/OV23	Common segment 6

Maintenance Yard) would range from approximately 14,000 to 200,000 cubic meters, which is equivalent to 11.5 to 161.1 acre-feet, or 3.75 to 52.5 million gallons (DIRS 180873-Nevada Rail Partners 2007,Table 2-2; DIRS 180919-Nevada Rail Partners 2007, Section 3.1.5). When compared to the total amount of water needed for railroad construction, and compared to existing groundwater resources in the respective hydrographic areas where the facilities would be constructed, the direct short-term impacts to groundwater resources in the respective hydrographic areas due to water withdrawals associated with construction of facilities and sidings would be small and long term. Direct and indirect impacts on groundwater resources also would be small. For this reason, DOE did not perform quantitative impact analyses for water wells that would be used (for example, at proposed base-case withdrawal rate) solely to support construction of these facilities and sidings (DIRS 176189-Converse Consultants 2006, Appendixes A and B; DIRS 180888-Converse Consultants 2007, Appendixes A through X).

G.1.2.4 Sensitivity Analysis

G.1.2.4.1 Caliente Rail Alignment

The productivity of the proposed wells would vary depending on a number of variables, including aquifer depth, aquifer lithology, permeability, well efficiency, degree of cementing or fracturing present in the host aquifer, the presence or absence of nearby faults or flow boundaries, or other factors. Therefore, it might be necessary to use one or more highly productive wells rather than all proposed wells within each hydrographic area. Higher withdrawal rates at one or more highly productive wells could help fulfill more of the required water demand within a hydrographic area if other wells had lower-than-expected productivities. It should be noted that the temporary nature of the construction water wells would require that short-term higher withdrawal rates be only temporarily imposed. This factor would help reduce potential long-term impacts of increased withdrawal at the applicable higher-productivity locations.

To allow for possible uncertainties in future well productivities and withdrawal rates, DOE considered the possibility of using more highly productive wells and performed sensitivity analyses to evaluate the degree of increased impacts expected to result from the imposition of higher (in other words, higher short-term or peak) withdrawal rates at such more productive water-well locations. For planning purposes, DOE assumed that a maximum withdrawal rate of 0.014 cubic meter (0.5 cubic foot) per second (approximately 852 liters [225 gallons] per minute) might, at least in theory, be imposed at any of the proposed new well locations (with the exception of proposed quarry wells, as described in Section G.1.2.5). Table G-5 lists the proposed new well locations where DOE performed sensitivity analysis calculations. The methodologies and analytical equations used for completing these sensitivity analyses are the same as described in Section G.1.2.2.

Table G-5. Proposed new well locations pumped at higher groundwater withdrawal rates (sensitivity analysis) for which DOE performed groundwater impacts analyses – Caliente rail alignment.

Name of proposed well	Hydrographic area number	Hydrographic area name	Alternative segment/ common segment
ClV2	204	Clover Valley	Eccles/common segment 1
PanV1	203	Panaca Valley	Eccles/common segment 1
PanV4	203	Panaca Valley	Caliente/common segment 1
PanV5	203	Panaca Valley	Caliente/common segment 1
PanV2/PanV24	203	Panaca Valley	Eccles/common segment 1
PanV6/PanV3	203	Panaca Valley	Eccles/common segment 1
PanV25/PanV26	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
PanV7/PanV8	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
PanV9/PanV10/PanV11/PanV12	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
PanV13/PanV15	203	Panaca Valley	Eccles/common segment 1 Caliente/common segment 1
DLV3	181	Dry Lake Valley	Common segment 1
DLV4	181	Dry Lake Valley	Common segment 1
PahV1/PahV2/PahV3	208	Pahroc Valley	Common segment 1
PahV7/PahV8/PahV9	208	Pahroc Valley	Common segment 1
GV2	172	Garden Valley	Garden Valley 2
GV10	172	Garden Valley	Garden Valley 1
RrV5	173A	Railroad Valley South	Common segment 2/South Reveille 3/common segment 3
RrV6/RrV11	173A	Railroad Valley South	Common segment 2/South Reveille 2/South Reveille 3/common segment 3
HC4	156	Hot Creek Valley	Common segment 3
HC5/HC7	156	Hot Creek Valley	Common segment 3
SCV3	149	Stone Cabin Valley	Common segment 3
SaF1/SaF2	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5
SaF4	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5
SaF5/SaF9	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5, Bonnie Claire 2/common segment 5
SaF7/SaF11	146	Sarcobatus Flat	Bonnie Claire 3/common segment 5, Bonnie Claire 2/common segment 5
OV9	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6
OV24/OV25/OV26	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6
OV12/OV18/OV19/OV20/OV21	228	Oasis Valley	Common segment 5/Oasis Valley 3/common segment 6
OV14/OV16/OV6/OV8	228	Oasis Valley	Common segment 5/Oasis Valley 1/common segment 6

DOE evaluated potential impacts on existing wells and existing springs caused by these higher-withdrawal-rate wells by evaluating the size of the radius of influence induced by pumping at the hypothetical higher withdrawal rate. DOE applied the same types of equations to the nearest existing well with a water right located nearest to each higher-withdrawal-rate well to calculate the estimated radius of influence induced by pumping at the existing well. The geology and hydrogeology associated with existing and proposed wells were evaluated to identify the appropriate flow equations in the same manner as described in Sections G.1.2.2.1 and G.1.2.2.2. In these sensitivity analysis calculations, pumping-rate assumptions used for existing wells were derived from annual duty (appropriated annual duty) and diversion rate data contained in the NDWR Water Rights Database.

G.1.2.4.2 Mina Rail Alignment

Sensitivity analyses were not required for well locations proposed for the Mina rail alignment. Calculations performed for evaluating groundwater impacts for the proposed Mina well locations initially assumed a maximum pumping rate expected to be applied at each location, approximately 852 liters (225 gallons) per minute, which is identical (with the exception of proposed new well location Cl-1a, where a withdrawal rate of approximately 1,300 liters [350 gallons] per minute or less was assumed) to the potentially higher withdrawal rate value used in each sensitivity analysis calculation completed for the Caliente alignment well locations.

G.1.2.5 Quarry Water Wells

G.1.2.5.1 Caliente Rail Alignment

The construction impacts assessments also included the evaluation of the potential impacts from pumping at new water wells proposed to support quarry operations along the Caliente rail alignment. DOE considered the potential for impacts to occur resulting from proposed groundwater withdrawals from the proposed quarry water well locations for both the Caliente and Mina rail alignments. Based on the review of the available information, DOE completed impacts analysis calculations for the following proposed quarry well locations:

- One water well (PanV23) associated with a potential quarry northwest of the community of Caliente in hydrographic area 203 in Lincoln County
- Up to two water wells (RrV8 and RrV10) associated with a potential quarry northeast of the South Reveille alternative segments 2 and 3 in hydrographic area 173A in Nye County
- Up to two water wells (AsV6 and AsV7) associated with a potential quarry in hydrographic area 142 in Nye County

Each quarry would operate for approximately 2 years following an initial startup period. Water consumption rates during the period of use of quarries have been estimated at approximately 90.8 liters (24 gallons) per minute, which is equivalent to approximately 131,000 liters (34,560 gallons) per day (DIRS 180888-Converse Consultants 2007, Table 2-4). The *Hydrogeologic DEIS Analysis Report, REV. 0, April 10, 2006* (DIRS 176189-Converse Consultants 2006, all) provides details pertaining to the characteristics and use of the water wells that would be associated with these potential quarry sites. DOE performed impacts analysis calculations for potential quarry wells PanV23, RrV8, and AsV6. An example of the methodology used for a quarry well impact calculation (for proposed well RrV8) is summarized below.

For proposed well site RrV8, DOE proposes a 90- to 120-meter (300- to 400-foot)-deep quarry well and anticipates that this well would be used to supply water at a withdrawal rate of 91 liters (24 gallons) per minute over approximately a 2-year period following an initial startup period (DIRS 176189-Converse

Consultants 2006, Appendix A). Based on geologic information for this area, the well would likely be screened in an alluvial aquifer adjacent to volcanic rock units. Available published information suggests that the volcanic rock materials might be either relatively permeable or relatively impermeable, depending on location. DOE assumed a semi-infinite-extent unconfined alluvial aquifer wherein the adjacent volcanic unit (lava-flow unit) was assumed to be an essentially impermeable rock unit. Based on hydrogeologic information for the area surrounding the proposed RrV8 well location, the host aquifer for the well location RrV8 was assumed to be a horizontal alluvial aquifer and unconfined. The semi-infinite aquifer case is considered to be conservative because the adjacent volcanic rock unit is not likely to be completely impermeable.

Because the potential quarry sites are typically located in bedrock-dominated terrain, wells installed near the quarry sites would be expected to be lower-productivity wells and, therefore, groundwater withdrawal rates at quarry water wells would not be expected to vary significantly from the specified average withdrawal rate of 91 liters (24 gallons) per minute. Therefore, DOE did not perform additional sensitivity analyses for the quarry water wells to assess any increased impacts that might result from imposing higher withdrawal rates at these well sites.

G.1.2.5.2 Mina Rail Alignment

The construction impacts assessments also included the evaluation of the potential impacts from pumping at new water wells proposed to support quarry operations along the Mina rail alignment. DOE evaluated impacts from one proposed quarry water well, WLc-2a, associated with a potential quarry in Garfield Hills in hydrographic area 110C in Mineral County. Each quarry used to support construction of the Mina alignment would operate for approximately 2 years following an initial startup period. The *Hydrogeologic DEIS Analysis Report, REV. 0, April 27, 2007* (DIRS 176189-Converse Consultants 2007, all) provides details pertaining to the characteristics and use of the water wells that would be associated with these potential quarry sites. Section G.1.2.5.1 provides an example of the methodology used for a quarry well impact calculation (for a proposed quarry well at location RrV8 along the Caliente rail alignment).

G.1.3 OPERATIONS IMPACTS ASSESSMENT

G.1.3.1 Caliente Rail Alignment

G.1.3.1.1 Overview

The operations impacts assessment included estimating groundwater-supply impacts associated with operation of the rail line and railroad construction and operations support facilities.

G.1.3.1.2 Facility Operations

Permanent facilities considered include the Staging Yard, the Maintenance-of-Way Facility, the Maintenance-of-Way Headquarters Facility, the Rail Equipment Maintenance Yard, the Cask Maintenance Facility, Facilities at the Interface with the Union Pacific Railroad Mainline, and rail sidings. These would be permanent facilities corresponding to an assumed railroad operations phase of up to 50 years.

G.1.3.1.3 Evaluation of Potential Hydrogeologic Impacts

Details on the water requirements activity and groundwater impacts at the rail operations facilities are provided in the *Facilities–Design Analysis Report Caliente Rail Corridor, Task 10: Facilities, Rev. 03* (DIRS 180919-Nevada Rail Partners 2007, Section 3.1.5). These facilities would require only limited amounts of water, with water required for operations estimated to range from approximately 9,500 to

23,000 liters (2,500 to 6,000 gallons) per day at the facilities, which is equivalent to approximately 6 to 16 liters (1.7 to 4.2 gallons) per minute. Operations water requirements were derived from estimated staffing and shift projections, a 190-liter per day (50-gallon per day) per capita use ratio, estimated shop process needs, and a multiplier of 1.5 to account for miscellaneous water needs (DIRS 180873-Nevada Rail Partners 2007, Section 3.1.5; DIRS 180919-Nevada Rail Partners 2007, Section 3.1.5). Water needed for meeting emergency water storage capacity requirements (for fire safety) are estimated to range from approximately 379,000 to 833,000 liters (100,000 to 220,000 gallons). Water needs for meeting water storage requirements at each facility could be readily met using a new low-productivity well. Because the well withdrawal rates (approximately 16 liters [4.2 gallons] per minute or less) required to support operation of these railroad operations support facilities are relatively low (DIRS 180919-Nevada Rail Partners 2007, Table 3-B), the magnitude of impacts on the host aquifers for the individual facility water-supply wells would be expected to be small. For this reason, DOE did not perform quantitative impacts analyses for water wells that would be used (for example, at proposed base-case withdrawal rate) solely to support operation of these facilities.

G.1.3.2 Mina Rail Alignment

G.1.3.2.1 Overview

The operations impacts assessment included estimating groundwater-supply impacts associated with operation of the rail line and railroad construction and operations support facilities.

G.1.3.2.2 Facility Operations

Permanent facilities considered include the Staging Yard at Hawthorne in hydrographic area 110C, the Maintenance-of-Way Facility at either Silver Peak in hydrographic area 143 or Klondike in hydrographic area 142, the Rail Equipment Maintenance Yard in hydrographic area 227A, and proposed sidings in several hydrographic areas. These would be permanent facilities corresponding to an assumed railroad operations period of up to 50 years.

G.1.3.2.3 Evaluation of Potential Hydrogeologic Impacts

Similar to the case for the Caliente rail alignment, DOE did not perform quantitative impact analyses for water wells that would support facilities operations or sidings. The reason for not performing quantitative analyses is the same as for the Caliente alignment – because required well withdrawal rates for wells supporting operations of facilities and sidings are very small, the magnitude of short-term or long-term impacts on the host aquifer for the individual facility water wells would be small.

G.2 Shared-Use Option

G.2.1 CONSTRUCTION IMPACTS ASSESSMENT – CALIENTE RAIL ALIGNMENT

Under the Shared-Use Option, additional commercial access sidings would be constructed as a third track alongside passing sidings. However, the total length of the additional sidings would be relatively short in comparison to the total length of the rail line. The water requirement for construction of the rail line under the Shared-Use Option would only increase by approximately 150,000 cubic meters (122 acre-feet), or approximately 2 percent, compared to the total estimated likely water demand of 7.52 million cubic meters (6,100 acre-feet) for construction of the rail line without shared use.

For purposes of this analysis, DOE assumed that the commercial access sidings would be in the same hydrographic areas the Caliente rail alignment would cross. Therefore, additional impacts to groundwater features in these areas would likely be small, given that the additional water requirement under the Shared-Use Option represents only a small portion of the total water demand for construction of the rail line without shared use. The overall impacts to groundwater resources in these areas would be similar to the impacts described in Section G.1.2.3.

Commercial-use facilities under the Shared-Use Option would likely be constructed close to the DOE-owned and -operated rail facilities and so would likely overlie the same hydrographic areas as the DOE facilities. Therefore, additional impacts to groundwater features in these areas as a result of construction of facilities under the Shared-Use Option would also be small. The overall impacts would be similar to the impacts described in Section G.1.2.3.

G.2.2 OPERATIONS IMPACTS ASSESSMENT – CALIENTE RAIL ALIGNMENT

Groundwater impacts for railroad operations along the Caliente rail alignment under the Shared-Use Option would be similar to those identified in Sections G.1.3.1 and G.1.3.2. Impacts to groundwater from operation of additional sidings would be small. There would be no continued need for water along the additional sidings, and possible changes to recharge, if any, would be the same as those at the completion of construction.

Commercial-only facilities would require water for daily operations. Water demand to operate these facilities has not yet been identified, but DOE assumes it would be small. Therefore, additional impacts to groundwater features would likely be small, and the overall impacts would be similar to those described in Section G.1.3.

G.2.3 CONSTRUCTION IMPACTS ASSESSMENT – MINA RAIL ALIGNMENT

Under the Shared-Use Option, additional commercial access sidings would be constructed as a third track alongside passing sidings. However, the total length of the additional sidings would be relatively short in comparison to the total length of the rail line. The water requirement for the construction of the rail line under the Shared-Use Option would only increase by approximately 147,000 cubic meters (119 acre-feet), or approximately 2 percent, compared to the total estimated likely water demand of 7.34 million cubic meters (5,950 acre-feet) for construction of the rail line without shared use.

For purposes of this analysis, DOE assumed that the commercial access sidings would be in the same hydrographic areas the Mina rail alignment would cross. Therefore, additional impacts to groundwater features in these areas would likely be low, given that the additional water requirement under the Shared-Use Option represents only a small portion of the total water demand for construction of the rail line without shared use. The overall impacts to groundwater resources in these areas would be similar to the impacts described in Section G.1.2.3.

Commercial-use facilities under the Shared-Use Option would likely be constructed close to the DOE-owned and -operated rail facilities and would likely overlie the same hydrographic areas as the DOE facilities. Therefore, additional impacts to groundwater features in these areas would also be small. The overall impacts would be similar to the impacts described in Section G.1.2.3.

G.2.4 OPERATIONS IMPACTS ASSESSMENT – MINA RAIL ALIGNMENT

Groundwater impacts for railroad operations along the Mina rail alignment under the Shared-Use Option would be similar to those identified in Sections G.1.3.1 and G.1.3.2. Impacts to groundwater from operation of additional sidings would be small. There would be no continued need for water along the additional sidings, and possible changes to recharge, if any, would be the same as those at the completion of construction.

Commercial-only facilities would require water for daily operations. Water demand to operate these facilities has not yet been identified, but DOE assumes it would be small. Therefore, additional impacts to groundwater features would likely be small, and the overall impacts would be similar to those described in Section G.1.3.

G.3 Glossary

aquitard	A confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.
cone of depression	The lowering of the water table in a cone-shaped depression around a pumped well.
evapotranspiration	The combined process of evaporation and transpiration. Evaporation is water loss to the atmosphere from sources such as soil, canopy interception, and water bodies; transpiration refers to the movement of water vapor from a plant to the air through the plant's stomata or leaves.
leaky aquifer	An aquifer that has an ***aquitard*** either above or below that allows water to leak into or out of the aquifer depending on the direction of the hydraulic gradient.
radius of influence	The distance from the well where the drawdown becomes insignificant and can be neglected.
screened	The portion of a well that is screened is the interval in the well where the casing contains slots to let in the water from the primary (most productive) water-bearing zone or zones.

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147766	Thiel 1999	Thiel Engineering Consultants 1999. Data Assessment & Water Rights/Resource Analysis of: Hydrographic Region #14 Death Valley Basin. Reno, Nevada: Thiel Engineering Consultants. ACC: MOL.19990218.0214.
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APPENDIX H

BIOLOGICAL RESOURCES

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ACRONYMS AND ABBREVIATIONS

BLM	Bureau of Land Management
DOE	U.S. Department of Energy
FWS	U.S. Fish and Wildlife Service
GPS	Global Positioning System
NDOW	Nevada Department of Wildlife
NNHP	Nevada Natural Heritage Program
HMA	herd management area

APPENDIX H

BIOLOGICAL RESOURCES

This appendix supports the descriptions of the affected environment for biological resources in Chapter 3 and the impacts analyses in Chapter 4 of the Rail Alignment EIS (DOE/EIS-0369). It describes the field survey methods and other technical data that support the biological resource analysis described in those chapters.

H.1 Introduction

Sections H.2 through H.5 of this appendix summarize the research and field methods the U.S. Department of Energy (DOE) used to compile information necessary to assess potential impacts on biological resources from implementation of the Proposed Action along either the Caliente rail alignment or the Mina rail alignment, and presents the information resulting from those varied efforts. Generally, this information is organized by biological resource.

This appendix summarizes information from previous studies and documents such as the *Environmental Baseline File for Biological Resources* (DIRS 104593-CRWMS M&O 1999, all), applicable BLM resource management plans, conservation plans for various species or communities, and other similar documents. Additionally, the appendix summarizes information obtained from BLM institutional knowledge (such as noxious and invasive weed locations and wild horse and burro herd management areas), Nevada Department of Wildlife institutional knowledge (including big game species distributions and habitat requirements), Nevada Natural Heritage Program occurrence database (DIRS 182061-NNHP 2005, all) of protected and sensitive species, the Southwest Regional Gap Analysis Project (SWReGAP) data of land cover (DIRS 174324-NatureServe 2004, all), and other similar data. The appendix also includes descriptions of the methods DOE used during field observations for vegetation, special status species, game species, and wild horses and burros. Figure H-1 shows survey locations along the Caliente rail alignment; Figure H-2 shows field observation points along the Mina rail alignment.

H.2 Vegetation

H.2.1 METHODS

H.2.1.1 Research

Prior to field surveys, DOE identified existing information regarding the occurrence and distribution of plant communities within the Caliente rail alignment and Mina rail alignment study areas (8 kilometers [5 miles] on either side of the centerline of the proposed rail alignment; a total width of 16 kilometers [10 miles]). This effort included literature searches and consultations with federal and state agencies including the U.S. Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (FWS), the Nevada Natural Heritage Program (NNHP), the Nevada Department of Wildlife (NDOW), and the Nevada Division of Forestry.

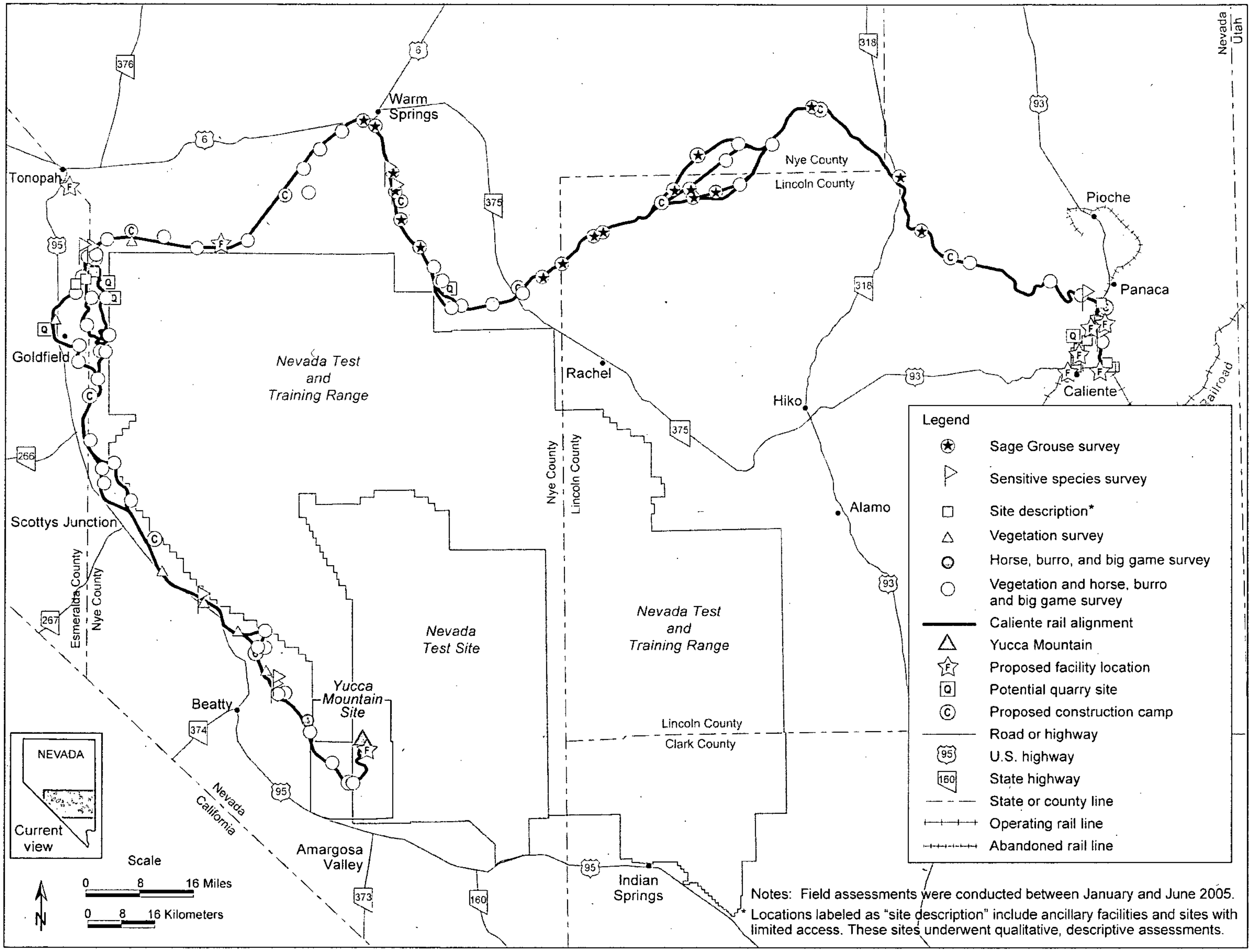

Figure H-1. Survey locations for biological resources along the Caliente rail alignment.

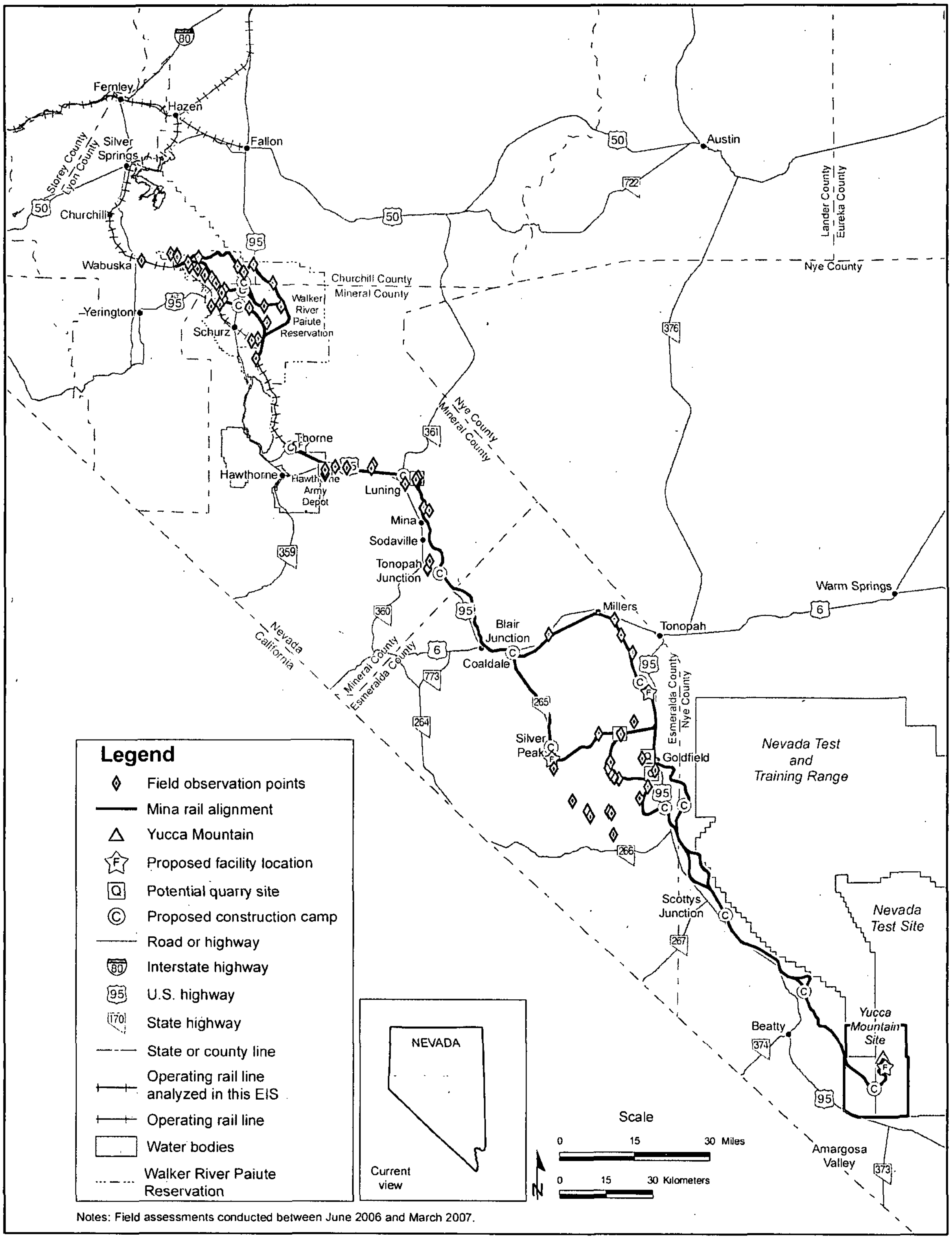

Figure H-2. Field observation points for biological resources along the Mina rail alignment.

DOE also obtained spatial data, in digital and print form, from the BLM, the Nevada Department of Wildlife, the Nevada Natural Heritage Program, the University of Nevada, Reno, and other sources, for computer-based and paper-based evaluation of biological resources within the study area. DOE assessed plant communities within the study area of the rail alignments and rail line construction and operations support facilities using the 2004 SWReGAP (DIRS 174324-NatureServe 2004). The SWReGap is a multi-institutional cooperative mapping and assessment of biodiversity within Arizona, Utah, Nevada, New Mexico, and Colorado and provides digital land-cover maps that contain plant community distribution data. This dataset also provides information about the existing natural vegetation to the level of dominant or codominant plant species, public and private land ownership, and management and conservation land status. DOE overlaid this information, in conjunction with digital, orthographically corrected, aerial photos (DIRS 174497-Keck Library 2004, all), onto maps of the two rail alignments and associated facilities and used to it identify unique vegetation communities within the study area (such as sagebrush and riparian), and identified areas where there could be sensitive species.

DOE then conducted field surveys in the study area along the proposed Caliente and Mina rail alignments to characterize the existing SWReGAP (DIRS 174324-NatureServe 2004) land-cover analyses in locations that closely represent the land-cover types. DOE also surveyed areas that are considered unique relative to the region, such as riparian habitat, playas, and sand dunes. Locations were also chosen to provide a relatively consistent survey among alternative segments, in order to adequately compare the alternative segments for the impact analysis.

H.2.1.2 Field Surveys

Caliente Rail Alignment

Field surveys for the proposed Caliente alignment included 72, 200-meter (660-foot)-long vegetation transects in which plant species were formally identified and the composition of plant communities was quantitatively assessed. The vegetation transects were located at various intervals along the entire proposed Caliente rail alignment, including all common segments and all alternative segments.

In addition to quantitative assessments, qualitative field observations were made at many of the sites where formal transect-based surveys were conducted and at other locations where no transects were established, including areas where limitations such as private property prevented access. These qualitative site descriptions typically consisted of a visual assessment of vegetation, landform, land use and level of disturbance, physical relationship to the proposed rail alignment, and the presence of water or evidence of the influence of water on the habitat.

DOE performed vegetation surveys along the proposed Caliente rail alignment from February 4 through March 11, 2005, from May 5 through May 7, 2005, on June 7 and 8, 2005, and from January 23 through January 27, 2006. Before conducting the 2005 vegetation surveys, and periodically throughout the course of the 2005 field surveys, Dr. Kent Ostler, an expert in regional plant ecology, provided survey personnel with guidance in the field regarding regional plant ecology and identification (DIRS 174634-Thebeau and Huenefeld 2005, p. 2). Surveys conducted in 2006 were performed by a qualified biologist following the same research methods and field survey protocols as outlined in this appendix.

DOE conducted vegetation sampling along a transect or straight line of 200 meters (660 feet) parallel to the proposed location of the rail alignment. The bearing or direction of each transect was determined using a geographic positioning system receiver or a compass. After establishing the starting point and the bearing of a transect, a 1-square-meter (11-square-foot) plot was sampled every 20 meters (66 feet), resulting in 10 sample plots or quadrats. In most cases, a wooden stake was driven into the ground to semi-permanently mark the location of the start and end of a transect. Photos and geographic positioning system location surveys were taken at the beginning and end of each transect.

Field personnel recorded vegetation survey data on the two-page data sheet used for vegetation assessments shown in Figure H-3. Trees, shrubs, cacti, invasive and noxious plants, and most grasses were identified by genus or species, whereas non-weed forb species were recorded as forbs, and lumped together. For each species identified within the quadrat, field personnel estimated the percent of the quadrat covered by that species and recorded that information on data sheets. Field personnel also recorded the percent cover for dead plant material, mosses, rock, and cryptobiotic soil crust (a crust formed by cyanobacteria, lichens, and mosses over the surface of the soils). The total percent cover in a quadrat could add to more than 100 due to overlap. Field personnel collected samples and took photographs of unrecognized plant species for subsequent identification. General descriptions of the landform, the slope, aspect, land use of the site (grazing, mining, wilderness), and the type of plant community present on the site were also recorded. The general description was used to identify the presence of indicator or key species present but occurring scattered and outside of transects. Such species included Joshua tree (*Yucca brevifolia*), Utah juniper (*Juniperus osteosperma*), and singleaf pinyon (*Pinus monophylla*).

Mina Rail Alignment

DOE performed field surveys along the proposed Mina rail alignment and associated facility and quarry locations during three separate field visits: June 12 through 15, 2006; December 11 through 13, 2006; and March 26-29, 2007. Surveys consisted of a visual assessment of vegetation, land use, disturbance, water resources, and potential habitat for wildlife and special status species within the study area.

General field observation points were taken at locations along the alignment where there was an obvious change in the landscape and/or land-cover type, and at "micro-site" locations. Micro-sites are small vegetative or physically dissimilar areas that occur within a larger continuous community type (such as rock outcrops, playas, vegetated sand dunes [Figure H-2]).

A list of special status species was provided by the Nevada Natural Heritage Program Database (DIRS 182061-NNHP 2005, all). These historical occurrences were overlaid on topographic maps of the project area and assessed in the field for the potential occurrence of special status species. Habitat assessment points were documented using Global Positioning System (GPS), photography, and data forms.

The assessment included identifying all plant species present and determining community type based on primary and secondary composition of plant species. In addition, the assessment used general observations of the landscape, including slope, aspect, elevation, land use, and any wildlife observations.

Special status species and any areas determined to be micro-sites were used to establish the specific survey locations along the proposed rail alignment and quarry sites.

H.2.1.3 Impact Analysis

DOE assessed potential adverse impacts on vegetation communities as a result of the Proposed Action described in Chapter 2 of the Rail Alignment EIS, which were based on the review of SWReGAP data and field observations. Direct long-term impacts include the loss of vegetation and fragmentation of vegetation communities and were assessed using Geographic Information System vegetation and construction datasets, and a Geographic Information System process called Intersect was used to quantify the amount of specific land-cover types that would be removed in relation to rail line, facility, and quarry footprints. Indirect short-term impacts were assessed using the same methods, however calculations for

TRANSECT ID:	DATE (mm/dd/yy):	RECORDER:	OBSERVERS:	LOCATION:	TRANSECT BEARING:

	GPS FILENAME - START:					
Coordinates	WAYPOINT	UTM N	UTM E	PDOP	WAAS USED?	ELEVATION
START TRANSECT					yes / no	
END TRANSECT					yes / no	
	GPS FILENAME - END (if different):					

TRANSECT START PHOTO:	TRANSECT END PHOTO:

SLOPE:	ASPECT:	LANDFORM (elaborate in Notes section): Valley Flat Toe Slope/Alluvuial Fan Slope Cliff/Scarp Other	LAND USE: Wilderness Mining Recreation Grazing Transportation Plowed Fields Urban/Developed Other

SW REGAP CLASS:

ESTIMATED DOMINANT SPECIES:

	NAME/CODE	EXTENT*	WAYPOINT	UTM N	UTM E	PDOP	WAAS	ELEVATION
Sensitive Species 1							yes / no	
Sensitive Species 2							yes / no	
Sensitive Species 3							yes / no	
* Categories for sens spp and inv/nox spp extent: Solitary, Few Clumped, Few Scattered, Many Clumped, Many Scattered, Dense, Other								
Invasive/Nox Species 1							yes / no	
Invasive/Nox Species 2							yes / no	
Invasive/Nox Species 3							yes / no	

NOTES:

Figure H-3. Vegetation data sheet (page 1 of 2).

TRANSECT ID:	DATE (mm/dd/yy):	RECORDER:	LOCATION:	TRANSECT BEARING:

QUADRAT NUMBER	1	2	3	4	5	6	7	8	9	10	NOTES/PHOTOS
SPECIES											
Forbs											
Litter											
Crypto											
Bare											

NOTES:

Figure H-3. Vegetation data sheet (page 2 of 2).

short-term impacts included the area from the toe of slope to the edge of the construction right-of-way and is outside of the rail line, facility, and quarry footprints. They are considered short-term impacts because DOE would minimize disturbance within the construction right-of-way and would mitigate or restore disturbed areas not used during the operations phase.

The magnitude of impact was determined based on the SWReGAP dataset. A small impact to vegetation would neither destabilize nor noticeably alter a specified land-cover type and would not affect the overall function or viability of the plant community. A moderate impact would noticeably alter a specific land-cover type, but not destabilize or affect important attributes of that land-cover type. An indication of a moderate impact pertains to a land-cover type that is uncommon within the Mojave and Great Basin Deserts, such as riparian vegetation. A large impact would significantly alter or destabilize the land-cover type. However, no large impacts were found to occur in the analysis.

H.2.2 VEGETATION COMMUNITIES

The vegetation communities present along the Caliente and Mina rail alignments are indicative of the Great Basin and the Mojave Deserts. Table H-1 lists the land-cover types and vegetation communities identified as potentially occurring within the Caliente rail alignment and Mina rail alignment regions of influence as described in the Southwest Regional Gap Analysis Project databases and confirmed by field surveys.

Table H-1. Southwest Regional Gap Analysis Project land-cover types within the Caliente rail alignment and Mina rail alignment study areas[a,b,c] (page 1 of 5).

Land-cover type	Characteristic plant species and distribution
Agriculture	This land-cover type includes row crops, irrigated pasture and hay fields, dry farm crops.
Barren	This land-cover type includes barren soil or rock with less than 5 percent vegetative cover.
Developed, Medium - High Intensity	Developed, Medium Intensity: Includes areas with a mixture of constructed materials and vegetation. Impervious surface accounts for 50 to 79 percent of the total cover. These areas most commonly include single-family housing units. Developed, High Intensity: Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 to 100 percent of the total cover.
Developed, Open Space - Low Intensity	Open Space: Includes areas with a mixture of some construction materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Developed, Low Intensity: Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 to 49 percent of total cover. These areas most commonly include single-family housing units.
Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland	This land-cover type occurs in mountain ranges from about 1,220 to more than 2,135 meters (4,000 to more than 7,000 feet). This type often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The variety of plant associations connected to this type reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include white fir, thinleaf alder, water birch, narrowleaf cottonwood, balsam poplar, Fremont cottonwood, red willow, Gooding's willow, and Douglas fir. Dominant shrubs include silver sagebrush, Redosier dogwood, narrowleaf willow, arroyo willow, Lemmon's willow, or yellow willow.

Table H-1. Southwest Regional Gap Analysis Project land-cover types within the Caliente rail alignment and Mina rail alignment study areas[a,b,c] (page 2 of 5).

Land-cover type	Characteristic plant species and distribution
Great Basin Pinyon-Juniper Woodland	This land-cover type occurs on dry mountain ranges and is typically found at lower elevations ranging from 1,600 to 2,600 meters (5,200 to 8,500 feet). These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Woodlands dominated by a mix of singleleaf pinyon and Utah juniper, and woodlands dominated solely by either species comprise this land-cover type. Associated species include shrubs such as desert mahogany, green manzanita, low sagebrush, black sagebrush, Great Basin sagebrush, mountain mahogany, littleleaf mountain mahogany, blackbrush, Gambel oak, scrub oak, bunch grasses needle-and-thread, Idaho fescue, bluebunch wheatgrass, Great Basin wild rye, and mutton grass.
Great Basin Xeric Mixed Sagebrush Shrubland	This land-cover type occurs in the Great Basin on dry flats and plains, alluvial fans, rolling hills, rocky hill slopes, saddles, and ridges at elevations between 1,000 to 2,600 meters (3,300 to 8,500 feet). Sites are dry, often exposed to desiccating winds, with typically shallow, rocky, non-saline soils. Shrublands are dominated by black sagebrush (mid and low elevations), low sagebrush (higher elevation), and may be codominated by Wyoming big sagebrush or yellow rabbitbrush.
Inter-Mountain Basins Big Sagebrush Shrubland	This widespread land-cover type occurs throughout much of the intermountain west and is found at slightly higher elevations farther south. Soils are typically deep with minimal salt, and often with a microphytic crust. This system is dominated by perennial grasses and forbs (greater than 25 percent cover) with big basin sagebrush, big sagebrush, Wyoming big sagebrush, threetip sagebrush, and/or antelope bitterbrush dominating or codominating the open to moderately dense (10 to 40 percent cover) shrub layer.
Inter-Mountain Basins Big Sagebrush Steppe	This land-cover type occurs throughout much of the Columbia Plateau and northern Great Basin and Wyoming, and is found at slightly higher elevations farther south. Soils are typically deep and non-saline, often with a microphytic crust. This shrub-steppe is dominated by perennial grasses and forbs with basin big sagebrush, big sagebrush, Wyoming big sagebrush, threetip sagebrush, and/or desert bitterbrush dominating or codominating the open to moderately dense shrub layer. Shadscale saltbush, yellow rabbitbrush, rubber rabbitbrush, horsebrush, or prairie sagewort may be common, especially in disturbed stands. Associated grasses include Indian ricegrass, plains reedgrass, thickspike wheatgrass, Idaho fescue, rough fescue, prairie junegrass, Sandberg bluegrass, and bluebunch wheatgrass. Common forbs are spiny phlox, sandworts, and milkvetches.
Inter-Mountain Basins Cliff and Canyon	This land-cover type is found from foothills to subalpine elevations and includes barren and sparsely vegetated landscapes of steep cliff faces, narrow canyons, and smaller rock outcrops of various bedrock types. Also included are unstable slopes with accumulations of broken rock (known as talus or scree) that typically occur below cliff faces. Widely scattered trees and shrubs may include white fir, twoneedle pinyon, limber pine, singleleaf pinyon, Juniper, big sagebrush, desert bitterbrush, curl-leaf mountain mahogany, Mormon tea, oceanspray, and other species often common in adjacent plant communities.
Inter-Mountain Basins Greasewood Flats	This land-cover type occurs throughout much of the western United States in intermountain basins. It typically occurs near drainages on stream terraces and flats or may form rings around playas. Sites typically have saline or salty soils, a shallow water table, and may flood intermittently, but remain dry for most growing seasons. This system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by greasewood. Fourwing saltbush, shadescale saltbush, or winterfat may be present to codominant.

Table H 1. Southwest Regional Gap Analysis Project land-cover types within the Caliente rail alignment and Mina rail alignment study areas[a,b,c] (page 3 of 5).

Land-cover type	Characteristic plant species and distribution
Inter-Mountain Basins Mixed Salt Desert Scrub	Includes shrublands of typically saline basins, lower mountain slopes, and plains across the intermountain western United States. The vegetation is characterized by a typically open to moderately dense shrubland composed of one or more saltbush (*Atriplex*) species such as shadescale saltbush, fourwing saltbush, cattle saltbush, or spinescale saltbush.
Inter-Mountain Basins Playa	This ecological system is composed of barren and sparsely vegetated playas (generally less than 10 percent plant cover) found in the intermountain western United States. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from filtering through the soil by an impermeable soil layer and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include iodinebush, greasewood, spiny hopsage, Lemon's alkaligrass, basin wildrye, saltgrass, and saltbush.
Inter-Mountain Basins Semi-Desert Grassland	This widespread land-cover type occurs throughout the intermountain western United States on dry plains and mesas, at approximately 1,450 to 2,320 meters (4,800 to 7,600 feet) in elevation. These grasslands occur in a wide range of landscape locations and on varied soil types. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or codominated by Indian ricegrass, three-awns, blue grama, needle-and-thread grass, Torrey's muhly, or James's galleta, and may include scattered shrubs and dwarf-shrubs of species of, sagebrush, saltbush, blackbrush, jointfir, snakeweed, or winterfat.
Inter-Mountain Basins Semi-Desert Shrub Steppe	This land-cover type occurs throughout the intermountain western United States, typically at lower elevations on alluvial fans and flats with moderate to deep soils. This semi-arid shrub-steppe is typically dominated by grasses (greater than 25 percent cover) with an open shrub layer, but includes sparse mixed shrublands without a strong grass layer. Characteristic grasses include Indian ricegrass, blue grama, inland saltgrass, needle-and-thread grass, James's galleta, Sandberg bluegrass, and alkali sacaton. The shrub layer is often a mixture of shrubs and dwarf-shrubs including fourwing saltbush, sand sagebrush, Greene's rabbitbrush, yellow rabbitbrush, jointfir, rabbitbrush, broom snakeweed, and winterfat.
Inter-Mountain Basins Wash	This barren and sparsely vegetated (generally less than 10 percent plant cover) land-cover type is restricted to intermittently flooded streambeds and banks that are often lined with *Sarcobatus vermiculatus*, rabbitbrush, Apache plume and/or silver sagebrush (in more northern and wetter stands). Spiny hopsage may also dominate in the Great Basin. Shrubs often form a continuous or intermittent linear canopy in and along drainages but do not extend out into flats.
Invasive Annual and Biennial Forbland	This land-cover type occurs in areas dominated by the invasive thistles (*Salsola* spp.), Mexican fireweed (*Kochia scoparia*), and halogeton (*Halogeton glomeratum*).
Invasive Annual Grassland	This land-cover type occurs in areas dominated by species of oats (*Avena* spp.), brome (*Bromus* spp.), and Mediterranean grasses (*Schismus* spp.).
Mojave Mid-Elevation Mixed Desert Scrub	This land-cover type represents the extensive desert scrub in the transition zone above creosote-burrobush desert scrub and below the lower montane woodlands (700 to 1,800 meters [2,300 to 5,900 feet] elevations) that occurs in the eastern and central Mojave Desert, around elevations of 700 to 1,800 meters. It is also common on lower slopes in the transition zone into the southern Great Basin. The vegetation in this land-cover type is quite variable. Codominant species include blackbrush, Eastern Mohave buckwheat, Nevada jointfir, spiny hopsage, spiny menodora, beargrass, buckhorn cholla, Mexican bladdersage, Parish's goldeneye, Joshua tree, or Mohave yucca.

Table H 1. Southwest Regional Gap Analysis Project land-cover types within the Caliente rail alignment and Mina rail alignment study areas[a,b,c] (page 4 of 5).

Land-cover type	Characteristic plant species and distribution
North American Arid West Emergent Marsh	This land-cover type is found throughout much of the arid and semi-arid regions of western North America. Natural marshes may occur in depressions in the landscape (ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to two meters. Water levels may be stable, or may fluctuate one meter or more over the course of the growing season. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils. The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of bulrush, cattail, rush, pondweed, knotweed, pond-lily, and canarygrass. This system may also include areas of relatively deep water with floating-leaved plants and submergent and floating plants.
North American Warm Desert Bedrock Cliff and Outcrop	This ecological system is found from subalpine to foothill elevations and includes barren and sparsely vegetated landscapes (generally less than 10 percent plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus slopes that typically occur below cliff faces. Species present are diverse and may include elephant tree, ocotillo, Bigelow's nolina, teddybear cholla, and other desert species, especially succulents. Lichens are predominant lifeforms in some areas. May include a variety of desert shrublands less than 0.02 square kilometer (5 acres) in size from adjacent areas.
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	This ecological system occurs in mountain canyons and valleys of southern Arizona, New Mexico, and adjacent Mexico and consists of mid- to low-elevation (1,100 to 1,800 meters [3,300 to 5,900 feet]) riparian corridors along perennial and seasonally intermittent streams. The vegetation is a mix of riparian woodlands and shrublands. Dominant trees include narrowleaf cottonwood, Rio Grande cottonwood, Fremont cottonwood, Arizona sycamore, Arizona walnut, velvet ash, and wingleaf soapberry. Shrub dominants include narrowleaf willow, plum, Arizona alder, and mule's fat. Vegetation is dependent upon annual or periodic flooding and associated sediment scour and annual rise in the water table for growth and reproduction.
North American Warm Desert Playa	This land-cover type is composed of barren and sparsely vegetated dry lakes (generally less than 10 percent plant cover) found across the warm deserts of North America. Playas form with intermittent flooding, followed by evaporation, leaving behind a saline or salty residue. Salt crusts are common, with small saltgrass beds present in depressions and sparse salt-tolerant shrubs around the margins. Soils often include an impermeable layer of clay. Large desert playas tend to be defined by vegetation rings formed in response to salinity. Given their common location in wind-swept desert basins, dune fields often form downwind of large playas. Species may include iodinebrush, seepweed, inland saltgrass, common spikerush, ricegrass, dropseed, crinklemat, or saltbush.
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	This land-cover type forms the vegetation matrix in broad valleys, lower bajadas (masses of gravel and sand deposited by streams as they emerge from narrow mountain valleys), plains, and low hills in the Mojave and lower Sonoran deserts. This desert scrub is characterized by a sparse to moderately dense layer (2 to 50 percent cover) of small-leaved, drought-tolerant, and broad-leaved shrubs. Creosote and burrobush are typically dominants, but many different shrubs, dwarf-shrubs, and cacti may be present or form typically sparse understories.

Table H-1. Southwest Regional Gap Analysis Project land cover types within the Caliente rail alignment and Mina rail alignment study areas[a,b,c] (page 5 of 5).

Land-cover type	Characteristic plant species and distribution
Sonora-Mojave Mixed Salt Desert Scrub	This land-cover type includes extensive open-canopied shrublands of typically salty basins in the Mojave and Sonoran deserts. Stands often occur around playas. Substrates are generally fine-textured, saline soils. Vegetation is typically composed of one or more saltbush species such as fourwing saltbush or cattle saltbush along with other species of saltbush. Species of iodinebush, pickleweed, seepweed, or other salt-loving plants are often present to codominant. Grasses may include alkali sacaton or inland saltgrass at varying densities.

a. Species and distribution description are derived from DIRS 174324-NatureServe 2004, all, and field studies.
b. Sources: DIRS 174399-MO9901COV97208.000; DIRS 174324-NatureServe 2004, all; DIRS 174324-NatureServe 2004, all.
c. To convert meters to feet, multiply by 3.2808.

H.2.3 NOXIOUS WEEDS AND INVASIVE SPECIES

There are numerous species considered to be noxious weeds or invasive species present in the region. Table H-2 lists such species, including their scientific name and general habitat requirements. Several of these species have been designated by the State of Nevada as noxious. For these species, the table displays the Nevada Department of Agriculture noxious weed category, and discusses primary habitat characteristics associated with each species. These categories are defined as follows:

- Category A, weeds not found or that are limited throughout the state and are controlled wherever they are found
- Category B, weeds in scattered populations in some counties in Nevada and that are actively excluded where possible
- Category C, weeds that are widespread in many counties in Nevada

Table H-2. Noxious weeds and invasive species[a] (page 1 of 4).

Common name(s)	Scientific name	Noxious weed category[b]	Habitat[c]
African mustard	*Malcolmia africana*	--	Found in disturbed areas and desert shrubland at elevations between 1,250 and 2,000 meters (4,100 to 6,600 feet).
Asian mustard	*Brassica tournefortii*	--	Found along roadsides and washes and in open areas below 800 meters (2,600 feet) in elevation. It is likely that the species will be designated as noxious by the state of Nevada in the near future.
Common crupina	*Crupina vulgaris*	A	Prefers well-drained, sandy, or loamy soils, and southern slopes on steep canyon grasslands. Also, it commonly grows along field edges, and in improved pastures, hayfields, and grass seed fields. It frequently infests gravel pits, roadsides, railroad embankments, and other rights-of-way. No information has been found that indicates it is or is not in Nevada.
Dalmation toadflax	*Linaria dalmatica*	A	Commonly found in cultivated fields, roadsides, railways, waste areas, clearcuts, overgrazed pastures and rangeland, and in plant communities that are typically open or disturbed. Neither Dalmation nor yellow toadflax (*Linaria vulgaris*) occur as frequently in intact wild lands and natural areas.

Table H-2. Noxious weeds and invasive species[a] (page 2 of 4).

Common name(s)	Scientific name	Noxious weed category[b]	Habitat[c]
Downy brome/ cheatgrass	*Bromus tectorum*	--	Grows in many climatic conditions. It is found primarily in locations that receive 15 to 56 centimeters (6 to 22 inches) of precipitation. Cheatgrass will grow in almost any type of soil. Research shows that it is most often found on coarse-textured soils and does not grow well on heavy, dry, or saline soils. Cheatgrass has been found growing in eroded soil areas and areas low in nitrogen. It grows in a narrow range of soil temperatures. It has been found in Nye and Esmeralda Counties (DIRS 174674-Carpenter and Murray [n.d.], all).
Dyer's woad	*Isatis tinctoria*	A	Found on disturbed and undisturbed sites, roadsides, railroad rights-of-way, fields, pastures, grain and alfalfa fields, forests, and rangeland. The species can grow on dry, rocky, or sandy soils.
Hoary cress/ Whitetop	*Cardaria draba*	C	Grows well in many environments, but they commonly grow in disturbed, alkaline soils with moderate moisture or acidic soils with limited moisture. They grow well in sub-irrigated pastures, hay fields (especially alfalfa), rangeland meadows, along roadsides, ditch banks, and in many other unshaded disturbed areas. They are aggressive invaders in much of Nevada because their seeds germinate and plants grow in moderately salty soils.
Halogeton	*Halogeton glomeratus*	--	An annual that is often found along rail roadbeds, roads, trails, and other places where the soil has been disturbed, in areas that have been overgrazed or burned over, and on dry lake beds. It can tolerate very saline soils. It cannot effectively compete with healthy native vegetation, but can form dense stands where native vegetation is sparse (DIRS 174505-Torell, Young, and Kvasnicka 2005, p. 1-3).
Houndstongue	*Cynoglossum officinale*	A	Can survive hot, dry summers, as well as cold winters. It is found on a variety of soils from well-drained, relatively coarse, alkaline soils to clay subsoil. It is tolerant of shade and prospers in wetter grasslands. It is found on roadsides, meadows, and disturbed places. Houndstongue has been found in Elko County, Nevada and can quickly spread to other areas of the state.
Klamath weed/ common St. Johnswort/ goatweed	*Hypericum perforatum*	A	A large, bushy plant that prefers dry, sandy, or gravelly soils and open, sunlit areas. It can be found in pastures, pinyon-juniper woodlands, foothill forests, waste places, and along roadsides. It may dominate a site as a monoculture. Klamath weed spreads by seed and by creeping horizontal stems that root when they touch the ground (DIRS 174671-Graham & Johnson [n.d.], all).
London rocket/ Tumbling mustard	*Sisymbrium irio*	--	Is common in irrigated cropland and orchards, and disturbed areas such as roadsides, fence lines, and ditches below 800 meters (2,600 feet) elevation.

Table H-2. Noxious weeds and invasive species[a] (page 3 of 4).

Common name(s)	Scientific name	Noxious weed category[b]	Habitat[c]
Medusahead	*Taeniatherum caput-medusae*	B	Invades grasslands, oak savannah, oak woodland, and chaparral communities. It grows in a wide range of climatic conditions. Clay or clay-loam soils with at least 25.4 centimeters (10 inches) of rainfall annually are most susceptible to invasion. However, medusahead has been found on coarse-textured soils, as well.
Musk thistle	*Carduus nutans*	B	Musk thistle is found in saline soils in low valleys to acidic soils at 3,048 meters (1,000 feet). It prefers moisture and sunlight, and it often grows in pastures, construction sites, ditches, and rangeland (DIRS 174670-Kadrmas and Johnson [n.d.], all).
Perennial pepperweed/Tall whitetop	*Lepidium latifolium*	C	Infests wet sites along streams, rivers, and wetlands. It is found in riparian areas of the entire western United States. Tall whitetop is very tolerant of salty soils and adapts well to many sites under adverse conditions. It is found in native hay meadows, abandoned agricultural lands, pastures, hayfields, residential areas, and along roadsides.
Purple loosestrife	*Lythrum salicaria*	A	Moist soils, especially on the fringes of water bodies and is potentially found around Meadow Valley Wash and the Amargosa River areas.
Red brome	*Bromus rubens*	--	A cool-season annual bunchgrass that commonly grows in open, disturbed areas below 1,524 meters (5,000 feet) elevation. It is less frost-tolerant than the closely related cheatgrass, and is more common in the Mojave region that in the Great Basin. It can form extensive monocultures, which, as the fine textured plants dry in the summer, dramatically increases the frequency of wildfires (DIRS 174673-Newman 1992, all).
Russian knapweed	*Acroptilon repens*	B	Common along roadsides, riverbanks, irrigation ditches, pastures, waste places, clearcuts, and croplands. Russian knapweed does not establish readily in healthy, natural habitats. It typically invades disturbed areas, forming dense single-species stands. Once established, Russian knapweed inhibits the growth of nearby plants to spread outward into undisturbed areas. Specimens have been found in Nye, Clark, and Esmeralda Counties.
Russian olive	*Elaeagnus angustifolia*	--	Invasive in many states and typically inhabits disturbed areas. It fixes nitrogen and can therefore persist in poor soils. It is drought and salt tolerant. In the Great Basin it grows at elevations of 240 to 600 meters (790 to 2,000 feet). It has been found in Meadow Valley Wash.

Table H-2. Noxious weeds and invasive species[a] (page 4 of 4).

Common name(s)	Scientific name	Noxious weed category[b]	Habitat[c]
Russian thistle	*Salsola spp.*	--	An annual that grows along fence lines, crop margins, and roadsides, in areas that have been overgrazed, and other places where the native vegetation has been disrupted. Its seeds are spread when the plant dies in the autumn and breaks free from its roots, allowing it to tumble freely in the wind (hence, the common name, "tumble weed"). Like halogeton, it can not effectively compete with intact communities of native vegetation (DIRS 174498-Taylor 1992, p. 66).
Saltcedar	*Tamarix ramosissima*	C	Requires a large amount of groundwater, and is most common in riparian areas and areas with a seasonally-high water table. The amount of water used by the species can lower the water table that supplies springs and shallow wells. It is extremely salt tolerant and accumulate salts in its deciduous leaves, which, when dropped, create soil conditions beneath the plant that are too salty for most other species to grow.
Scotch thistle	*Onopordum acanthium*	B	An invasive weed that infests disturbed and neglected lands. It prefers sites near ditch banks and rivers but also infests pastureland, crops, rangeland, and roadsides. Although scotch thistle prefers disturbed areas with high soil moisture, drier areas do not limit its invasive nature. It commonly invades overgrazed lands, rangeland, pastures, roadsides, and construction sites.
Spotted knapweed	*Centaurea maculosa*	A	Found in rangelands that have disturbed soils and that receive less than 20 centimeters (7.9 inches) of precipitation annually. Spotted knapweed is believed to produce a substance that retards the growth of other nearby species (DIRS 174672-Graham & Johnson [n.d.], all).
Yellow starthistle	*Centaurea solstitalis*	A	Found in rangelands that receive less than 38 centimeters (15 inches) of annual precipitation, grows in disturbed areas such as roadside ditches and construction areas, and is also found on rangelands and hay pastures. It has been observed in Clark County (DIRS 174669-Johnson et al. [n.d.]).
Yellow toadflax/ Butter-n-eggs	*Linaria vulgaris*	A	Commonly found in cultivated fields, roadsides, railways, waste areas, clearcuts, overgrazed pastures and rangeland, and in plant communities that are typically open or disturbed. It is not found as frequently in intact wild lands and natural areas.

a. Source: DIRS 130301-Hickman 1993, all.

b. Nevada Department of Agriculture noxious weed category definitions: A = weeds not found or limited in distribution throughout the state, controlled wherever found; B = weeds established in scattered populations in some counties of the state, actively excluded where possible; C = weeds currently established and generally widespread in many counties of the state (DIRS 174543-NDOA 2005, all).

c. To convert meters to feet, multiply by 3.2808; to convert centimeters to inches, multiply by 0.3937.

H.3 Wildlife

H.3.1 METHODS

H.3.1.1 Research

DOE gathered information regarding wildlife potentially found within the study area of the Caliente rail alignment and Mina rail alignment from reviews of BLM resource management plans, field guides, NatureServe database, discussion with and acquisition of GIS data from federal and state agencies (BLM, NDOW), and field observations. Using the information gathered from these sources, DOE developed general descriptions and locations of the wildlife communities relative to the proposed alignments, including sage-grouse habitat and mule deer, elk, and antelope winter and summer range.

H.3.1.2 Field Surveys

DOE did not perform field surveys specifically to characterize the wildlife communities along the Caliente and Mina rail alignments. Wildlife observed during the surveys discussed in Section H.3.1.2 were documented and included in the field notes and data sheets. All surveys were conducted during daylight hours; therefore, field personnel would not have observed species that are exclusively nocturnal, but they recorded signs or other indicators of the presence of these species.

H.3.1.2.1 Sage-Grouse Habitat Quality Surveys

DOE performed field surveys in habitat for greater sage-grouse (*Cetrocercus urophasianus*) and other sage-dependent species. To assess the quality of sagebrush (*Artemisia* ssp.) habitat, the percentage of sagebrush cover and sagebrush height were measured along 18, 50-meter (160-feet) transects along the rail alignments within sage-grouse population management units. DOE performed assessments of sagebrush habitat for potential suitability as winter habitat for sage-grouse from February 27, 2005 through March 9, 2005, along the Caliente rail alignment.

At sites predetermined for sage-grouse habitat surveys, a sage-grouse habitat transect was set up as an extension of the previously completed vegetation survey, in the same direction and along the same bearing. A 50-meter (160-foot) tape measure was staked and stretched out along the alignment from the predetermined transect start point. A digital photo was taken, Universal Transverse Mercator coordinates collected and recorded, and a wooden stake driven into the ground at the beginning and end of transects. On data sheets, a sample of which is presented in Figure H-4, sagebrush canopy cover (by species of sagebrush, *Artemisia* spp.) was recorded using the line-intercept method that required measuring the amount of live sagebrush that occurs along the line created by the tape measure. Gaps in live canopy of less than 5 centimeters (2 inches) were ignored. Additionally, at each 5-meter (16-foot) increment along the tape, starting at the 5-meter (16-foot) point, the height and species of the nearest sagebrush plant were recorded.

Sage-grouse habitat quality surveys were not performed for the Mina alignment since there is no designated sage-grouse habitat within the study area.

H.3.1.2.2 Big Game Surveys

For big game surveys, the appropriate BLM or Nevada Department of Wildlife management unit was identified and overlain on the proposed rail alignment study area. DOE conducted big game surveys in areas where the proposed rail alignment and documented big game habitat would intersect. Field study included the survey of 66, 800-meter (2,600-foot) transects along the length of the proposed rail alignment to identify signs of habitat use by big game species. An 800-meter transect was chosen to take into consideration indirect impacts, which is 500 meters (1,640 feet) beyond the 300-meter (1,000-foot)-wide proposed construction right-of-way. Rather than attempt to describe population sizes or habitat quality, these field surveys were designed specifically to determine use of the areas near the proposed rail alignment by game species. DOE conducted field surveys, which included track and pellet counts, to verify use of the area and identify important migration corridors. Section H.5 provides additional information on the big game surveys (methods and equipment).

H.3.2 WILDLIFE COMMUNITIES

Sections 3.2.7 and 3.3.7 of the Rail Alignment EIS describe the wildlife species potentially occurring within the Caliente and Mina rail alignments regions of influence, respectively. However, in several cases, the list of species in several groups of wildlife were too numerous and the data too extensive to include in those sections. Therefore, the information is included in this appendix.

Table H-3 lists the game species identified in the Nevada Administrative Code Sections 503.020, 503.045, 503.060 and their occurrence in the biological resources study area for the Caliente and Mina rail alignments. Table H-4 lists bird species and their occurrence within the study area for the Caliente and Mina rail alignments. Table H-5 lists the protection status, a description of preferred habitat, and the probability of occurrence for 23 bat species potentially found along the Caliente and Mina rail alignments. Table H-6 lists amphibians and reptiles potentially found along the Caliente and Mina rail alignments, including their protection status and a description of preferred habitat.

H.3.3 IMPACT ANALYSIS

DOE assessed potential adverse impacts on wildlife as a result of the Proposed Action described in Chapter 2 of the Rail Alignment EIS, based on the review of Nevada Department of Wildlife datasets, review of BLM resource management plans, and field observations. Direct long-term impacts include the loss of and fragmentation of habitat and potential death of individuals. Indirect short-term impacts include avoidance, change in movement patterns, and potential contamination of water resources in the event of derailment. The potential for impacts on game species, including mule deer, elk, antelope, and sage-grouse, were determined based on the location of the rail line, facilities, and quarries in relation to their identified habitat range. In addition, DOE used the SWReGAP data and field observations to determine the likelihood of an occurrence of a particular species based on its known preferred habitat and the vegetation community present.

The magnitude of impact was determined based on the type of habitat (such as crucial winter range, yearlong, migratory corridor) through which the rail line would pass. A small impact to wildlife would neither destabilize nor noticeably alter the species' habitat or population. A moderate impact would noticeably alter a species' habitat or population, but would not destabilize it. A large impact would significantly alter or destabilize a species' habitat and population. However, no large impacts were found to occur in the analysis.

TRANSECT ID:	DATE (mm/dd/yy):	RECORDER:	OBSERVERS:		LOCATION:	TRANSECT BEARING:
	GPS FILENAME - START:					
Coordinates	WAYPOINT	UTM N	UTM E	PDOP	WAAS USED?	ELEVATION
START TRANSECT					yes / no	
END TRANSECT					yes / no	
	GPS FILENAME - END (if different):					
TRANSECT START PHOTO:			TRANSECT END PHOTO:			
SLOPE:	ASPECT:	LANDFORM (elaborate in Notes section): Valley Flat Toe Slope/Alluvuial Fan Slope Cliff/Scarp Other		LAND USE: Wilderness Mining Recreation Grazing Transportation Plowed Fields Urban/Developed Other		
SW REGAP CLASS:						
ESTIMATED DOMINANT SPECIES:						

Big sagebrush intercepts (include units)	Total	% Cover

Big Sagebrush Height at: (ARTRT)	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m

Other sagebrush spp. intercepts (include units)	Total	% Cover

Other Sagebrush Height at:	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m

Figure H-4. Data sheet for assessing sage-grouse habitat quality.

Table H-3. Nevada game species[a] and their occurrence in the biological resources study areas for the Caliente and Mina rail alignments (page 1 of 2).

Common name	Scientific name	Occurrence within the study area[b] Caliente rail alignment	Mina rail alignment
Game mammals			
Pronghorn antelope	*Antilocapra americana*	Present	Present
Black bear	*Ursus americanus*	Absent	Absent
Mule deer	*Odocoileus hemionus*	Present	Present
Mountain goat	*Oreamnos americanus*	Absent	Absent
Mountain lion	*Felis concolor*	Present	Present
Moose	*Alces alces*	Absent	Absent
Peccary	*Pecari angulatus*	Absent	Absent
Cottontail rabbit	*Sylvilagus* spp	Present	Present
Pygmy rabbit	*Sylvilagus idahoensis*	Present	Absent
Snowshoe rabbit	*Lepus americanus*	Absent	Absent
Black-tailed jackrabbit	*Lepus californicus*	Present	Present
Bighorn sheep	*Ovis canadensis*	Present	Present
Elk	*Cervus elaphus*	Present	Present
Upland and migratory game birds			
Blue grouse	*Dendragapus obscurus*	Absent	Absent
Ruffed grouse	*Bonasa umbellus*	Absent	Absent
Sage-grouse	*Centrocercus urophasianus*	Potentially present	Potentially present
Sharp-tailed grouse	*Tympanuchus phasianellus*	Absent	Absent
Chukar	*Alectoris chukar*	Present	Present
Gray (Hungarian) partridge	*Perdix perdix*	Absent	Absent
Snow partridge	*Tetrogallus himalayensis*	Absent	Absent
Ring-necked pheasant	*Phasianus colchicus*	Present	Present
White-wing pheasant	*Phasianus colchicus*	Absent	Absent
Northern bobwhite quail	*Colinus virginianus*	Absent	Absent
California quail	*Callipepla californicus*	Absent	Absent
Gambel's quail	*Callipepla gambelii*	Present	Present
Mountain quail	*Oreortyx pictus*	Absent	Absent
Scaled quail	*Callipepla squamata*	Absent	Absent
Wild turkey	*Meleagris gallopavo*	Present	Present
American crow	*Corvus brachyrhynchos*	Present	Present
Ducks, geese, and swans	Family *Anatidae*	Present only in wetland/marsh areas	Present only in wetland/marsh areas
Wild doves and pigeons	Family *Columbidae*	Present	Present
Cranes	Family *Gruidae*	Present only in wetland/marsh areas	Present only in wetland/marsh areas
Rails, coots, and gallinules	Family *Rallidae*	Present only in wetland/marsh areas	Present only in wetland/marsh areas

Table H-3. Nevada game species[a] and their occurrence in the biological resources study areas for the Caliente and Mina rail alignments (page 2 of 2).

Common name	Scientific name	Occurrence within the study area[b]	
		Caliente rail alignment	Mina rail alignment
Woodcocks and snipes	Family *Scolopacidae*	Present only in wetland/marsh areas	Present only in wetland/marsh areas
Game fish			
Bonneville cutthroat trout	*Oncorhynchus clarki utah*	Absent	Absent
Lahontan cutthroat trout	*Oncorhynchus clarki henshawi*	Absent	Present
Snake River cutthroat trout	*Oncorhynchus clarki bouvieri*	Absent	Absent
Salmon	*Oncorhynchus* ssp.	Absent	Absent
Atlantic salmon	*Salmo salar*	Absent	Absent
Brook trout	*Salvelinus fontinalis*	Absent	Absent
Brown trout	*Salmo trutta*	Absent	Present
Bull trout	*Salvelinus confluentis*	Absent	Absent
Lake trout	*Salvelinus namyaycush*	Absent	Absent
Rainbow trout	*Oncorhynchus mykiss*	Absent	Present
Redband trout	*Oncorhynchus mykiss gibbsi*	Absent	Absent
Mountain whitefish	*Prosopium williamsoni*	Absent	Present
Black bullhead	*Ameiurus melas*	Absent	Absent
Brown bullhead	*Ameiurus nebulosus*	Absent	Absent
Channel catfish	*Ictalurus punctatus*	Absent	Present
White catfish	*Ameiurus catus*	Absent	Present
Striped bass	*Morone saxatilis*	Absent	Absent
White bass	*Morone chrysops*	Absent	Present
Largemouth black bass	*Micropterus salmoides*	Absent	Present
Smallmouth black bass	*Micropterus dolomieu*	Absent	Absent
Spotted bass	*Micropterus punctulatus*	Absent	Present
Black crappie	*Pomoxis nigromaculatus*	Absent	Absent
White crappie	*Pomoxis annularis*	Absent	Present
Sacramento perch	*Archoplites interruptus*	Absent	Absent
Yellow perch	*Perca flavescens*	Absent	Present
Bluegill sunfish	*Lepomis macrochirus*	Absent	Present
Green sunfish	*Lepomis cyanellus*	Absent	Absent
Redear sunfish	*Lepomis microlophus*	Absent	Absent
Walleye	*Stizostedion vitreum*	Absent	Present

a. Source: Nevada Administrative Code Sections 503.020, 503.045, and 503.060.
b. Sources: DOE field surveys; DIRS 182061-NNHP 2005; BLM RMPs (DIRS 174518-BLM 2005; DIRS 103079-BLM 1998; DIRS 173224-BLM 1997; DIRS 179560-BLM 2001).

Table H-4. Non-game bird species and their potential occurrence in the biological resources study areas for the Caliente and Mina rail alignments[a] (page 1 of 3).

Common name	Scientific name	Description	Potential occurrence Caliente	Potential occurrence Mina
Northern goshawk	*Accipiter gentilis*	Feeds on small mammals, nests in large tree limbs or crotch of tree.	Low	Low
Tricolored blackbird	*Agelaius tricolor*	Found in riparian habitat and grasslands; nests in marsh thickets.	None	None
Sage sparrow	*Amphispiza belli*	Prefers sagebrush or shadscale scrub; nests in depression on ground or in shrub.	High	High
Golden eagle	*Aquila chrysaetos*	Found in high deserts shrub habitat and montane; feeds on small mammals, birds, fish, insects; nests usually in tall trees or cliffs.	Low	Low
Long-eared owl	*Asio otus*	Nests in woodlands and hunts in open grasslands.	Low	Low
Western burrowing owl	*Athene cunicularia hypugaea*	Found in grassy shrub-steppe and juniper-pinyon woodlands; feeds on small mammals, frogs, birds; nests in abandoned burrows on ground.	Moderate	Low
Juniper titmouse	*Baeolophus griseus*	Found in pinyon-juniper woodlands; nests in tree cavities.	None	Low
Ferruginous hawk	*Buteo regalis*	Prefers open grassland and shrub-steppe communities; nests in various sites including trees, cliffs, power poles, and hillsides.	Moderate	Moderate
Red-tailed hawk	*Buteo jamaicensis*	Found in open shrub-steppe and montane; feeds on small mammals, birds, reptiles, insects; nests in tree branches.	High	High
Swainson's hawk	*Buteo swainsoni*	Feeds on reptiles, rodents, birds, insects; nests in tree or bush, power pole or cliff.	High	High
Western snowy plover	*Charadrius alexandrinus nivosus*	Found in sandy areas, salt flats, and shorelines; eats insects and aquatic invertebrates.	Low	High
Mountain plover	*Charadrius montanus*	Prefers grasslands, plowed fields, and sandy deserts; nests on ground in short grass or bare ground.	Low	Low
Black tern	*Chlidonia niger*	Found in desert marshlands.	Low	Low
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	Found in thick riparian habitats or forests; nests in cottonwood trees.	Low	Low
Yellow warbler	*Dendroica petechia*	Found in riparian communities; nests in tree or shrub branches.	Low	Low
Southwestern willow flycatcher	*Empidonax traillii extimus*	Found in thick riparian areas with mature willow.	Low	Low

Table H-4. Non-game bird species and their potential occurrence in the biological resources study areas for the Caliente and Mina rail alignments [a] (page 2 of 3).

Common name	Scientific name	Description	Potential occurrence Caliente	Potential occurrence Mina
Prairie falcon	*Falco mexicanus*	Found in grasslands, alkali meadows and lower elevation montane; feeds on mammals, birds, insects; nests in high ledges.	Moderate	Moderate
Peregrine falcon	*Falco peregrinus*	Nests in high cliffs near water; feeds on mostly fish and waterfowl.	None	Low
Common loon	*Gavia immer*	Lakes with deep and shallow areas.	None	None
Common yellowthroat	*Geothlypis trichas*	Found in marshes, riparian areas; nests in cattails, brush, or grasses near water.	None	Low
Greater sandhill crane	*Grus Canadensis tabida*	Marsh areas or agricultural fields.	None	None
Pinyon jay	*Gymnorhinus cyanocephalus*	Prefers pinyon-juniper woodlands; nests in colonies.	None	Low
Bald eagle	*Haliaeetus leucocephahis*	Feeds on fish, small mammals, birds; nests near rivers and lakes in tall trees.	None	Low
Harlequin duck	*Histriontcus histrionicus*	Lakes.	None	None
Yellow-breasted chat	*Icteria virens*	Found in woodlands, scrub, fence rows; nests in bushes or trees in dense vegetation.	None	Low
Loggerhead shrike	*Lanius ludovicianus*	Found in shrub-steppe and pinyon-juniper woodlands; nests in bush or tree.	High	High
Long-billed curlew	*Numenius americanus*	Found in grasslands and wet meadows; nests on ground in short grasslands.	Moderate	Low
Macgillivray's warbler	*Oporornis tolmiei*	Prefers shrubby riparian woodlands; nests on ground.	None	Low
Flammulated owl	*Otus flammeolus*	Found in pinyon-juniper woodlands; feeds on insects.	Low	Moderate
Osprey	*Pandion haliaetus*	Near lakes and rivers with fish; nests in tall trees, power poles, towers.	None	Low
American white pelican	*Pelicanus erythrorhynchos*	Rivers, lakes, reservoirs.	None	None
Vesper sparrow	*Pooecetes gramineus*	Found in prairies, dry shrublands, sagebrush communities; nests on ground.	Moderate	Moderate
White-faced ibis	*Plegadis chihi*	Marshes, ponds, rivers; nests in low trees, bulrushes, or on a floating mat.	None	Low
Phainopepla	*Phainopepla nitens*	Found in pinyon-juniper or shadscale scrub; feeds on insects or berries.	Low	Low
Yuma clapper rail	*Rallus longirostris yumaensis*	Freshwater habitats with bulrushes and cattails.	None	Low
Red-naped sapsucker	*Sphyarpicus nuchalis*	Found mostly in montane forests or riparian woodlands; nests in dead trees.	Low	Low

Table H-4. Non-game bird species and their potential occurrence in the biological resources study areas for the Caliente and Mina rail alignments[a] (page 3 of 3).

Common name	Scientific name	Description	Potential occurrence Caliente	Potential occurrence Mina
Sage thrasher	*Oreoscoptes montanus*	Found in sagebrush shrub communities; feeds on insects on the ground; nests in sagebrush or on ground in concealed nests.	High	High
Crissal thrasher	*Toxostoma crissale*	Found in desert scrub, tall riparian brush or chaparral; nests in low tree or shrub.	Low	Low
Orange-crowned warbler	*Vermivora celata*	Found in low elevation shrub communities; nests on ground.	Low	Low
Lucy's warbler	*Vermivora luciae*	Found in deserts or riparian woodlands; nests in tree cavity.	Low	Low
Gray vireo	*Vireo vivinior*	Found in shrub-steppe and pinyon-juniper woodlands.	Moderate	Moderate
Wilson's warbler	*Wilsonia pusilla*	Prefers open areas in moist woodlands or thickets; nests on ground at base of shrub.	Low	Low

a. Sources: DIRS 182061-Hopkins 2006, all; DIRS 181899-USAF 2007, p. 40; DIRS 174518-BLM 2005, p. 3.6-10; DIRS 103079-BLM 1998; DIRS 182067-List Serve 2007; DIRS 174412-Ryser 1985, all.

Table H-5. Bat species' protection status and occurrence along the Caliente and Mina rail alignments[a] (page 1 of 4).

Scientific name	Common name	Protection status	Description	Probability of occurrence along Caliente rail alignment	Probability of occurrence along Mina rail alignment
Antrouzous pallidus	Pallid bat	Nevada protected, BLM-sensitive	Statewide, year-round resident, records in vicinity of alignment, especially around the Yucca Mountain repository area.	High	High
Choeronycteris mexicana	Mexican long-tongued bat	Unprotected	Known only from one individual found in Las Vegas. Extreme northern edge of range. Prefers desert canyons with riparian vegetation.	Low	None
Corynorhinus townsendii	Townsend's big-eared bat	Nevada sensitive, BLM-sensitive	Statewide, year-round resident; highly dependent on caverns and mines, susceptible to disturbance.	High	High
Eptesicus fuscus	Big brown bat	BLM-sensitive	Statewide, year-round resident; tolerant of and uses human-built structures.	High	None

Table H-5. Bat species' protection status and occurrence along the Caliente and Mina rail alignments[a] (page 2 of 4).

Scientific name	Common name	Protection status	Description	Probability of occurrence along Caliente rail alignment	Probability of occurrence along Mina rail alignment
Euderma maculatum	Spotted bat	Nevada threatened, BLM-sensitive	Scattered across Nevada, typically at higher elevations; roosts in cliff faces. Only Nevada mammal classified as threatened.	Moderate	Moderate
Eumops perotis californicus	Greater western mastiff bat	Nevada sensitive, BLM-sensitive	Only one dead specimen found in Las Vegas; occurs in various habitats ranging from desert scrub to montane coniferous forests; typically roosts in cliff crevices and boulder cracks, does not appear to hibernate.	Low	None
Idionycteris phyllotis	Allen's lappet-browed bat	Nevada protected, BLM-sensitive	Recorded only in Clark County, but may occur as far north as southern Lincoln and Nye Counties. Probable resident that migrates from higher summer elevations to lower winter elevations; typically roosts in tree cavities, but has been observed in mines and caverns.	Low	Low
Lasionycteris noctivagans	Silver-haired bat	BLM-sensitive	A forest-associated species, more common in mature forests; found primarily at higher latitudes and altitudes in coniferous and mixed deciduous/coniferous forests of pinyon-juniper, subalpine fir, white fir, limber pine, aspen, cottonwood, and willow. Probably a transient spring and fall migrant.	Low	Low
Lasiurus blossevillii	Western red bat	Nevada sensitive, BLM-sensitive	Forest-dwelling, thought to be a transient, very rare in Nevada, only two records until 1999 and development of acoustic detecting equipment. Three acoustical records have occurred since.	Low	Low
Lasiurus cinereus	Hoary bat	BLM-sensitive	Rare in Nevada, thought to be primarily a summer migrant, tree roosting.	Low	Low
Lasiurus xanthinus	Western yellow bat	Unprotected	Closely associated with fan-palms, found in palm groves in upper Moapa Valley. May be expanding its range due to use of palms in urban landscaping.	Low	None
Macrotus californicus	California leaf-nosed bat	Nevada sensitive, BLM-sensitive	No observations have occurred north of Clark County.	Low	None

Table H-5. Bat species' protection status and occurrence along the Caliente and Mina rail alignments[a] (page 3 of 4).

Scientific name	Common name	Protection status	Description	Probability of occurrence along Caliente rail alignment	Probability of occurrence along Mina rail alignment
Myotis califorincus	California myotis	BLM-sensitive	Resident throughout Nevada, widespread and locally common; will roost anywhere from caves to buildings to exfoliating tree bark. Found in habitats from desert scrub to forests.	High	High
Myotis ciliolabrum	Small-footed myotis	BLM-sensitive	Statewide resident; tends to prefer mid to high elevations in southern Nevada. Roosts in trees, mines, and caves. Inhabits a variety of habitats including desert scrub, grasslands, sagebrush steppe, blackbrush, greasewood, pinyon-juniper woodlands, pine-fir forests, agriculture, and urban areas.	High	High
Myotis evotis	Long-eared myotis	BLM-sensitive	Year-round, high elevation forest-dwelling resident. In southern part of Nevada found only in ponderosa forests. Roosts in hollow trees, under exfoliating bark, crevices in small rock outcrops, and occasionally in mines, caves, buildings, and bridges.	Low	Low
Myotis lucifugus	Little brown myotis	BLM-sensitive	Probably a year-round resident, found in the northern part of Nevada in high elevation coniferous forests. Must be close to water; day roosts in hollow trees, rock outcrops, buildings, and occasionally mines and caves. One of the species most commonly found in human structures.	Low	Low
Myotis thysanodes	Fringed myotis	Nevada protected, BLM-sensitive	Year-round resident of southern and central Nevada. Widespread but rare. Roost and nursery areas are easily disturbed; roosts in mines, caves, trees, and buildings.	Moderate (historic occurrence in Beatty area)	Moderate (historic occurrence in Beatty area)
Myotis velifer	Cave myotis	BLM-sensitive	Only recorded in one location in extreme southern Nevada at the Lake Mead National Recreational Area. Typically roosts in caves and bridges, commonly observed using swallow nests.	Low	None

Table H-5. Bat species' protection status and occurrence along the Caliente and Mina rail alignments[a] (page 4 of 4).

Scientific name	Common name	Protection status	Description	Probability of occurrence along Caliente rail alignment	Probability of occurrence along Mina rail alignment
Myotis volans	Long-legged myotis	BLM-sensitive	Probable resident found throughout Nevada, but more commonly in the north and central portions. Appears to prefer pinyon-juniper, Joshua tree woodlands, and montane coniferous forest habitats. Not found in low desert. Roosts in hollow trees and hibernates in caves and mines, but also uses rock crevices, caves, mines, and buildings.	Moderate (historic occurrence in Beatty area)	Moderate (historic occurrence in Beatty area)
Myotis yumanensis	Yuma myotis	BLM-sensitive	Tends to occur in the western and southern portions of Nevada, but recent records from eastern Nevada indicate it might be more widespread. Inhabits various habitats including sagebrush, salt desert scrub, agriculture, playa, and riparian habitats. One of few bat species that thrive in urban environments.	Low	Low
Nyctinomops macrotis	Big free-tailed bat	BLM-sensitive	Observed only in Clark County. Appears to be a transient, but has been commonly seen in the fall along the Muddy River basin.	Low	Low
Pipestrellus hesperus	Western pipistrelle	BLM-sensitive	Resident found throughout Nevada but is more prevalent in the south and west areas of the state. Prefers desert habitats of blackbrush, creosote, salt desert shrub, and sagebrush. In the summer, roosts in crevices, snags, under rocks, or in buildings. Hibernates in caves and mines in the winter.	High	High
Tadarida braziliensis	Brazilian free-tailed bat	Nevada protected, BLM-sensitive	A summer resident scattered across Nevada but commonly found in the southern portion. A ubiquitous colonial rooster, will use cliff faces, mines, caves, buildings, bridges, and hollow trees. Some summer colonies have up to 100,000 bats.	High	High

a. Source: DIRS 181865-Bradley et al. 2006, all.

Table H-6. Reptile and amphibian species occurrence along the Caliente and Mina rail alignments.[a]

Scientific name	Common name	Protection status	Description
Amphibians			
Ambystoma tigrinum	Tiger salamander	None	Found in ponds, reservoirs, streams, and stock ponds in deserts, sagebrush areas, grasslands, and mountain meadows.
Bufo boreas nelsoni	Amargosa toad	BLM-sensitive	Found in or near springs and wet meadows. Takes shelter under shrubs, woody material, and rocks, and may be found in rodent burrows.
Bufo cognatus	Great Plains toad	None	Found in streams, marshes, irrigation ditches, flooded fields, and adjacent creosote bush desert or sagebrush areas.
Bufo microscaphus	Southwestern toad	BLM-sensitive	May be found in cottonwood-willow associations, creeks, pools, irrigation ditches, flooded fields, and reservoirs.
Bufo punctatus	Red-spotted toad	None	Found in rocky, desert streams and adjacent open grassland and scrubland.
Bufo woodhousei	Woodhouse's toad	None	Found in grasslands, floodplains, and sagebrush flats and sandy areas near streams, marshes, and irrigation ditches.
Rana catesbeiana	Bullfrog	None	Found in ponds or slow moving streams with thick aquatic vegetation.
Rana pipiens[b]	Northern leopard frog	Nevada protected	Found in banks and shallow portions of marshes, ponds, lakes, reservoirs, beaver ponds, streams, and other bodies of permanent water. Also found in irrigation ditches and wet meadows.
Hyla regilla	Pacific treefrog	None	Found in grasslands, woodlands, farmlands, and desert areas in ponded wetlands, reservoirs, roadside ditches, and slow streams.
Scaphiopus intermontanus	Great Basin spadefood	None	Found in wet areas within pinion-juniper woods and sagebrush flats.
Reptiles			
Gopherus agassizii	Desert tortoise	Threatened	Found in desert shrubland habitat in the Mojave Desert.
Sauromalus obesus[b]	Common chuckwalla	None[c]	Found in rocky areas (rocky outcrops, lava flows, and rocky hillsides) within the Great Basin, Mohave, and Sonoran Deserts.

a. Source: DIRS 174414-Stebbins 2003, pp. 152, 204, 209, 211, 212, 213, 214, 215, 223, and 241.
b. Recorded only along the Mina rail alignment.
c. Being considered for a status change to "species of concern" in Nevada.

H.4 Special Status Species

H.4.1 METHODS

H.4.1.1 Research

DOE obtained information on federally and state-protected species from the Nevada Natural Heritage Program (DIRS 182061-NNHP 2005, all), an element occurrence database that maintains an inventory on the locations, biology, and conservation status of all threatened, endangered, sensitive, and at-risk species and biological communities in the state. DOE obtained additional information through discussions with resource management agencies and reviewing BLM resource management plans and similar documents. DOE consultation with the FWS provided a list of species protected under the Endangered Species Act that could occur along the Caliente and Mina rail alignments. Using the information gathered from these sources, DOE mapped species locations within the study area, and used the information for on-site verification investigations in 2005 (Caliente rail alignment) and 2007 (Mina rail alignment) and for the assessment of potential impacts.

H.4.1.2 Field Surveys

DOE conducted field surveys for sensitive plant species, sage-grouse habitat quality, and big game habitat use along the Caliente rail alignment in 2005 and along the Mina rail alignment in 2007 to support the evaluations of potential impacts of the proposed project on these resources. Section H.4.1.2.1 describes the methods DOE used for these surveys.

H.4.1.2.1 Sensitive Plant Species Surveys

DOE performed surveys for sensitive plant species along the Caliente rail alignment from May 6 through May 16, 2005 and along the Mina rail alignment during the field surveys described in Section H 2.1.2. DOE used the same field equipment described for the previous vegetation surveys for the sensitive plant species surveys. Field personnel used a datasheet to record the data gathered during these surveys (see Figure H-5).

Transects were centered along the rail alignments at the point closest to the known sensitive species location, as documented by the Nevada Natural Heritage Program element occurrence database (DIRS 182061-NNHP 2005, all). Locations of the start and end of the transect were recorded using a geographic positioning system unit, and the transect was photographed and staked. Two teams of two biologists examined the area for presence of the species in question; the two teams went in opposite directions with each team member walking 30 meters (100 feet) from the rail alignment centerline for 1 kilometer (0.6 mile). They covered a total distance of 2 kilometers (1.2 miles) in search of the target species or indicative habitat or sign. After reaching the end point of the transect, the biologists spread out an additional 30 meters from their original line and walked the transect back to the starting point. This approach resulted in a 2-kilometer (1.2-mile)-long, 180-meter (590-foot)-wide transect being inspected. When target species were located, the habitat and associated plant community surrounding the target species were documented to evaluate for uniqueness. The locations of locally rare or sparsely distributed species were determined and recorded using a geographic positioning system receiver, and photographed. For species that were locally common, individual plants were counted and their distribution was assessed and recorded on the data sheets shown in Figure H-3.

H.4.1.3 Impact Analysis

Potential adverse impacts on special status species as a result of the proposed actions provided in Chapter 2 were assessed based on the review of the NNHP dataset, review of BLM resource management plans, and field observations. Direct long-term impacts include the loss of and fragmentation of special status species suitable habitat and potential death of individuals. Indirect impacts include potential avoidance and/or displacement of animal species during construction and disturbance from passing trains. The potential for impacts on special status species was determined based on the location of the documented occurrence within the study area and in relation to the rail line, facilities, and quarries. In addition, DOE used the SWReGAP data and field observations to determine the likelihood of an occurrence of a particular species based on its known preferred habitat and the vegetation community present.

The magnitude of impact was determined based on the type of habitat. A small impact to a special status species would neither destabilize nor noticeably alter the species' habitat or population. A moderate impact would noticeably alter a species' habitat or population, but would not destabilize it. A large impact would significantly alter or destabilize a species' habitat and population. However, no large impacts were found to occur in the analysis.

H.5 Wild Horses, Burros, and Big Game Species

H.5.1 METHODS

H.5.1.1 Research

Before beginning fieldwork, DOE identified any existing information regarding the occurrence and distribution of herd management areas and big game habitats within the region of influence of the proposed rail alignment. These efforts included literature searches and consultations with land management agencies and authorities, including the BLM and the Nevada Department of Wildlife.

H.5.1.2 Field Surveys

DOE performed surveys along the Caliente rail alignment from February 4 through March 11, 2005, from May 5 through May 10, 2005, and on June 7 and 8, 2005, to assess relative use of areas by horses, burros, and big game. DOE performed surveys along the Mina rail alignment during the field surveys described in Section H 2.1.2.

DOE performed observational sampling along linear transects. Transect dimensions were 800 meters (2,600 feet) long, unless blocked by terrain, by 120 meters (390 feet) wide. The sampling interval was continuous, with three observers spaced 30 meters (100 feet) apart. At the beginning of each transect, the type of BLM or Nevada Department of Wildlife management unit (for example, wild horse and burro herd management area, game habitat) potentially affected was determined, the locations of the start and end of the transect were recorded using a geographic positioning system receiver, and the transect was photographed and staked as described above. Field notes concerning the surrounding terrain and special habitat features, such as water sources or fences, were recorded on the data sheets for horse and burro and big game habitat use surveys shown in Figure H-6.

The bearing of the transect was determined as described for vegetation surveys in Section H.2.1.2. Transects were walked by teams of three biologists, one walking along the center line of the proposed rail alignment, with each of the others 30 meters (100 feet) to either side. When only two biologists were available for surveys, this fact was noted on the data sheet and resultant data were interpreted to adjust for the decrease in area covered. Observers documented the presence of any visible large ungulates, wild horses, or burros, and their estimated distance from the transect. Notes were also recorded regarding the presence of small or nongame wildlife species, including birds, rabbits, foxes, coyotes, badgers, reptiles, and amphibians, or evidence of habitat use by these species, such as scat, owl pellets, or burrows.

Track counts were conducted in which discrete sets of mule deer, pronghorn antelope, bighorn sheep, wild horse, or burro tracks were identified and counted. Sets of animal tracks that crossed the path of more than one observer were counted only once. Areas of high track density were noted and roughly delineated using waypoints identified by a geographic positioning system to assist in determining migration routes and forage areas.

TRANSECT ID:	DATE (mm/dd/yy):	RECORDER:	OBSERVERS:	LOCATION:	TRANSECT BEARING:

GPS FILENAME - START:

Coordinates	WAYPOINT	UTM N	UTM E	PDOP	WAAS USED?	ELEVATION
START TRANSECT					yes / no	
END TRANSECT					yes / no	

GPS FILENAME - END (if different):

TRANSECT START PHOTO:	TRANSECT END PHOTO:

SLOPE:	ASPECT:	LANDFORM (elaborate in Notes section): Valley Flat Toe Slope/Alluvuial Fan Slope Cliff/Scarp Other	LAND USE: Wilderness Mining Recreation Grazing Transportation Plowed Fields Urban/Developed Other

SW REGAP CLASS:

ESTIMATED DOMINANT SPECIES:

	NAME/CODE	EXTENT*	WAYPOINT	UTM N	UTM E	PDOP	WAAS	ELEVATION
Sensitive Species 1							yes / no	
Sensitive Species 2							yes / no	
Sensitive Species 3							yes / no	
Sensitive Species 4							yes / no	
Sensitive Species 5							yes / no	
Sensitive Species 6							yes / no	
Sensitive Species 7							yes / no	
Sensitive Species 8							yes / no	
*Categories for sens spp and inv/nox spp extent: Solitary, Few Clumped, Few Scattered, Many Clumped, Many Scattered, Dense, Other								
Invasive/Nox Species 1							yes / no	
Invasive/Nox Species 2							yes / no	
Invasive/Nox Species 3							yes / no	

NOTES:

Figure H-5. Data sheet for sensitive plant species survey.

Pellet counts were conducted in which individual piles of large ungulate, wild horse, or burro scat that appeared to be less than 3 months old (based on degree of weathering), were identified and counted. Bighorn sheep, pronghorn antelope, and mule deer scat were sometimes difficult to differentiate by appearance alone. In these cases, the species was determined by examining other evidence (habitat, terrain, tracks, known distribution information). In the case of wild horses, stallion piles, which consist of two or more depositions of scat, were counted separately from single depositions resulting from mares and subordinate stallions. In some cases, burro scat was difficult to differentiate from foal and yearling horses and a determination of species was based on other evidence, such as the presence of other horse scat or tracks. Evidence of commercial sheep grazing activities was noted where present, because these operations can hinder the assessment of deer and antelope tracks and pellets.

H.5.2 HERD MANAGEMENT AREAS (HMAs)

The Caliente rail alignment and the Mina rail alignment each would cross a number of herd management areas. Section H.5.2.1 describes herd management areas the Caliente rail alignment would cross; Section H.5.2.2 describes herd management areas the Mina rail alignment would cross. The primary sources for information about each area listed are the BLM Draft Ely District Resource Management Plan (DIRS 174518-BLM 2005, all) and additional information DOE gathered from herd management plans and evaluations, as indicated in the descriptions.

H.5.2.1 Caliente Rail Alignment

H.5.2.1.1 Miller Flat and Little Mountain Herd Management Areas

The Miller Flat HMA and Little Mountain HMA are in Lincoln County, Nevada, approximately 3.2 kilometers (2 miles) northeast of the City of Caliente and, combined, are approximately 580 square kilometers (140,000 acres) in size. Both the Caliente and the Eccles alternative segments would cross the Little Mountain HMA. Each herd management area has an appropriate management level of nine to 15 horses. A 2004 census (DIRS 174047-Bennet 2005, p. 2) indicates that there are 40 horses in the Little Mountain HMA and 35 horses in the Miller Flat HMA. The herds move from Miller Flat to Little Mountain in the winter and move back to Miller Flat during the summer. The 2005 Draft Ely District Resource Management Plan (DIRS 174518-BLM 2005, p. 3.8-6) indicates that forage, water, space, and habitat in these herd management areas are inadequate and recommends removing the horses and eliminating the HMA status. Permanent water sources consist of nine small springs on both private and public lands primarily in the Miller Flat HMA, Clover Creek, and water troughs installed for livestock. Only two small springs are available to horses and burros within the Little Mountain HMA, so the resident horses and burros are forced to travel to the Miller Flat HMA for water (DIRS 173057-BLM [n.d.], all).

H.5.2.1.2 Highland Peak Herd Management Area

Caliente common segment 2 would cross the Highland Peak HMA, which covers 550 square kilometers (140,000 acres) to the west of Panaca. The primary water source is in the central portion of the HMA at Bennett Springs, but several small springs are also found on the Highland Peak Range (DIRS 173059-BLM n.d., all). The appropriate management level for the Highland Peak HMA is 364 horses; however, the current population (2007) is approximately 150 horses (DIRS 174047-Bennet 2005, p. 2). Field observations from the winter of 2005 suggest that the eastern end of common segment 1 also supports a very high level of use by horses, and the portion of the segment at Bennett Pass shows evidence of seasonal horse use, which was confirmed during the May 2005 field effort, during which 35 horses were counted in the pass. The Draft Ely District Resource Management Plan (DIRS 174518-BLM 2005, p. 3.8-6) lists the habitat of this HMA as inadequate in the winter and does not rate the forage, space, and

TRANSECT ID:	DATE (mm/dd/yy):	RECORDER:	OBSERVERS:		LOCATION:	TRANSECT BEARING:
	GPS FILENAME - START:					
Coordinates	WAYPOINT	UTM N	UTM E	PDOP	WAAS USED?	ELEVATION
START TRANSECT					yes / no	
END TRANSECT					yes / no	
	GPS FILENAME - END (if different):		TRANSECT LENGTH: meters			
SLOPE:	ASPECT:	LANDFORM (elaborate in Notes section): Valley Flat Toe Slope/Alluvial Fan Slope Cliff/Scarp Other		LAND USE: Wilderness Mining Recreation Grazing Transportation Plowed Fields Urban/Developed Other		
ESTIMATED PLANT COMMUNITY:				MANAGEMENT UNIT (if applicable):		

	STALLION PELLET	MARE PELLET	TRACK COUNT
HORSE			
	PELLET COUNT		
BURRO			
MULE DEER			
BIGHORN			
PRONGHORN			

Wildlife observed/distance from transect:
Notes:
Photo, transect start:
Photo, transect end:
Photo, supplemental 1:
Photo, supplemental 2:

Figure H-6. Data sheet for assessing horse, burro, and big game habitat use.

genetic viability of the HMA; the Plan recommends that this HMA be combined with the Dry Lake and Rattlesnake HMAs.

H.5.2.1.3 Rattlesnake Herd Management Area

The Rattlesnake HMA, covering approximately 290 square kilometers (71,000 acres), is approximately 27 kilometers (17 miles) west of the City of Caliente in the Dry Lake Valley. Caliente common segment 1 would cross a small portion of the northeast corner of the HMA. The HMA has an appropriate management level of one horse to account for incidental use by wild horses from the Dry Lake HMA to the north during years with exceptionally high snowfall. The primary water sources include three springs, small ephemeral reservoirs, and cattle troughs. The 2003 census found no resident horses (DIRS 174332-BLM n.d., all; DIRS 174047-Bennet 2005, p. 2). The 2005 Draft Ely District Resource Management Plan (DIRS 174518-BLM 2005, p. 3.8-7) lists the habitat as inadequate during the summer months and does not rate the forage, water, space, and genetic viability of the HMA. The Draft Ely District Resource Management Plan recommends that this HMA be combined with the Dry Lake and Highland Peak HMAs.

H.5.2.1.4 Dry Lake Herd Management Area

The Dry Lake HMA is in Lincoln County west of the town of Pioche and encompasses approximately 2,000 square kilometers (490,000 acres). Common segment 1 would cross the Dry Lake HMA in Dry Lake Valley and in the North Pahroc Range. The appropriate management level for this HMA is 94 horses. In August 2003, 23 horses were removed from the HMA, and the BLM population estimate is 72 horses. Primary water sources for the HMA are artesian springs and freshwater seeps in the Schell Creek, Pahroc, Bristol, and Fairview Mountain Ranges (DIRS 182069-Nevada Bureau of Land Management 2007, all; DIRS 174047-Bennet 2005, all). The 2005 Draft Ely District Resource Management Plan (DIRS 174518-BLM 2005, p. 3.8-6) rates forage, water, space, habitat, and genetic viability as adequate, and recommends that this HMA be combined with the Rattlesnake and Highland Peak HMAs.

H.5.2.1.5 Seaman Herd Management Area

Common segment 1 would cross the Seaman HMA, which is approximately 56 kilometers (35 miles) south of Lund in both Nye and Lincoln Counties. It encompasses approximately 1,350 square kilometers (338,400 acres) and is currently being managed for a target population of 159 horses (DIRS 174333-BLM n.d., all). A 2004 population estimate indicates that there are 99 horses using the HMA (DIRS 174047-Bennet 2005, p. 2). The resident horses' summer range is in the Seaman and Grant Mountains in the western portion of the herd management area, and their winter range is in the Coal and White River Valleys. Water sources are very limited (rated as marginal in the 2005 Draft Ely District Resource Management Plan) and emergency removal of horses is anticipated in dry years (DIRS 174333-BLM [n.d.], all). Space is rated as adequate, but habitat is rated as inadequate due to the lack of summer habitat. Forage and genetic viability is unrated in the 2005 Draft District Resource Management Plan, but the Plan recommends removing the herd and eliminating the herd management area status of the land (DIRS 174518-BLM 2005, p. 3.8-7).

H.5.2.1.6 Reveille Herd Management Area

The Reveille HMA is 80 kilometers (50 miles) east of Tonopah and 19 kilometers (12 miles) south of Warm Springs. Common segment 3 would cross this HMA. The HMA covers 510 square kilometers (130,000 acres) and is currently managed for a target population of 138 horses. The 2006 BLM census flight located 78 wild burros in the area (DIRS 182310-Dwyer 2007, all). A significant portion of the Reveille herd has established residency outside the boundaries of the HMA, suggesting that the current target population might not be appropriate for the available habitat (DIRS 173060-BLM [n.d.], all; DIRS 174046-Bennet 2005, all).

H.5.2.1.7 Stone Cabin Herd Management Area

The Stone Cabin HMA is 45 kilometers (28 miles) east of Tonopah and encompasses approximately 1,600 square kilometers (404,000 acres). Caliente common segment 3 would cross this HMA, which is of historic significance to wild horse management. The first wild horse roundup approved by the U.S. Congress occurred here after the passage of the Wild Free-Roaming Horse and Burro Act of 1971 (Public Law 92-195). It is also the historic home of the "Stone Cabin Grey" wild horse type; however, recent horse gathers and drought have reduced the number of horses with "Stone Cabin Grey" characteristics to only a few individuals (DIRS 174330-BLM [n.d.], all). The appropriate management level is 364 horses, and the current population as of 2007 is approximately 150 horses (DIRS 182310-Dwyer 2007, all). DOE field personnel observed evidence of a high level of use by horses during the 2005 field surveys near common segment 3 in the northern portion of Stone Cabin Valley. Personnel observed a herd of at least 12 horses several times from U.S. Highway 6 in Stone Cabin Valley within approximately 3 kilometers (1.9 miles) of the Caliente rail alignment. Personnel also observed 12 horses approximately 1 kilometer (0.62 mile) south of the Caliente rail alignment in this area.

H.5.2.1.8 Saulsbury Herd Management Area

The Saulsbury HMA is 26 kilometers (16 miles) east of Tonopah and is separated into two parcels totaling 570 square kilometers (140,000 acres), with an interconnecting segment of U.S. Forest Service land. Common segment 3 would cross the southern extent of this HMA. The area was intended to be managed under a Memorandum of Understanding between the U.S. Forest Service and the BLM, but it is currently managed as smaller individual units by the agency of jurisdiction. The appropriate management level is 40 horses, and the population as of 2007 is approximately 30 horses (DIRS 182310-Dwyer 2007, all). The resident horses spend their time in both administrative areas (DIRS 174329-BLM [n.d.], all; DIRS 174046-Bennett 2005, all).

H.5.2.1.9 Goldfield Herd Management Area

The Goldfield HMA is east of the community of Goldfield in Nye and Esmeralda Counties. Goldfield alternative segments 1, 3, and 4 along the Caliente rail alignment would cross this HMA. There is a potential quarry site in the northeastern portion of the HMA, adjacent to Goldfield alternative segment 3. The area encompasses 260 square kilometers (64,000 acres) and is in a transitional zone between the Mojave and Great Basin Deserts vegetation types. It provides suitable habitat only for burros, although the appropriate management level is 125 horses and 50 burros. The 2004 population estimate was 15 burros, although unofficial sightings suggest as many as 20. The BLM gathered and removed all resident wild horses in 1995, 1996, and 1997 (DIRS 173062-BLM [n.d.], all; DIRS 174046-Bennet 2005, p. 2). During the 2005 surveys, one burro was observed and evidence of habitat use by burros was noted near the northern end of common segment 4.

H.5.2.1.10 Montezuma Peak Herd Management Area

Goldfield alternative segment 4 would cross the Montezuma Peak HMA, which is west of the community of Goldfield. There is a potential quarry site in the eastern portion of the HMA, adjacent to Goldfield 4. The Montezuma Peak HMA encompasses 305 square kilometers (75,500 acres). The appropriate management level is 157 horses. The 2006 BLM census flight located 58 horses, 18 burros, and 3 mules (DIRS 182310-Dwyer 2007, all; DIRS 173061-BLM [n.d.], all; DIRS 174046-Bennet 2005, all).

H.5.2.1.11 Stonewall Herd Management Area

The Stonewall HMA is west of Lida Junction and south of Goldfield in Nye County. Caliente common segment 4 and both the Bonnie Claire alternative segments would cross the HMA, which encompasses 100 square kilometers (25,000 acres) and provides suitable habitat only for burros, although the appropriate management level is for 50 horses and 25 burros (DIRS 182310-Dwyer 2007, all). A 2006 partial BLM census flight located 17 burros around the Stonewall Falls area. Other sightings have indicated that some of the 34 resident burros from the adjoining Goldfield HMA wander through the Stonewall HMA (DIRS 173063-BLM [n.d.], all; DIRS 174046-Bennet 2005, p. 2). Observations made during the 2005 field surveys along Bonnie Claire alternative segment 2 suggest that burros occasionally use the area. Along Bonnie Claire alternative segment 3, within the Stonewall HMA, field observations suggest a relatively high level of past and present use of this area by burros. Field personnel noted signs of limited use of the area by horses near the northern end of Bonnie Claire 3, and noted evidence of habitat use by burros near the southern end of common segment 4.

H.5.2.1.12 Bullfrog Herd Management Area

The Bullfrog HMA surrounds the town of Beatty in Nye County. Common segment 6 would cross this HMA, which encompasses 520 square kilometers (130,000 acres) and is suitable habitat only for wild burros. Only a portion of the HMA has had an appropriate management level established, which was for 183 burros and 12 horses. The 2006 BLM census flight located 32 burros, though the population is estimated to be approximately 70 (DIRS 182310-Dwyer 2007, all). The burro population in the area is estimated to be 34. Unofficial sightings suggest the presence of wild horses and additional burros (DIRS 173064-BLM 2007, all; DIRS 174046-Bennett 2005, all). During the 2005 field surveys, personnel observed several herds of approximately 13 burros each near common segment 6 in the Crater Flat area. Field personnel noted evidence of burros consistently along common segment 6 south of Beatty Wash, with higher levels of use within the Bullfrog HMA.

H.5.2.2 Mina Rail Alignment

H.5.2.2.1 Horse Mountain Herd Management Area

The Horse Mountain HMA is located at the northern boundary of the Walker River Paiute Reservation in Lyon and Churchill counties. Schurz alternative segment 6 would run adjacent to the southern periphery of the HMA, but would not intersect. The Horse Mountain HMA encompasses approximately 193 square kilometers (47,691 acres). In 2000, there was an estimated population of 95 wild horses in this area and no burros (DIRS 182310-Dwyer 2007, all). Currently, there are no known herds that occupy the Horse Mountain HMA, due to modifications or diversions of water resources that once supported herds (DIRS 181843-Axtell 2007).

H.5.2.2.2 Pilot Mountain Herd Management Area

The Pilot Mountain HMA is located in Mineral and Esmeralda Counties, extending from the Monte Cristo mountain range in the southern boundary of the HMA, and continuing northwest along the Pilot Mountain range to the Gabbs Valley Range. The Pilot Mountain HMA is large, encompassing 1,937 square kilometers (478,641 acres). Mina common segment 1 follows the southwestern boundary of the HMA, but would not intersect any of the designated wild horse and burro habitat. The 2006 estimated population of Pilot Mountain HMA is approximately 286 horses (DIRS 182310-Dwyer 2007, all). There are no known burros (DIRS 181843-Axtell 2007).

H.5.2.2.3 Silver Peak Herd Management Area

The Silver Peak HMA is located in Esmeralda County, directly west of Silver Peak and Montezuma alternative segment 1. The proposed rail alignment would not intersect the designated Silver Peak HMA, but would occur adjacent to the eastern boundary. The Silver Peak HMA is approximately 970 square kilometers (239,691 acres). In 2006, all horses were removed from the HMA due to recurrent drought, starvation, and genetics issues (DIRS 182310 Dwyer 2007, all).

H.5.2.2.4 Goldfield Herd Management Area

The Goldfield HMA is located in Esmeralda and Nye Counties, east of the town of Goldfield. Montezuma alternative segment 2 would intersect this HMA. A 2006 BLM census flight located six horses and no burros; however, burro tracks and scat are evident throughout the HMA. Numbers fluctuate dramatically due to burro movement into the Nevada Test Site. There is an estimated population of about 20 to 30 burros in the Goldfield HMA (DIRS 182310-Dwyer 2007, all).

H.5.2.2.5 Montezuma Peak Herd Management Area

The Montezuma Peak HMA is within the Montezuma Range and borders the Goldfield HMA to the east and the Palmetto HMA to the southwest. Montezuma alternative segments 1, 2, and 3 would intersect or run adjacent to the designated HMA. The Montezuma Peak HMA is about 310 square kilometers (76,602 acres) with an estimated 146 wild horses and 10 burros (DIRS 181843-Axtell 2007). However, a 2006 BLM census flight located 58 horses and 18 burros (DIRS 182310-Dwyer 2007, all). During the December 2006 and March 2007 field surveys, several wild horses were observed in the area near the proposed North Clayton quarry site on the west facing side of the Montezuma Range.

H.5.2.2.6 Stonewall Herd Management Area

The Stonewall HMA is west of Lida Junction and south of Goldfield in Nye County. Caliente common segment 4 and both the Bonnie Claire alternative segments would cross the HMA, which encompasses 100 square kilometers (25,000 acres) and provides suitable habitat only for burros, although the appropriate management level is for 50 horses and 25 burros. Annual counts have not recorded any resident animals, but subsequent sightings have indicated that some of the 34 resident burros from the adjoining Goldfield HMA wander through the Stonewall HMA (DIRS 173063-BLM [n.d.], all; DIRS 174048-Bennet and Thebeau 2005, all). Observations made during the 2005 field surveys along Bonnie Claire alternative segment 2 suggest that burros occasionally use the area. A partial 2006 census flight located 17 burros in the area around Stonewall Fall. Along Bonnie Claire alternative segment 3, within the Stonewall HMA, field observations suggest a relatively high level of past and present use of this area by burros. Field personnel noted signs of limited use of the area by horses near the northern end of Bonnie Claire 3, and noted evidence of habitat use by burros near the southern end of common segment 4.

H.5.2.2.7 Bullfrog Herd Management Area

The Bullfrog HMA surrounds the town of Beatty in Nye County. Common segment 6 would cross this HMA, which encompasses 520 square kilometers (130,000 acres) and is suitable habitat only for wild burros. Only a portion of the HMA has had an appropriate management level established, which was for 183 burros and 12 horses. The burro population in the area is estimated to be 34. A 2006 BLM census flight located 17 burros around the Stonewall Falls area (DIRS 182310-Dwyer 2007, all). Unofficial sightings suggest the presence of wild horses and additional burros (DIRS 173064-BLM 2007, all; DIRS 174046-Bennet 2005, all). During the 2005 field surveys, personnel observed several herds of approximately 13 burros each near common segment 6 in the Crater Flat area. Field personnel noted evidence of burros consistently along common segment 6 south of Beatty Wash, with higher levels of use within the Bullfrog HMA.

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APPENDIX I

NOISE AND VIBRATION ASSESSMENT METHODOLOGY

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APPENDIX I

NOISE AND VIBRATION IMPACT ASSESSMENT METHODOLOGY

This appendix provides detailed information on the methodology DOE used to develop the assessment of potential impacts from noise and vibration described in Sections 4.2.8 and 4.3.8 of the Rail Alignment EIS (DOE/EIS-0639D).

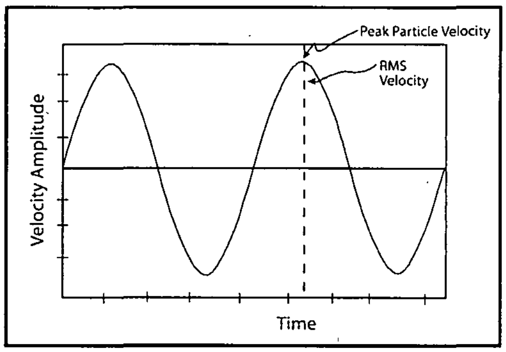
Section **I.4** defines terms shown in ***bold italics***.

I.1 Noise and Vibration Terminology

Noise is considered a source of pollution because it can be a human health hazard. Potential health hazards range from hearing impairment at very high noise levels to annoyance at moderate to high noise levels. Noise is defined as sound waves that are unwanted and perceived as a nuisance by humans. Sound waves are characterized by frequency and measured in ***hertz***; sound pressure level is expressed as ***decibels*** (dB).

With the exception of prohibiting nuisance noise, neither the State of Nevada nor local governments have established numerical noise standards. Many federal agencies use ***day-night average noise levels*** (DNL) as guidelines for land-use compatibility and to assess the impact of noise on people. Noise levels for perceptible frequencies are weighted (***A-weighted decibels*** [dBA]) to simulate the frequency response of the human ear.

Wayside noise refers collectively to train noise generated by steel wheels rolling on steel rail and diesel engine noise. Horn noise refers to the sound of locomotive warning horns, which are sounded at railroad crossings. Horn noise typically dominates over wayside noise at locations near grade crossings. There are three ground-vibration impacts of general concern: annoyance to humans, damage to buildings, and interference with vibration-sensitive activities. There are two measurements for evaluating ground vibration: ***peak particle velocity*** and ***root-mean-square velocity***. Peak particle velocity is the maximum instantaneous positive or negative peak of the vibration signal, measured as a distance per time (such as millimeters or inches per second). This measurement has been used historically to evaluate shock-wave type vibrations from actions like blasting, pile driving, and mining activities, and their relationship to building damage. The root-mean-square velocity is an average or smoothed vibration amplitude, commonly measured over 1-second intervals. It is expressed on a log scale in decibels (VdB) referenced to 0.000001 (10^{-6}) inch per second and is not to be confused with noise decibels (DIRS 155970-DOE 2002, p. 3-101). It is more suitable for addressing human annoyance and characterizing background vibration conditions because it better represents the response time of humans to ground vibration signals. A typical background level of ground vibration is



Peak Particle and Root-Mean-Square Vibration Velocity

52 VdB, and the human threshold for the perception of ground vibration is 65 VdB (DIRS 148155-Hanson, Saurenman, and Towers 1998, p. 46.17).

Vibration criteria for structural damage in fragile or extremely fragile buildings have separate structural criteria based on peak particle velocity and an approximation of VdB that have been segregated into impulse and rail impacts. Table I-1 lists these criteria.

Table I-1. Benchmark ground-vibration criteria for buildings and human annoyance.[a]

Category	Frequent events (more than 70 per day) VdB[b]	Infrequent events (fewer than 70 per day)		Impact of concern
		Peak particle velocity (inches per second)[c]	VdB	
Annoyance or interference				
Highly sensitive building[d]	65	NA[e]	65	Sensitive equipment
Residential[f]	72	NA	80	Human disturbance
Institutional[g]	75	NA	83	Human disturbance
Structural damage				
Fragile buildings	NA	0.20	Approximately 100 (Impulse) 92 (Rail)	Structural damage
Extremely fragile buildings	NA	0.12	Approximately 95 (Impulse) 88 (Rail)	Structural damage

a. Source: DIRS 177297-Hanson, Towers, and Meister 2006, pp. 8-3 and 12-13.
b. Root-mean-square velocity expressed in decibels (VdB) referenced to 10^{-6} inch per second.
c. To convert to millimeters per second, multiply by 25.4.
d. Buildings with vibration-sensitive equipment (for example, at research institutions and medical facilities).
e. NA = not applicable.
f. Homes or buildings where people sleep.
g. Schools, churches, and office buildings.

I.2 Noise Analysis Methodology

DOE used the following methods to determine if constructing and operating the proposed rail line would result in an increase of the DNL of 3 dBA and if the DNL would equal or exceed 65 dBA:
Noise Models – DOE used a wayside noise model, based on past Surface Transportation Board (STB) noise studies including *Conrail Acquisition Environmental Impact Statement* (DIRS 174622-STB 1997, all) and *Draft Environmental Assessment for the Canadian National/Illinois Central Acquisition Environmental Assessment* (DIRS 174623-Kaiser 1998, all). Section I.2.1 lists the equations for this model. The horn noise model is based on data from *Draft Environmental Impact Statement, Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings* (DIRS 174551-DOT 1999, all; the 1999 Federal Railroad Administration DEIS). The overall noise model results are sensitive to horn noise, locomotive and rail car noise, train length, and train speed. DOE used wayside reference levels, the horn noise model, and equations shown in this appendix to generate noise contours. Finally, DOE used Cadna (DIRS 178129-DataKustik n.d., all), an environmental noise computer program, to calculate building shielding effects, where appropriate. DOE selected the individual components of the overall noise model because of the size of the noise measurement database, statistical reliability, and other factors.

Measure Ambient Noise – To establish a baseline for determining if there would be a 3 dBA or greater increase in noise, DOE measured ambient noise in the study area at seven representative locations – Caliente, Garden Valley, Goldfield, Silver Springs, Schurz, Mina, and Silver Peak. Substantial train activity already exists in Caliente; therefore, DOE used a combination of modeling and measurements to determine the difference between existing and future noise levels in that area. DOE measured ***ambient noise levels*** using Norsonics 118 octave band analyzers. For low ambient sound environments, DOE used special low-noise 1-inch diameter precision microphones. DOE measured vibration levels with a Rion SA-77 narrow band analyzer and high sensitivity seismic accelerometers.

Estimate or Measure Existing and Future Noise Exposure – DOE estimated noise exposure in terms of the DNL using information on distances and noise propagation paths to sensitive receptors and future operation plans.

Count Noise-Sensitive Receptors – DOE estimated the number of noise-sensitive receptors within the 65 DNL noise contours for the Proposed Action and Shared-Use Option, or where the DNL would increase by at least 3 dBA. DOE used digital aerial photographs and Geographic Information System software to estimate the number of receptors, including residences, schools, and places of worship, within the 65 DNL noise contour for future train volumes. The final result of this analysis was an estimate of the total number of receptors likely to be exposed to a DNL of 65 dBA or greater and the number of receptors where the DNL would increase by at least 3 dBA under the Proposed Action or the Shared-Use Option.

I.2.1 WAYSIDE NOISE MODEL METHODOLOGY

Wayside noise refers collectively to noise the railcars and locomotives would generate. DOE used noise measurements of past STB noise studies (including DIRS 174622-STB 1997, all; DIRS 174623-Kaiser 1998, all) to establish the basis for the wayside noise level projections. Noise from railcars is caused by the steel wheels rolling on the steel rails. This sound is referred to as wheel/rail noise. Wheel/rail noise varies as a function of speed and can increase by as much as 15 dBA if wheels or rails are in poor condition. One of the most common problems that creates additional noise from wheels is the formation of flat surfaces on wheels caused by wheels sliding during hard braking.

The main components of locomotive noise are the exhaust of the diesel engines, cooling fans, general engine noise, and the wheel/rail interaction. Noise associated with the engine exhaust and cooling fans usually dominates; the noise level depends on the throttle setting (most locomotives have eight throttle settings) and not on locomotive speed.

Tests have shown that locomotive noise levels change by about 2 dBA for each step change in throttle setting, meaning that noise levels increase by about 16 dBA as the locomotive throttle is moved from notch one to notch eight (DIRS 174623-Kaiser 1998, all). Because locomotive engineers constantly adjust throttle settings as necessary, only rough estimates of throttle settings are usually available for noise projections. Numerous field measurements of freight train operations indicate that locomotive noise can be projected with reasonable accuracy by assuming a base condition of throttle position six and adjusting noise levels when better information about typical throttle position is known.
Given the maximum train passby sound level of freight cars and a locomotive under a specific set of reference conditions, the noise models allow estimating the maximum train passby sound level, the sound exposure level, the DNL, and other noise metrics for varying distances from the track, varying train speeds, and varying schedules. The standard approach to projecting railcar noise is to model cars as moving, incoherent (in other words, random), dipole line sources, wherein the cars are sources of sound moving in a straight line, which is equal in both directions from the track center line. The basic equations used for the wayside noise model are:

$$SEL_{cars} = L_{eqref} + 10\log(T_{passby}) + 30\log(S/S_{ref})$$

For locomotives, which can be modeled as moving monopole point sources, the corresponding equation is:

$$SEL_{locos} = SEL_{ref} + 10\log(N_{locos}) - 10\log(S/S_{ref})$$

The total train sound exposure level is computed by logarithmically adding SEL_{locos} and SEL_{cars}:

$$DNL_{100'} = SEL + 10\log(N_d + 10*N_n) - 49.4$$

$$DNL = DNL_{100'} + 15\log(100/D)$$

The parameters that apply to the equations above are:

SEL_{cars} = Sound Exposure Level of rail cars

L_{eqref} = Reference Level Equivalent of rail car (passby L_{eq})

T_{passby} = Train passby time, in seconds

S = Train speed, in miles per hour

S_{ref} = Reference train speed

SEL_{locos} = Sound Exposure Level of locomotive

SEL_{ref} = Reference Sound Exposure Level of locomotive

N_{locos} = Number of locomotives

N_d = Number of trains during daytime

N_n = Number of trains during nighttime

D = Distance from tracks, in feet

Table I-2 shows the reference noise levels used in this study.

Table I-2. Reference noise levels.[a]

Description	Average level (dBA)
Horn SEL 1st 0.125 mile[b,c]	107
Horn SEL 2nd 0.125 mile[b,c]	110
Locomotive SEL (40 miles per hour at 100 feet)[d]	95
Rail car L_{eq} (40 miles per hour at 100 feet)[e]	82

a. dBA = A-weighted decibels; L_{eq} = equivalent sound level; SEL = sound exposure level.
b. To convert miles to kilometers, multiply by 1.6093.
c. Source: DIRS 174551-DOT 1999, all.
d. Source: DIRS 174622-STB 1997, all.
e. Source: DIRS 174623-Kaiser 1998, all.

I.2.2 HORN NOISE MODEL METHODOLOGY

The key components in projecting noise exposure from horn noise are the horn sound level, the duration of the horn noise, the distance of the receptor from the tracks, and the number of trains running during daytime and nighttime hours.

The Federal Railroad Administration requires train engineers to sound horns when approaching public grade crossings unless a Quiet Zone has been established. Horn sounding is generally not required at private crossings. Federal Railroad Administration regulations in 49 CFR 229.129 require all lead locomotives to have an audible warning device that produces a minimum sound level of 96 dBA at a distance of 30 meters (100 feet) in front of the locomotive.

Most freight train audible warning devices are air horns. The maximum sound level of the air horns can usually be adjusted to some degree by adjusting the air pressure. Maximum sound levels are typically 105 to 110 dBA at 30 meters (100 feet) in front of the trains, well above the 96 dBA required by the Federal Railroad Administration.

The Federal Railroad Administration finalized its rule on horn noise on April 27, 2005 (*Use of Locomotive Horns at Highway-Rail Grade Crossings; Final Rule* (70 *Federal Register* 21843). This rule essentially provides communities with means to establish quiet zones in which horns are not sounded if sufficient safety measures are installed at grade crossings. The rule will also likely have an effect on horn noise levels nationally because of a number of changes in how horns will be sounded. For example, the rule limits the maximum level to 110 dBA. Previously, there were no maximum horn noise level limits. Additionally, the noise measurement technique used to establish horn noise levels will change and limits on how long horns can be sounded will be implemented. All of these changes will likely result in somewhat lower horn noise levels nationally.

Because of the high noise levels created by train horns, noise exposure is dominated by horn noise near any grade crossing where sounding horns is required. Additional noise sources associated with grade crossings are the grade-crossing bells that start sounding just before the gates are lowered and idling traffic that must wait at the crossing. Such noises are usually insignificant compared to the horn noise. Freight train horn noise levels can vary for a variety of reasons, including the manner in which an engineer sounds the horn. Consequently, it is important to base horn noise reference levels on a large sample size. A substantial amount of horn noise data is available from the 1999 Federal Railroad Administration DEIS (DIRS 174551-DOT 1999, all).

The Federal Railroad Administration data indicate that horn noise levels increase from the point at which the horn is sounded 0.40 kilometer (0.25 mile) from the grade crossing to when it stops sounding at the grade crossing. In the first 0.2-kilometer (0.125-mile) segment, the energy average sound exposure level measured at a distance of 30 meters (100 feet) from the tracks was found to be 107 dBA, and in the second 0.2-kilometer segment, 110 dBA. The 1999 Federal Railroad Administration DEIS (DIRS 174551-DOT 1999, all) simplified the horn noise contour shape as a five-sided polygon, when it is actually a teardrop shape. *Final Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Texas* (DIRS 173225-STB 2003, all) discusses this subject in detail. DOE used the more accurate teardrop horn noise contour shape for this analysis. The attenuation or drop-off rate of horn noise is assumed to be 4.5 dBA per doubling of distance away from the tracks (DIRS 174551-DOT 1999, all).

To properly calculate building shielding effects, both wayside and horn noise were characterized by representative frequency spectra. Low-frequency sound can diffract or bend more easily than high-frequency sound over or around buildings or terrain; therefore, it is important to model horn and wayside noise separately according to frequency content. Figures I-1 and I-2 show these representative horn and wayside noise spectra. The relative spectrum shapes and absolute noise levels shown in Table I-2 were used in the modeling.

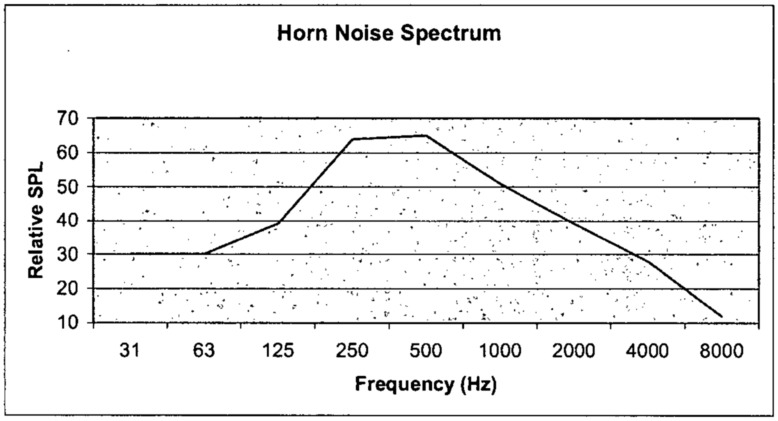


Figure I-1. Horn noise spectrum. (Source: DIRS 173225-STB 2003, p. 4-34. Hz = hertz; SPL = sound pressure level.)

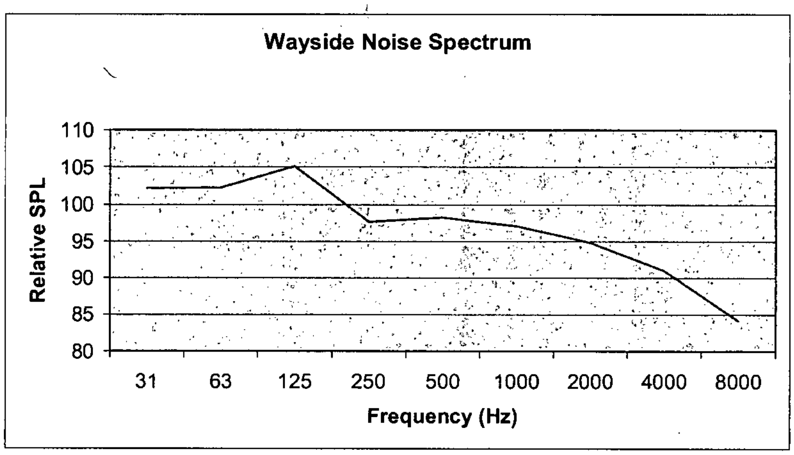


Figure I-2. Wayside noise spectrum. (Source: DIRS 173225-STB 2003, p. 4-34. Hz = hertz; SPL = sound pressure level.)

In general, the tear-drop shapes, shown in the figures in Section 4.2.8 and 4.3.8 of this EIS, are noise contours at grade crossings where horns might be sounded; noise contours shown in other areas are due to wayside noise. DOE used the noise contours in these figures, aerial photographs, and Geographic Information System software to identify and count any receptors that would be exposed to 65 DNL under the Proposed Action or the Shared-Use Option.

Counts of noise-sensitive receptors are approximate for several reasons, including changes in land use since the aerial photographs were taken (1994 to 2007), and difficulties in determining whether a structure is inhabited or uninhabited. In general, the approach was to count any structure within a noise contour as being inhabited. DOE also examined aerial photographs of portions of the proposed rail alignment not shown in these figures. However, these areas are generally uninhabited and no potential receptors were identified.

I.3 Vibration Analysis Methodology

The vibration analysis methodology is based on Federal Transit Administration Methods (DIRS 177297-Hanson, Towers, and Meister 2006, all).

I.3.1 CONSTRUCTION VIBRATION

Vibration due to construction activities, assuming point sources with normal propagation conditions, can be calculated on the basis of the following equation:

$$PPV_{equip} = PPV_{ref} \times (25/D)^{1.5}$$

Where: PPV_{equip} is the peak particle velocity in inches per second of the equipment adjusted for distance.

PPV_{ref} is the reference vibration level of equipment in inches per second at 25 feet.

D is the distance from the equipment to the receptor.

I.3.2 TRAIN VIBRATION

Vibration levels due to trains were estimated on the basis of generalized ground-surface vibration curves, as shown in Figure I-3.

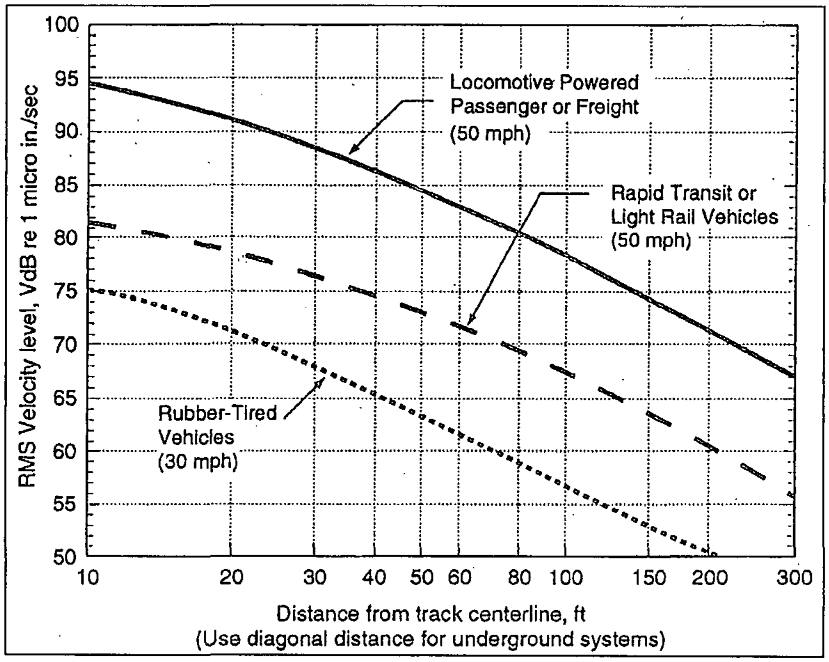


Figure I-3. Generalized ground surface vibration curves. (Source: DIRS 177297-Hanson, Towers, and Meister 2006.)

I.4 Glossary

ambient noise	The sum of all sounds (noise is unwanted sound) at a specific location over a specific time.
day-night average noise level	The energy average of ***A-weighted decibel*** sound levels over 24 hours, which 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. The effect of nighttime adjustment is that one nighttime event, such as a train passing by between 10 p.m. and 7 a.m., is equivalent to 10 similar events during the daytime.
decibel (dB)	A standard unit for measuring sound pressure levels based on a reference sound pressure of 0.0002 dyne per square centimeter. This is the smallest sound a human can hear.
decibel, A-weighted (dBA)	A frequency-weighted ***noise*** unit that corresponds approximately to the frequency response of the human ear and thus correlates well with loudness. It is widely used for traffic and industrial noise measurements.
hertz	A unit of frequency equal to one cycle per second.
peak particle velocity	The maximum instantaneous positive or negative peak of the vibration signal, measured as a distance per time (such as millimeters or inches per second). This measurement has been used historically to evaluate shock-wave type vibrations from actions like blasting, pile driving, and mining activities, and their relationship to building damage.
root mean-square velocity	An average or smoothed vibration amplitude, commonly measured over 1-second intervals. It is expressed on a log scale in ***decibels (VdB)*** referenced to 0.000001 (10^{-6}) inch per second and is not to be confused with noise ***decibels***.

I.5 References

178129	DataKustik [n.d.]	DataKustik [n.d.]. Cadna A, Software for Environmental Noise, Computer Aided Noise Abatement. Greifenberg, Germany: DataKustik. TIC: 258792.
155970	DOE 2002	DOE (U.S. Department of Energy) 2002. Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; MOL.20020524.0315; MOL.20020524.0316; MOL.20020524.0317; MOL.20020524.0318; MOL.20020524.0319; MOL.20020524.0320.
174551	DOT 1999	DOT (U.S. Department of Transportation) 1999. Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings. Washington, D.C.: U.S. Department of Transportation, Office of Railroad Development. ACC: MOL.20050824.0327.
148155	Hanson, Saurenman, and Towers 1998	Hanson, C.E.; Saurenman, H.J.; and Towers, D.A. 1998. "Rail Transportation Noise and Vibration." Chapter 46 of Handbook of Acoustical Measurements and Noise Control. Harris, C.M., ed. 3rd Edition. New York, New York: McGraw-Hill. TIC: 250744.

177297	Hanson, Towers, and Meister 2006	Hanson, C.E.; Towers, D.A.; and Meister, L.D. 2006. Transit Noise and Vibration Impact Assessment. FTA-VA-90-1003-06. Washington, D.C.: U.S. Department of Transportation, Federal Transit Administration. ACC: MOL.20060814.0190.
174623	Kaiser 1998	Kaiser, E.K. 1998. "Re: Railroad Control Application, Finance Docket No. 33556 — Canadian National — Control — Illinois Central: Release of Draft Environmental Assessment for Public Review and Comment." Letter from E.K. Kaiser (STB) to Interested Parties, November 9, 1998, with enclosure. ACC: MOL.20050824.0324.
174622	STB 1997	STB (Surface Transportation Board) 1997. Before the Surface Transportation Board, Finance Docket No. 33388, CSX Corporation and CSX Transportation, Inc., Norfolk Southern Corporation and Norfolk Southern Railway Company — Control and Operating Leases/Agreements — Conrail Inc. and Consolidated Rail Corporation. Railroad Control Application, Volume 6A of Environmental Report. CSX/NS-23. Washington, D.C.: Surface Transportation Board. ACC: MOL.20060404.0002.
173225	STB 2003	STB (Surface Transportation Board) 2003. Final Environmental Impact Statement, Construction and Operation of a Rail Line from the Bayport Loop in Harris County, Texas. Decision ID No. 33543. Finance Docket No. 34079. [Washington, D.C.]: Surface Transportation Board. ACC: MOL.20050418.0040.

APPENDIX J

SOCIOECONOMICS

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ACRONYMS AND ABBREVIATIONS

DIRS	Document Input Reference System
DOE	U.S. Department of Energy
EIS	environmental impact statement
FEIS	final environmental impact statement
LOS	level of service
REMI	Regional Economic Models, Inc.
SEIS	supplemental environmental impact statement

APPENDIX J

SOCIOECONOMICS

This appendix provides details to support the analysis results reported in Sections 4.2.9 and 4.3.9 of the Rail Alignment EIS.

Section J.2 defines terms shown in ***bold italics***.

J.1 INTRODUCTION

The U.S. Department of Energy (DOE or the Department) used an economic-demographic forecasting model known as *Policy Insight*, developed by Regional Economic Models, Inc. (REMI®) (DIRS 178610-Bland 2007, all), to generate employment, ***real disposable income***, and ***gross regional product*** data for Lyon, Mineral, Clark, Lincoln, Nye, Esmeralda, and Washoe Counties, and Carson City. *Policy Insight* is an eight-region model, seven of the regions being Lyon, Mineral, Clark, Lincoln, Nye, and Esmeralda Counties, and Washoe County-Carson City. Because of the configuration of the DOE version of the model, Carson City and Washoe County are considered as a single economic entity.

The REMI® model has been in use since 1980 to generate year-by-year estimates of the total regional effects of any specific policy initiative. For this analysis DOE used *Policy Insight*, version 9.0 (DIRS 182251-REMI 2007, all). The model has the following features:

- It is calibrated to local conditions using a relatively large amount of local data.
- It combines several different kinds of analytical tools (including economic-base, input-output, and econometric models).
- It allows users to manipulate an unusually large number of input variables and gives forecasts for an unusually large number of output variables.
- It allows users to generate forecasts for any combination of future years, allowing users special flexibility in analyzing the timing of economic impacts.
- It accounts for business cycles.

The description of existing economic conditions in the Caliente and Mina rail alignments regions of influence and the forecast values of populations, gross regional product, and real disposable income draw on data from version 9.0 of *Policy Insight*. The description implicitly includes revenue from the DOE Payments Equal to Taxes program, described in detail in the *Final* (Yucca Mountain FEIS; DIRS 155970-DOE 2001, p. 3-90), and the *Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain Nye County, Nevada* (Repository SEIS DOE/EIS-0250F-51). Revenue from this program is not described separately. Because the model is based on nationally collected data for which there is a lag between collection and issuance by the national agencies, and another lag before the data are incorporated into the *Policy Insight* model, there is always a gap of approximately 2 to 3 years between the current year and the last history year. The year 2004 is the last history year for the *Policy Insight* model (version 9.0) used in this baseline forecast.

To compensate for this time lag, the model's employment update feature is specifically designed to accommodate new historical data provided by users, which update the model's growth-rate assumptions. *Policy Insight* version 9.0 uses an employment update module that relies on data from the Nevada Department of Education, Training, and Rehabilitation for 2004 through 2006. This version also incorporates information from the latest Clark County population projections prepared by the University of Nevada, Las Vegas (DIRS 178806-CBER 2006, all) and the latest population projections developed by the Nevada State Demographer (DIRS 178807-Hardcastle 2006, all).

Impacts are stated in terms of the number of jobs, gross regional product, real disposable income, and state and local government spending. Direct economic effects are the changes in jobs, gross regional product, and income in sectors that would supply directly needed goods and services, such as heavy-duty equipment, during the proposed railroad construction and operations phase.

Items included as *Policy Insight* inputs include direct employment and costs, as follows:

- Employment in the following sectors:
  - Construction
  - Professional and Technical Services
  - Government Employees – Federal Civilian, State and Local
  - Administrative Support Services
  - Food services
  - Repair and Maintenance
  - Mining (surface mining for quarry sites)
  - Transportation
- For sectors for which wage data for the project are available, wage adjustments on the differential between project wages and model wages are made.
- Costs (increase in demand) for the following sectors are included:
  - Utilities
  - Wholesale Sales
  - Administrative Support Services
  - Construction
  - Mining (surface mining for quarry sites)
  - Accommodations
  - Food Services
  - Repair and Maintenance
  - Professional and Technical Services
  - Transportation

This appendix presents results from runs of *Policy Insight* version 9.0 (DIRS 182251-REMI 2007, all) made in March 2007 (DIRS 179558-Bland 2007, all; DIRS 180485-Bland 2007, all) for the Caliente rail alignment and in April 2007 (DIRS 180689-Bland 2007, all) for the Mina rail alignment. As described in Sections 4.2.9 and 4.3.9 of the Rail Alignment EIS, the *Policy Insight* model forecasts changes to baseline economic and demographic conditions that would be associated with the Proposed Action. For the Caliente rail alignment, DOE modeled two scenarios for this analysis, one with the Nevada Railroad

Control Center and National Transportation Operations Center in Lincoln County (Scenario 1) and one with these facilities in Nye County (Scenario 2). For the Mina rail alignment, DOE modeled two scenarios for this analysis, one with the Nevada Railroad Control Center and National Transportation Operations Center in Mineral County (Scenario 1) and one with these facilities in Nye County (Scenario 2). This appendix provides results for both rail alignments from each scenario for each Nevada county in the socioeconomics region of influence (for the Caliente rail alignment, Lincoln, Nye, Esmeralda, and Clark Counties; for the Mina rail alignment, Lyon, Mineral, Nye, Esmeralda, and Clark Counties, and Washoe County-Carson City).

This appendix also describes the methodology used to quantify impacts to public services, level of service on roadways, and traffic delays at rail-highway grade crossings.

J.1.1 RAILROAD CONSTRUCTION – CALIENTE RAIL ALIGNMENT

Table J-1 lists percent changes to the baseline that would be associated with the Caliente rail alignment construction phase. The table lists data by county, but does not break the data down by scenario for Esmeralda and Clark Counties because the percent changes would be the same under either scenario. Lincoln and Nye Counties would experience slightly different percent changes under the two scenarios. Rail Alignment EIS Section 3.2.9, Table 3-61, lists baseline numbers. Section 4.2.9, Table 4-101, lists absolute changes to the baseline.

Table J-1. Percent changes from baseline during the construction phase – Caliente rail alignment[a] (page 1 of 2).

	Variable				
Year	Population	Total Employment	State and local government spending	Real disposable personal income	Total gross regional product
			Lincoln County		
Scenario 1					
2010	0.89	4.56	1.28	4.11	28.36
2011	1.20	4.67	1.62	2.57	17.29
2012	1.42	5.55	1.87	3.01	19.99
2013	1.50	3.36	1.84	2.31	8.64
2014	1.65	2.86	1.91	2.95	3.83
Scenario 2					
2010	0.87	4.42	1.26	4.06	26.18
2011	1.16	4.67	1.61	2.56	17.29
2012	1.41	5.54	1.86	3.00	19.99
2013	1.49	3.35	1.83	2.31	8.64
2014	1.56	2.41	1.80	2.32	3.35
			Nye County		
Scenario 1					
2010	0.12	1.24	0.33	0.89	3.06
2011	0.13	1.08	0.34	0.56	2.44
2012	0.19	1.36	0.40	0.83	3.50
2013	0.23	0.87	0.36	0.62	2.00
2014	0.23	0.40	0.32	0.32	0.67

Table J-1. Percent changes from baseline during the construction phase – Caliente rail alignment[a] (page 2 of 2).

	Variable				
Year	Population	Total Employment	State and local government spending	Real disposable personal income	Total gross regional product
			Nye County *(continued)*		
Scenario 2					
2010	0.12	1.24	0.33	0.89	3.06
2011	0.13	1.08	0.34	0.56	2.44
2012	0.19	1.38	0.40	0.85	3.57
2013	0.24	0.90	0.37	0.64	2.11
2014	0.24	0.42	0.33	0.33	0.71
			Esmeralda County		
2010	0.41	2.73	1.35	7.32	9.47
2011	0.69	2.73	1.79	7.35	1.15
2012	0.91	2.67	2.15	7.57	1.13
2013	0.99	1.92	2.01	4.10	4.47
2014	1.12	1.78	1.95	3.44	1.68
			Clark County		
2010	0.02	0.14	0.02	0.17	0.15
2011	0.03	0.14	0.04	0.17	0.15
2012	0.04	0.14	0.05	0.17	0.15
2013	0.05	0.08	0.05	0.10	0.09
2014	0.04	0.04	0.05	0.06	0.05

a. Sources: DIRS 179558-Bland 2007, all; DIRS 180485-Bland 2007, all.

J.1.2 RAILROAD OPERATIONS – CALIENTE RAIL ALIGNMENT

Tables J-2 through J-5 list impacts associated with the railroad operations phase for the Caliente rail alignment.

Table J-2. Changes from baseline for railroad operations[a] – Caliente rail alignment – Lincoln County (page 1of 4).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County					
2015	102	88	1,001,520	4,148,820	4,414,644
2016	114	89	1,138,761	4,311,450	4,595,292
2017	127	93	1,268,163	4,486,950	6,164,730
2018	136	93	1,375,569	4,609,800	6,415,110
2019	145	94	1,476,657	4,722,120	6,585,930

Table J-2. Changes from baseline for railroad operations[a] – Caliente rail alignment – Lincoln County (page 2 of 4).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County (continued)					
2020	153	95	1,560,078	4,819,230	6,781,320
2021	160	95	1,640,340	4,915,170	6,950,970
2022	164	96	1,694,979	4,988,880	7,077,330
2023	167	96	1,734,291	5,048,550	7,176,780
2024	171	96	1,787,643	5,123,430	7,304,310
2025	174	96	1,828,242	5,191,290	7,427,160
2026	177	97	1,865,214	5,260,320	7,557,030
2027	178	97	1,894,113	5,322,330	7,651,800
2028	180	97	1,918,215	5,384,340	7,793,370
2029	181	98	1,947,699	5,451,030	7,933,770
2030	183	98	1,972,620	5,517,720	8,058,960
2031	184	98	1,994,265	5,585,580	8,186,490
2032	185	98	2,014,389	5,655,780	8,288,280
2033	186	99	2,033,109	5,729,490	8,434,530
2034	187	99	2,052,999	5,806,710	8,501,220
2035	187	99	2,068,677	5,882,760	8,542,170
2036	188	99	2,080,026	5,956,470	8,661,510
2037	188	100	2,088,918	6,029,010	8,773,830
2038	187	100	2,093,364	6,102,720	8,877,960
2039	187	100	2,098,863	6,182,280	8,994,960
2040	186	100	2,104,947	6,265,350	9,058,140
2041	185	100	2,101,788	6,342,570	9,009,000
2042	185	100	2,108,808	6,437,340	9,116,640
2043	186	100	2,119,338	6,540,300	9,257,040
2044	185	101	2,122,029	6,638,580	9,390,420
2045	185	101	2,124,252	6,740,370	9,337,770
2046	185	101	2,129,985	6,850,350	9,481,680
2047	186	101	2,140,281	6,973,200	9,637,290
2048	187	101	2,154,906	7,108,920	9,796,410
2049	188	102	2,169,882	7,251,660	9,961,380
2050	189	102	2,187,549	7,400,250	10,129,860
2051	190	102	2,196,324	7,429,933	10,170,492
2052	191	103	2,205,133	7,459,736	10,211,287
2053	191	103	2,213,978	7,489,658	10,252,246
2054	192	104	2,222,859	7,519,700	10,293,369

Table J-2. Changes from baseline for railroad operations[a] – Caliente rail alignment – Lincoln County (page 3 of 4).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County (continued)					
2055	193	104	2,231,775	7,549,862	10,334,657
2056	194	105	2,240,727	7,580,146	10,376,111
2057	195	105	2,249,715	7,610,551	10,417,731
2058	195	105	2,258,739	7,641,078	10,459,518
2059	196	106	2,267,799	7,671,727	10,501,472
2060	197	106	2,276,895	7,702,499	10,543,595
2061	198	107	2,286,028	7,733,395	10,585,887
2062	198	107	2,295,198	7,764,415	10,628,348
2063	199	108	2,304,404	7,795,559	10,670,980
2064	200	108	2,313,647	7,826,828	10,713,782
2065	201	108	2,322,928	7,858,222	10,756,757
2066	202	109	2,332,245	7,889,742	10,799,904
2067	202	109	2,341,600	7,921,389	10,843,223
Scenario 2: Assuming Transportation Operations Center and Railroad Control Center in Nye County					
2015	88	66	865,952	2,890,066	3,394,153
2016	93	67	928,200	2,956,782	3,490,084
2017	99	70	990,336	3,055,036	4,990,050
2018	103	70	1,039,719	3,115,884	5,181,956
2019	107	71	1,088,399	3,175,589	5,298,965
2020	110	71	1,127,135	3,229,418	5,447,529
2021	114	71	1,166,568	3,286,739	5,571,557
2022	115	71	1,189,968	3,330,055	5,659,334
2023	116	72	1,205,187	3,366,325	5,724,845
2024	118	72	1,230,927	3,413,134	5,811,434
2025	119	72	1,249,652	3,456,441	5,898,005
2026	120	72	1,267,210	3,502,063	5,991,631
2027	121	72	1,280,072	3,543,030	6,051,292
2028	121	72	1,290,606	3,583,989	6,160,128
2029	122	73	1,305,812	3,629,619	6,265,411
2030	122	73	1,318,695	3,675,240	6,355,484
2031	123	73	1,330,399	3,723,193	6,449,127
2032	123	73	1,342,103	3,773,529	6,518,131
2033	124	73	1,353,799	3,826,170	6,631,586
2034	124	73	1,366,669	3,882,391	6,665,560
2035	125	74	1,377,208	3,937,390	6,674,937
2036	125	74	1,386,568	3,992,380	6,764,992

Table J-2. Changes from baseline for railroad operations[a] – Caliente rail alignment – Lincoln County (page 4 of 4).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2037	125	74	1,394,753	4,047,353	6,849,215
2038	125	74	1,399,438	4,101,190	6,925,300
2039	125	74	1,405,288	4,159,707	7,015,407
2040	125	74	1,412,308	4,221,709	7,049,355
2041	125	74	1,414,648	4,281,414	6,975,610
2042	125	74	1,421,672	4,351,648	7,051,695
2043	125	74	1,432,198	4,428,921	7,159,335
2044	126	75	1,439,222	4,504,979	7,264,635
2045	126	75	1,445,068	4,583,378	7,182,700
2046	126	75	1,453,271	4,667,618	7,295,020
2047	127	75	1,463,796	4,760,031	7,414,429
2048	128	75	1,476,662	4,861,786	7,536,075
2049	129	76	1,489,541	4,967,095	7,662,452
2050	130	76	1,503,585	5,075,913	7,790,034
2051	131	76	1,509,616	5,096,273	7,821,281
2052	131	77	1,515,671	5,116,715	7,852,653
2053	132	77	1,521,751	5,137,239	7,884,151
2054	132	77	1,527,855	5,157,845	7,915,776
2055	133	77	1,533,983	5,178,534	7,947,527
2056	133	78	1,540,136	5,199,306	7,979,405
2057	134	78	1,546,314	5,220,161	8,011,412
2058	134	78	1,552,517	5,241,100	8,043,547
2059	135	79	1,558,744	5,262,122	8,075,810
2060	135	79	1,564,996	5,283,229	8,108,204
2061	136	79	1,571,274	5,304,421	8,140,727
2062	136	80	1,577,576	5,325,698	8,173,380
2063	137	80	1,583,904	5,347,060	8,206,165
2064	138	80	1,590,257	5,368,508	8,239,081
2065	138	81	1,596,636	5,390,041	8,272,129
2066	139	81	1,603,040	5,411,661	8,305,309
2067	139	81	1,609,470	5,433,368	8,338,623

a. Sources: DIRS 179558-Bland 2007, all; DIRS 180485-Bland 2007, all.
b. Data expressed in dollars.

Table J-3. Changes from baseline for railroad operations[a] – Caliente rail alignment – Nye County (page 1 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County					
2015	143	56	617,270	3,587,624	7,035,854
2016	149	53	647,337	3,463,212	7,037,582
2017	154	54	675,180	3,446,165	7,775,518
2018	159	54	700,701	3,451,968	8,083,646
2019	163	55	724,280	3,483,277	8,349,515
2020	167	56	746,807	3,537,518	8,674,915
2021	171	58	768,362	3,607,239	8,974,574
2022	174	59	788,982	3,682,680	9,252,561
2023	178	61	809,415	3,761,070	9,509,683
2024	181	62	828,678	3,846,761	9,768,114
2025	184	63	846,988	3,930,861	10,025,514
2026	187	64	864,980	4,017,722	10,282,161
2027	190	65	881,781	4,105,752	10,501,982
2028	192	66	898,066	4,198,264	10,771,362
2029	195	67	914,468	4,289,665	11,029,737
2030	197	67	929,901	4,383,487	11,265,186
2031	199	68	944,747	4,482,375	11,504,339
2032	201	69	958,939	4,584,306	11,717,697
2033	203	70	972,732	4,692,086	11,963,537
2034	205	70	987,076	4,797,725	12,139,316
2035	207	71	1,001,103	4,901,715	12,279,437
2036	209	71	1,015,143	5,013,146	12,502,016
2037	211	72	1,030,038	5,130,696	12,736,016
2038	213	73	1,044,967	5,251,487	12,958,873
2039	215	73	1,060,563	5,377,659	13,204,573
2040	218	74	1,076,042	5,503,259	13,380,353
2041	220	74	1,091,321	5,634,252	13,451,389
2042	222	75	1,106,449	5,769,130	13,673,411
2043	224	75	1,121,846	5,913,320	13,930,531
2044	227	76	1,137,359	6,061,852	14,189,047
2045	229	77	1,152,569	6,211,565	14,247,826
2046	232	77	1,168,504	6,370,627	14,505,506
2047	235	78	1,184,451	6,539,107	14,787,421
2048	238	78	1,199,766	6,718,339	15,068,221
2049	240	79	1,216,215	6,904,041	15,349,300
2050	243	80	1,231,530	7,094,751	15,643,473
2051	247	81	1,248,771	7,194,076	15,862,478

Table J-3. Changes from baseline for railroad operations[a] – Caliente rail alignment – Nye County (page 2 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County (continued)					
2052	250	82	1,266,254	7,294,792	16,084,549
2053	254	83	1,283,981	7,396,917	16,309,729
2054	257	84	1,301,957	7,500,472	16,538,062
2055	261	86	1,320,184	7,605,477	16,769,591
2056	265	87	1,338,666	7,711,952	17,004,361
2057	268	88	1,357,407	7,819,917	17,242,418
2058	272	89	1,376,410	7,929,394	17,483,808
2059	276	90	1,395,680	8,040,404	17,728,577
2060	280	92	1,415,219	8,152,968	17,967,773
2061	284	93	1,435,032	8,267,108	18,228,444
2062	288	94	1,455,122	8,382,845	18,483,638
2063	292	96	1,475,493	8,500,203	18,742,405
2064	296	97	1,496,150	8,619,204	19,004,794
2065	300	98	1,517,096	8,739,871	19,270,857
2066	304	100	1,538,335	8,862,227	19,540,644
2067	308	101	1,559,871	8,986,296	19,814,209
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	148	59	638,317	3,761,433	7,505,082
2016	154	56	671,990	3,640,104	7,517,835
2017	160	57	703,041	3,625,830	8,266,986
2018	166	58	731,507	3,635,892	8,588,151
2019	170	59	757,786	3,671,694	8,866,845
2020	175	60	782,777	3,731,130	9,205,911
2021	179	62	806,610	3,805,191	9,519,237
2022	183	63	829,378	3,885,921	9,811,269
2023	187	65	851,830	3,969,576	10,083,060
2024	191	66	872,925	4,061,421	10,356,138
2025	194	67	892,979	4,150,809	10,627,461
2026	197	68	912,542	4,243,239	10,897,848
2027	200	69	930,946	4,336,956	11,131,848
2028	203	70	948,659	4,435,119	11,415,456
2029	206	71	966,420	4,532,346	11,687,481
2030	208	72	983,151	4,630,626	11,936,808
2031	210	73	999,110	4,735,107	12,190,230
2032	213	73	1,014,449	4,842,747	12,417,327
2033	215	74	1,029,261	4,955,652	12,677,535
2034	217	75	1,044,611	5,067,855	12,867,075

Table J-3. Changes from baseline for railroad operations[a] – Caliente rail alignment – Nye County (page 3 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2035	219	75	1,059,611	5,178,303	13,021,749
2036	221	76	1,074,598	5,296,005	13,258,791
2037	224	77	1,090,463	5,420,142	13,507,533
2038	226	77	1,106,340	5,548,140	13,745,745
2039	228	78	1,122,908	5,680,584	14,006,304
2040	230	79	1,139,288	5,812,560	14,197,716
2041	233	79	1,155,515	5,951,673	14,283,477
2042	235	80	1,171,509	6,095,817	14,521,689
2043	238	80	1,187,784	6,247,215	14,794,767
2044	240	81	1,204,129	6,403,527	15,067,962
2045	243	81	1,220,252	6,561,126	15,143,778
2046	246	82	1,236,983	6,728,553	15,417,675
2047	249	83	1,253,807	6,905,925	15,716,844
2048	251	83	1,270,023	7,093,242	16,014,141
2049	255	84	1,287,351	7,288,398	16,312,491
2050	258	85	1,303,462	7,490,574	16,623,126
2051	261	86	1,321,710	7,595,440	16,855,846
2052	265	87	1,340,214	7,701,775	17,091,824
2053	269	88	1,358,976	7,809,598	17,331,105
2054	272	90	1,378,002	7,918,930	17,573,737
2055	276	91	1,397,293	8,029,794	17,819,765
2056	280	92	1,416,855	8,142,209	18,069,238
2057	284	94	1,436,691	8,256,198	18,322,203
2058	288	95	1,456,804	8,371,783	18,578,709
2059	292	96	1,477,199	8,488,986	18,838,807
2060	296	98	1,497,880	8,607,830	19,102,546
2061	300	99	1,518,850	8,728,337	19,369,977
2062	304	100	1,540,113	8,850,532	19,641,152
2063	309	102	1,561,674	8,974,437	19,916,124
2064	313	103	1,583,537	9,100,077	20,194,945
2065	317	105	1,605,707	9,227,476	20,477,670
2066	322	106	1,628,186	9,356,659	20,764,352
2067	326	108	1,650,980	9,487,650	21,055,049

a. Sources: DIRS 179558-Bland 2007, all; DIRS 180485-Bland 2007, all.
b. Data expressed in dollars.

Table J-4. Changes from baseline for railroad operations[a] – Caliente rail alignment – Esmeralda County (page 1 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County					
2015	14	11	124,992	895,739	701,737
2016	15	11	136,313	893,335	728,820
2017	16	11	144,510	894,511	755,607
2018	16	11	152,480	897,486	784,038
2019	17	12	159,981	902,288	813,518
2020	18	12	164,562	908,345	842,297
2021	18	12	170,427	916,626	872,824
2022	18	12	174,891	924,740	903,235
2023	19	12	179,358	933,682	934,366
2024	19	12	183,473	943,101	965,962
2025	19	12	187,003	952,491	997,910
2026	20	12	190,297	962,240	1,030,325
2027	20	13	193,123	972,228	1,063,083
2028	20	13	195,949	984,080	1,096,320
2029	20	13	198,655	995,349	1,130,029
2030	20	13	201,129	1,006,523	1,164,310
2031	20	13	203,601	1,018,011	1,199,533
2032	21	13	205,837	1,029,759	1,235,819
2033	21	13	207,838	1,041,843	1,272,097
2034	21	13	209,722	1,053,825	1,309,553
2035	21	13	211,253	1,065,446	1,346,993
2036	21	13	212,784	1,077,306	1,386,779
2037	21	13	214,314	1,089,716	1,426,590
2038	21	13	215,608	1,102,758	1,466,372
2039	21	13	217,253	1,116,247	1,508,500
2040	21	13	218,662	1,130,344	1,551,804
2041	21	13	219,956	1,144,791	1,595,102
2042	21	13	221,014	1,159,815	1,639,567
2043	21	13	221,836	1,169,539	1,685,205
2044	21	13	222,425	1,178,575	1,730,835
2045	21	13	222,778	1,189,156	1,777,661
2046	21	13	223,013	1,195,033	1,825,631
2047	21	13	223,129	1,212,666	1,874,780
2048	21	13	223,131	1,231,468	1,925,099
2049	21	14	223,013	1,251,441	1,976,596
2050	21	14	222,660	1,258,527	2,028,081
2051	21	14	223,088	1,260,945	2,031,977

Table J-4. Changes from baseline for railroad operations[a] – Caliente rail alignment – Esmeralda County (page 2 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County (continued)					
2052	21	14	223,517	1,263,367	2,035,881
2053	21	14	223,946	1,265,795	2,039,793
2054	21	14	224,376	1,268,227	2,043,711
2055	21	14	224,808	1,270,663	2,047,638
2056	21	14	225,239	1,273,104	2,051,572
2057	21	14	225,672	1,275,550	2,055,514
2058	21	14	226,106	1,278,001	2,059,463
2059	21	14	226,540	1,280,456	2,063,419
2060	21	14	226,975	1,282,916	2,067,384
2061	21	14	227,411	1,285,381	2,071,356
2062	21	14	227,848	1,287,851	2,075,535
2063	22	14	228,286	1,290,325	2,079,323
2064	22	14	228,725	1,292,804	2,083,317
2065	22	14	229,164	1,295,288	2,087,320
2066	22	14	229,604	1,297,776	2,091,330
2067	22	14	230,046	1,300,270	2,095,348
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	14	11	125,053	895,279	701,735
2016	15	11	136,330	892,489	728,784
2017	16	11	144,525	893,387	755,563
2018	16	11	152,488	896,190	783,994
2019	17	12	159,981	900,867	813,476
2020	18	12	164,550	906,842	842,263
2021	18	12	170,403	915,050	872,789
2022	18	12	174,852	923,148	903,204
2023	19	12	179,305	932,078	934,331
2024	19	12	183,406	941,478	965,938
2025	19	12	186,921	950,866	997,877
2026	20	12	190,202	960,607	1,030,297
2027	20	13	193,015	970,600	1,063,048
2028	20	13	195,829	982,443	1,096,281
2029	20	13	198,525	993,717	1,129,985
2030	20	13	200,987	1,004,888	1,164,273
2031	20	13	203,450	1,016,392	1,199,496
2032	21	13	205,679	1,028,145	1,235,768
2033	21	13	207,672	1,040,224	1,272,045
2034	21	13	209,549	1,052,208	1,309,498

Table J-4. Changes from baseline for railroad operations[a] – Caliente rail alignment – Esmeralda County (page 3 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2035	21	13	211,074	1,063,834	1,346,936
2036	21	13	212,600	1,075,697	1,386,716
2037	21	13	214,125	1,088,147	1,426,524
2038	21	13	215,416	1,101,202	1,466,302
2039	21	13	217,058	1,114,713	1,508,413
2040	21	13	218,467	1,128,814	1,551,725
2041	21	13	219,759	1,143,266	1,595,204
2042	21	13	220,816	1,158,289	1,639,493
2043	21	13	221,639	1,168,040	1,685,123
2044	21	13	222,228	1,177,088	1,730,761
2045	21	13	222,582	1,187,680	1,777,574
2046	21	13	222,820	1,193,556	1,825,544
2047	21	13	222,938	1,211,162	1,874,689
2048	21	13	222,942	1,229,957	1,924,994
2049	21	14	222,827	1,249,907	1,976,496
2050	21	14	222,477	1,256,975	2,027,980
2051	21	14	222,905	1,259,390	2,031,877
2052	21	14	223,333	1,261,810	2,035,780
2053	21	14	223,762	1,264,234	2,039,692
2054	21	14	224,192	1,266,663	2,043,610
2055	21	14	224,623	1,269,097	2,047,537
2056	21	14	225,054	1,271,535	2,051,471
2057	21	14	225,487	1,273,978	2,055,412
2058	21	14	225,920	1,276,426	2,059,361
2059	21	14	226,354	1,278,878	2,063,317
2060	21	14	226,789	1,281,335	2,067,282
2061	21	14	227,225	1,283,797	2,071,253
2062	21	14	227,661	1,286,263	2,075,223
2063	22	14	228,099	1,288,734	2,079,220
2064	22	14	228,537	1,291,210	2,083,214
2065	22	14	228,976	1,293,691	2,087,217
2066	22	14	229,416	1,296,177	2,091,227
2067	22	14	229,857	1,298,667	2,095,245

a. Sources: DIRS 179558-Bland 2007, all; DIRS 180485-Bland 2007, all.
b. Data expressed in dollars.

Table J-5. Changes from baseline for railroad operations[a] – Caliente rail alignment – Clark County (page 1 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County					
2015	1008	74	4,087,278	13,340,457	10,872,342
2016	900	23	3,678,726	10,452,897	5,507,307
2017	798	1	3,288,905	8,488,935	2,705,040
2018	709	-3	2,937,741	7,346,898	1,704,924
2019	631	3	2,632,044	6,730,425	1,740,375
2020	563	13	2,364,008	6,533,748	2,320,344
2021	505	24	2,135,695	6,462,261	3,311,451
2022	457	36	1,941,311	6,703,281	4,195,854
2023	416	47	1,778,576	6,998,355	5,338,476
2024	382	57	1,641,522	7,311,096	6,301,620
2025	352	64	1,518,672	7,605,819	7,122,726
2026	326	71	1,416,718	7,909,083	7,801,326
2027	304	76	1,323,059	8,096,283	8,480,511
2028	283	79	1,241,113	8,363,745	8,890,245
2029	264	83	1,167,169	8,613,657	9,390,771
2030	249	85	1,102,362	8,801,676	9,712,170
2031	234	88	1,043,277	8,944,065	10,122,606
2032	222	89	994,196	9,221,355	10,586,511
2033	212	90	953,948	9,408,204	10,818,405
2034	204	91	921,656	9,702,576	11,229,777
2035	199	92	903,825	9,908,145	11,336,130
2036	195	93	885,912	10,140,741	11,640,096
2037	192	94	883,701	10,372,050	11,818,755
2038	192	94	884,871	10,631,439	12,228,957
2039	193	94	893,751	10,783,188	12,335,895
2040	197	94	912,717	11,050,533	12,694,968
2041	200	94	933,941	11,283,363	12,798,981
2042	206	95	958,511	11,568,141	13,173,966
2043	210	96	990,873	11,862,747	13,407,966
2044	218	96	1,023,165	12,256,569	13,830,453
2045	225	98	1,063,413	12,789,270	14,269,437
2046	234	99	1,104,656	13,339,755	14,725,737
2047	242	101	1,150,356	13,960,440	15,287,337
2048	251	105	1,191,715	14,516,424	15,991,209
2049	259	107	1,234,022	15,101,424	16,675,308
2050	267	110	1,267,473	15,927,210	17,496,180
2051	269	111	1,281,157	16,099,174	17,685,084

Table J-5. Changes from baseline for railroad operations[a] – Caliente rail alignment – Clark County (page 2 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Lincoln County (continued)					
2052	272	112	1,294,990	16,272,994	17,876,027
2053	275	113	1,308,972	16,448,691	18,069,032
2054	278	115	1,323,104	16,626,285	18,264,120
2055	281	116	1,337,390	16,805,797	18,461,315
2056	284	117	1,351,829	16,987,247	18,660,640
2057	287	118	1,366,425	17,170,655	18,862,116
2058	290	120	1,381,178	17,356,044	19,065,767
2059	294	121	1,396,090	17,543,435	19,271,617
2060	297	122	1,411,164	17,732,849	19,479,690
2061	300	124	1,426,400	17,924,308	19,690,010
2062	303	125	1,441,801	18,117,834	19,902,600
2063	307	126	1,457,367	18,313,450	20,117,485
2064	310	128	1,473,102	18,511,177	20,334,691
2065	313	129	1,489,007	18,711,040	20,554,241
2066	317	130	1,505,084	18,913,060	20,776,162
2067	320	132	1,521,334	19,117,262	21,000,480
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	1014	81	4,108,478	13,956,345	11,675,781
2016	907	30	3,707,742	11,113,479	6,248,151
2017	807	8	3,324,602	9,194,094	3,427,983
2018	719	3	2,980,142	8,034,273	2,356,614
2019	641	8	2,677,791	7,471,386	2,365,272
2020	575	18	2,415,336	7,230,015	2,972,034
2021	519	29	2,190,369	7,158,411	3,918,330
2022	471	41	2,001,566	7,426,224	4,891,770
2023	431	52	1,841,054	7,703,514	6,017,310
2024	397	62	1,708,469	8,034,156	6,997,770
2025	368	70	1,587,807	8,337,771	7,854,210
2026	343	77	1,487,070	8,650,044	8,586,630
2027	320	81	1,395,576	8,801,442	9,230,130
2028	300	85	1,316,952	9,095,814	9,711,000
2029	282	89	1,244,178	9,327,708	10,211,760
2030	266	91	1,179,360	9,524,736	10,551,060
2031	252	94	1,122,498	9,711,819	10,996,830
2032	240	95	1,073,475	10,015,902	11,497,590
2033	231	97	1,037,673	10,184,733	11,764,350
2034	223	98	1,006,434	10,470,213	12,230,010

Table J-5. Changes from baseline for railroad operations[a] – Caliente rail alignment – Clark County (page 3 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2035	219	99	991,926	10,738,260	12,407,850
2036	215	100	975,195	10,970,856	12,675,780
2037	212	100	972,972	11,237,850	12,889,890
2038	212	101	976,365	11,505,780	13,424,580
2039	213	101	988,650	11,649,105	13,549,770
2040	217	102	1,007,604	11,916,450	13,855,140
2041	221	102	1,031,004	12,193,740	14,066,910
2042	226	103	1,056,744	12,487,410	14,495,130
2043	232	103	1,091,259	12,737,790	14,746,680
2044	239	104	1,123,551	13,130,910	15,205,320
2045	247	105	1,166,022	13,691,340	15,608,970
2046	256	107	1,207,323	14,214,330	16,225,560
2047	264	109	1,250,730	14,835,600	16,787,160
2048	273	113	1,296,594	15,445,170	17,490,330
2049	281	115	1,336,725	16,030,170	18,174,780
2050	289	118	1,374,633	16,837,470	19,138,860
2051	292	120	1,389,475	17,019,262	19,345,499
2052	295	121	1,404,477	17,203,016	19,554,370
2053	298	122	1,419,641	17,388,755	19,765,496
2054	302	123	1,434,968	17,576,498	19,978,901
2055	305	125	1,450,461	17,766,269	20,194,610
2056	308	126	1,466,122	17,958,089	20,412,648
2057	312	128	1,481,951	18,151,980	20,633,041
2058	315	129	1,497,952	18,347,964	20,855,812
2059	318	130	1,514,125	18,546,064	21,080,990
2060	322	132	1,530,473	18,746,304	21,308,598
2061	325	133	1,546,997	18,948,705	21,538,664
2062	329	135	1,563,700	19,153,291	21,771,213
2063	332	136	1,580,583	19,360,086	22,006,274
2064	336	137	1,597,648	19,569,114	22,243,873
2065	340	139	1,614,898	19,780,399	22,484,036
2066	343	140	1,632,333	19,993,965	22,726,793
2067	347	142	1,649,957	20,209,837	22,972,171

a. Sources: DIRS 179558-Bland 2007, all; DIRS 180485-Bland 2007, all.
b. Data expressed in dollars.

J.1.3 RAILROAD CONSTRUCTION – MINA RAIL ALIGNMENT

Table J-6 lists percent changes to the baseline that would be associated with the Mina rail alignment construction phase. The table lists data by county, but does not break the data down by scenario for Lyon, Esmeralda, and Clark Counties because the percent changes would be the same for under either scenario. Mineral and Nye Counties would experience slightly different percent changes under the two scenarios. Section 3.3.9, Table 3-61, lists baseline numbers. Rail Alignment EIS Section 4.3.9, Table 4-245, lists absolute changes to the baseline. As a sensitivity analysis, the socioeconomic analysis for the Mina rail alignment assesses the impacts of the project's construction phase on the combined area of Washoe County-Carson City. This alternative analysis assumes that 50 percent of the construction workers come from the Washoe County-Carson City area. Table J-7 includes percent changes to the baseline for this combined area.

Table J-6. Percent changes from baseline for railroad construction – Mina rail alignment[a] (page 1 of 2).

	Variable				
Year	Population	Total Employment	State and local government spending	Real disposable personal income	Total gross regional product
			Lyon County		
2010	0.00	0.02	0.00	0.02	0.04
2011	0.01	0.02	0.01	0.03	0.02
2012	0.01	0.02	0.01	0.03	0.02
2013	0.01	0.01	0.01	0.02	0.01
2014	0.01	0.01	0.01	0.01	0.01
			Mineral County		
Scenario 1					
2010	0.75	4.87	1.19	3.72	1.63
2011	1.08	5.36	1.53	4.19	13.97
2012	1.36	6.09	1.76	4.47	14.13
2013	1.36	3.47	1.45	2.62	7.21
2014	1.33	2.25	1.32	1.83	1.72
Scenario 2					
2010	0.74	4.78	1.18	3.70	1.52
2011	1.08	5.36	1.52	4.18	13.97
2012	1.35	6.09	1.75	4.47	14.13
2013	1.35	3.47	1.45	2.62	7.21
2014	1.27	1.87	1.27	1.42	1.52
			Nye County		
Scenario 1					
2010	0.04	0.42	0.12	0.29	0.58
2011	0.05	0.34	0.12	0.14	0.36
2012	0.09	0.54	0.16	0.32	0.80
2013	0.14	0.54	0.17	0.38	0.93
2014	0.15	0.19	0.16	0.17	0.27

Table J-6. Percent changes from baseline for railroad construction – Mina rail alignment[a] (page 2 of 2).

Year	Population	Total Employment	State and local government spending	Real disposable personal income	Total gross regional product
			Nye County *(continued)*		
Scenario 2					
2010	0.04	0.34	0.13	0.15	0.37
2011	0.10	0.55	0.17	0.33	0.83
2012	0.15	0.56	0.18	0.40	1.02
2013	0.16	0.22	0.17	0.19	0.38
2014	0.15	0.09	0.16	0.12	0.15
			Esmeralda County		
2010	0.45	5.655	2.70	17.63	27.52
2011	0.68	6.136	3.04	17.90	10.03
2012	1.62	13.85	4.36	27.15	56.67
2013	2.46	11.07	4.10	18.78	53.00
2014	3.08	10.70	4.61	15.22	41.35
			Clark County		
2010	0.02	0.14	0.02	0.14	0.13
2011	0.03	0.14	0.03	0.14	0.13
2012	0.04	0.14	0.04	0.14	0.13
2013	0.04	0.06	0.04	0.06	0.06
2014	0.04	0.03	0.04	0.04	0.03

a. Sources: DIRS 182251-REMI 2007, all; DIRS 179558-Bland 2007, all; DIRS 180690-Bland 2007, all; DIRS 180689-Bland 2007 all.

Table J-7. Percent changes from baseline on Washoe County-Carson City for railroad construction – Mina rail alignment[a].

Year	Population	Total Employment	State and local government spending	Real disposable personal income	Total gross regional product
			Washoe County-Carson City		
2010	0.03	0.24	0.03	0.24	0.20
2011	0.06	0.24	0.06	0.24	0.21
2012	0.07	0.23	0.08	0.24	0.20
2013	0.07	0.08	0.07	0.09	0.07
2014	0.06	0.05	0.07	0.06	0.04

a. Source: DIRS 181590-Bland 2007, all.

J.1.4 RAILROAD OPERATIONS – MINA RAIL ALIGNMENT

Tables J-8 through J-12 list impacts associated with the railroad operations phase for the Mina rail alignment, and Table J-13 lists the results of the alternative analysis for the combined area of Washoe County-Carson City.

Table J-8. Changes from baseline for railroad operations[a] – Mina rail alignment – Lyon County (page 1 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County					
2015	8	1	34,972	123,575	54,815
2016	8	1	35,669	121,762	51,188
2017	8	1	36,330	125,120	52,018
2018	8	1	36,956	126,079	52,861
2019	8	1	37,454	127,331	54,534
2020	8	1	37,799	129,425	56,066
2021	8	1	38,251	130,829	58,851
2022	8	1	38,423	132,643	60,945
2023	8	1	38,770	135,568	62,618
2024	8	1	39,187	137,101	64,724
2025	8	1	39,407	140,306	66,807
2026	8	1	39,789	143,372	69,603
2027	8	1	40,068	146,028	71,136
2028	9	1	40,241	148,262	72,809
2029	9	1	40,484	151,609	74,623
2030	9	1	40,693	155,926	76,296
2031	9	1	41,042	158,582	80,344
2032	9	1	41,286	162,630	81,175
2033	9	1	41,460	165,695	81,877
2034	9	1	41,705	169,287	86,054
2035	9	1	42,015	172,493	88,569
2036	9	1	42,260	174,342	89,681
2037	9	1	42,541	177,723	91,213
2038	9	1	43,033	183,866	94,010
2039	9	1	43,477	186,908	95,402
2040	9	1	43,934	190,219	99,017
2041	9	1	44,249	193,916	101,825
2042	9	1	44,706	198,374	103,206
2043	9	1	45,057	200,012	105,721
2044	9	1	45,607	207,558	109,348
2045	9	1	46,238	211,396	113,818
2046	9	1	46,800	218,685	116,602
2047	9	1	47,455	227,390	122,171
2048	9	1	48,075	234,070	123,856
2049	10	1	48,777	243,278	128,876
2050	10	1	49,339	249,959	134,164

Table J-8. Changes from baseline for railroad operations[a] – Mina rail alignment – Lyon County (page 2 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County (continued)					
2051	10	1	50,128	253,958	136,311
2052	10	1	50,930	258,021	138,491
2053	10	1	51,745	262,150	140,707
2054	10	1	52,573	266,344	142,959
2055	10	1	53,414	270,606	145,246
2056	11	1	54,269	274,935	147,570
2057	11	2	55,137	279,334	149,931
2058	11	2	56,019	283,804	152,330
2059	11	2	56,916	288,344	154,767
2060	11	2	57,826	292,958	157,243
2061	11	2	58,752	297,645	159,759
2062	12	2	59,692	302,407	162,315
2063	12	2	60,647	307,246	164,912
2064	12	2	61,617	312,162	167,551
2065	12	2	62,603	317,156	170,232
2066	12	2	63,605	322,231	172,955
2067	13	2	64,622	327,386	175,723
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	8	1	33,543	104,187	43,101
2016	8	1	33,333	99,168	37,241
2017	7	1	33,122	100,148	36,679
2018	7	1	32,876	99,305	36,398
2019	7	1	32,572	99,023	37,798
2020	7	1	32,186	99,303	38,631
2021	7	1	31,975	99,445	40,582
2022	7	1	31,589	100,565	42,257
2023	7	1	31,378	102,517	43,510
2024	7	1	31,272	103,069	45,614
2025	7	1	31,108	104,881	47,007
2026	7	1	30,968	106,553	49,098
2027	7	1	30,897	108,926	49,791
2028	7	1	30,722	110,327	51,193
2029	6	1	30,721	112,978	52,863
2030	6	1	30,581	116,039	54,116
2031	6	1	30,825	118,274	56,770
2032	6	1	30,790	120,509	58,018

Table J-8. Changes from baseline for railroad operations[a] – Mina rail alignment – Lyon County (page 3 of 3).

Year	Variable: Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2033	6	1	30,825	123,011	57,743
2034	6	1	30,895	125,914	61,505
2035	6	1	31,000	128,276	62,210
2036	6	1	31,140	130,126	63,041
2037	6	1	31,351	132,677	64,153
2038	6	1	31,631	136,723	66,388
2039	6	1	31,936	139,760	67,508
2040	6	1	32,251	142,524	70,012
2041	6	1	32,497	144,818	71,416
2042	7	1	32,813	148,445	71,690
2043	7	1	33,059	150,641	74,483
2044	7	1	33,469	155,952	76,437
2045	7	1	34,065	159,785	80,339
2046	7	1	34,521	165,680	82,293
2047	7	1	34,978	171,602	87,028
2048	7	1	35,492	176,885	87,037
2049	7	1	35,984	183,581	91,770
2050	7	1	36,475	189,152	94,837
2051	7	1	36,208	186,510	94,087
2052	7	1	36,788	189,494	95,593
2053	7	1	37,376	192,526	97,122
2054	7	1	37,974	195,607	98,676
2055	8	1	38,582	198,736	100,255
2056	8	1	39,199	201,916	101,859
2057	8	1	39,826	205,147	103,489
2058	8	1	40,464	208,429	105,144
2059	8	1	41,111	211,764	106,827
2060	8	1	41,769	215,152	108,536
2061	8	1	42,437	218,594	110,272
2062	8	1	43,116	222,092	112,037
2063	9	1	43,806	225,645	113,829
2064	9	1	44,507	229,256	115,651
2065	9	1	45,219	232,924	117,501
2066	9	1	45,942	236,651	119,381
2067	9	1	46,678	240,437	121,291

a. Sources: DIRS 182251-REMI 2007, all; DIRS 179558-Bland 2007, all; DIRS 180690-Bland 2007, all; DIRS 180689-Bland 2007, all.
b. Data expressed in dollars.

Table J-9. Changes from baseline for railroad operations[a] – Mina rail alignment – Mineral County (page 1 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County					
2015	66	63	534,362	3,033,927	2,168,478
2016	68	62	552,813	3,081,312	2,170,584
2017	70	65	575,172	3,185,442	3,698,253
2018	71	64	593,307	3,222,063	3,809,754
2019	73	63	608,283	3,250,260	3,842,514
2020	74	63	618,930	3,274,830	3,915,288
2021	74	62	628,290	3,297,060	3,961,035
2022	75	62	634,257	3,315,780	3,986,424
2023	75	61	638,469	3,333,330	3,997,188
2024	75	61	641,511	3,349,710	4,019,652
2025	74	61	642,330	3,364,920	4,047,498
2026	74	60	641,979	3,380,130	4,081,194
2027	73	60	640,107	3,394,170	4,087,746
2028	73	60	637,767	3,409,380	4,146,246
2029	72	60	634,257	3,423,420	4,194,567
2030	71	59	630,279	3,438,630	4,229,082
2031	70	59	625,716	3,456,180	4,268,043
2032	69	59	621,387	3,474,900	4,280,445
2033	69	59	617,058	3,494,790	4,337,424
2034	68	59	613,548	3,517,020	4,316,013
2035	67	58	610,272	3,539,250	4,266,171
2036	67	58	607,464	3,561,480	4,303,494
2037	66	58	605,826	3,584,880	4,333,563
2038	66	58	604,422	3,609,450	4,360,239
2039	65	58	603,486	3,635,190	4,399,785
2040	65	58	603,018	3,663,270	4,378,842
2041	64	57	602,316	3,690,180	4,252,950
2042	64	57	601,848	3,720,600	4,273,074
2043	64	57	601,497	3,752,190	4,318,353
2044	64	57	601,380	3,786,120	4,367,376
2045	64	57	600,678	3,820,050	4,225,104
2046	63	57	600,093	3,857,490	4,275,531
2047	63	57	599,508	3,897,270	4,327,362
2048	63	57	598,923	3,940,560	4,382,820
2049	63	57	597,987	3,983,850	4,438,863
2050	63	57	596,466	4,027,140	4,496,544

Table J-9. Changes from baseline for railroad operations[a] – Mina rail alignment – Mineral County (page 2 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County (continued)					
2051	62	57	594,075	4,010,998	4,478,521
2052	62	56	591,694	3,994,922	4,460,570
2053	62	56	589,322	3,978,909	4,442,691
2054	62	56	586,960	3,962,961	4,424,884
2055	61	56	584,608	3,947,077	4,407,148
2056	61	55	582,264	3,931,256	4,389,484
2057	61	55	579,931	3,915,499	4,371,890
2058	61	55	577,606	3,899,804	4,354,366
2059	60	55	575,291	3,884,173	4,336,913
2060	60	55	572,985	3,868,605	4,319,530
2061	60	54	570,688	3,853,099	4,302,216
2062	60	54	568,401	3,837,655	4,284,972
2063	59	54	566,123	3,822,273	4,267,797
2064	59	54	563,854	3,806,952	4,250,691
2065	59	53	561,594	3,791,693	4,233,653
2066	59	53	559,343	3,776,495	4,216,684
2067	59	53	557,101	3,761,358	4,199,783
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	58	44	469,946	2,012,871	1,530,465
2016	55	44	453,939	1,997,687	1,519,952
2017	54	46	446,230	2,055,043	3,042,087
2018	53	45	438,170	2,056,248	3,150,949
2019	51	45	430,344	2,057,461	3,182,539
2020	50	45	421,704	2,060,980	3,253,892
2021	49	45	414,341	2,065,651	3,297,165
2022	48	44	406,520	2,071,501	3,319,429
2023	47	44	399,157	2,077,369	3,325,349
2024	46	44	392,385	2,084,424	3,341,677
2025	45	43	385,248	2,091,418	3,362,737
2026	43	43	378,236	2,098,464	3,388,494
2027	42	43	371,099	2,105,501	3,386,154
2028	41	43	364,318	2,113,674	3,435,347
2029	40	43	357,298	2,120,711	3,473,887
2030	39	42	350,759	2,128,919	3,498,544
2031	39	42	344,441	2,139,449	3,527,794
2032	38	42	338,955	2,151,140	3,530,099

Table J-9. Changes from baseline for railroad operations[a] – Mina rail alignment – Mineral County (page 3 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2033	37	42	334,158	2,164,036	3,576,951
2034	36	42	330,301	2,178,102	3,545,379
2035	36	41	327,029	2,193,347	3,485,691
2036	36	41	324,451	2,207,335	3,512,619
2037	35	41	322,813	2,222,527	3,532,561
2038	35	41	321,652	2,237,737	3,548,837
2039	35	41	321,179	2,254,135	3,578,156
2040	34	41	320,950	2,271,755	3,546,584
2041	34	41	320,720	2,289,287	3,409,764
2042	34	41	320,841	2,309,195	3,419,019
2043	34	40	321,084	2,330,324	3,452,984
2044	34	40	321,669	2,353,742	3,490,459
2045	34	40	321,899	2,377,177	3,337,154
2046	34	40	322,029	2,402,951	3,375,834
2047	34	40	322,033	2,431,031	3,415,544
2048	34	40	321,929	2,461,521	3,458,938
2049	34	40	321,353	2,490,789	3,502,194
2050	34	40	320,304	2,519,986	3,546,654
2051	33	40	318,712	2,508,913	3,532,056
2052	33	40	317,435	2,498,857	3,517,899
2053	33	40	316,163	2,488,841	3,503,798
2054	33	39	314,895	2,478,865	3,489,754
2055	33	39	313,633	2,468,930	3,475,767
2056	33	39	312,376	2,459,034	3,461,835
2057	33	39	311,124	2,449,177	3,447,959
2058	33	39	309,877	2,439,361	3,434,139
2059	32	39	308,635	2,429,583	3,420,375
2060	32	39	307,398	2,419,845	3,406,665
2061	32	38	306,166	2,410,146	3,393,010
2062	32	38	304,939	2,400,485	3,379,411
2063	32	38	303,716	2,390,864	3,365,865
2064	32	38	302,499	2,381,281	3,352,374
2065	32	38	301,286	2,371,736	3,338,937
2066	32	38	300,079	2,362,230	3,325,554
2067	31	37	298,876	2,352,761	3,312,225

a. Sources: DIRS 182251-REMI 2007, all; DIRS 179558-Bland 2007, all; DIRS 180690-Bland 2007, all; DIRS 180689-Bland 2007, all.
b. Data expressed in dollars.

Table J-10. Changes from baseline for railroad operations[a] – Mina rail alignment – Nye County (page 1 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County					
2015	84	16	362,670	1,558,161	1,743,161
2016	82	13	357,388	1,439,852	1,663,601
2017	81	15	353,392	1,400,823	2,268,491
2018	79	15	349,783	1,371,434	2,413,571
2019	78	15	346,723	1,363,383	2,501,460
2020	77	16	344,483	1,369,094	2,640,551
2021	76	16	343,231	1,385,055	2,752,731
2022	76	17	342,529	1,407,564	2,844,549
2023	75	17	342,880	1,433,916	2,913,439
2024	75	18	343,582	1,464,755	2,988,932
2025	75	18	344,518	1,495,175	3,067,879
2026	75	19	346,004	1,526,904	3,147,300
2027	75	19	347,677	1,558,355	3,191,342
2028	75	19	349,549	1,593,122	3,286,948
2029	75	20	351,737	1,627,191	3,369,739
2030	75	20	354,077	1,660,369	3,432,780
2031	75	20	356,417	1,696,221	3,500,640
2032	75	20	359,108	1,733,661	3,537,189
2033	76	21	361,799	1,774,611	3,620,259
2034	76	21	365,227	1,813,415	3,616,749
2035	76	21	368,655	1,851,327	3,584,601
2036	77	21	372,446	1,895,175	3,643,101
2037	77	21	376,810	1,939,635	3,694,302
2038	78	21	381,559	1,986,575	3,741,381
2039	78	21	386,556	2,031,786	3,801,051
2040	79	22	391,669	2,078,726	3,797,541
2041	80	22	396,817	2,124,635	3,679,650
2042	81	22	402,199	2,173,969	3,717,369
2043	81	22	407,616	2,228,959	3,779,712
2044	82	22	413,279	2,287,125	3,846,681
2045	83	22	418,895	2,342,115	3,712,689
2046	84	23	424,932	2,406,132	3,783,222
2047	85	23	430,829	2,471,985	3,856,599
2048	87	23	437,217	2,546,478	3,930,921
2049	88	23	443,418	2,621,691	4,009,032
2050	89	23	449,268	2,698,074	4,089,708

Table J-10. Changes from baseline for railroad operations[a] – Mina rail alignment – Nye County (page 2 of 3).

Year	Variable				
	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County (continued)					
2051	90	24	455,557	2,735,847	4,146,963
2052	91	24	461,935	2,774,148	4,205,019
2053	93	24	468,402	2,812,985	4,263,889
2054	94	25	474,959	2,852,366	4,323,582
2055	95	25	481,609	2,892,299	4,384,111
2056	97	26	488,351	2,932,790	4,445,488
2057	98	26	495,188	2,973,849	4,507,724
2058	99	26	502,121	3,015,482	4,570,831
2059	101	27	509,150	3,057,698	4,634,821
2060	102	27	516,278	3,100,505	4,699,708
2061	103	27	523,506	3,143,911	4,765,502
2062	105	28	530,835	3,187,925	4,832,218
2063	106	28	538,266	3,232,556	4,899,868
2064	108	29	545,802	3,277,811	4,968,465
2065	109	29	553,443	3,323,699	5,038,023
2066	111	29	561,191	3,370,230	5,108,554
2067	112	30	569,048	3,417,413	5,180,072
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	87	17	379,045	1,623,843	2,134,782
2016	86	19	379,022	1,590,264	2,751,255
2017	86	19	378,951	1,565,460	2,908,386
2018	85	19	379,220	1,562,652	3,009,591
2019	85	20	379,993	1,572,714	3,161,925
2020	85	20	381,467	1,594,710	3,288,051
2021	85	21	383,304	1,621,971	3,393,117
2022	85	21	386,065	1,654,731	3,476,889
2023	85	22	388,978	1,690,416	3,567,330
2024	85	22	391,938	1,727,271	3,660,228
2025	86	23	395,378	1,764,009	3,753,711
2026	86	23	398,795	1,801,449	3,812,328
2027	86	24	402,340	1,841,346	3,921,138
2028	86	24	406,130	1,882,179	4,018,716
2029	87	24	409,968	1,920,906	4,096,521
2030	87	25	413,712	1,963,026	4,178,538
2031	88	25	417,620	2,005,497	4,228,380
2032	88	25	421,493	2,052,297	4,325,607

Table J-10. Changes from baseline for railroad operations[a] – Mina rail alignment – Nye County (page 3 of 3).

Year	Variable				
	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2033	89	25	426,009	2,097,342	4,336,605
2034	89	25	430,478	2,141,685	4,319,055
2035	90	26	435,416	2,191,293	4,391,829
2036	90	26	440,692	2,242,305	4,458,051
2037	91	26	446,378	2,296,242	4,519,593
2038	92	26	452,427	2,349,360	4,595,175
2039	93	26	458,582	2,403,414	4,606,524
2040	94	27	464,666	2,455,830	4,504,266
2041	95	27	471,065	2,515,383	4,557,267
2042	96	27	477,348	2,578,797	4,636,359
2043	97	27	484,029	2,643,615	4,718,727
2044	98	27	490,546	2,707,497	4,599,972
2045	99	28	497,426	2,779,686	4,688,658
2046	100	28	504,329	2,855,853	4,777,695
2047	101	28	511,559	2,937,285	4,870,944
2048	103	28	518,766	3,022,812	4,965,831
2049	104	29	525,564	3,110,328	5,062,941
2050	105	29	532,753	3,159,582	5,138,323
2051	107	29	540,211	3,203,815	5,210,258
2052	108	30	547,774	3,248,668	5,283,201
2053	110	30	555,443	3,294,149	5,357,164
2054	111	31	563,219	3,340,266	5,432,164
2055	113	31	571,104	3,387,029	5,508,213
2056	114	32	579,099	3,434,447	5,585,326
2057	116	32	587,207	3,482,528	5,663,520
2058	118	32	595,427	3,531,283	5,742,808
2059	119	33	603,763	3,580,720	5,823,206
2060	121	33	612,216	3,630,849	5,904,729
2061	123	34	620,787	3,681,680	5,987,394
2062	124	34	629,478	3,733,223	6,071,216
2063	126	35	638,290	3,785,487	6,156,212
2064	128	35	647,226	3,838,483	6,242,397
2065	130	36	656,287	3,892,221	6,329,789
2066	131	36	665,475	3,946,711	6,418,405
2067	19	7	97,912	535,275	1,256,385

a. Sources: DIRS 182251-REMI 2007, all; DIRS 179558-Bland 2007, all; DIRS 180690-Bland 2007, all; DIRS 180689-Bland 2007, all.
b. Data expressed in dollars.

Table J-11. Changes from baseline for railroad operations[a] – Mina rail alignment – Esmeralda County (page 1 of 3).

Year	Variable				
	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County					
2015	37	46	333,646	3,537,174	6,485,641
2016	40	47	368,625	3,515,455	6,661,215
2017	44	47	403,848	3,518,072	6,841,384
2018	48	48	440,953	3,536,957	7,029,744
2019	51	50	477,822	3,567,475	7,222,791
2020	54	51	508,146	3,603,793	7,412,327
2021	58	52	544,785	3,649,456	7,610,042
2022	62	53	588,445	3,703,296	7,814,787
2023	66	54	633,748	3,761,814	8,020,707
2024	71	55	676,009	3,820,317	8,228,970
2025	74	56	710,077	3,876,457	8,432,552
2026	77	57	742,037	3,933,781	8,632,637
2027	79	58	772,007	3,991,131	8,836,219
2028	82	59	800,807	4,047,289	9,038,629
2029	84	59	828,436	4,101,124	9,241,057
2030	86	60	851,500	4,154,972	9,443,469
2031	88	61	873,043	4,209,969	9,651,746
2032	89	61	891,191	4,267,340	9,857,664
2033	90	62	907,464	4,324,667	10,062,427
2034	91	63	920,695	4,382,023	10,267,197
2035	92	63	930,298	4,437,045	10,470,785
2036	92	64	937,091	4,493,235	10,674,383
2037	92	64	942,596	4,550,589	10,879,159
2038	92	65	946,230	4,609,159	11,087,421
2039	92	65	950,563	4,668,872	11,294,520
2040	91	65	948,228	4,727,451	11,492,272
2041	90	66	941,446	4,786,011	11,698,200
2042	89	66	929,984	4,843,402	11,899,458
2043	87	66	914,191	4,893,709	12,098,358
2044	85	66	894,069	4,935,859	12,285,571
2045	83	66	874,061	4,983,868	12,484,484
2046	81	66	854,989	5,021,325	12,671,684
2047	79	66	837,320	5,086,893	12,870,597
2048	77	66	819,535	5,153,649	13,057,797
2049	76	66	801,631	5,222,744	13,268,410
2050	74	66	783,259	5,268,395	13,467,319

Table J-11. Changes from baseline for railroad operations[a] – Mina rail alignment – Esmeralda County (page 2 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County (continued)					
2051	74	66	784,764	5,278,517	13,493,193
2052	74	66	786,272	5,288,659	13,519,117
2053	74	66	787,782	5,298,819	13,545,090
2054	74	66	789,296	5,309,000	13,571,114
2055	75	66	790,812	5,319,200	13,597,187
2056	75	66	792,332	5,329,419	13,623,311
2057	75	67	793,854	5,339,658	13,649,485
2058	75	67	795,379	5,349,917	13,675,709
2059	75	67	796,907	5,360,196	13,701,983
2060	75	67	798,438	5,370,494	13,728,308
2061	75	67	799,972	5,380,812	13,754,684
2062	76	67	801,509	5,391,150	13,781,110
2063	76	67	803,049	5,401,508	13,807,587
2064	76	67	804,592	5,411,885	13,834,115
2065	76	68	806,138	5,422,283	13,860,694
2066	76	68	807,687	5,432,700	13,887,323
2067	76	68	809,238	5,443,138	13,914,004
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	37	46	333,664	3,535,969	6,485,513
2016	40	47	368,575	3,513,757	6,661,035
2017	44	47	403,797	3,516,059	6,841,201
2018	48	48	440,893	3,534,774	7,029,571
2019	51	50	477,753	3,565,191	7,222,619
2020	54	51	508,062	3,601,469	7,412,164
2021	58	52	544,686	3,647,117	7,609,883
2022	62	53	588,330	3,700,962	7,814,628
2023	66	54	633,616	3,759,500	8,020,553
2024	71	55	675,859	3,818,040	8,228,830
2025	74	56	709,911	3,874,228	8,432,408
2026	77	57	741,857	3,931,588	8,632,489
2027	79	58	771,814	3,988,966	8,836,060
2028	82	59	800,602	4,045,152	9,038,475
2029	84	59	828,219	4,099,014	9,240,893
2030	86	60	851,273	4,152,890	9,443,310
2031	88	61	872,807	4,207,918	9,651,576
2032	89	61	890,948	4,265,301	9,857,498

Table J-11. Changes from baseline for railroad operations[a] – Mina rail alignment – Esmeralda County (page 3 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2033	90	62	907,215	4,322,659	10,062,255
2034	91	63	920,441	4,380,039	10,267,018
2035	92	63	930,039	4,435,072	10,470,596
2036	92	64	936,830	4,491,278	10,674,176
2037	92	64	942,333	4,548,656	10,878,954
2038	92	65	945,964	4,607,224	11,087,212
2039	92	65	950,297	4,666,950	11,294,293
2040	91	65	947,962	4,725,511	11,492,045
2041	90	66	941,181	4,784,072	11,697,974
2042	89	66	929,719	4,841,449	11,899,223
2043	87	66	913,928	4,891,799	12,098,123
2044	85	66	893,808	4,933,958	12,285,331
2045	83	66	873,804	4,981,990	12,484,244
2046	81	66	854,737	5,019,456	12,671,444
2047	79	66	837,071	5,085,032	12,870,349
2048	77	66	819,291	5,151,797	13,057,544
2049	76	66	801,392	5,220,887	13,268,166
2050	74	66	783,024	5,266,565	13,467,070
2051	74	66	784,529	5,276,684	13,492,944
2052	74	66	786,036	5,286,822	13,518,867
2053	74	66	787,546	5,296,979	13,544,840
2054	74	66	789,059	5,307,156	13,570,864
2055	75	66	790,575	5,317,352	13,596,937
2056	75	66	792,094	5,327,568	13,623,060
2057	75	67	793,616	5,337,804	13,649,233
2058	75	67	795,141	5,348,059	13,675,457
2059	75	67	796,668	5,358,334	13,701,731
2060	75	67	798,199	5,368,629	13,728,055
2061	75	67	799,733	5,378,943	13,754,430
2062	76	67	801,269	5,389,277	13,780,856
2063	76	67	802,808	5,399,632	13,807,332
2064	76	67	804,351	5,410,006	13,833,860
2065	76	68	805,896	5,420,400	13,860,438
2066	76	68	807,445	5,430,814	13,887,067
2067	76	68	808,996	5,441,247	13,913,748

a. Sources: DIRS 182251-REMI 2007, all; DIRS 179558-Bland 2007, all; DIRS 180690-Bland 2007, all; DIRS 180689-Bland 2007, all.
b. Data expressed in dollars.

Table J-12. Changes from baseline for railroad operations[a] – Mina rail alignment – Clark County (page 1 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County					
2015	904	63	3,662,945	11,734,492	9,631,874
2016	803	21	3,286,151	9,158,889	5,096,391
2017	710	4	2,925,899	7,489,604	2,839,156
2018	627	2	2,601,864	6,524,786	2,062,276
2019	556	8	2,321,009	6,087,944	2,258,708
2020	494	17	2,075,309	5,908,934	2,811,814
2021	442	28	1,864,709	5,829,197	3,767,271
2022	397	39	1,686,761	6,034,685	4,677,098
2023	359	49	1,535,831	6,364,496	5,712,548
2024	328	58	1,408,192	6,649,976	6,569,597
2025	301	65	1,297,042	6,926,834	7,373,387
2026	277	71	1,203,333	7,185,404	7,998,167
2027	256	75	1,113,532	7,364,716	8,640,789
2028	237	78	1,041,066	7,632,214	9,033,617
2029	220	82	970,737	7,863,874	9,497,229
2030	206	83	910,541	7,997,686	9,818,687
2031	192	85	858,008	8,212,101	10,175,829
2032	181	86	814,554	8,462,481	10,550,534
2033	173	88	778,869	8,649,248	10,872,284
2034	166	88	747,618	8,908,684	11,211,279
2035	161	89	733,122	9,131,721	11,461,964
2036	159	90	719,714	9,381,236	11,764,994
2037	157	91	719,726	9,649,329	11,853,317
2038	156	91	718,544	9,864,013	12,193,214
2039	158	91	730,899	9,988,594	12,456,756
2040	161	91	746,460	10,211,631	12,673,557
2041	164	91	768,807	10,435,534	12,801,017
2042	170	91	791,154	10,622,864	13,152,614
2043	174	92	821,282	10,889,752	13,438,959
2044	181	92	847,946	11,273,512	13,795,517
2045	188	93	883,748	11,764,654	14,222,859
2046	195	95	921,609	12,279,454	14,714,856
2047	202	97	956,284	12,817,654	15,152,717
2048	209	99	990,853	13,350,308	15,784,517
2049	216	101	1,026,484	13,911,300	16,357,208
2050	222	103	1,057,831	14,567,108	17,142,314

Table J-12. Changes from baseline for railroad operations[a] – Mina rail alignment – Clark County (page 2 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County (continued)					
2051	224	105	1,069,252	14,724,387	17,327,397
2052	226	106	1,080,797	14,883,364	17,514,478
2053	229	107	1,092,466	15,044,058	17,703,579
2054	231	108	1,104,261	15,206,486	17,894,722
2055	234	109	1,116,184	15,370,669	18,087,929
2056	236	110	1,128,235	15,536,623	18,283,221
2057	239	111	1,140,416	15,704,370	18,480,623
2058	242	113	1,152,729	15,873,928	18,680,155
2059	244	114	1,165,175	16,045,316	18,881,842
2060	247	115	1,177,755	16,218,555	19,085,707
2061	249	116	1,190,471	16,393,664	19,291,772
2062	252	118	1,203,325	16,570,664	19,500,063
2063	255	119	1,216,317	16,749,575	19,710,602
2064	258	120	1,229,449	16,930,418	19,923,414
2065	260	121	1,242,723	17,113,213	20,138,524
2066	263	123	1,256,141	17,297,982	20,355,957
2067	266	124	1,269,703	17,484,746	20,575,737
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	911	74	3,691,958	12,528,945	10,694,151
2016	813	32	3,326,322	10,060,479	6,194,331
2017	722	15	2,979,452	8,480,394	3,963,843
2018	642	13	2,666,582	7,533,513	3,204,864
2019	573	19	2,394,651	7,114,536	3,365,622
2020	514	28	2,156,766	6,917,625	3,945,474
2021	462	38	1,952,859	6,837,831	4,918,680
2022	419	49	1,781,606	7,061,184	5,837,130
2023	383	59	1,635,134	7,364,214	6,891,300
2024	352	68	1,513,079	7,685,496	7,747,740
2025	325	75	1,404,117	7,989,111	8,569,080
2026	303	81	1,312,740	8,274,474	9,247,680
2027	282	85	1,227,330	8,400,132	9,872,460
2028	264	88	1,155,960	8,694,504	10,300,680
2029	247	91	1,091,259	8,943,948	10,800,270
2030	233	93	1,032,174	9,077,796	11,139,570
2031	220	95	981,864	9,301,149	11,567,790
2032	210	97	938,457	9,578,322	11,997,180

Table J-12. Changes from baseline for railroad operations[a] – Mina rail alignment – Clark County (page 3 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2033	202	98	907,218	9,747,153	12,300,210
2034	195	99	879,255	10,024,443	12,747,150
2035	191	100	866,970	10,283,130	12,979,980
2036	188	101	853,632	10,497,006	13,300,560
2037	186	102	853,632	10,738,260	13,442,130
2038	186	102	856,908	11,006,190	13,906,620
2039	188	102	869,310	11,140,155	14,134,770
2040	191	102	887,094	11,389,950	14,405,040
2041	195	103	910,494	11,667,240	14,640,210
2042	200	103	934,011	11,881,350	15,045,030
2043	205	104	966,303	12,184,380	15,366,780
2044	212	104	995,202	12,576,330	15,848,820
2045	219	105	1,033,227	13,059,540	16,240,770
2046	228	107	1,071,135	13,582,530	16,857,360
2047	234	109	1,110,213	14,157,000	17,348,760
2048	242	112	1,149,291	14,743,170	18,087,030
2049	250	114	1,184,976	15,339,870	18,677,880
2050	256	117	1,220,778	15,995,070	19,641,960
2051	259	118	1,233,959	16,167,766	19,854,031
2052	262	119	1,247,281	16,342,327	20,068,392
2053	265	121	1,260,748	16,518,773	20,285,068
2054	268	122	1,274,360	16,697,124	20,504,083
2055	270	123	1,288,119	16,877,400	20,725,462
2056	273	124	1,302,027	17,059,623	20,949,232
2057	276	126	1,316,085	17,243,813	21,175,418
2058	279	127	1,330,294	17,429,992	21,404,046
2059	282	129	1,344,657	17,618,181	21,635,142
2060	285	130	1,359,175	17,808,402	21,868,733
2061	288	131	1,373,850	18,000,677	22,104,847
2062	292	133	1,388,683	18,195,027	22,343,510
2063	295	134	1,403,677	18,391,477	22,584,749
2064	298	136	1,418,832	18,590,047	22,828,594
2065	301	137	1,434,151	18,790,761	23,075,070
2066	304	139	1,449,635	18,993,642	23,324,209
2067	308	140	1,465,287	19,198,713	23,576,037

a. Sources: DIRS 182251-REMI 2007, all; DIRS 179558-Bland 2007, all; DIRS 180690-Bland 2007, all; DIRS 180689-Bland 2007, all.
b. Data expressed in dollars.

Table J-13. Changes from baseline for railroad operations[a] – Mina rail alignment – Washoe County-Carson City (page 1 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County					
2015	313	24	1,434,226	4,404,941	3,276,281
2016	273	9	1,262,376	3,446,060	1,774,516
2017	238	2	1,108,539	2,767,354	1,055,586
2018	208	2	974,079	2,374,445	848,039
2019	182	4	859,158	2,153,210	877,009
2020	160	7	760,382	2,051,420	1,102,386
2021	142	11	677,024	2,037,052	1,383,197
2022	126	15	604,484	2,044,294	1,677,605
2023	113	18	544,175	2,089,078	1,954,672
2024	101	20	490,400	2,122,684	2,178,587
2025	91	23	443,528	2,182,027	2,392,252
2026	82	24	401,453	2,200,115	2,579,979
2027	73	25	362,068	2,213,424	2,695,809
2028	66	26	325,798	2,226,619	2,771,555
2029	59	27	293,506	2,246,725	2,861,212
2030	53	27	264,977	2,275,759	2,937,262
2031	47	28	239,588	2,323,620	3,003,729
2032	43	28	217,592	2,390,310	3,074,666
2033	40	28	201,068	2,447,749	3,138,069
2034	37	29	187,730	2,526,139	3,226,989
2035	35	29	179,909	2,588,695	3,307,064
2036	34	29	174,013	2,662,405	3,342,386
2037	34	29	172,979	2,740,682	3,400,886
2038	34	29	175,687	2,823,210	3,445,124
2039	34	29	179,944	2,858,635	3,490,321
2040	36	29	187,680	2,936,916	3,565,692
2041	38	29	197,789	3,039,444	3,583,476
2042	40	29	208,880	3,144,418	3,672,981
2043	42	29	220,884	3,264,928	3,739,788
2044	44	29	235,135	3,407,450	3,838,887
2045	47	30	250,544	3,569,974	3,949,803
2046	50	31	265,567	3,768,980	4,105,881
2047	52	31	280,940	3,978,515	4,288,986
2048	55	32	296,291	4,239,729	4,499,118
2049	58	33	309,898	4,517,218	4,704,336
2050	60	34	323,610	4,762,590	4,976,010

Table J-13. Changes from baseline for railroad operations[a] – Mina rail alignment – Washoe County-Carson City (page 2 of 3).

	Variable				
Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 1: Assuming Railroad Control Center and National Transportation Operations Center in Mineral County (continued)					
2051	61	35	327,610	4,821,460	5,037,518
2052	62	35	331,660	4,881,057	5,099,785
2053	62	35	335,760	4,941,391	5,162,823
2054	63	36	339,910	5,002,470	5,226,640
2055	64	36	344,111	5,064,305	5,291,245
2056	65	37	348,365	5,126,904	5,356,649
2057	66	37	352,671	5,190,277	5,422,862
2058	66	38	357,030	5,254,433	5,489,893
2059	67	38	361,433	5,319,382	5,557,752
2060	68	39	365,911	5,385,134	5,626,451
2061	69	39	370,434	5,451,698	5,695,998
2062	70	40	375,013	5,519,086	5,766,405
2063	71	40	379,648	5,587,306	5,837,683
2064	71	41	384,341	5,656,370	5,909,841
2065	72	41	389,092	5,726,287	5,982,892
2066	73	42	393,901	5,797,069	6,056,845
2067	74	42	398,770	5,868,725	6,131,713
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County					
2015	313	24	1,433,250	4,398,246	3,231,649
2016	273	8	1,261,260	3,432,671	1,720,961
2017	238	2	1,106,586	2,753,964	995,327
2018	207	1	971,568	2,367,755	783,323
2019	182	3	856,368	2,146,516	821,223
2020	160	7	756,756	2,040,264	1,039,904
2021	141	10	672,840	2,010,276	1,311,786
2022	125	14	599,742	2,024,209	1,597,266
2023	112	17	538,875	2,077,920	1,878,804
2024	100	20	484,542	2,102,599	2,102,706
2025	90	22	437,391	2,157,480	2,307,456
2026	80	24	394,758	2,182,266	2,486,250
2027	72	25	354,816	2,213,424	2,606,544
2028	64	25	318,546	2,222,155	2,695,680
2029	58	26	286,254	2,240,035	2,771,946
2030	51	26	256,887	2,269,064	2,847,996
2031	46	27	231,498	2,319,156	2,910,006
2032	41	27	208,944	2,385,846	2,967,554

Table J-13. Changes from baseline for railroad operations[a] – Mina rail alignment – Washoe County-Carson City (page 3 of 3).

Year	Population	Total Employment	State and local government spending[b]	Real disposable personal income[b]	Total gross regional product[b]
Scenario 2: Assuming Railroad Control Center and National Transportation Operations Center in Nye County (continued)					
2033	38	27	192,699	2,452,211	3,035,414
2034	35	28	179,361	2,530,601	3,128,796
2035	33	28	170,703	2,604,311	3,199,950
2036	32	28	164,529	2,678,021	3,244,194
2037	32	28	162,936	2,754,071	3,302,694
2038	32	28	165,087	2,841,064	3,342,474
2039	32	28	169,065	2,869,794	3,374,280
2040	34	28	176,247	2,943,611	3,436,290
2041	35	28	185,796	3,028,285	3,454,056
2042	37	28	196,326	3,131,029	3,525,644
2043	39	28	208,611	3,251,539	3,597,014
2044	42	28	222,021	3,391,830	3,687,104
2045	44	29	236,880	3,552,120	3,798,036
2046	47	29	251,064	3,751,129	3,936,314
2047	50	30	266,157	3,951,745	4,114,890
2048	52	31	280,944	4,201,795	4,302,745
2049	55	32	294,003	4,481,510	4,499,084
2050	57	33	306,873	4,717,955	4,739,454
2051	58	33	310,666	4,776,273	4,798,037
2052	58	34	314,506	4,835,311	4,857,345
2053	59	34	318,394	4,895,080	4,917,385
2054	60	34	322,330	4,955,587	4,978,168
2055	61	35	326,314	5,016,842	5,039,703
2056	61	35	330,347	5,078,854	5,101,997
2057	62	36	334,431	5,141,633	5,165,062
2058	63	36	338,565	5,205,188	5,228,907
2059	64	37	342,749	5,269,528	5,293,540
2060	65	37	346,986	5,334,664	5,358,973
2061	65	38	351,275	5,400,604	5,425,214
2062	66	38	355,617	5,467,360	5,492,274
2063	67	38	360,013	5,534,941	5,560,163
2064	68	39	364,463	5,603,358	5,628,891
2065	69	39	368,968	5,672,620	5,698,469
2066	69	40	373,529	5,742,738	5,768,907
2067	70	40	378,146	5,813,723	5,840,215

a. Source: DIRS 181590-Bland 2007, all.
b. Data expressed in dollars.

J.1.5 PUBLIC SERVICES IMPACT ANALYSIS

To estimate potential impacts to public services, DOE assessed the changes to the county or community baseline capacity (assuming no railroad). This assessment, as described in detail in Sections 4.2.9 and 4.3.9 of the Rail Alignment EIS, is a qualitative analysis. To perform the analysis, DOE identified the relevant changes that would affect public services (population changes) and characterized the magnitude of the changes as either a positive or negative impact on public services. The analysis then qualitatively described whether the burden or benefit associated with the change would degrade or supplement the delivery of public services to the county or community. Using this methodology, DOE concluded whether impacts to the various public services in counties and communities would be small, moderate, or large.

J.1.6 TRAFFIC DELAY AT RAIL-HIGHWAY GRADE CROSSINGS

DOE estimated the delay road vehicles would experience at rail-highway grade crossings. For each grade crossing analyzed, DOE calculated the time that a given crossing would be closed for each train event and estimated the average delay per vehicle on that crossing in a 24-hour period. DOE used the following steps in the delay calculation:

<u>Step 1</u>: Calculation of blocked crossing time (T)

$$T = 0.5 + \frac{L}{V \times 88}$$

T	= Blocked crossing time per train event, in minutes.
0.5	= Time necessary for any warning devices (such as gates) to engage and disengage, in minutes. Not all crossings have gates, so blocked crossing times could be overestimated for such cases.
L	= Train length, in feet.
V	= Train speed, in miles per hour.
88	= Conversion factor from miles per hour to feet per minute.

<u>Step 2</u>: Calculation of average crossing delay per vehicle (D)

$$D = \frac{T \times \left[\frac{R_D}{(R_D - R_A)} \right]}{2}$$

D	= Average crossing delay per vehicle, in minutes.
R_D	= Vehicle departure rate[a], in vehicles per hour per lane.
R_A	= Vehicle arrival rate (average daily traffic divided by the number of lanes), in vehicles per hour per lane.
2	= Factor to account for the fact that vehicles do not experience delay for the entire time that crossing is blocked. Vehicles arrive, on average, at the midpoint of the train blocked crossing time.

a. Vehicle departure rate is a measure of the rate at which vehicles can return to free-flow speed from a state where vehicles are stopped. Vehicle departure rates depend on a number of factors such as the presence of warning signals, numbers and types of lanes, width of lanes, road grade, sight distance, curve radius, and traffic type. Because there were not enough data available to characterize each grade crossing, DOE used default values. This analysis assumes 1,800 vehicles per hour , 1,400 vehicles per hour for arterials, 900 vehicles per hour for collectors, and 700 vehicles per hour for local roads (DIRS 176524-TRB 2001, all).

Step 3: Calculation of the number of delayed vehicles per day (N_V)

$$N_V = \frac{T}{1{,}440} \times N_T \times ADT$$

N_V = Number of delayed vehicles per day.

N_T = Number of daily trains.[a]

ADT = Average daily traffic, in number of vehicles per day in both directions of traffic.

a. If different estimates for average train daily traffic were available, the highest estimate was considered.

Step 4: Calculation of average vehicle delay in a 24-hour period (D_{24}) in minutes

$$D_{24} = \frac{N_V}{ADT} \times D$$

J.1.7 LEVEL OF SERVICE ANALYSIS

The calculation of level of service (LOS) for baseline and adjusted scenarios is based on the methodology included in the Highway Capacity Manual for Class I two-lane highways (DIRS 176524-TRB 2001, Chapter 20). Two-lane highways can be divided in two types: Class I, on which users expect to drive at relatively high speeds; and Class II, on which users do not expect to travel at high speeds (that is, scenic/recreational routes). This section summarizes the complete methodology.

As described in Sections 3.2.9 and 3.3.9 of the Rail Alignment EIS, roadway performance can be characterized in terms of level of service, which is a qualitative ranking of traffic conditions experienced by roadway users. There are six levels of service that can characterize the performance of roadways, with level A representing the best operating conditions (free flow), and level F the worst.

The determination of the level of service of a given roadway is based on factors that affect how users perceive the quality of service they are receiving, such as speed, travel time, freedom to maneuver, traffic interruptions, and comfort. For Class I two-lane highways, level of service is determined in relation to percent of time-spent-following (PTSF) and average travel speed. PTSF is the average percent of travel time vehicles must travel behind slower vehicles due to the inability to pass on a two-lane highway. Table J-14 lists the criteria to determine level of service. If the passenger-car equivalent flow rate is higher than the highway capacity, the facility is oversaturated and the level is F.

Table J-14. Criteria to calculate LOS in Class I two-lane highways.[a]

Level of Service	Percent time-spent-following	Average travel speed (miles per hour)
A	Less than or equal to 35 percent	Greater than 55
B	Between 35 percent and 50 percent	Between 50 and 55
C	Between 50 percent and 65 percent	Between 45 and 50
D	Between 65 percent and 80 percent	Between 40 and 45
E	Greater than 80 percent	Less than or equal to 40

a. Source: DIRS 176524-TRB 2001, Chapter 20.

Calculation of PTSF

The PTSF is estimated based on the demand flow rate (V_p), the directional distribution of traffic, and the percentage of no-passing zones.

$$PTSF = 100 \times (1 - e^{-0.000879V_p}) + f_{d/np} \qquad \text{where}$$

PTSF = percent time-spent-following

V_p = demand flow rate

$f_{d/np}$ = adjustment for the combined effect of the directional distribution of traffic and of the percentage of no-passing zones on percent time-spent-following

The flow rate V_p is an adjusted measure of traffic volume (in vehicles per hour), taking into account the percentage of daily traffic that occurs during the peak 15-minute period (peak-hour factor), a grade adjustment factor, and a heavy-vehicle adjustment factor that accounts for the percentage of trucks and recreational vehicles (RVs) on the road.

$$V_p = V / (PHF \times F_G \times F_{HV}) \qquad \text{where}$$

V_p = passenger-car equivalent flow rate for peak 15-minute period (veh/h)

V = demand volume for the peak hour (veh/h)

PHF = peak-hour factor

F_G = grade adjustment factor

F_{HV} = heavy-vehicle adjustment factor

In all level of service calculations included in this analysis, the distribution of traffic within the peak hour is assumed to be uniform. Therefore, the peak-hour factor is assumed to be 1. All roadways are also assumed to be flat, so the grade adjustment factor is also 1. The heavy-vehicle adjustment factor varied by roadway segment.

Calculation of average travel speed

The average travel speed (ATS) is estimated from the free flow speed (FFS), the demand flow rate (V_p), and an adjustment factor for the percentage of no-passing zones.

$$ATS = FFS - 0.00776V_p - f_{np} \qquad \text{where}$$

ATS = average travel speed (miles per hour)

FFS = Free flow speed (miles per hour)

V_p = demand flow rate (vehicles per hour)

f_{np} = adjustment for percentage of no passing zones

J.2 Glossary

gross regional product	The dollar value of all final goods and services produced in a given year in a specific region (such as the ***region of influence***).
real disposable income	The value of total income received after taxes; it is the income available for spending or saving; also referred to as ***real disposable personal income***.
real disposable personal income	See ***real disposable income***.
region of influence	The physical area that bounds the environmental, sociologic, economic, or cultural features of interest for the purpose of analysis.

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APPENDIX K

RADIOLOGICAL HEALTH AND SAFETY

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APPENDIX K

RADIOLOGICAL HEALTH AND SAFETY

K.1 Radiation and Human Health

K.1.1 RADIATION

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

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

K.1.2 RADIOACTIVITY

Radioactivity is the property or characteristic of an unstable atom to undergo spontaneous transformation (to disintegrate or decay) with the emission of energy as radiation. Usually the emitted radiation is ionizing radiation. The result of the process, called ***radioactive decay***, is the transformation of an unstable atom (a ***radionuclide***) into a different atom, accompanied by the release of energy (as radiation) as the atom reaches a more stable, lower energy configuration.

Radioactive decay produces three main types of ionizing radiation—alpha particles, beta particles, and gamma or X-rays. Neutrons emitted during nuclear fission are another type of ionizing radiation. These types of ionizing radiation can have different characteristics and levels of energy and, thus, varying abilities to penetrate and interact with atoms in the human body. Because each type has different characteristics, each requires different amounts of material to stop (shield) the radiation. Alpha particles are the least penetrating and can be stopped by a thin layer of material such as a single sheet of paper. However, if radioactive atoms (called radionuclides) emit alpha particles in the body when they decay, there is a concentrated deposition of energy near the point where the radioactive decay occurs. Shielding beta particles requires thicker layers of material such as several reams of paper or several inches of wood or water. Shielding from gamma rays, which are highly penetrating, requires very thick material such as several inches to several feet of heavy material (for example, concrete or lead). Deposition of the energy by gamma rays is dispersed across the body in contrast to the local energy deposition by an alpha particle. Some gamma radiation will pass through the body without interacting with it. Shielding from neutrons, which are also highly penetrating, requires materials that contain light elements such as hydrogen.

In a nuclear reactor, heavy atoms such as uranium and plutonium can undergo another process, called ***fission***, after the absorption of a subatomic particle (usually a neutron). In fission, a heavy atom splits into two lighter atoms and releases energy in the form of radiation and the kinetic energy of the two new lighter atoms. The new lighter atoms are called ***fission products***. The fission products are usually unstable and undergo ***radioactive decay*** to reach a more stable state.

Some of the heavy atoms might not fission after absorbing a subatomic particle. Rather, a new nucleus is formed that tends to be unstable (like fission products) and undergo radioactive decay.

The radioactive decay of fission products and unstable heavy atoms is the source of the radiation from ***spent nuclear fuel*** and ***high-level radioactive waste*** that makes these materials hazardous in terms of potential human health impacts.

K.1.3 EXPOSURE TO RADIATION AND RADIATION DOSE

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

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

More detailed information on the concepts of radiation dose and dose equivalent are in publications of the National Council on Radiation Protection and Measurements (DIRS 101857-NCRP 1993, all) and the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, all).

The factors used to convert estimates of radionuclide intake (by inhalation or ingestion) or external exposure to radionuclides (by ***groundshine*** or ***cloudshine*** [immersion]) to radiation dose are called ***dose conversion factors*** or ***dose coefficients***. The International Commission on Radiological Protection and federal agencies such as the U.S. Environmental Protection Agency (EPA) publish these factors (DIRS

172935-ICRP 2001, all; DIRS 175544-EPA 2002, all). They are based on original recommendations of the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, all).

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

K.1.4 BACKGROUND RADIATION

Nationwide, on average, members of the public are exposed to approximately 360 millirem per year from natural and manmade sources (DIRS 101855-NCRP 1987, p. 53). About 60 millirem per year is from medical radiation and consumer products. About 300 millirem per year is from natural sources (DIRS 100472-NCRP 1987, p. 149). The largest natural sources are radon-222 and its radioactive decay products in homes and buildings, which contribute about 200 millirem per year. Additional natural sources include radioactive material in the earth (primarily the uranium and thorium decay series, and potassium-40) and cosmic rays from space filtered through the atmosphere. With respect to exposures resulting from human activities, the combined doses from weapons testing fallout, consumer and industrial products, and air travel (***cosmic radiation***) account for the remaining approximately 3 percent of the total annual dose. Nuclear fuel cycle facilities contribute less than 0.1 percent (0.05 millirem per year) of the total dose.

K.1.5 IMPACTS TO HUMAN HEALTH FROM EXPOSURE TO RADIATION

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

K.1.5.1 Acute Exposures at High Dose Rates

Exposures to high levels of radiation at high dose rates over a short period (less than 24 hours) can result in acute radiation effects. Minor changes in blood characteristics might be noted at doses in the range of 25 to 50 rad. The external symptoms of radiation sickness begin to appear following acute exposures to levels of radiation of about 50 to 100 rad and can include anorexia, nausea, and vomiting. More severe symptoms occur at higher doses and can include death at doses higher than 200 to 300 rad of total body irradiation, depending on the level of medical treatment received. Information on the effects of acute exposures on humans was obtained from studies of the survivors of the Hiroshima and Nagasaki bombings and from studies following a multitude of acute accidental exposures.

Acute exposures have occurred following detonations of nuclear weapons, both in wartime and during weapons testing, and in other events involving testing of nuclear materials. In addition, there is a potential for acute exposures in the event of an accident at an operating nuclear electric generating station, although Nuclear Regulatory Commission regulations require that the electric utilities design their stations such that these events are extremely unlikely. Such exposures could occur only if there were a highly unlikely failure of the containment vessel surrounding the nuclear reactor and a large release of fission products from the generating station following an accident.

In contrast, accidents during the shipment of spent nuclear fuel or high-level radioactive waste do not have the potential to release sufficient fission products to lead to acute exposures that might immediately threaten the life of the surrounding public. This is because the fission product ***source term*** in the spent nuclear fuel would have decayed by a factor of 10,000 or more by the time DOE would ship the material to the proposed repository. Thus, there would not be sufficient energy generated by the fission products in the spent nuclear fuel being shipped to melt the fuel elements and vaporize fission products, as postulated for an accident at an operating nuclear electric generating station.

K.1.5.2 Chronic Exposures at Low Dose Rates

The radiation dose estimates discussed in the Rail Alignment EIS are associated with exposure to radiation at low dose rates. Such exposures can be chronic (continuous or nearly continuous), such as those to workers who are escorts. In some instances, exposures to low levels of radiation would be intermittent (for example, infrequent exposures to an individual from radiation emitted from shipping casks as they are transported). ***Cancer*** induction is the principal potential risk to human health from exposure to low levels of radiation. However, this cancer induction is a statistical process because exposure to radiation conveys only a chance of developing cancer, not a certainty. Furthermore, other causes, such as exposure to chemical agents, can induce cancer in individuals.

K.1.6 DOSE-TO-HEALTH EFFECT CONVERSION FACTORS

Cancer is the principal potential risk to human health from exposure to low or chronic levels of radiation. Radiological health impacts are expressed as the incremental changes in the number of expected fatal cancers (referred to as ***latent cancer fatalities***) for populations and as the incremental increases in lifetime probabilities of contracting a fatal cancer for an individual. The estimates are based on the dose received and on dose-to-health-effect conversion factors recommended by the Interagency Steering Committee on Radiation Standards (DIRS 174559-Lawrence 2002, all). The Interagency Steering Committee on Radiation Standards is comprised of eight federal agencies (the Environmental Protection Agency, the Nuclear Regulatory Commission, DOE, the Department of Defense, the Department of Homeland Security, the Department of Transportation, the Occupational Safety and Health Administration, and the Department of Health and Human Services), three federal observer agencies (the Office of Science and Technology Policy, the Office of Management and Budget, and the Defense Nuclear Facilities Safety Board), and two state observer agencies (Illinois and Pennsylvania). The Committee estimated that, for the general population and workers, a collective dose of 1 person-rem would yield 6×10^{-4} excess latent cancer fatalities.

Sometimes, calculations of the number of latent cancer fatalities associated with radiation dose do not yield whole numbers, and, especially in environmental applications, can yield numbers less than 1.0. For example, if each individual in a population of 100,000 received a total radiation dose of 0.001 rem, the collective radiation dose would be 100 person-rem and the corresponding estimated number of latent cancer fatalities would be 0.06 (100,000 persons × 0.001 rem × 0.0006 latent cancer fatalities per person-rem). How should one interpret a nonintegral number of latent cancer fatalities, such as 0.06? The answer is to interpret the result as a statistical estimate. That is, 0.06 is the average number of latent cancer fatalities that would result if the same exposure situation were applied to many different groups of 100,000 people. For most groups, no one would incur a latent cancer fatality from the 0.001 rem radiation dose each member would have received. In a small fraction of the groups (about 6 percent), one latent cancer fatality would result; in exceptionally few groups, two or more latent cancer fatalities would occur. The average number of latent cancer fatalities over all of the groups would be 0.06. The most likely outcome for any single group is zero latent cancer fatalities.

K.1.7 COMPARISON TO OTHER DOSE-TO-HEALTH EFFECT CONVERSION FACTORS

The dose-to-health effect conversion factor recommended by the Interagency Steering Committee on Radiation Standards is higher than the dose-to-health effect conversion factors used in the Yucca Mountain FEIS, 0.0004 latent cancer fatality per person-rem for workers and 0.0005 latent cancer fatality per person-rem for individuals among the general population (DIRS 155970-DOE 2002, p. 3-97). The dose-to-health effect conversion factors are similar to the lethality adjusted cancer risk coefficients published in 2007 by the International Commission on Radiological Protection in ICRP 103: *Recommendations of the ICRP*, 0.00041 per person-rem for workers and 0.00055 per person-rem for individuals among the general population. The dose-to-health effect conversion factor recommended by the Interagency Steering Committee on Radiation Standards is also similar to the dose-to-health effect conversion factors published by the National Research Council in the *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2* (DIRS 181250-National Research Council 2006, p. 15), which ranged from 0.00041 to 0.00061 latent cancer fatality per person-rem for solid cancers and 0.000050 to 0.000070 latent cancer fatality per person-rem for leukemia, and the age-specific dose-to-health effect conversion factor published by the Environmental Protection Agency, 0.000575 latent cancer fatality per person-rem (DIRS 153733-EPA 2000, Table 7.3, p. 179).

K.1.8 LINEAR NO-THRESHOLD MODEL

The premise of the Linear No-Threshold Model, as used in radiation health effects research, is that there will be some risk, even at low radiation doses. The use of the Linear No-Threshold Model was reviewed in *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2* (DIRS 181250-National Research Council 2006, all). The BEIR VII committee examined materials that included arguments that low doses of radiation are more harmful than the Linear No-Threshold Model would suggest. The BEIR VII committee concluded that radiation health effects research, taken as a whole, does not support this view.

K.1.9 RADIATION HORMESIS

The premise of radiation ***hormesis*** is that a threshold or decrease in effect exists at low radiation doses, and that use of the Linear No-Threshold Model exaggerates the health effects of low levels of ionizing radiation. The issue of radiation hormesis was also reviewed in *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2* (DIRS 181250-National Research Council 2006, all). The BEIR VII committee did not accept the hypothesis that the risks are lower than predicted by the Linear No-Threshold Model, that they are nonexistent, or that low doses of radiation might even be beneficial. The BEIR VII committee concluded that there will be some risk, even at low radiation doses.

K.1.10 OTHER RADIATION HEALTH EFFECTS

Other health effects such as nonfatal cancers and genetic effects can occur as a result of chronic exposure to radiation. These other health effects were evaluated by the International Commission on Radiological Protection and are listed in Table K-1.

The dose-to-health effect conversion factors for cancer listed in Table K-1, 0.00041 per person-rem for workers and 0.00055 per person-rem for individuals among the general population, are based on cancer incidence data but include consideration of cancer lethality and life impairment. Table K-1 also lists dose-to-health effect conversion factors for heritable effects, 0.00001 per person-rem for workers and 0.00002 per person-rem for individuals among the general population. The total detriment, 0.00040 per person-rem for workers and 0.00060 per person-rem for individuals among the general population, is consistent with the dose-to-health effect conversion factor recommended by the Interagency Steering Committee on Radiation Standards. While DOE recognizes the existence of health effects other than fatal cancers, the Department has chosen to quantify the impacts in the Rail Alignment EIS in terms of latent cancer fatalities, in part because these other health effects are a small portion of the total detriment from exposure to radiation.

Radiation exposure has also been demonstrated to increase the risk of other diseases, particularly cardiovascular disease, in persons exposed to high therapeutic doses and also atomic bomb survivors exposed to more modest doses.

The issue of health effects other than cancer was reviewed in *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2* (DIRS 181250-National Research Council 2006, all). The BEIR VII committee concluded that there was no direct evidence of increased risk of noncancer diseases at low doses, and data were inadequate to quantify this risk if it exists. Radiation exposure has also been shown to increase risks of some benign tumors, but the BEIR VII committee also concluded that data were inadequate to quantify this risk.

Table K-1. Detriment-adjusted nominal risk coefficients for cancer and genetic effects from exposure to radiation.

Population	Cancer (per rem)	Heritable effects (per rem)	Total (per rem)
Whole population	5.5×10^{-4}	2×10^{-5}	6.0×10^{-4}
Adults	4.1×10^{-4}	1×10^{-5}	4.0×10^{-4}

a. Source: ICRP Publication 103: *Recommendations of the ICRP.*

K.1.11 EXPOSURE IN UTERO

Studies of prenatal exposure or exposure in early life to diagnostic X-rays have shown that there is a significantly increased risk of leukemia and childhood cancer following a diagnostic dose of 1 to 2 rem to the embryo or fetus *in utero*. In recognition of this, exposure of declared pregnant workers is specifically addressed in DOE and Nuclear Regulatory Commission radiation protection regulations (10 Code of Federal Regulations [CFR] 835.206 and 10 CFR 20.1208), which limit the exposure of the embryo/fetus to 0.5 rem from the period of conception to birth.

K.2 Transportation Methods and Data

K.2.1 TRANSPORTATION ROUTES

K.2.1.1 Distances and Population Densities

There are many possible segments that could make up the rail alignment from its junction with the Union Pacific Railroad Mainline near Caliente, Nevada, to the repository, or its junction with the Union Pacific Railroad Mainline near Hazen, Nevada, to the repository. For the radiological transportation analyses, DOE composed four specific rail alignments from the possible segments, for both the Caliente and Mina rail corridors: (1) the rail alignment with the highest exposed population, (2) the longest distance rail alignment, (3) the rail alignment with the lowest exposed population, and (4) the shortest distance rail alignment. In addition, DOE evaluated potential radiological impacts to workers and the public at the possible locations of the Staging Yard (Caliente-Indian Cove, Caliente-Upland, Eccles-North, and Hawthorne).

The distances were determined using geographic information system data that described the rail alignment segments. The method used to estimate the population densities within 800 meters (0.5 mile) of the rail segments is described by Johnson and Michelhaugh (DIRS 181276-Johnson and Michelhaugh 2003, Section 2.5). The population densities were determined using 2000 census data for an 800-meter (0.5-mile) band on either side of the rail alignment for urban, rural, and suburban population density zones. Urban areas were defined as areas with a population density greater than 3,326 people per square kilometer. Rural areas were defined as areas with a population density of less than 139 people per square kilometer. Suburban areas were areas with a population density between 139 and 3,326 people per square kilometer. Table K-2 lists the distance and population densities for the rail alignments. There are no urban areas along the rail alignments.

For the four potential Staging Yard locations, the population densities were determined for an 800-meter (0.5-mile) area around the Staging Yard footprint. Three of the potential Staging Yard locations (Eccles-North, Caliente-Upland, and Caliente-Indian Cove) are in Lincoln County. The Staging Yard at Hawthorne would be in Mineral County. Based on 2000 census data, there would be no residents within 800 meters of the Staging Yard at Hawthorne. Table K-3 lists the population densities for the Staging Yard locations.

K.2.1.2 Population Escalation Factors

The population densities presented in Tables K-2 and K-3 are based on 2000 census data. In the radiological transportation analyses, the estimated population impacts were escalated to the year 2067 to account for potential population growth along the rail alignments and near the Staging Yard locations during operation of the proposed railroad. The population escalation factors are based on U.S. Census Bureau 2000 data and population forecasts developed using the Regional Economics Model, Inc., REMI *Policy Insight* model (DIRS 174681-REMI 2004, all), which is updated with population projections to 2024 from the Nevada State Demographer (DIRS 174313-Nevada State Demographer [n.d.], all). Table K-4 lists the escalation factors.

K.2.2 SHIPMENTS

Estimates of shipments of spent nuclear fuel and high-level radioactive waste to the repository have been developed incorporating the use of transport, aging, and disposal canisters and updated cask-handling assumptions at each reactor site. Table K-5 summarizes the number of rail casks that would be shipped to the repository under the Proposed Action. Using these estimates, there would be 9,495 rail casks shipped under the Proposed Action (DIRS 181377-BSC 2007, Section 7). The 9,495 rail casks would be shipped using 2,833 trains.

K.2.3 INCIDENT-FREE TRANSPORTATION

Radiation doses during normal, incident-free transportation of radioactive materials results from exposure of workers and the public to the external radiation field that surrounds the shipping containers. The radiation dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the containers. The intensity of the radiation field around the spent nuclear fuel or high-level radioactive waste shipping container was assumed to be at its regulatory maximum, 10 millirem per hour at 2 meters (80 inches) from the railcar that holds the shipping container [10 CFR 71.47(b)(3)]. In addition, because most spent nuclear fuel and high-level radioactive waste would be placed in canisters before being shipped, the intensity of the radiation field around an empty shipping container was assumed not to contribute to the radiation dose for workers or members of the public.

Table K-2. Distances and population densities for the Caliente and Mina rail alignments (page 1 of 2).

Rail alignment	Segment	Total exposed population	Total distance (km)[b]	County	Urban distance (km)[b]	Suburban distance (km)[b]	Rural distance (km)[a]	Urban density (people/km^2)[c]	Suburban density (people/km^2)[c]	Rural density (people/km^2)[b]
Caliente rail alignment[a]										
Highest population	Caliente	279	538.9	Lincoln	0	0.35	148.75	0	133.65	0.64
				Nye	0	0	358.64	0	0	0.10
				Esmeralda	0	0.12	31.08	0	221.43	0.24
Shortest distance	Caliente	213	527.4	Lincoln	0	0.35	138.81	0	133.65	0.55
				Nye	0	0	384.75	0	0	0.10
				Esmeralda	0	0	3.44	0	0	0
Longest distance	Eccles	112	541.1	Lincoln	0	0	134.88	0	0	0.16
				Nye	0	0	375.02	0	0	0.10
				Esmeralda	0	0.12	31.08	0	221.43	0.24
Lowest population	Eccles	78	530.2	Lincoln	0	0	134.88	0	0	0.16
				Nye	0	0	391.87	0	0	0.10
				Esmeralda	0	0	3.44	0	0	0
Mina rail alignment										
Highest population	Hazen	941	545.8	Churchill	0	0	18.61	0	0	5.76
				Lyon	0	0.88	89.09	0	121.98	4.33
				Mineral	0	0	0154.81	0	0	0.38
				Esmeralda	0	0.11	132.76	0	221.43	0.058
				Nye	0	0	149.55	0	0	0.22
Shortest distance	Hazen	904	520.5	Churchill	0	0	17.70	0	0	6.06
				Lyon	0	0.88	76.01	0	121.98	4.86
				Mineral	0	0	149.23	0	0	0.49
				Esmeralda	0	0	151.06	0	0	0.029
				Nye	0	0	125.67	0	0	0.26

Table K-2. Distances and population densities along the Caliente and Mina rail alignments (page 2 of 2).

Rail alignment	Segment	Total exposed population	Total distance (km)[b]	County	Urban distance (km)[b]	Suburban distance (km)[b]	Rural distance (km)[b]	Urban density (people/km²)[c]	Suburban density (people/km²)[c]	Rural density (people/km²)[c]
Mina rail alignment (*continued*)										
Longest distance	Hazen	901	569.8	Churchill	0	0	32.05	0	0	3.34
				Lyon	0	0.88	85.69	0	121.98	4.49
				Mineral	0	0	145.77	0	0	0.39
				Esmeralda	0	0	175.17	0	0	0.0035
				Nye	0	0	130.24	0	0	0.25
Lowest population	Hazen	878	558.3	Churchill	0	0	17.70	0	0	6.06
				Lyon	0	0.88	75.83	0	121.98	4.87
				Mineral	0	0	163.07	0	0	0.36
				Esmeralda	0	0	175.17	0	0	0.0035
				Nye	0	0	125.67	0	0	0.26

a. There are no urban areas along the Caliente rail alignment.
b. km = kilometers; to convert kilometers to miles, multiply by 0.621371.
c. km^2 = square kilometers; to convert people per square kilometer to people per square mile, multiply by 2.589988.

Table K-3. Population densities near possible locations for the Staging Yard.

Location[a]	Exposed population	Population density (people per square kilometer)[b]
Caliente-Indian Cove	8	1.56
Caliente-Upland	2	0.384
Eccles-North	2	0.234
Hawthorne	0	0

a. The Caliente and Eccles Staging Yard locations would be in Lincoln County, Nevada; the Hawthorne Staging Yard location would be in Mineral County, Nevada.
b. To convert people per square kilometer to people per square mile, multiply by 2.589988.

Table K-4. Population escalation factors.

County	2000 population	Estimated 2067 population	Escalation factor
Churchill	24,157	53,524	2.2157
Esmeralda	1,061	1,084	1.0219
Lincoln	4,165	6,944	1.6673
Lyon	35,685	172,377	4.8305
Mineral	5,071	3,715	0.7327
Nye	32,978	131,075	3.9746

Table K-5. Rail casks that would be shipped to the repository.[a]

Type	Trains	Rail casks
Pressurized-water reactor spent nuclear fuel	1,363	4,047
Boiling-water reactor spent nuclear fuel	929	2,759
Naval spent nuclear fuel	80	400
DOE spent nuclear fuel	74	365
High-level radioactive waste	387	1,924
Totals	2,833	9,495

a. Source: DIRS 181377-BSC 2007, Section 7.

The rail alignment would consist of a single set of tracks with multiple sidings. Rail casks would be shipped to the repository using dedicated trains. For shipments of commercial spent nuclear fuel, there would be three casks containing spent nuclear fuel per train. For shipments of DOE spent nuclear fuel and high-level radioactive waste, there would be five casks per train. In both cases, two buffer railcars, two locomotives, and one escort railcar would be present in the dedicated train. Escorts would also be present in all areas for all rail shipments.

Radiological impacts were determined for members of the public during normal, incident-free transportation of the casks. For members of the public, radiation doses were estimated for people located within 800 meters (0.5 mile) of the rail alignment. These exposures are referred to as off-link radiation doses. Once the train left the Union Pacific Mainline, there would be normally no additional stops en route to the repository, except at the Staging Yard, and the rail alignment will be constructed with the goal of transporting shipments of spent nuclear fuel and high-level radioactive waste from the Staging Yard to the repository without a stop for a crew change (DIRS 180923-Nevada Rail Partners 2007, Section 5.1). Therefore, under normal circumstances, there would be no off-link exposures of members of the public at any en route stops. Members of the public could, however, be exposed while the train was stopped at the Staging Yard.

Exposures of individuals using the rail line are referred to as on-link radiation doses. Two trains would not be able to share the single track simultaneously, and consequently, there would be no on-link radiation doses for any members of the public because no members of the public would be sharing the track with the cask trains.

Two groups of workers would be present on the train en route to the repository, engineers and conductors, referred to as rail workers, and escorts. Engineers and conductors would be located in the train locomotives at least 150 feet from the closest rail cask and would be shielded from radiation exposure by the locomotives; therefore there would be no radiation doses for these workers en route to the repository. Escorts would be situated closer to the casks and would not be shielded by the locomotives, therefore radiation doses have been estimated for these workers en route to the repository.

The train would not stop en route to the repository, therefore there would be no radiation doses from any en route stops for workers. Radiation doses have been estimated for workers located at sidings who could be exposed when a train with casks containing spent nuclear fuel or high-level radioactive waste passed a train carrying empty casks or other materials stopped at a siding. Radiation doses have also been estimated for workers present at the Maintenance-of-Way Trackside Facility who could be exposed when a train with casks containing spent nuclear fuel or high-level radioactive waste passed by the workers en route to the repository. Workers at the Staging Yard would also be exposed to radiation during railcar handling operations. Radiation doses were estimated for two groups of workers at the Staging Yard, workers directly involved in railcar handling operations (involved workers) and workers not directly involved in railcar handling operations (noninvolved workers).

K.2.3.1 Collective Dose Estimation Methodology

Collective radiation doses were estimated based on unit risk factors. Unit risk factors provide an estimate of the radiation doses from transporting one shipment or container of radioactive material over a unit distance of travel in a given population density zone.

Unit risk factors may also provide an estimate of the radiation dose from one container or shipment being stopped at a location such as the Staging Yard, the radiation dose from one container or shipment passing a location such as the Maintenance-of-Way Facility, or the radiation dose from one container or shipment passing a train stopped at a siding. There were five types of unit risk factors used to estimate collective incident-free radiation doses:

- Unit risk factors that were used to estimate incident-free radiation doses that depended on the number of casks, the population density in each population zone, and the distance in each population zone.
- Unit risk factors that were used to estimate incident-free radiation doses that depended on the number of casks and the distance in each population zone.
- Unit risk factors that were used to estimate incident-free radiation doses that depended on the number of casks and the population density around locations such as the Staging Yard.
- Unit risk factors that were used to estimate incident-free radiation doses that depended on the number of trains (shipments) and the distance in each population zone.
- Unit risk factors that were used to estimate incident-free radiation doses that depended on the number of casks.

The unit risk factors were combined with the cask, shipment, population density, and distance data using the following equations:

$$\text{Incident-Free Dose} = \sum_m \sum_k \sum_j \sum_i C_k \times PD_{j,m} \times D_{j,m} \times EF_m \times URF_{i,j}$$

$$\text{Incident-Free Dose} = \sum_m \sum_k \sum_j \sum_i C_k \times D_{j,m} \times URF_{i,j}$$

$$\text{Incident-Free Dose} = \sum_m \sum_k \sum_j \sum_i C_k \times PD_m \times EF_m \times URF_{i,j}$$

$$\text{Incident-Free Dose} = \sum_m \sum_k \sum_j \sum_i T_k \times D_{j,m} \times URF_{i,j}$$

$$\text{Incident-Free Dose} = \sum_k \sum_j \sum_i C_k \times URF_{i,j}$$

Where:

C_k	=	Number of casks for fuel type k
T_k	=	Number of trains (shipments) for fuel type k
$PD_{j,m}$	=	Population density in population zone j in county m (persons per square kilometer)
PD_m	=	Population density at Staging Yard in county m (persons per square kilometers)
$D_{j,m}$	=	Distance in population zone j in county m (kilometers)
EF_m	=	Population escalation factor for county m
$URF_{i,j}$	=	Unit risk factor for receptor i in population zone j (person-rem per kilometer per persons per square kilometers, person-rem per kilometer, person-rem per person per square kilometers, or person-rem)

The unit risk factors used to estimate radiation doses were estimated using the RADTRAN 5 computer code (DIRS 150898-Neuhauser and Kanipe 2000, all; DIRS 155430-Neuhauser, Kanipe, and Weiner 2000, all; DIRS 155970, DOE 2002, p. J-40) and the RISKIND computer code (DIRS 101483-Yuan et al. 1995, all). Both RADTRAN and RISKIND have been verified and validated for estimating incident-free radiation doses during transportation of radioactive material (DIRS 101845-Maheras and Pippen 1995, all; DIRS 177031-Osborn et al. 2005, all; DIRS 102060-Biwer et al. 1997, all).

The incident-free unit risk factors used in the analysis in the Rail Alignment EIS are based on *Transportation Health and Safety Calculation/Analysis Documentation in Support of the Final EIS for Yucca Mountain Repository* (DIRS 157144-Jason Technologies 2001, Tables 4-20 and 4-21) and the following additional assumptions:

- There would be no on-link radiation doses for members of the public, as no members of the public would share the single track with the cask trains.
- There would be no radiation doses at stops for members of the public, workers, or escorts.

- There would be no radiation doses for rail workers (engineers or conductors) en route to the repository. There would, however, be radiation doses for escorts en route to the repository.
- Escorts would be present on the trains in all areas en route to the repository and would also be present at the Staging Yard.
- A train containing commercial spent nuclear fuel would contain 3 casks. A train containing DOE spent nuclear fuel and high-level radioactive waste would contain 5 casks.
- Unit risk factors were estimated for workers located at the Maintenance-of-Way Trackside Facility, workers located at sidings, and noninvolved workers at the Staging Yard.

At the Staging Yard, there would be three groups of involved workers: inspectors, escorts, and rail workers. For the purposes of this analysis, inspectors would be present for 1 hour at a distance of 1 meter from the railcar containing the rail cask (DIRS 157144-Jason Technologies 2001, p. 88). Escorts would be present at a distance of 30 meters (100 feet) from the rail cask for a period of 2 hours. Radiation doses to rail workers were estimated using the time- and distance-weighted "b" factors contained in RADTRAN5 Technical Manual (DIRS 155430-Neuhauser, Kanipe, and Weiner 2000, Appendix B). For noninvolved workers at the Caliente Staging Yard, 65 workers would be present 100 meters (330 feet) from the rail casks for 2 hours. At the Mina Staging Yard, 55 workers would be present 100 meters (330 feet) from the rail casks for 2 hours.

At the Maintenance-of-Way Trackside Facility, 40 workers would be present at the facility 60 meters (200 feet) from the railroad tracks. At sidings, up to 10 workers (an engineer, a conductor, and escorts) would be present 7.62 meters (25 feet) from the railroad tracks. Workers would not be continuously present at sidings. Under the Proposed Action, a loaded cask train could pass an empty cask train or a train containing other materials at a siding up to 53 times for the Caliente rail alignment or 29 times for the Mina rail alignment. Under the Shared-Use Option, a loaded cask train could pass an empty cask train or a train containing other materials at a siding up to 114 times for the Caliente rail alignment or 62 times for the Mina rail alignment. For the Maintenance-of-Way Trackside Facilities and passes at sidings, the train containing loaded spent nuclear fuel or high-level radioactive waste would pass the facility or siding at about 50 kilometers (30 miles) per hour.

Table K-6 contains the unit risk factors for workers and members of the public used in this analysis. Because multiple casks would be shipped in the same train, some unit risk factors depend on the number of casks, while other unit risk factors depend on the number of trains. This is noted in Table K-6.

K.2.3.2 Maximally Exposed Individual Scenarios

Maximally exposed individuals are hypothetical workers and members of the public who would receive the highest radiation doses. Radiation doses for these hypothetical individuals were estimated for cask shipments en route to the repository and for railcar handling activities at the Staging Yards.

The scenarios used to estimate the radiation doses are based on the scenarios analyzed in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Section J.1.3.2.2) and the following additional assumptions. For workers, radiation doses were estimated for inspectors, escorts, and Staging Yard workers, including involved workers and noninvolved workers, under several operating scenarios. In the first scenario, a worker located at the Maintenance-of-Way Trackside Facility is exposed to a loaded cask train as it passed the facility en route to the repository. In the second scenario, a worker located at a siding is exposed to a loaded cask as it passed the siding en route to the repository. The assumptions used to evaluate these scenarios are listed in the previous section.

Table K-6. Incident-free unit risk factors.

Receptor	Type of zone or person	Unit risk factor[a]	Unit risk factor[b]
Public			
Off-link (public along rail alignment)	Rural	5.01×10^{-8}	5.08×10^{-8}
(person-rem/km per persons per square kilometer)[c]	Suburban	6.24×10^{-8}	6.33×10^{-8}
(based on number of casks)	Urban	1.04×10^{-7}	1.05×10^{-7}
On-link (public sharing rail alignment)	Rural	0	0
(person-rem per kilometer)[d]	Suburban	0	0
(based on number of casks)	Urban	0	0
Residents near stops en route to the repository	Rural	0	0
(person-rem per kilometer)[d]	Suburban	0	0
(based on number of casks)	Urban	0	0
Residents located near Staging Yard (person-rem per persons per square kilometer)[c] (based on number of casks)	Site-specific	1.06×10^{-6}	1.08×10^{-6}
Workers			
En route rail workers (engineers and conductors)	Rural	0	0
(person-rem per kilometer)[d]	Suburban	0	0
(based on number of trains)	Urban	0	0
En route rail workers at stops	Rural	0	0
(person-rem per kilometer)[d]	Suburban	0	0
(based on number of casks)	Urban	0	0
En route escorts	Rural	2.08×10^{-4}	2.08×10^{-4}
(person-rem per kilometer)[d]	Suburban	2.59×10^{-4}	2.59×10^{-4}
(based on number of trains)	Urban	4.32×10^{-4}	4.32×10^{-4}
En route escorts at stops	Rural	0	0
(person-rem per kilometer)[d]	Suburban	0	0
(based on number of casks)	Urban	0	0
Workers at Maintenance-of-Way Trackside Facility (person-rem per pass) (based on number of casks)	Rural	3.72×10^{-6}	3.88×10^{-6}
Workers at Siding (person-rem per pass) (based on number of casks)	Rural	4.50×10^{-5}	4.50×10^{-5}
Workers at Staging Yard (involved)	Escorts	2.08×10^{-2}	2.08×10^{-2}
(person-rem/train or cask)	Inspector	1.70×10^{-2}	1.70×10^{-2}
(escort based on number of trains, inspector and railyard workers based on number of casks)	Railyard workers	1.60×10^{-3}	1.68×10^{-3}
Workers at Staging Yard (noninvolved)	Caliente	1.30×10^{-3}	1.37×10^{-3}
(person-rem/cask) (based on number of casks)	Mina	1.10×10^{-3}	1.16×10^{-3}

a. Unit risk factors for shipments of commercial and DOE spent nuclear fuel and high-level radioactive waste.
b. Unit risk factors for shipments of Naval spent nuclear fuel.
c. To convert person-rem per kilometer per persons per square kilometer to person-rem per mile per persons per square mile, multiply by 0.623171.
d. To convert person-rem per kilometer to person-rem per mile, multiply by 1.609344.

For members of the public, two scenarios were evaluated. In the first scenario, a resident living 18 meters (60 feet) from the rail line is exposed to all loaded casks as they passed by en route to the repository. The passing train is traveling at a speed of 24.2 kilometers (15 miles) per hour. In the second scenario, a resident living near the Staging Yard is exposed to all loaded casks at the Staging Yard for a duration of 2 hours per cask. The distances from the Staging Yard for these residents are listed in Table K-7 and were based on site-specific data around each Staging Yard.

Table K-7. Distance to members of the public around staging yards.

Staging Yard location	Distance (meters)[a]	Type of location
Caliente-Indian Cove	1,600	Residence
Caliente-Upland	400	Residence
Eccles	1,500	Residence
Hawthorne	660	Business

a. To convert meters to feet, multiply by 3.280840.

K.2.4 TRANSPORTATION ACCIDENT RISKS

The radiological dose risks from transporting spent nuclear fuel and high-level radioactive waste could result from: 1) accidents in which there is no breach of the containment provided by the transportation cask, but there is loss of shielding because of lead shield displacement, and 2) accidents that release and disperse radioactive material from the transportation cask. In the Rail Alignment EIS, the risk to the general public from the radiological consequences of transportation accidents is called dose risk. Dose risk is the sum of the products of the probabilities (dimensionless) and the consequences (in person-rem) of all potential transportation accidents. The probability of a single accident is usually determined by historical information on accidents of a similar type and severity. The consequences are estimated by analysis of the quantity of radionuclides likely to be released, potential exposure pathways, potentially affected population, likely weather conditions, and other information.

As an example, the dose risk from a single accident that had a probability of 0.001 (1 chance in 1,000), and would cause a population dose of 20,000 person-rem in a population if it did occur, would be 20 person-rem. If that population was subject to 1,000 similar accident scenarios, the total dose risk would be 20,000 person-rem. Using the conversion factor of 0.0006 latent cancer fatality per person-rem, an analysis would estimate a health and safety risk of 12 latent cancer fatalities from this population dose risk.

Potential accidents ranged from accidents with high probabilities and low consequences to accidents with low probabilities and high consequences. The analyses used the following information to determine the risks of accidents:

- The number of shipments
- The distances and population densities along the rail alignments in rural, suburban, and urban areas
- The kind and amount of radioactive material that would be transported
- Track-class-specific accident rates
- ***Conditional probabilities*** of release and the fraction of cask contents that could be released in accidents

Conditional probability is the probability of an accident of a given severity category, given that an accident occurs.

- Conditional probabilities of amounts of lead shielding displacement that could occur during accidents, and the resulting radiation dose rates
- Exposure scenarios including inhalation, ingestion, groundshine, resuspension, and immersion pathways, Nevada-specific agricultural factors, and neutral atmospheric dispersion factors

As in the incident-free transportation analysis, the RADTRAN 5 computer code (DIRS 150898-Neuhauser and Kanipe 2000, all; DIRS 155430-Neuhauser, Kanipe, and Weiner 2000, all; DIRS 155970-DOE 2002, Section J.1.4.2) was used to estimate unit risk factors for each radionuclide of concern in spent nuclear fuel and high-level radioactive waste. RADTRAN has been verified and validated for estimating the accident risks from transporting radioactive material (DIRS 101845-Maheras and Pippen 1995, all; DIRS 177031-Osborn et al. 2005, all). The unit risk factors were combined with radionuclide inventories, number of shipments, accident rates, conditional probabilities of release, ***release fractions***, distance, and population densities to determine the dose risk for populations within 80 kilometers (50 miles) of the rail alignment. For accidents involving loss of shielding, the unit risk factors were also estimated using RADTRAN 5. The methods and data used to estimate the dose risks are based on the following:

Release fraction is the fraction of material released during an accident.

- The distances and population densities reflect specific rail alignments. This is discussed in Section K.2.1.1.
- The number of rail casks to be shipped has been estimated to be 9,495. This is discussed in Section K.2.3.
- Track Class-specific rail accident rates were used in the analysis. This is discussed in Section K.2.4.1.
- The radionuclide inventories are as discussed in Section K.2.4.2.
- Radiation dosimetry has been used to estimate unit risk factors and radiation doses. This is discussed in Section K.2.4.7.
- Health risk conversion factors have been used to estimate the number of latent cancer fatalities. This is discussed in Section K.1.6

Transportation accidents are organized into categories based on the severity of the accident. These categories are known as severity categories.

For the inhalation, immersion, resuspension, and groundshine pathways, the dose risk is given by:

$$\text{Dose Risk} = AR \times \sum_p \sum_n \sum_m \sum_j \sum_i \sum_k PD_{m,p} \times D_{m,p} \times I_{i,n} \times CP_{j,n} \times RF_{i,j,n} \times EF_p \times URF_{i,k}$$

Where:

AR	=	Accident rate (accidents/km)
$PD_{m,p}$	=	Population density in population zone m in county p (people/km^2)
$D_{m,p}$	=	Distance in population zone m in county p (km)
$I_{i,n}$	=	Total inventory of radionuclide i for fuel type n (Ci)
$CP_{j,n}$	=	Conditional probability for severity category j and fuel type n
$RF_{i,j,n}$	=	Release fraction for radionuclide i and severity category j for fuel type n

EF_p = Population escalation factor for county p

$URF_{i,k}$ = Unit risk factor for radionuclide i and pathway k (person-rem/Ci per person/km^2)

For the ingestion pathway, the dose risk is given by:

$$\text{Dose Risk} = AR \times \sum_p \sum_n \sum_j \sum_i D_{rural,p} \times I_{i,n} \times CP_{j,n} \times RF_{i,j,n} \times FTF_i \times URF_i$$

Where:

AR = Accident rate (accidents/km)

$D_{rural,p}$ = Distance in rural population zone in county p (km)

$I_{i,n}$ = Total inventory of radionuclide i for fuel type n (Ci)

$CP_{j,n}$ = Conditional probability for severity category j and fuel type n

$RF_{i,j,n}$ = Release fraction for radionuclide i and severity category j and fuel type n

FTF_i = Food transfer factor for radionuclide i (Ci/Ci deposited) (state-specific)

URF_i = Ingestion unit risk factor for radionuclide i (person-rem/Ci × Ci deposited)

For loss of shielding accidents, the dose risk is given by:

$$\text{Dose Risk} = AR \times \sum_p \sum_n \sum_m \sum_j C_n \times PD_{m,p} \times D_{m,p} \times CP_{j,n} \times EF_p \times URF_{j,n}$$

Where:

AR = Accident rate (accidents/km)

C_n = Number of casks for fuel type n

$PD_{m,p}$ = Population density in population zone m in county p (people/km^2)

$D_{m,p}$ = Distance in population zone m in county p (km)

$CP_{j,n}$ = Conditional probability for severity category j and fuel type n

EF_p = Population escalation factor for county p

$URF_{j,n}$ = Loss of shielding unit risk factor for severity category j and fuel type n (person-rem/km per person/km^2)

K.2.4.1 Transportation Accident Rates

In this analysis, the Department used a combination of rail accident rates based on both train-kilometers and railcar-kilometers to estimate accident dose risks (see Table K-8). These rates were for Track Class 3 and include derailments and collisions (DIRS 180220-Bendixen and Facanha 2007, all).

Enrichment is the fraction of atoms of a specified isotope in a mixture of isotopes of the same element when this fraction exceeds that in the naturally occurring mixture. By convention, uranium enrichment is given on a weight basis.

Decay time is the time since the spent nuclear fuel has been discharged from the reactor.

Burnup is the total energy released per initial unit mass of nuclear fuel as a result of irradiation. The commonly used units of burnup are megawatt-days per metric ton of heavy metal (MWd/MTHM).

Table K-8. Track Class 3 rail accident rates.[a]

Train-based accident rate (accidents per train-kilometer) [b]	Railcar-based accident rate (accidents per railcar-kilometer) [c]
7.5×10^{-7}	1.7×10^{-8}

a. Source: DIRS 180220-Bendixen and Facanha 2007, p. 2.
b. To convert accidents per train-kilometer to accidents per train-mile, multiply by 1.609344.
c. To convert accidents per railcar-kilometer to accidents per railcar-mile, multiply by 1.609344.

K.2.4.2 Radionuclide Inventory

The primary sources of the radionuclide inventory information for the Rail Alignment EIS are:

- *PWR Source Term Generation and Evaluation* (DIRS 169061-BSC 2004, all)
- *BWR Source Term Generation and Evaluation* (DIRS 164364-BSC 2003, all)
- *Source Term Estimates for DOE Spent Nuclear Fuels* (DIRS 169354-DOE 2004, all)
- *Recommended Values for HLW Glass for Consistent Usage on the Yucca Mountain Project* (DIRS 180471-BSC 2007, all)

The radionuclide inventory used in the Rail Alignment EIS represents the radioactivity contained in about 65,600 metric tons of heavy metal (MTHM) of spent nuclear fuel and high-level radioactive waste which would be shipped to the repository by rail. The remaining 4,400 MTHM would be shipped to the repository using trucks and is not evaluated in the Rail Alignment EIS. The updated radionuclide inventories are listed in Tables K-9 through K-14.

DOE spent nuclear fuel was organized into 34 groups based on the fuel compound, fuel ***enrichment***, fuel cladding material, and fuel cladding condition (DIRS 171271-DOE 2004, all). The characteristics of the spent nuclear fuel, including percent enrichment, ***decay time***, and ***burnup***, affect the radionuclide inventory and thereby the radiation dose. The descriptions below are for a typical spent nuclear fuel for each group.

- Group 1: Uranium Metal, Zirconium Alloy Clad, Low-Enriched Uranium—This group contains uranium metal fuel compounds with zirconium alloy cladding. The end-of-life effective enrichment ranges from 0.5 to 1.7 percent. The cladding is in fair to poor condition. This group of fuel comprises approximately 2,103 MTHM.
- Group 2: Uranium Metal, Non-Zirconium Alloy Clad, Low-Enriched Uranium—This group contains uranium metal fuel compounds with no known zirconium alloy cladding. The end-of-life effective enrichment ranges from 0.2 to 3.4 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 8 MTHM.

- Group 3: Uranium-Zirconium—This group contains uranium-zirconium alloy fuel compounds with zirconium alloy cladding. The end-of-life effective enrichment ranges from 0.5 to 92.9 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 0.66 MTHM.
- Group 4: Uranium-Molybdenum—This group contains uranium-molybdenum alloy fuel compounds with various types of cladding. The end-of-life effective enrichment ranges from 2.4 to 25.8 percent. If present, the cladding is in good to poor condition. This group of fuel comprises approximately 3.9 MTHM.
- Group 5: Uranium Oxide, Intact Zirconium Alloy Clad, Highly Enriched Uranium—This group contains uranium oxide fuel compounds with intact zirconium alloy cladding. The end-of-life effective enrichment ranges from 23.1 to 92.5 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 1 MTHM.
- Group 6: Uranium Oxide, Intact Zirconium Alloy Clad, Medium-Enriched Uranium—This group contains uranium oxide fuel compounds with intact zirconium alloy cladding. The end-of-life effective enrichment ranges from 5 to 6.9 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 1.9 MTHM.
- Group 7: Uranium Oxide, Intact Zirconium Alloy Clad, Low-Enriched Uranium—This group contains uranium oxide fuel compounds with intact zirconium alloy cladding. The end-of-life effective enrichment ranges from 0.6 to 4.9 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 89.6 MTHM.
- Group 8: Uranium Oxide, Intact Stainless Steel/Hastelloy Clad, Highly Enriched Uranium—This group contains uranium oxide fuel compounds with intact stainless steel or hastelloy cladding. The end-of-life effective enrichment ranges from 91 to 93.2 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 0.19 MTHM.
- Group 9: Uranium Oxide, Intact Stainless Steel Clad, Medium-Enriched Uranium—This group contains uranium oxide fuel compounds with intact stainless steel cladding. The end-of-life effective enrichment ranges from 5.5 to 20 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 0.69 MTHM.
- Group 10: Uranium Oxide, Intact Stainless Steel Clad, Low-Enriched Uranium—This group contains uranium oxide fuel compounds with stainless steel cladding. The end-of-life effective enrichment ranges from 0.2 to 1.9 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 0.9 MTHM.
- Group 11: Uranium Oxide, Non-Intact or Declad Non-Aluminum Clad, Highly Enriched Uranium—This group contains uranium oxide fuel compounds with no known aluminum cladding. The end-of-life effective enrichment ranges from 21 to 93.3 percent. If present, the cladding is in poor condition. This group of fuel comprises approximately 0.82 MTHM.
- Group 12: Uranium Oxide, Non-Intact or Declad Non-Aluminum Clad, Medium-Enriched Uranium—This group contains uranium oxide fuel compounds with no known aluminum cladding. The end-of-life effective enrichment ranges from 5.2 to 18.6 percent. If present, the cladding is in poor condition. This group of fuel comprises approximately 0.47 MTHM.
- Group 13: Uranium Oxide, Non-Intact or Declad Non-Aluminum Clad, Low-Enriched Uranium—This group contains uranium oxide fuel compounds with no known aluminum cladding. The end-of-life effective enrichment ranges from 1.1 to 3.2 percent. If present, the cladding is in poor condition. This group of fuel comprises approximately 82.5 MTHM.
- Group 14: Uranium Oxide, Aluminum Clad, Highly Enriched Uranium—This group contains uranium oxide fuel compounds with aluminum cladding. The end-of-life effective enrichment ranges

from 58.1 to 89.9 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 4.6 MTHM.

- Group 15: Uranium Oxide, Aluminum Clad, Medium-Enriched Uranium and Low-Enriched Uranium—This group contains uranium oxide fuel compounds with aluminum cladding. The end-of-life effective enrichment ranges from 8.9 to 20 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 0.29 MTHM.
- Group 16: Uranium-Aluminum, Highly Enriched Uranium—This group contains uranium-aluminum alloy fuel compounds with aluminum cladding. The end-of-life effective enrichment ranges from 21.9 to 93.3 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 7.5 MTHM.
- Group 17: Uranium-Aluminum, Medium-Enriched Uranium—This group contains uranium-aluminum alloy fuel compounds with aluminum cladding. The end-of-life effective enrichment ranges from 9 to 20 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 2.6 MTHM.
- Group 18: Uranium-Silicide—This group contains uranium-silicide fuel compounds with aluminum cladding. The end-of-life effective enrichment ranges from 5.2 to 22 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 7.2 MTHM.
- Group 19: Thorium/Uranium Carbide, TRISO- or BISO-Coated Particles in Graphite—This group contains thorium/uranium carbide fuel compounds with TRISO- or BISO-coated particles. TRISO-coated particles consist of an isotropic pyrocarbon outer layer, a silicon carbide layer, an isotropic carbon layer, and a porous carbon buffer inner layer. BISO-coated particles consist of an isotropic pyrocarbon outer layer and a low density porous carbon buffer inner layer. The end-of-life effective enrichment ranges from 71.4 to 84.4 percent. The coating is in good condition. This group of fuel comprises approximately 24.7 MTHM.
- Group 20: Thorium/Uranium Carbide, Mono-Pyrolytic Carbon-Coated Particles in Graphite—This group contains thorium/uranium carbide fuel compounds with mono-pyrolytic carbon-coated particles. The end-of-life effective enrichment ranges from 80.6 to 93.2 percent. The coating is in poor condition. This group of fuel comprises approximately 1.6 MTHM.
- Group 21: Plutonium/Uranium Carbide, Nongraphite Clad, Not Sodium Bonded—This group contains plutonium/uranium carbide fuel compounds with stainless steel cladding. The end-of-life effective enrichment ranges from 1 to 67.3 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 0.08 MTHM.
- Group 22: Mixed Oxide, Zirconium Alloy Clad—This group contains plutonium/uranium oxide fuel compounds with zirconium alloy cladding. The end-of-life effective enrichment ranges from 1.3 to 21.3 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 1.6 MTHM.
- Group 23: Mixed Oxide, Stainless Steel Clad—This group contains plutonium/uranium and plutonium oxide fuel compounds with stainless steel cladding. The end-of-life effective enrichment ranges from 2.1 to 87.4 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 10.7 MTHM.
- Group 24: Mixed Oxide, Non-Stainless Steel/Non-Zirconium Alloy Clad—This group contains plutonium/uranium oxide fuel compounds with no known stainless steel or zirconium alloy cladding. The end-of-life effective enrichment ranges from 5 to 54.3 percent. The cladding is in poor to nonintact condition. This group of fuel comprises approximately 0.11 MTHM.

- Group 25: Thorium/Uranium Oxide, Zirconium Alloy Clad—This group contains thorium/uranium oxide fuel compounds with zirconium alloy cladding. The end-of-life effective enrichment ranges from 10.1 to 98.4 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 42.6 MTHM.
- Group 26: Thorium/Uranium Oxide, Stainless Steel Clad—This group contains thorium/uranium oxide fuel compounds with stainless steel cladding. The end-of-life effective enrichment ranges from 7.6 to 97.8 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 7.6 MTHM.
- Group 27: Uranium-Zirconium Hydride, Stainless Steel/Incoloy Clad, Highly Enriched Uranium—This group contains uranium-zirconium hydride fuel compounds with stainless steel or incoloy cladding. The end-of-life effective enrichment ranges from 42.5 to 93.2 percent. The cladding is in good to fair condition. This group of fuel comprises approximately 0.16 MTHM.
- Group 28: Uranium-Zirconium Hydride, Stainless Steel/Incoloy Clad, Medium-Enriched Uranium—This group contains uranium-zirconium hydride fuel compounds with stainless steel or incoloy cladding. The end-of-life effective enrichment ranges from 11.9 to 20 percent. The cladding is in good to poor condition. This group of fuel comprises approximately 1.4 MTHM.
- Group 29: Uranium-Zirconium Hydride, Aluminum Clad, Medium-Enriched Uranium—This group contains uranium-zirconium hydride fuel compounds with aluminum cladding. The end-of-life effective enrichment ranges from 16.8 to 20 percent. The cladding is in good condition. This group of fuel comprises approximately 0.35 MTHM.
- Group 30: Uranium-Zirconium Hydride, Declad—This group contains uranium-zirconium hydride fuel compounds that have been declad. The end-of-life effective enrichment is about 89.7 percent. This group of fuel comprises approximately 0.03 MTHM.
- Group 31: Metallic Sodium Bonded—This group contains a wide variety of spent nuclear fuel that has the common attribute of containing metallic sodium bonding between the fuel matrix and the cladding. The end-of-life effective enrichment ranges from 0.1 to 93.2 percent. If present, the cladding is in good to poor condition. This group of fuel comprises approximately 59.9 MTHM. This spent nuclear fuel will be treated and will be disposed of as high-level radioactive waste.
- Group 32: Naval Fuel—Naval nuclear fuel is highly robust and designed to operate in a high-temperature, high-pressure environment for many years. This fuel is highly enriched (93 to 97 percent) in uranium-235. In addition, to ensure that the design will be capable of withstanding battle shock loads, the naval fuel material is surrounded by large amounts of zirconium alloy. This group of fuel comprises approximately 65 MTHM.
- Group 33: Canyon Stabilization—This spent nuclear fuel is being treated and will be disposed of as high-level radioactive waste.
- Group 34: Miscellaneous—This group contains spent nuclear fuel that does not fit into other groups. The spent nuclear fuel in this group was generated from numerous reactors of different types. The end-of-life effective enrichment ranges from 14.6 to 90 percent. If present, the cladding is in good to poor condition. This group of fuel comprises approximately 0.44 MTHM.

The DOE spent nuclear fuel radionuclide inventories are in the year 2010 for the amount of spent nuclear fuel that would be shipped in rail casks. These radionuclide inventories were compiled from data contained in *Source Term Estimates for DOE Spent Nuclear Fuels* (DIRS 169354-DOE 2004, Volume II, Appendix C). For naval spent nuclear fuel, the radionuclide inventory is for 400 casks. The single-cask naval spent fuel inventory was compiled from information provided by the Department of the Navy (DIRS

155857-McKenzie 2001, Table 3). Tables K-9 through K-12 list the radionuclide inventories for DOE spent nuclear fuel.

For commercial spent nuclear fuel, the radionuclide inventories are for the amount of spent nuclear fuel that would be shipped in rail casks. For pressurized water reactor spent nuclear fuel, 85,914 spent nuclear fuel assemblies are estimated to be shipped in rail casks (DIRS 181377-BSC 2007, Section 7). For boiling water reactor spent nuclear fuel, 121,932 spent nuclear fuel assemblies are estimated to be shipped in rail casks (DIRS 181377-BSC 2007, Section 7). For the purposes of analysis, all shipping casks were assumed to be full and all trains were assumed to have a full complement of casks. This increases the number of spent nuclear fuel assemblies to 87,057 for pressurized water reactor spent nuclear fuel and 123,537 for boiling water reactor spent nuclear fuel. The representative pressurized water reactor assembly would have a burnup of 60,000 megawatt-days per metric ton of heavy metal (MWd/MTHM), an enrichment of 4 percent, and a decay time of 10 years (DIRS 169061-BSC 2004, all). The representative boiling water reactor assembly would have a burnup of 50,000 MWd/MTHM, an enrichment of 4 percent, and a decay time of 10 years (DIRS 164364-BSC 2003, all). Table K-13 contains the radionuclide inventory for commercial spent nuclear fuel.

The high-level radioactive waste radionuclide inventory is based on 5,316 canisters for Hanford Site high-level radioactive waste, 528 canisters for Idaho National Laboratory high-level radioactive waste, 3,490 canisters of Savannah River Site high-level radioactive waste, and 277 canisters of high-level radioactive waste from West Valley (DIRS 181377-BSC 2007, Section 7). For the purposes of analysis, all shipping casks containing high-level radioactive waste were assumed to be full and all trains were assumed to have a full complement of casks. This increases the amount of high-level radioactive waste to 5,325 canisters for Hanford Site high-level radioactive waste, 550 canisters for Idaho National Laboratory high-level radioactive waste, 3,500 canisters of Savannah River Site high-level radioactive waste, and 300 canisters of high-level radioactive waste from West Valley. Table K-14 lists the radionuclide inventory for high-level radioactive waste.

K.2.4.3 Conditional Probabilities and Release Fractions

In this appendix, DOE spent nuclear fuel is organized into 34 groups based on the fuel compound, fuel matrix, fuel enrichment, fuel cladding material, and fuel cladding condition. Table K-15 lists these spent nuclear fuel groups. Commercial spent nuclear fuel is organized into two groups, pressurized-water-reactor spent nuclear fuel and boiling-water-reactor spent nuclear fuel. High-level radioactive waste is organized into four groups, Idaho high-level waste, Hanford high-level waste, Savannah River high-level radioactive waste, and West Valley high-level radioactive waste. These groups were assigned to a set of 10 conditional probabilities and release fractions known as release fraction groups based on the characteristics and behaviors of the spent nuclear fuel or high-level radioactive waste (see Tables K-16 through K-26). Release fractions were specified for inert gases, volatile constituents such as cesium and ruthenium, particulates, and activation products such as Co-60 that were deposited on the exterior surfaces of the spent nuclear fuel (also known as crud).

For loss of shielding accidents, the Rail Alignment EIS uses unit risk factors for six severity categories of accidents (DIRS 155970-DOE 2002, p. J-54, Table J-19). These unit risk factors are listed in Tables K-27 and K-28.

Tables K-16 through K-26 also list "one-group" release fractions. One-group release fractions are defined as the sum of the products of the conditional probability and release fraction for all six accident severity categories:

$$\text{One Group Release Fraction} = \sum_{\text{Severity Category, } i=1}^{6} \text{Conditional Probability}_i \times \text{Release Fraction}_i$$

Similarly, the one-group unit risk factors listed in Tables K-27 and K-28 are defined as the sum of the products of the conditional probability and unit risk factor for all six accident severity categories:

$$\text{One Group Unit Risk Factor} = \sum_{\text{Severity Category, } i=1}^{6} \text{Conditional Probability}_i \times \text{Unit Risk Factor}_i$$

The conditional probabilities and release fractions listed in Tables K-16 through K-28 would be mostly a direct consequence of error on the part of transport vehicle operators, operators of other vehicles, or persons who maintain vehicles and rights-of-way. The number and severity of the accidents would be minimized through the use of trained and qualified personnel.

Others have argued that other kinds of human error could also contribute to accident consequences: (1) undetected error in the design and certification of transportation packaging (cask) used to ship radioactive material, (2) hidden or undetected defects in the manufacture of these packages, and (3) error in preparing the packages for shipment. DOE has concluded that U.S. Nuclear Regulatory Commission and U.S. Department of Transportation regulations and regulatory practices address the design, manufacture, and use of transportation packaging and are effective in preventing these kinds of human error by requiring:

- Independent Nuclear Regulatory Commission review of designs to ensure compliance with requirements (10 CFR Part 71)
- Nuclear Regulatory Commission-approved and audited quality assurance programs for design, manufacturing, and use of transportation packages

In addition, federal provisions (10 CFR Part 21) provide additional assurance of timely and effective actions to identify and initiate corrective actions for undetected design or manufacturing defects. Furthermore, conservatism in the approach to safety incorporated in the regulatory requirements and practices provides confidence that design or manufacturing defects that might remain undetected or operational deficiencies would not lead to a meaningful reduction in the performance of a package under normal or accident conditions of transportation.

K.2.4.4 Atmospheric Conditions

Because it is not possible to forecast the atmospheric conditions that might exist during an accident, DOE selected neutral weather conditions (Pasquill Stability Class D) for the transportation risk assessments for the Rail Alignment EIS. The accident calculation methodology includes a probabilistic component that includes the atmospheric stability; therefore, DOE assumed neutral conditions. Atmospheric conditions affect the dispersion of radionuclides that could be released during an accident. Neutral weather conditions are typified by moderate wind speeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. On the basis of observations from National Weather Service surface meteorological stations at 177 locations in the United States, on an annual average, neutral conditions (Pasquill Class C and D) occur 11 percent and 47 percent of the time, respectively. Stable conditions (Pasquill Class E and F) occur 12 percent and 21 percent of the time, respectively. Unstable conditions (Pasquill Class A and B) occur 1 percent and 7 percent of the time, respectively (DIRS 104800-CRWMS M&O 1999, p. 40).

Table K-9. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 1 through 8 (page 1 of 2).[a,b]

	Uranium metal				Uranium oxide			
					Zirconium clad (intact)			Stainless steel/hastelloy clad (intact)
Radionuclide	Zirconium clad LEU Group 1 (Ci)	Non-zirconium clad LEU Group 2 (Ci)	Uranium-zirconium Group 3 (Ci)	Uranium-molybdenum Group 4 (Ci)	HEU Group 5 (Ci)	MEU Group 6 (Ci)	LEU Group 7 (Ci)	HEU Group 8 (Ci)
Ac-227	5.0E-3	5.8E-4	3.0E-3	8.4E-3	5.4E-3	2.9E-5	4.2E-3	1.0E-4
Am-241	7.1E+5	2.1E+4	1.4E+4	1.8E+2	4.6E+2	4.8E+3	3.7E+5	4.6E-1
Am-242m	4.4E+2	3.4E+1	2.2E+0	2.8E-2	8.6E-1	9.7E+0	7.8E+2	3.5E-5
Am-243	3.7E+2	6.4E+0	1.3E+0	1.6E-2	1.8E+0	2.1E+1	1.7E+3	4.1E-6
C-14	1.1E+3	2.0E+3	7.0E+2	1.1E+1	5.3E+1	1.6E+0	6.6E+2	9.5E-1
Cl-36	5.2E-2	3.7E+1	1.2E-3	4.8E-3	2.8E-1	2.7E-2	2.1E+0	5.1E-3
Cm-243	1.7E+1	6.6E+0	3.1E-1	4.0E-3	7.5E-1	8.7E+0	7.6E+2	9.8E-7
Cm-244	6.5E+3	8.9E+1	6.5E+0	8.3E-2	1.5E+2	1.7E+3	1.6E+5	8.9E-6
Co-60	2.7E+4	4.6E+5	4.0E+4	6.8E+2	1.6E+4	1.2E+2	4.7E+4	2.5E+2
Cs-134	1.1E+2	1.5E+2	5.0E+0	1.2E-1	1.8E+0	1.9E+1	2.6E+3	1.0E-2
Cs-135	7.6E+1	1.9E+0	5.0E+0	4.0E+0	7.0E+0	4.9E-1	4.2E+1	1.3E-1
Cs-137	9.3E+6	2.2E+5	9.0E+5	1.3E+5	3.4E+5	4.8E+4	4.9E+6	5.7E+3
Eu-154	5.2E+4	1.2E+3	4.2E+3	6.9E+1	2.3E+2	7.8E+2	9.1E+4	2.4E+0
Eu-155	2.5E+3	7.7E+2	3.9E+2	1.3E+2	1.7E+2	8.5E+1	1.2E+4	2.5E+0
Fe-55	4.7E+1	6.2E+3	3.7E+1	1.7E+0	2.8E+2	6.8E+0	1.1E+3	4.2E+0
H-3	2.6E+4	4.2E+3	1.5E+4	4.9E+2	6.5E+2	7.6E+2	8.7E+4	9.4E+0
I-129	6.5E+0	1.3E-1	4.7E-1	1.1E-1	1.7E-1	3.3E-2	2.9E+0	3.0E-3
Kr-85	2.1E+5	7.5E+3	2.4E+4	3.7E+3	9.6E+3	1.0E+3	1.3E+5	1.5E+2
Np-237	6.4E+1	1.9E+0	3.5E+0	3.3E-1	3.0E-1	3.8E-1	3.1E+1	4.8E-3
Pa-231	1.2E-2	1.1E-3	5.0E-3	1.7E-2	1.0E-2	4.3E-5	6.9E-3	2.0E-4
Pb-210	2.0E-3	3.6E-4	2.7E-3	3.5E-5	3.7E-7	2.7E-6	2.2E-3	3.1E-9
Pm-147	4.7E+3	1.6E+4	6.2E+2	1.1E+2	2.8E+2	5.6E+1	8.9E+3	4.0E+0
Pu-238	1.5E+5	3.6E+3	4.0E+3	6.5E+1	2.9E+2	2.5E+3	2.1E+5	1.2E+0
Pu-239	2.2E+5	7.1E+3	1.2E+4	1.8E+3	2.0E+2	3.9E+2	4.0E+4	2.8E+0

Table K-9. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 1 through 8 (page 2 of 2).[a,b]

	Uranium metal				Uranium oxide			
					Zirconium clad (intact)			Stainless steel/hastelloy clad (intact)
Radionuclide	Zirconium clad LEU Group 1 (Ci)	Non-zirconium clad LEU Group 2 (Ci)	Uranium-zirconium Group 3 (Ci)	Uranium-molybdenum Group 4 (Ci)	HEU Group 5 (Ci)	MEU Group 6 (Ci)	LEU Group 7 (Ci)	HEU Group 8 (Ci)
Pu-240	1.7E+5	3.5E+3	5.2E+3	7.1E+1	7.3E+1	5.1E+2	4.4E+4	3.6E-1
Pu-241	4.5E+6	1.4E+5	9.1E+4	1.1E+3	3.5E+3	3.2E+4	3.2E+6	2.7E+0
Pu-242	1.1E+2	1.9E+0	1.3E+0	1.6E-2	1.9E-1	2.2E+0	1.7E+2	8.2E-6
Ra-226	5.6E-3	9.7E-4	7.4E-3	9.4E-5	1.0E-6	7.3E-6	6.0E-3	8.2E-9
Ra-228	4.9E-4	2.4E-5	7.4E-4	1.1E-5	1.9E-6	1.8E-7	5.7E-4	3.4E-8
Ru-106	4.4E-3	1.1E+3	2.1E-4	2.9E-5	2.1E-3	2.6E-1	5.1E+2	6.3E-7
Se-79	8.4E+1	3.1E+0	7.8E+0	1.5E+0	3.1E+0	4.2E-1	3.9E+1	5.5E-2
Sn-126	6.6E+0	2.5E+0	7.5E+0	3.4E+0	2.7E+0	8.5E-1	7.2E+1	4.8E-2
Sr-90	6.7E+6	1.6E+5	7.9E+5	1.1E+5	3.2E+5	3.2E+4	3.4E+6	5.4E+3
Tc-99	2.8E+3	5.9E+1	2.8E+2	4.2E+1	1.1E+2	1.3E+1	1.2E+3	1.9E+0
Th-229	1.8E-3	1.8E-4	2.7E-3	3.8E-5	3.7E-6	4.0E-6	2.3E-3	6.4E-8
Th-230	5.6E-1	8.8E-2	6.7E-1	8.6E-3	9.6E-5	6.9E-4	5.5E-1	7.3E-7
Th-232	4.9E-4	2.4E-5	7.5E-4	1.1E-5	1.9E-6	1.8E-7	5.8E-4	3.5E-8
Tl-208	3.0E-2	2.0E-2	2.9E-2	8.7E-4	5.5E-3	6.0E-3	5.1E-1	8.8E-5
U-232	8.2E-2	5.4E-2	7.8E-2	2.3E-3	1.5E-2	1.6E-2	1.4E+0	2.4E-4
U-233	3.9E-1	3.9E-2	5.7E-1	8.0E-3	8.0E-4	8.5E-4	5.0E-1	1.3E-5
U-234	1.4E+3	1.9E+2	1.5E+3	1.9E+1	2.6E-1	1.7E+0	1.2E+3	1.6E-3
U-235	4.8E+1	8.2E-2	6.0E-3	2.0E+0	9.9E-1	2.0E-1	2.3E+0	3.9E-1
U-236	9.7E+1	2.8E+0	1.7E+1	1.3E+0	3.7E+0	2.6E-1	3.3E+1	6.7E-2
U-238	7.0E+2	2.1E+0	3.3E-1	1.0E+0	2.1E-2	6.0E-1	3.0E+1	4.7E-3

a. LEU = low enriched uranium; MEU = medium enriched uranium; HEU = high enriched uranium.
b. Source: Compiled from data contained in DIRS 169354-DOE 2004, Volume II, Appendix C.

Table K-10. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 9 through 16 (page 1 of 2).[a,b]

	Uranium oxide							Uranium-aluminum
	Stainless steel clad (intact)		Not aluminum clad nonintact or declad			Aluminum clad		
Radionuclide	HEU Group 9 (Ci)	LEU Group 10 (Ci)	HEU Group 11 (Ci)	MEU Group 12 (Ci)	LEU Group 13 (Ci)	HEU Group 14 (Ci)	MEU and LEU Group 15 (Ci)	HEU Group 16 (Ci)
Ac-227	1.4E-4	9.5E-4	5.6E-3	8.5E-4	4.2E-3	8.8E-4	1.3E-5	1.0E-3
Am-241	1.1E+0	1.8E+4	1.9E+4	1.5E+3	4.7E+4	4.9E+3	4.8E+1	5.2E+3
Am-242m	1.1E-4	8.8E+0	3.8E+1	3.0E+0	1.1E+2	9.9E-1	1.6E-2	1.6E+0
Am-243	1.2E-5	4.5E+0	3.7E+1	6.5E+0	2.3E+2	1.5E+1	5.4E-2	1.8E+1
C-14	2.7E+0	1.9E+3	2.8E+2	1.5E+1	8.5E+1	1.6E-2	2.1E-4	3.0E-1
Cl-36	1.5E-2	3.6E+1	5.2E+0	8.4E-2	6.5E-1	1.7E-25	4.7E-28	2.7E-4
Cm-243	4.2E-6	1.4E+0	2.0E+0	2.7E+0	1.1E+2	2.5E+0	7.9E-3	3.7E+0
Cm-244	4.9E-5	6.3E+1	3.9E+2	5.3E+2	2.6E+4	2.1E+3	1.7E+0	3.3E+3
Co-60	1.1E+4	4.4E+5	1.0E+5	1.6E+4	8.1E+4	5.1E+1	1.1E+0	3.6E+2
Cs-134	1.7E+2	5.2E+0	6.8E+2	7.1E+0	4.4E+2	7.4E+4	1.3E+4	1.3E+6
Cs-135	3.6E-1	1.1E+0	1.8E+0	2.0E+0	1.4E+1	5.5E+0	1.2E-1	9.7E+0
Cs-137	2.4E+4	1.6E+5	1.0E+5	1.3E+5	1.2E+6	3.2E+6	9.6E+4	6.9E+6
Eu-154	3.2E+1	8.1E+2	3.0E+3	3.3E+2	1.7E+4	5.9E+4	2.5E+3	2.1E+5
Eu-155	1.3E+2	2.4E+2	6.1E+2	2.0E+2	3.4E+3	2.0E+4	1.1E+3	1.1E+5
Fe-55	8.5E+3	4.6E+3	3.5E+4	1.1E+3	5.4E+3	4.6E+3	1.9E+2	3.7E+4
H-3	7.3E+1	3.9E+3	7.3E+2	5.1E+2	1.4E+4	7.5E+3	3.3E+2	2.3E+4
I-129	8.7E-3	9.7E-2	4.4E-2	5.6E-2	5.7E-1	1.1E+0	2.7E-2	2.0E+0
Kr-85	1.4E+3	4.4E+3	4.8E+3	5.2E+3	4.2E+4	1.8E+5	8.9E+3	6.0E+5
Np-237	1.4E-2	1.7E+0	4.5E-1	1.9E-1	4.1E+0	2.2E+1	3.4E-1	3.4E+1
Pa-231	3.4E-4	2.0E-3	7.3E-3	2.0E-3	9.9E-3	2.7E-3	4.6E-5	3.5E-3
Pb-210	2.4E-9	3.5E-4	5.5E-5	8.4E-7	1.2E-5	6.4E-5	1.4E-6	8.7E-5
Pm-147	7.5E+3	1.7E+3	3.0E+4	1.0E+3	6.6E+3	1.4E+5	7.1E+4	4.2E+6
Pu-238	3.9E+0	3.1E+3	7.1E+3	8.0E+2	2.9E+4	7.8E+4	7.2E+2	1.1E+5
Pu-239	8.0E+0	5.7E+3	9.7E+2	1.6E+2	4.4E+3	7.4E+2	1.5E+1	1.3E+3

Table K-10. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 9 through 16 (page 2 of 2).[a,b]

	Uranium oxide							Uranium-aluminum
	Stainless steel clad (intact)		Not aluminum clad nonintact or declad			Aluminum clad		
Radionuclide	HEU Group 9 (Ci)	LEU Group 10 (Ci)	HEU Group 11 (Ci)	MEU Group 12 (Ci)	LEU Group 13 (Ci)	HEU Group 14 (Ci)	MEU and LEU Group 15 (Ci)	HEU Group 16 (Ci)
Pu-240	1.0E+0	2.3E+3	6.7E+2	1.6E+2	5.5E+3	4.1E+2	8.8E+0	7.1E+2
Pu-241	1.8E+1	1.2E+5	1.1E+5	1.0E+4	5.2E+5	1.0E+5	2.2E+3	2.3E+5
Pu-242	2.4E-5	1.4E+0	5.6E+0	6.7E-1	2.3E+1	1.5E+0	1.3E-2	2.0E+0
Ra-226	8.5E-9	9.4E-4	1.5E-4	2.3E-6	4.2E-5	2.9E-4	4.8E-6	3.6E-4
Ra-228	9.2E-8	1.9E-5	1.4E-3	5.6E-7	4.3E-6	1.9E-8	2.3E-10	1.2E-6
Ru-106	3.8E+2	2.1E+0	1.6E+3	3.3E-2	2.7E-1	1.6E+3	5.1E+3	3.6E+5
Se-79	1.6E-1	2.7E+0	7.9E-1	9.5E-1	8.3E+0	1.9E+1	4.7E-1	3.4E+1
Sn-126	1.4E-1	2.0E+0	6.9E-1	9.8E-1	1.2E+1	1.7E+1	4.2E-1	3.0E+1
Sr-90	2.3E+4	1.2E+5	9.6E+4	1.2E+5	9.3E+5	3.0E+6	9.2E+4	6.5E+6
Tc-99	5.6E+0	4.7E+1	2.8E+1	3.3E+1	2.8E+2	6.2E+2	1.5E+1	1.1E+3
Th-229	1.0E-7	1.7E-4	4.0E-3	1.8E-6	3.4E-5	7.6E-6	1.1E-7	9.7E-6
Th-230	1.2E-6	8.6E-2	1.3E-2	2.2E-4	5.3E-3	5.2E-2	9.1E-4	6.8E-2
Th-232	9.9E-8	1.9E-5	1.4E-3	5.7E-7	4.4E-6	2.9E-8	4.2E-10	1.5E-6
Tl-208	2.9E-4	1.3E-2	2.0E-1	3.3E-3	7.6E-2	7.0E-2	1.6E-3	1.2E-1
U-232	8.0E-4	3.6E-2	5.4E-1	9.0E-3	2.1E-1	1.9E-1	4.7E-3	3.4E-1
U-233	3.7E-5	3.6E-2	8.2E-1	4.5E-4	9.7E-3	4.2E-3	7.8E-5	6.7E-3
U-234	4.4E-3	1.9E+2	2.9E+1	5.4E-1	1.7E+1	2.3E+2	6.6E+0	4.3E+2
U-235	2.7E-1	1.8E-1	2.4E+0	1.3E-1	4.6E+0	7.8E+0	6.2E-2	1.3E+1
U-236	1.9E-1	2.6E+0	9.8E-1	1.1E+0	7.5E+0	2.4E+1	5.6E-1	4.2E+1
U-238	1.9E-1	2.6E-1	3.6E-1	1.3E-1	2.7E+1	1.3E-1	8.3E-2	3.2E-1

a. LEU = low enriched uranium; MEU = medium enriched uranium; HEU = high enriched uranium.
b. Source: Compiled from data contained in DIRS 169354-DOE 2004, Volume II, Appendix C.

Table K-11. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 17 through 24 (page 1 of 2).[a,b]

			Thorium/uranium carbide		Plutonium/ uranium carbide	Mixed oxide		
Radionuclide	Uranium-aluminum MEU Group 17 (Ci)	Uranium silicide Group 18 (Ci)	TRISO or BISO particles in graphite Group 19 (Ci)	Mono-pyrolytic carbon particles Group 20 (Ci)	Not graphite nonsodium bonded Group 21 (Ci)	Zirconium clad Group 22 (Ci)	Stainless steel clad Group 23 (Ci)	Non-stainless steel non-zirconium clad Group 24 (Ci)
Ac-227	6.1E-5	2.7E-4	2.6E+0	2.3E-1	2.1E-8	1.6E-1	4.2E-2	4.9E-3
Am-241	1.9E+3	8.6E+3	2.3E+3	1.8E+2	8.9E+2	5.8E+5	2.5E+5	3.0E+4
Am-242m	1.3E+0	6.1E+0	2.2E+0	1.4E-1	1.7E+1	1.2E+3	2.1E+3	2.8E+2
Am-243	1.1E+0	4.4E+0	4.0E+1	2.7E+0	9.0E-1	1.1E+3	4.4E+2	6.1E+1
C-14	3.0E-2	1.2E+0	2.0E+1	1.4E+0	2.2E-1	8.3E+3	2.6E+3	3.7E+2
Cl-36	2.5E-5	1.2E-3	9.2E-1	6.2E-2	2.9E-6	1.6E+2	4.9E+1	7.0E+0
Cm-243	4.3E-1	2.0E+0	3.0E+1	1.5E+0	4.9E+0	7.7E+1	5.8E+2	7.4E+1
Cm-244	3.3E+1	1.3E+2	9.0E+3	3.8E+2	2.1E+1	1.2E+4	7.7E+3	1.2E+3
Co-60	3.0E+1	9.1E+2	2.3E+3	2.7E+1	8.9E+1	1.9E+6	3.5E+6	6.4E+5
Cs-134	1.3E+5	2.6E+5	3.7E+3	1.5E+1	2.0E+2	9.4E+1	4.1E+4	5.1E+3
Cs-135	1.3E+0	4.8E+0	2.1E+1	1.4E+0	4.0E-1	3.2E+1	4.9E+1	6.4E+0
Cs-137	9.1E+5	2.5E+6	1.5E+6	7.8E+4	1.6E+4	1.5E+6	2.3E+6	3.2E+5
Eu-154	2.4E+4	9.2E+4	3.9E+4	9.3E+2	3.0E+2	8.6E+4	1.1E+5	1.8E+4
Eu-155	1.1E+4	3.7E+4	5.9E+3	6.3E+1	3.8E+2	5.3E+3	6.7E+4	9.0E+3
Fe-55	1.0E+4	4.7E+4	1.6E+0	5.3E-3	2.6E+1	2.0E+4	4.8E+5	5.5E+4
H-3	3.3E+3	8.8E+3	6.9E+3	2.3E+2	6.0E+1	1.7E+4	1.7E+4	2.7E+3
I-129	2.4E-1	6.6E-1	8.7E-1	5.9E-2	1.1E-2	7.8E-1	1.3E+0	1.7E-1
Kr-85	8.7E+4	2.2E+5	7.9E+4	2.3E+3	4.7E+2	4.2E+4	8.5E+4	1.2E+4
Np-237	2.3E+0	4.7E+0	1.1E+1	7.3E-1	2.5E-2	1.1E+1	5.6E+0	7.6E-1
Pa-231	3.4E-4	1.2E-3	4.1E+0	2.8E-1	5.7E-8	2.0E-1	6.1E-2	8.7E-3
Pb-210	1.0E-6	1.2E-5	7.3E-4	8.3E-5	4.1E-9	1.6E-3	3.2E-4	1.1E-5
Pm-147	7.5E+5	1.8E+6	5.2E+3	1.7E+1	1.1E+3	1.9E+3	2.2E+5	2.8E+4
Pu-238	4.8E+3	8.8E+3	1.5E+5	9.5E+3	2.2E+2	1.5E+5	3.8E+4	3.0E+3

Table K-11. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 17 through 24 (page 2 of 2).[a,b]

			Thorium/uranium carbide		Plutonium/ uranium carbide	Mixed oxide		
Radionuclide	Uranium-aluminum MEU Group 17 (Ci)	Uranium silicide Group 18 (Ci)	TRISO or BISO particles in graphite Group 19 (Ci)	Mono-pyrolytic carbon particles Group 20 (Ci)	Not graphite nonsodium bonded Group 21 (Ci)	Zirconium clad Group 22 (Ci)	Stainless steel clad Group 23 (Ci)	Non-stainless steel non-zirconium clad Group 24 (Ci)
Pu-239	1.3E+3	6.7E+3	1.2E+2	7.9E+0	1.0E+3	2.2E+4	1.5E+5	0.0E+0
Pu-240	7.1E+2	3.5E+3	2.2E+2	1.6E+1	8.4E+2	1.3E+4	1.1E+5	3.9E+3
Pu-241	1.0E+5	4.9E+5	3.1E+4	1.1E+3	2.3E+4	1.3E+6	4.2E+6	2.6E+4
Pu-242	4.5E-1	2.0E+0	3.4E+0	2.3E-1	2.7E-1	1.3E+2	4.4E+1	1.8E+0
Ra-226	9.0E-6	4.7E-5	1.2E-3	1.6E-4	1.5E-8	4.4E-3	9.2E-4	5.1E-5
Ra-228	1.2E-7	4.9E-6	7.8E-1	5.4E-2	8.1E-13	4.1E-2	1.2E-2	1.7E-3
Ru-106	6.4E+4	1.7E+5	6.5E-1	7.9E-2	5.9E+1	7.4E-1	1.2E+4	1.5E+3
Se-79	4.1E+0	1.1E+1	1.8E+1	1.2E+0	8.5E-2	1.4E+1	1.3E+1	1.7E+0
Sn-126	3.7E+0	1.0E+1	1.9E+1	1.3E+0	3.7E-1	1.3E+1	4.0E+1	5.2E+0
Sr-90	8.6E+5	2.3E+6	1.5E+6	7.4E+4	5.8E+3	1.4E+6	1.2E+6	1.7E+5
Tc-99	1.4E+2	3.9E+2	2.9E+2	1.9E+1	3.3E+0	4.8E+2	4.8E+2	6.2E+1
Th-229	5.5E-7	5.1E-6	5.8E+0	6.2E-1	1.6E-8	1.2E-1	2.9E-2	2.7E-3
Th-230	3.6E-3	8.4E-3	1.2E-1	1.1E-2	3.1E-6	4.0E-1	9.6E-2	9.1E-3
Th-232	1.4E-7	6.4E-6	2.5E+0	1.7E-1	1.2E-12	4.1E-2	1.3E-2	1.8E-3
Tl-208	9.8E-3	1.7E-2	5.8E+2	3.5E+1	4.3E-3	6.0E+0	2.5E+0	3.7E-1
U-232	2.9E-2	4.8E-2	1.6E+3	9.4E+1	1.2E-2	1.6E+1	6.7E+0	1.0E+0
U-233	5.0E-4	4.3E-3	1.8E+3	1.2E+2	2.5E-6	2.5E+1	7.7E+0	1.1E+0
U-234	3.7E+1	4.7E+1	2.4E+2	1.7E+1	2.2E-2	8.7E+2	2.7E+2	3.9E+1
U-235	4.4E-1	1.2E+0	3.6E+0	2.4E-1	1.9E-4	4.0E+1	1.2E+1	1.8E+0
U-236	4.7E+0	1.2E+1	7.4E+0	5.0E-1	1.1E-3	1.6E+1	5.1E+0	7.3E-1
U-238	7.9E-1	2.2E+0	4.5E-2	3.0E-3	1.8E-2	8.0E+0	5.0E+0	3.9E-1

a. LEU = low enriched uranium; MEU = medium enriched uranium; HEU = high enriched uranium.
b. Source: Compiled from data contained in DIRS 169354-DOE 2004, Volume II, Appendix C.

Table K-12. Radionuclide inventories in the year 2010 for DOE spent nuclear fuel groups 25 through 34 (page 1 of 3).[a,b]

	Thorium/uranium oxide		Uranium/zirconium hydride					
			Stainless steel/incoloy clad		Aluminum clad			
Radionuclide	Zirconium clad Group 25 (Ci)	Stainless steel clad Group 26 (Ci)	HEU Group 27 (Ci)	MEU Group 28 (Ci)	MEU Group 29 (Ci)	Declad Group 30 (Ci)	Naval spent nuclear fuel Group 32[c] (Ci)	Miscellaneous Group 34 (Ci)
Ac-227	3.9E+1	7.4E+0	2.1E-5	6.5E-5	2.1E-5	2.7E-4	3.9E-2	5.0E-3
Am-241	1.1E+2	7.1E+3	3.8E+2	1.1E+2	3.0E+1	1.1E+2	2.0E+4	2.7E+3
Am-242m	7.3E-1	1.6E+1	8.2E-1	7.2E-2	1.9E-2	3.3E-2	1.8E+2	6.9E+0
Am-243	1.5E-1	1.5E+1	1.1E+0	7.7E-3	2.4E-3	4.2E-3	2.7E+2	1.5E+1
C-14	4.4E+1	1.2E+2	4.4E+0	6.7E+0	4.4E-1	3.6E+0	6.4E+3	3.9E+1
Cf-252	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	4.8E-4	0.0E+0
Cl-36	8.5E-1	2.2E+0	9.3E-2	1.5E-1	4.3E-4	8.0E-2	2.8E+2	7.0E-1
Cm-242	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	5.6E+2	0.0E+0
Cm-243	1.8E-1	1.0E+0	1.1E+0	8.8E-3	2.4E-3	1.7E-3	3.2E+2	8.1E-1
Cm-244	9.8E+0	2.2E+2	1.1E+2	8.2E-2	2.6E-2	8.6E-3	2.5E+4	5.4E+1
Cm-245	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	2.9E+0	0.0E+0
Cm-246	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	5.6E-1	0.0E+0
Cm-247	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	3.8E-6	0.0E+0
Cm-248	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	1.0E-5	0.0E+0
Co-60	1.5E+3	9.5E+4	2.3E+4	5.8E+4	2.2E+2	9.8E+1	1.5E+6	1.1E+4
Co-60 (Crud)	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	2.3E+3	0.0E+0
Cs-134	3.5E+2	1.1E+1	9.8E+3	4.0E+3	7.1E+2	7.0E-4	3.4E+7	8.8E+1
Cs-135	1.3E+1	2.6E+0	6.9E-1	1.7E+0	3.2E-1	9.1E-1	1.8E+3	4.4E+0
Cs-137	8.8E+5	1.4E+5	8.0E+4	1.4E+5	2.4E+4	2.8E+4	1.8E+8	2.1E+5
Eu-154	9.1E+3	3.2E+3	2.7E+3	7.1E+2	1.0E+4	1.2E+1	0.0E+0	5.1E+2
Eu-155	1.3E+3	3.0E+2	9.8E+2	1.3E+3	3.1E+3	1.6E+0	0.0E+0	2.3E+3
Fe-55	1.6E+1	3.8E+3	1.2E+4	3.4E+4	6.0E+1	1.4E-1	0.0E+0	3.7E+2
H-3	1.8E+3	5.5E+2	2.5E+2	5.2E+2	8.5E+1	2.5E+1	5.6E+5	1.1E+3
I-129	7.5E-1	1.3E-1	2.5E-2	3.8E-2	7.4E-3	2.1E-2	4.8E+1	1.1E-1
Kr-85	5.6E+4	5.8E+3	5.8E+3	1.2E+4	1.9E+3	3.9E+2	1.4E+7	1.3E+4

Table K-12. Radionuclide inventories in the year 2010 for DOE pent nuclear fuel groups 25 through 34 (page 2 of 3).[a,b]

	Thorium/uranium oxide		Uranium/zirconium hydride					
			Stainless steel/incoloy clad		Aluminum clad			
Radionuclide	Zirconium clad Group 25 (Ci)	Stainless steel clad Group 26 (Ci)	HEU Group 27 (Ci)	MEU Group 28 (Ci)	MEU Group 29 (Ci)	Declad Group 30 (Ci)	Naval spent nuclear fuel Group 32[c] (Ci)	Miscellaneous Group 34 (Ci)
Nb-93m	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	1.4E+3	0.0E+0
Nb-94	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	7.2E+4	0.0E+0
Ni-59	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	2.5E+4	0.0E+0
Ni-63	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	3.1E+6	0.0E+0
Np-237	5.9E-2	1.5E-1	4.2E-1	6.5E-2	1.5E-2	3.7E-2	6.4E+2	3.6E-1
Pa-231	5.7E+1	9.1E+0	5.3E-5	2.3E-4	5.6E-5	4.4E-4	2.1E-1	1.2E-2
Pb-210	5.6E-3	1.1E-3	1.9E-8	1.2E-9	9.8E-10	2.0E-8	3.6E-4	7.7E-6
Pd-107	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	2.4E+1	0.0E+0
Pm-147	1.7E+3	2.3E+2	1.8E+4	9.3E+4	1.4E+4	4.1E-1	0.0E+0	2.2E+4
Pu-238	2.2E+2	2.9E+3	1.8E+3	5.3E+1	1.3E+1	2.1E+1	4.8E+6	8.6E+2
Pu-239	1.3E+1	3.8E+2	4.9E+1	2.9E+2	5.7E+1	1.6E+2	4.8E+3	2.1E+3
Pu-240	7.6E+0	2.7E+2	4.0E+1	1.1E+2	2.3E+1	6.0E+1	5.6E+3	1.9E+2
Pu-241	1.1E+3	7.1E+4	1.1E+4	4.9E+3	1.0E+3	3.3E+2	1.6E+6	1.7E+4
Pu-242	1.9E-2	2.2E+0	1.7E-1	1.2E-2	3.1E-3	6.6E-3	3.2E+1	7.2E-1
Ra-226	6.8E-3	1.7E-3	7.8E-8	5.4E-9	3.0E-9	4.8E-8	2.2E-3	2.0E-5
Ra-228	2.2E+0	3.5E-1	7.3E-7	1.0E-5	2.0E-6	7.2E-6	7.2E-5	3.1E-4
Rh-102	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	1.1E+1	0.0E+0
Ru-106	1.8E-2	3.5E-3	1.4E+3	4.0E+3	6.4E+2	9.7E-11	2.4E+6	3.9E+1
Se-79	1.7E+1	2.9E+0	4.5E-1	6.8E-1	1.3E-1	3.7E-1	1.4E+2	1.6E+0
Sm-151	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	5.6E+5	0.0E+0
Sn-126	1.9E+1	3.2E+0	4.2E-1	6.3E-1	1.2E-1	3.5E-1	4.8E+2	3.6E+0
Sr-90	8.9E+5	1.4E+5	7.5E+4	1.3E+5	2.3E+4	2.5E+4	1.8E+8	1.9E+5
Tc-99	1.5E+2	3.1E+1	1.4E+1	2.3E+1	4.4E+0	1.3E+1	2.8E+4	4.5E+1
Th-229	2.2E+1	4.9E+0	5.1E-6	9.0E-6	2.7E-6	2.2E-5	3.8E-3	1.8E-3
Th-230	4.9E-1	9.0E-2	1.6E-5	1.2E-6	4.1E-7	3.7E-6	7.2E-1	1.9E-3

Table K-12. Radionuclide inventories in the Year 2010 for DOE spent nuclear fuel groups 25 through 34 (page 3 of 3).[a,b]

	Thorium/uranium oxide		Uranium/zirconium hydride					
			Stainless steel/incoloy clad		Aluminum clad			
Radionuclide	Zirconium clad Group 25 (Ci)	Stainless steel clad Group 26 (Ci)	HEU Group 27 (Ci)	MEU Group 28 (Ci)	MEU Group 29 (Ci)	Declad Group 30 (Ci)	Naval spent nuclear fuel Group 32[c] (Ci)	Miscellaneous Group 34 (Ci)
Th-232	4.5E+0	8.0E-1	8.5E-7	1.3E-5	2.4E-6	7.2E-6	9.2E-5	2.7E-2
Tl-208	7.2E+3	1.1E+3	5.0E-3	8.7E-4	1.9E-4	3.4E-4	0.0E+0	4.5E-1
U-232	2.0E+4	2.9E+3	1.4E-2	2.5E-3	5.3E-4	9.1E-4	2.2E+2	1.2E+0
U-233	1.4E+4	2.5E+3	2.4E-3	6.3E-3	1.3E-3	3.5E-3	1.2E+0	8.7E+1
U-234	3.9E+2	7.4E+1	1.2E-1	8.7E-3	2.1E-3	8.1E-3	6.0E+3	4.4E+0
U-235	3.0E-2	5.3E-1	2.1E-1	5.0E-1	1.3E-1	2.6E-2	1.2E+2	2.1E-1
U-236	6.3E-2	2.2E-1	4.7E-1	6.6E-1	1.3E-1	3.6E-1	1.0E+3	1.3E+0
U-238	1.8E-3	1.1E-1	1.6E-2	3.9E-1	9.7E-2	1.5E-2	4.8E-1	8.6E-2
Zr-93	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	4.4E+3	0.0E+0

a. LEU = low enriched uranium; MEU = medium enriched uranium; HEU = high enriched uranium.
b. Source: Compiled from data contained in DIRS 169354-DOE 2004, Volume II, Appendix C.
c. Radionuclide inventory is for 400 casks. Single cask Naval spent fuel inventory is from DIRS 155857-McKenzie 2001, Table 3.
Note: There would be no shipments of group 31 or group 33 spent nuclear fuel under the Proposed Action.

Table K-13. Radionuclide inventories for commercial spent nuclear fuel shipped in rail casks.[a]

Radionuclide	Pressurized water reactor commercial spent nuclear fuel assembly inventory (Ci)[b]	Pressurized water reactor commercial spent nuclear fuel total inventory (Ci)[b]	Boiling water reactor commercial spent nuclear fuel assembly inventory (Ci)[c]	Boiling water reactor commercial spent nuclear fuel total inventory (Ci)[c]
Am-241	1.28E+03	1.11E+08	3.73E+02	4.61E+07
Am-242m	7.99E+00	6.96E+05	2.88E+00	3.56E+05
Am-243	3.93E+01	3.42E+06	8.63E+00	1.07E+06
C-14	4.35E-01	3.79E+04	1.69E-01	2.09E+04
Cd-113m	2.34E+01	2.03E+06	6.23E+00	7.69E+05
Ce-144	6.99E+01	6.09E+06	1.73E+01	2.14E+06
Cm-242	6.60E+00	5.75E+05	2.38E+00	2.94E+05
Cm-243	2.48E+01	2.16E+06	5.55E+00	6.86E+05
Cm-244	5.85E+03	5.09E+08	9.23E+02	1.14E+08
Cm-245	8.16E-01	7.10E+04	9.07E-02	1.12E+04
Cm-246	4.07E-01	3.54E+04	4.26E-02	5.26E+03
Co-60	2.17E+03	1.89E+08	1.14E+02	1.41E+07
Co-60 (Crud)	1.69E+01	1.47E+06	5.66E+01	6.99E+06
Cs-134	5.43E+03	4.73E+08	1.31E+03	1.62E+08
Cs-137	7.16E+04	6.23E+09	2.41E+04	2.98E+09
Eu-154	3.01E+03	2.62E+08	7.79E+02	9.62E+07
Eu-155	6.42E+02	5.59E+07	1.93E+02	2.39E+07
Fe-55 (Crud)	2.09E+02	1.82E+07	9.84E+01	1.22E+07
H-3	3.05E+02	2.66E+07	1.05E+02	1.30E+07
I-129	2.76E-02	2.40E+03	9.22E-03	1.14E+03
Kr-85	3.39E+03	2.95E+08	1.17E+03	1.45E+08
Np-237	2.94E-01	2.56E+04	8.74E-02	1.08E+04
Pm-147	6.06E+03	5.28E+08	2.11E+03	2.61E+08
Pu-238	3.98E+03	3.46E+08	1.02E+03	1.26E+08
Pu-239	1.75E+02	1.52E+07	5.41E+01	6.68E+06
Pu-240	3.63E+02	3.16E+07	1.27E+02	1.57E+07
Pu-241	5.64E+04	4.91E+09	1.57E+04	1.94E+09
Pu-242	2.48E+00	2.16E+05	7.08E-01	8.75E+04
Ru-106	4.04E+02	3.52E+07	9.05E+01	1.12E+07
Sb-125	5.20E+02	4.53E+07	1.45E+02	1.79E+07
Sr-90	4.51E+04	3.93E+09	1.66E+04	2.05E+09
U-232	3.61E-02	3.14E+03	8.74E-03	1.08E+03
U-234	5.24E-01	4.56E+04	2.39E-01	2.95E+04
U-236	1.77E-01	1.54E+04	7.45E-02	9.20E+03
U-238	1.46E-01	1.27E+04	6.24E-02	7.71E+03
Y-90	4.51E+04	3.93E+09	1.66E+04	2.05E+09

a. Sources: DIRS 169061-BSC 2004, all; DIRS 164364-BSC 2003, all.
b. Total inventory for pressurized water reactor spent nuclear fuel shipped in rail casks is based on 87,057 assemblies (calculated from rail shipments and cask capacities from DIRS 181377-BSC 2007, Section 7.
c. Total inventory for boiling water reactor spent nuclear fuel shipped in rail casks is based on 123,537 assemblies (calculated from rail shipments and cask capacities from DIRS 181377-BSC 2007, Section 7.

Table K-14. Radionuclide inventories for high-level radioactive waste (page 1 of 2).

Radionuclide	Hanford high-level radioactive waste[a] (Ci)	Idaho high-level radioactive waste[b] (Ci)	Savannah River Site high-level radioactive waste[c] (Ci)	West Valley high-level radioactive waste[d] (Ci)
Ac-227	0.00E+00	7.38E+01	0.00E+00	4.92E+01
Am-241	5.41E+03	1.08E+05	7.98E+05	4.58E+04
Am-242	7.86E-03	0.00E+00	0.00E+00	6.56E+02
Am-242m	7.86E-03	0.00E+00	4.55E+02	6.58E+02
Am-243	6.42E-03	1.13E+01	1.29E+03	6.10E+02
Ba-137m	4.76E+06	2.80E+07	2.18E+08	4.80E+06
C-14	1.29E-02	0.00E+00	0.00E+00	0.00E+00
Cd-113m	0.00E+00	7.79E+03	8.96E-08	0.00E+00
Ce-144	0.00E+00	0.00E+00	6.30E+03	0.00E+00
Cf-249	0.00E+00	0.00E+00	1.25E+01	0.00E+00
Cf-251	0.00E+00	0.00E+00	2.87E+01	0.00E+00
Cm-242	7.86E-03	0.00E+00	0.00E+00	5.43E+02
Cm-243	3.99E-04	8.28E+00	1.45E+03	0.00E+00
Cm-244	1.24E-02	1.57E+02	6.51E+06	6.15E+03
Cm-245	1.71E-06	0.00E+00	5.22E+02	0.00E+00
Cm-246	4.02E-08	0.00E+00	1.52E+02	0.00E+00
Cm-247	1.43E-14	0.00E+00	5.99E-03	0.00E+00
Cm-248	4.32E-15	0.00E+00	0.00E+00	0.00E+00
Co-60	3.98E+02	1.87E+03	2.50E+06	0.00E+00
Cs-134	6.75E+01	6.71E+02	8.40E+05	0.00E+00
Cs-135	7.53E+01	0.00E+00	9.17E+02	1.93E+02
Cs-137	4.90E+06	2.80E+07	2.33E+08	5.08E+06
Eu-152	0.00E+00	7.74E+02	0.00E+00	0.00E+00
Eu-154	2.08E+04	5.03E+04	5.88E+06	0.00E+00
Eu-155	1.41E+02	1.82E+03	2.35E+03	0.00E+00
H-3	6.70E+03	0.00E+00	0.00E+00	0.00E+00
I-129	2.61E+00	3.61E+01	2.57E-01	0.00E+00
Nb-93m	6.42E+02	2.00E+03	5.15E+02	2.03E+02
Nb-94	2.48E-03	0.00E+00	0.00E+00	0.00E+00
Ni-59	0.00E+00	1.03E+03	7.56E+02	1.19E+02
Ni-63	0.00E+00	9.06E+04	4.94E+04	9.64E+03
Np-237	2.85E+00	1.06E+02	1.19E+02	3.55E+01
Np-238	0.00E+00	0.00E+00	0.00E+00	2.97E+00
Np-239	0.00E+00	0.00E+00	0.00E+00	6.10E+02
Pa-231	0.00E+00	2.05E+02	0.00E+00	4.91E+01
Pd-107	0.00E+00	0.00E+00	4.52E+00	0.00E+00
Pm-147	9.15E+03	0.00E+00	1.70E+07	0.00E+00
Pr-144	0.00E+00	0.00E+00	6.30E+03	0.00E+00
Pu-238	5.04E+04	3.42E+03	2.08E+07	5.19E+03
Pu-239	8.37E+02	5.20E+04	1.72E+05	1.56E+03
Pu-240	7.26E+02	9.25E+03	1.17E+05	1.11E+03
Pu-241	2.98E+04	6.10E+04	1.22E+07	2.67E+04
Pu-242	1.58E+00	7.53E-01	3.89E+02	3.04E-03
Ra-226	2.60E-03	6.78E-02	0.00E+00	0.00E+00
Ra-228	0.00E+00	1.58E+01	0.00E+00	2.07E+00

Table K-14. Radionuclide inventories for high-level radioactive waste (page 2 of 2).

Radionuclide	Hanford high-level radioactive waste[a] (Ci)	Idaho high-level radioactive waste[b] (Ci)	Savannah River Site high-level radioactive waste[c] (Ci)	West Valley high-level radioactive waste[d] (Ci)
Ru-106	0.00E+00	1.51E+00	1.65E+04	0.00E+00
Sb-125	2.72E+02	1.86E+03	0.00E+00	0.00E+00
Sb-126	0.00E+00	0.00E+00	0.00E+00	7.59E+00
Sb-126m	0.00E+00	0.00E+00	0.00E+00	5.42E+01
Se-79	0.00E+00	9.19E+01	2.07E+02	0.00E+00
Sm-151	0.00E+00	2.46E+06	4.27E+05	5.08E+04
Sn-126	4.12E+01	4.36E+02	1.08E+02	5.42E+01
Sr-90	6.01E+06	3.06E+07	2.67E+08	2.89E+06
Tc-99	1.58E+03	2.24E+04	5.46E+04	8.90E+02
Th-229	0.00E+00	1.51E+00	3.07E-01	7.51E-03
Th-230	1.72E-01	0.00E+00	2.76E-02	3.28E-04
Th-232	4.48E-08	6.02E+00	3.30E+00	2.54E+00
Tl-208	0.00E+00	0.00E+00	0.00E+00	6.65E-01
U-232	2.75E-03	3.01E+01	1.29E+00	0.00E+00
U-233	2.76E-04	3.84E+02	9.63E+01	6.10E+00
U-234	4.28E+01	1.66E+02	2.84E+02	2.65E+00
U-235	2.73E-01	6.78E+00	2.10E+00	2.15E-05
U-236	7.12E-01	4.52E+00	2.64E+01	4.58E-04
U-237	0.00E+00	0.00E+00	0.00E+00	6.40E-01
U-238	1.36E-02	1.50E+02	1.81E+02	0.00E+00
Y-90	6.01E+06	3.06E+07	2.67E+08	2.89E+06
Zr-93	0.00E+00	3.62E+03	6.58E+02	2.03E+02

a. The Hanford high-level radioactive waste radionuclide inventory represents the radionuclide inventory in 5,325 canisters (DIRS 181377-BSC 2007, Section 7; DIRS 180471-BSC 2007, Table 8).
b. The Idaho high-level radioactive waste radionuclide inventory represents the radionuclide inventory in 550 canisters (DIRS 181377-BSC 2007, Section 7; DIRS 180471-BSC 2007, Table 19).
c. The Savannah River Site high-level radioactive waste radionuclide inventory represents the radionuclide inventory in 3,500 canisters (DIRS 181377-BSC 2007, Section 7; DIRS 180471-BSC 2007, Table 3).
d. The West Valley high-level radioactive waste radionuclide inventory represents the radionuclide inventory in 300 canisters (DIRS 181377-BSC 2007, Section 7; DIRS 180471-BSC 2007, Table 17.

Table K-15. Spent nuclear fuel groups, spent nuclear fuel descriptions, and release fraction groups (page 1 of 2).

Spent nuclear fuel group	Description	Release fraction group
1	Uranium metal, zirconium clad, low enriched uranium	1
2	Uranium metal, non-zirconium clad, low enriched uranium	1
3	Uranium-zirconium	1
4	Uranium-molybdenum	1
5	Uranium oxide, zirconium clad (intact), high enriched uranium	2
6	Uranium oxide, zirconium clad (intact), medium enriched uranium	2
7	Uranium oxide, zirconium clad (intact), low enriched uranium	2
8	Uranium oxide, stainless steel/hastelloy clad (intact), high enriched uranium	2
9	Uranium oxide, stainless steel clad (intact), high enriched uranium	2

Table K-15. Spent nuclear fuel groups, spent nuclear fuel descriptions, and release fraction groups (page 2 of 2).

Spent nuclear fuel group	Description	Release fraction group
10	Uranium oxide, stainless steel clad (intact), low enriched uranium	2
11	Uranium oxide, non-aluminum clad (nonintact or declad), high enriched uranium	3
12	Uranium oxide, non-aluminum clad (nonintact or declad), medium enriched uranium	3
13	Uranium oxide, non-aluminum clad (nonintact or declad), low enriched uranium	3
14	Uranium oxide, aluminum clad, high enriched uranium	3
15	Uranium oxide, aluminum clad, medium enriched uranium and low enriched uranium	3
16	Uranium-aluminum, high enriched uranium	4
17	Uranium-aluminum, medium enriched uranium	4
18	Uranium silicide	4
19	Thorium/uranium carbide, TRISO- or BISO-coated particles in graphite	5
20	Thorium/uranium carbide, mono-pyrolytic carbon-coated articles in graphite	6
21	Plutonium/uranium carbide, nongraphite clad, not sodium bonded	3
22	Mixed oxide, zirconium clad	2
23	Mixed oxide, stainless steel clad	2
24	Mixed oxide, non-stainless steel/non-zirconium clad	2
25	Thorium/uranium oxide, zirconium clad	2
26	Thorium/uranium oxide, stainless steel clad	2
27	Uranium-zirconium hydride, stainless steel/incoloy clad, high enriched uranium	7
28	Uranium-zirconium hydride, stainless steel/incoloy clad, medium enriched uranium	7
29	Uranium-zirconium hydride, aluminum clad, medium enriched uranium	7
30	Uranium-zirconium hydride, aluminum clad, declad	7
31[a]	Metallic sodium bonded	–
32	Naval spent nuclear fuel	Navy
33[a]	Canyon stabilization	–
34	Miscellaneous	1
PWR	Pressurized water reactor	PWR
BWR	Boiling water reactor	BWR
HLW	Hanford, Idaho, Savannah River Site, and West Valley high-level radioactive waste	HLW

a. Under the Proposed Action in the Rail Alignment EIS, there would be no shipments of DOE groups 31 and 33 spent nuclear fuel.

Table K-16. Accident severity categories, conditional probabilities, and release fractions for commercial pressurized water reactor spent nuclear fuel (PWR Release Fraction Group).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	1.96E-1	5.87E-9	1.34E-7	1.34E-7	1.37E-3
3	4.91E-5	8.39E-1	1.68E-5	2.52E-7	2.52E-7	9.44E-3
4	5.77E-7	8.00E-1	8.71E-6	1.32E-5	1.32E-5	4.42E-3
5	1.10E-7	8.35E-1	3.60E-5	1.37E-5	1.37E-5	5.36E-3
6	8.52E-10	8.47E-1	5.71E-5	4.63E-5	1.43E-5	1.59E-2
one-group	--	4.93E-5	8.34E-10	2.67E-11	2.67E-11	5.20E-7

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-26.

Table K-17. Accident severity categories, conditional probabilities, and release fractions for commercial boiling water reactor spent nuclear fuel (BWR Release Fraction Group).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	2.35E-2	7.04E-10	1.47E-8	1.47E-8	5.59E-4
3	4.91E-5	8.39E-1	1.68E-5	2.52E-7	2.52E-7	9.44E-3
4	5.77E-7	8.00E-1	8.71E-6	1.32E-5	1.32E-5	4.42E-2
5	1.10E-7	8.37E-1	4.12E-5	1.82E-5	1.82E-5	5.43E-3
6	8.52E-10	8.45E-1	7.30E-5	5.94E-5	1.96E-5	1.60E-2
one-group	--	4.27E-5	8.35E-10	2.26E-11	2.26E-11	5.11E-7

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-27.

Table K-18. Accident severity categories, conditional probabilities, and release fractions for naval spent nuclear fuel (Navy Release Fraction Group).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99996	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	4.02E-5	1.52E-2	4.55E-9	9.10E-9	9.10E-9	1.37E-3
3	6.32E-6	8.39E-2	1.68E-6	2.52E-8	2.52E-8	9.44E-3
4	1.22E-7	8.00E-2	8.98E-7	1.34E-6	1.34E-6	4.47E-2
5	1.51E-8	9.44E-2	4.00E-6	1.80E-6	1.80E-6	5.36E-3
6	1.66E-10	9.04E-2	5.49E-6	4.67E-6	1.93E-6	2.86E-2
one-group	--	1.15E-6	1.10E-11	7.17E-13	7.16E-13	1.20E-7

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-46.

Table K-19. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel groups 1, 2, 3, 4, and 34 (Release Fraction Group 1).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	2.84E-4	1.71E-6	3.91E-7	1.10E-8	2.96E-5
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	2.13E-3	2.36E-6	3.55E-6	3.55E-6	1.18E-2
5	1.10E-7	4.00E-3	7.87E-5	1.77E-5	9.68E-8	1.61E-4
6	8.52E-10	4.68E-2	9.63E-4	2.47E-4	2.73E-6	7.17E-3
one-group	--	1.27E-8	7.69E-11	1.93E-11	2.49E-12	8.00E-9

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-33.

Table K-20. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel groups 5, 6, 7, 8, 9, 10, 22, 23, 24, 25, and 26 (Release Fraction Group 2).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	1.96E-1	5.87E-9	1.34E-7	1.34E-7	1.37E-3
3	4.91E-5	8.39E-1	1.68E-5	2.52E-7	2.52E-7	9.44E-3
4	5.77E-7	8.00E-1	8.71E-6	1.32E-5	1.32E-5	4.42E-3
5	1.10E-7	8.35E-1	3.60E-5	1.37E-5	1.37E-5	5.36E-3
6	8.52E-10	8.47E-1	5.71E-5	4.63E-5	1.43E-5	1.59E-2
one-group	--	4.93E-5	8.34E-10	2.67E-11	2.67E-11	5.20E-7

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-26.

Table K-21. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel groups 11, 12, 13, 14, 15, and 21 (Release Fraction Group 3).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	1.15E-4	3.44E-10	7.15E-9	7.15E-9	2.38E-5
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	2.13E-3	2.36E-6	3.55E-6	3.55E-6	1.18E-2
5	1.10E-7	4.00E-3	3.14E-7	9.68E-8	9.68E-8	1.61E-4
6	8.52E-10	1.67E-2	2.68E-6	2.29E-6	2.04E-6	6.15E-3
one-group	--	6.12E-9	1.41E-12	2.34E-12	2.34E-12	7.78E-9

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-35.

Table K-22. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel groups 16, 17, and 18 (Release Fraction Group 4).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	2.84E-4	8.53E-5	1.10E-8	1.10E-8	4.11E-5
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	2.13E-3	2.36E-6	3.55E-6	3.55E-6	1.18E-2
5	1.10E-7	4.00E-3	3.53E-3	9.68E-8	9.68E-8	4.26E-4
6	8.52E-10	4.68E-2	2.92E-2	2.73E-6	2.73E-6	1.03E-2
one-group	--	1.27E-8	3.72E-9	2.49E-12	2.49E-12	8.48E-9

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-39.

Table K-23. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel group 19 (Release Fraction Group 5).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	1.02E-4	6.12E-11	6.12E-11	6.12E-11	0.00E+0
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	4.77E-3	7.89E-8	7.89E-8	7.89E-8	0.00E+0
5	1.10E-7	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
6	8.52E-10	1.70E-3	2.84E-8	2.62E-8	2.62E-8	0.00E+0
one-group	--	6.70E-9	4.79E-14	4.79E-14	4.79E-14	0.00E+0

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-41.

Table K-24. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel group 20 (Release Fraction Group 6).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	5.14E-1	3.70E-7	3.70E-7	3.70E-7	0.00E+0
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	4.77E-1	7.89E-6	7.89E-6	7.89E-6	0.00E+0
5	1.10E-7	7.64E-1	6.32E-6	5.73E-7	5.73E-7	0.00E+0
6	8.52E-10	7.45E-1	7.57E-6	5.82E-6	3.02E-6	0.00E+0
one-group	--	2.02E-5	1.96E-11	1.89E-11	1.89E-11	0.00E+0

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-43.

Table K-25. Accident severity categories, conditional probabilities, and release fractions for DOE spent nuclear fuel groups 27, 28, 29, and 30 (Release Fraction Group 7).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	1.15E-4	3.44E-8	7.15E-7	7.15E-7	2.38E-5
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	2.13E-3	2.36E-4	3.55E-4	3.55E-4	1.18E-2
5	1.10E-7	1.97E-2	1.97E-2	8.99E-5	1.93E-6	7.15E-4
6	8.52E-10	7.98E-2	7.91E-2	5.43E-4	1.76E-4	8.58E-3
one-group	--	7.91E-9	2.37E-9	2.43E-10	2.33E-10	7.84E-9

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-45.

Table K-26. Accident severity categories, conditional probabilities, and release fractions for Idaho, Hanford, and Savannah River Site high-level radioactive waste (HLW Release Fraction Group).[a]

Accident severity category	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
1	0.99991	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
2	3.87E-5	0.00E+0	6.22E-8	6.22E-8	6.22E-8	0.00E+0
3	4.91E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
4	5.77E-7	0.00E+0	7.89E-6	7.89E-6	7.89E-6	0.00E+0
5	1.10E-7	0.00E+0	9.29E-8	9.29E-8	9.29E-8	0.00E+0
6	8.52E-10	0.00E+0	2.74E-6	2.74E-6	2.74E-6	0.00E+0
one-group	--	0.00E+0	6.97E-12	6.97E-12	6.97E-12	0.00E+0

a. Source: DIRS 157144-Jason Technologies 2001, Table 5-48.

Table K-27. Accident severity categories, conditional probabilities, and unit risk factors for loss of shielding accidents for steel-lead-steel rail casks.[a]

Accident severity category	Conditional probability	Unit risk factor (person-rem per people/km^2)[b]
1	0.9999	3.86E-5
2	6.44E-6	7.22E-3
3	4.90E-5	2.03E-3
4	4.46E-7	1.24E-2
5	2.37E-5	2.41E-3
6	5.18E-9	2.97E-2
one-group	--	3.88E-5

a. Source: DIRS 155970-DOE 2002, Table J-19.
b. To convert person-rem per people/km^2 to person-rem per people/$mile^2$, multiply by 0.38610.

Table K-28. Accident severity categories, conditional probabilities, and unit risk factors for loss of shielding accidents for monolithic steel rail casks.[a]

Accident severity category	Conditional probability	Unit risk factor (person-rem per people/km^2)[b]
1	1.0000	3.86E-5
2	0	3.86E-5
3	0	3.86E-5
4	0	3.86E-5
5	0	3.86E-5
6	0	3.86E-5
one-group	--	3.86E-5

a. Source: DIRS 155970-DOE 2002, Table J-19.
b. To convert person-rem per people/km^2 to person-rem per people/mile^2, multiply by 0.38610.

K.2.4.5 Population Density Zones

DOE used three population density zones (urban, rural, and suburban) for the transportation risk assessment. The Department defined urban areas as areas with a population density greater than 3,326 people per square kilometer; rural areas as areas with a population density less than 139 people per square kilometer; and suburban areas as areas with a population density between 139 and 3,326 people per square kilometer. The Department based the actual population densities, which Table K-2 lists, on 2000 census data. The radiological impacts were escalated to the year 2067 using the escalation factors listed in Table K-4.

K.2.4.6 Exposure Pathways

DOE calculated radiological doses for an individual located near the scene of the accident and for populations within 80 kilometers (50 miles) of the accident. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure (immersion or cloudshine) from the passing cloud, ingestion of contaminated food, direct exposure (groundshine) from radioactivity deposited on the ground, and inhalation of resuspended radioactive particles from the ground (resuspension).

K.2.4.7 Unit Risk Factors and Radiation Dosimetry

As discussed in this section, DOE estimated the radiation doses from transportation accidents using unit risk factors. The Department estimated unit risk factors using the RADTRAN 5 computer code (DIRS 150898-Neuhauser and Kanipe 2000, all; DIRS 155430-Neuhauser, Kanipe, and Weiner 2000, all) for five pathways: (1) ingestion, (2) inhalation, (3) immersion, (4) resuspension, and (5) groundshine. Table K-29 lists the unit risk factors.

DOE estimated the unit risk factors listed in Table K-29 using the ICRP inhalation and ingestion dose coefficients (DIRS 172935-ICRP 2001, all) and the EPA groundshine and immersion dose coefficients (DIRS 175544-EPA 2002, all). These dose coefficients are based on the recommendations by the International Commission on Radiological Protection in ICRP Publication 60 (DIRS 101836-ICRP 1991, all) and incorporate the dose coefficients from ICRP Publication 72 (DIRS 152446-ICRP 1996, all). For each radionuclide, the dose coefficients used to estimate the unit risk factors in Table K-29 are listed in DIRS 176975-BMI 2006, Table 5 and include radioactive progeny (DIRS 176975-BMI 2006, Table 2). The lung absorption type and the value for the fractional absorption to blood from the small intestine (f_1) for each radionuclide are also listed in DIRS 176975-BMI 2006, Table 5.

Incident-free transportation unit risk factors are calculated using the RADTRAN 5 and RISKIND computer codes. These unit risk factors are estimates of the radiation dose from transporting one cask containing spent nuclear fuel or high-level radioactive waste over a unit distance (for example, 1 kilometer) through an area having a population density of one person per unit of area (for example, 1 person per square kilometer). As in the incident-free transportation analysis, using unit risk factors simplifies the analysis of transportation risks and also improves its transparency and traceability.

For transportation accidents, unit risk factors provide estimates of:

- The radiation dose to an average person in a surrounding unit area (for example, a population density of one person per square kilometer) that could result if one curie of a specified radionuclide were released;
- The dose to a general population from ingestion of contaminated food from the accidental release of one curie of a specified radionuclide. The unit risk factor includes the assumption that all contaminated food is consumed.

For transportation accidents where a portion of a cask's radiation shield was damaged or lost (loss-of-shielding accidents), and for cases in which the cask's shield might remain intact, unit risk factors provide estimates of the resulting radiation dose to a person in a surrounding unit area after an accident.

K.2.4.8 Accidents Involving Hazardous Chemicals

DOE would ship spent nuclear fuel and high-level radioactive waste on the proposed rail line using dedicated trains, and hazardous chemical cargos would not be present on the same train as the spent nuclear fuel or high-level radioactive waste. In addition, trains carrying other materials to or from the repository would pull off onto sidings to let cask trains pass, which would greatly reduce the potential for accidents, including those involving hazardous chemicals.

Table K-29. Unit risk factors used in the transportation risk assessment (page 1 of 3).

Radionuclide	Physical form	Ingestion pathway unit risk factor (person-rem/ Ci × Ci deposited)	Inhalation pathway unit risk factor (person-rem/ Ci per people/km^2) [a]	Immersion pathway unit risk factor (person-rem/ Ci per people/km^2)	Resuspension pathway unit risk factor (person-rem/ Ci per people/km^2)	Groundshine pathway unit risk factor (person-rem/ Ci per people/km^2)
Ac-227 plus progeny	Particulates	2.12E+6	6.34E+0	3.75E-6	2.76E+1	2.21E-1
Am-241	Particulates	3.50E+5	2.98E+0	1.45E-7	1.36E+1	1.98E-2
Am-242m plus progeny	Particulates	3.33E+5	2.63E+0	1.37E-7	1.19E+1	1.46E-2
Am-243 plus progeny	Particulates	3.51E+5	2.92E+0	1.90E-6	1.33E+1	1.77E-1
Be-10	Particulates	1.92E+3	2.50E-3	2.97E-8	1.14E-2	3.00E-3
C-14	Inert gas	1.01E+3	3.91E-6	4.98E-9	0.00E+0	0.00E+0
Cd-113m	Particulates	4.02E+4	2.21E-3	1.95E-8	9.37E-3	6.33E-4
Ce-144 plus progeny	Particulates	9.19E+3	2.55E-3	7.39E-7	5.09E-3	7.00E-3
Cf-252	Particulates	1.57E+5	1.42E+0	7.85E-10	4.69E+0	5.21E-5
Cl-36	Cesium	1.63E+3	5.18E-4	3.57E-8	2.37E-3	9.85E-3
Cm-242	Particulates	2.10E+4	3.69E-1	8.67E-10	5.18E-1	1.74E-5
Cm-243	Particulates	2.62E+5	2.21E+0	1.14E-6	9.73E+0	6.35E-2
Cm-244	Particulates	2.10E+5	1.92E+0	7.33E-10	8.28E+0	2.76E-4
Cm-245	Particulates	3.67E+5	2.98E+0	7.56E-7	1.36E+1	7.06E-2
Cm-246	Particulates	3.67E+5	2.98E+0	6.69E-10	1.36E+1	5.04E-4
Cm-247 plus progeny	Particulates	3.33E+5	2.76E+0	3.20E-6	1.26E+1	2.83E-1

Table K-29. Unit risk factors used in the transportation risk assessment (page 2 of 3).

Radionuclide	Physical form	Ingestion pathway unit risk factor (person-rem/ Ci × Ci deposited)	Inhalation pathway unit risk factor (person-rem/ Ci per people/km^2) [a]	Immersion pathway unit risk factor (person-rem/ Ci per people/km^2)	Resuspension pathway unit risk factor (person-rem/ Ci per people/km^2)	Groundshine pathway unit risk factor (person-rem/ Ci per people/km^2)
Cm-248	Particulates	1.35E+6	1.07E+1	5.08E-10	4.86E+1	3.88E-4
Co-58	Particulates	1.29E+3	1.49E-4	9.60E-6	1.10E-4	1.09E-2
Co-60	Particulates	5.95E+3	2.21E-3	2.56E-5	8.45E-3	3.97E-1
Co-60	Crud	5.95E+3	2.21E-3	2.56E-5	8.45E-3	3.97E-1
Cs-134	Cesium	3.32E+4	4.68E-4	1.52E-5	1.44E-3	1.21E-1
Cs-135	Cesium	3.50E+3	4.90E-5	2.05E-9	2.24E-4	2.37E-5
Cs-137 plus progeny	Cesium	2.27E+4	3.26E-4	5.50E-6	1.44E-3	3.04E-1
Eu-154	Particulates	3.50E+3	3.76E-3	1.24E-5	1.54E-2	3.05E-1
Eu-155	Particulates	5.60E+2	4.90E-4	4.63E-7	1.85E-3	8.80E-3
Fe-55	Particulates	5.77E+2	2.71E-5	0.00E+0	8.99E-5	0.00E+0
Fe-59	Particulates	3.15E+3	2.63E-4	1.21E-5	1.30E-4	8.21E-3
H-3	Inert gas	3.15E+1	1.71E-5	0.00E+0	0.00E+0	0.00E+0
I-129	Cesium	1.92E+5	2.55E-3	6.11E-8	1.17E-2	1.72E-2
Kr-85	Inert gas	0.00E+0	0.00E+0	4.60E-7	0.00E+0	0.00E+0
Mn-54	Particulates	1.24E+3	1.07E-4	8.26E-6	2.24E-4	3.28E-2
Nb-93m	Particulates	2.10E+2	3.63E-5	6.57E-10	1.54E-4	2.44E-4
Nb-94	Particulates	2.97E+3	7.81E-4	1.55E-5	3.57E-3	1.31E+0
Nb-95	Particulates	1.01E+3	1.07E-4	7.51E-6	4.27E-5	4.22E-3
Ni-59	Particulates	1.10E+2	9.24E-6	0.00E+0	4.22E-5	0.00E+0
Ni-63	Particulates	2.62E+2	3.42E-5	0.00E+0	1.54E-4	0.00E+0
Np-237 plus progeny	Particulates	1.94E+5	1.63E+0	2.04E-6	7.46E+0	1.86E-1
Pa-231	Particulates	1.24E+6	2.42E+0	3.38E-7	1.10E+1	3.33E-2
Pb-210 plus progeny	Particulates	3.31E+6	3.19E-1	6.52E-8	1.39E+0	1.79E-2
Pd-107	Particulates	6.47E+1	4.19E-5	0.00E+0	1.91E-4	0.00E+0
Pm-147	Particulates	4.55E+2	3.48E-4	1.87E-9	1.15E-3	2.77E-6
Pu-238	Particulates	4.02E+5	1.14E+0	7.56E-10	5.13E+0	4.63E-4
Pu-239	Particulates	4.37E+5	1.14E+0	7.51E-10	5.19E+0	2.50E-4
Pu-240	Particulates	4.37E+5	1.14E+0	7.39E-10	5.19E+0	5.27E-4
Pu-241	Particulates	8.40E+3	1.21E-2	1.37E-11	5.15E-2	6.40E-7
Pu-242	Particulates	4.21E-5	1.07E+0	6.28E-10	4.86E+0	4.37E-4
Ra-226 plus progeny	Particulates	4.90E+5	2.52E-1	1.80E-5	1.15E+0	1.47E+0
Ra-228 plus progeny	Particulates	1.21E+6	1.86E-1	9.66E-6	7.21E-1	1.74E-1
Rh-102	Particulates	4.55E+3	1.21E-3	2.09E-5	4.09E-3	2.16E-1
Ru-106 plus progeny	Ruthenium	1.22E+4	2.00E-3	2.28E-6	4.56E-3	1.62E-2
Sb-125 plus progeny	Particulates	2.27E+3	3.96E-4	4.04E-6	1.32E-3	4.25E-2
Se-79	Particulates	5.07E+3	7.81E-5	8.49E-10	3.57E-4	1.45E-5
Sm-151	Particulates	1.71E+2	2.84E-4	5.32E-12	1.28E-3	2.63E-6
Sn-126 plus progeny	Particulates	8.87E+3	2.02E-3	1.94E-5	9.20E-3	1.73E+0
Sr-90 plus progeny	Particulates	5.37E+4	2.67E-3	1.92E-7	1.18E-2	6.07E-2
Tc-99	Particulates	1.12E+3	2.84E-4	6.17E-9	1.30E-3	5.69E-5
Th-228 plus progeny	Particulates	2.51E+5	3.07E+0	1.65E-5	9.18E+0	1.11E-1
Th-229 plus progeny	Particulates	1.07E+6	6.11E+0	3.01E-6	2.79E+1	3.05E-1
Th-230	Particulates	3.67E+5	9.95E-1	3.21E-9	4.54E+0	5.61E-4
Th-232	Particulates	4.02E+5	1.78E+0	1.57E-9	8.11E+0	3.99E-4

Table K-29. Unit risk factors used in the transportation risk assessment (page 3 of 3).

Radionuclide	Physical form	Ingestion pathway unit risk factor (person-rem/ Ci × Ci deposited)	Inhalation pathway unit risk factor (person-rem/ Ci per people/km^2) [a]	Immersion pathway unit risk factor (person-rem/ Ci per people/km^2)	Resuspension pathway unit risk factor (person-rem/ Ci per people/km^2)	Groundshine pathway unit risk factor (person-rem/ Ci per people/km^2)
U-232	Particulates	5.77E+5	2.63E+0	2.54E-9	1.18E+1	5.76E-4
U-233	Particulates	8.92E+4	6.82E-1	3.05E-9	3.11E+0	5.28E-4
U-234	Particulates	8.57E+4	6.68E-1	1.32E-9	3.05E+0	5.14E-4
U-235 plus progeny	Particulates	8.28E+4	6.05E-1	1.50E-6	2.76E+0	1.37E-1
U-236	Particulates	8.22E+4	6.18E-1	8.32E-10	2.82E+0	4.43E-4
U-238 plus progeny	Particulates	8.47E+4	5.68E-1	3.49E-7	2.59E+0	1.04E-1
Zr-93	Particulates	1.92E+3	7.10E-4	0.00E+0	3.24E-3	0.00E+0

a. To convert person-rem/Ci per people/km^2 to person-rem/Ci per people/mile^2, multiply by 0.386102.

K.2.4.9 Criticality During Accidents

Criticality is the term used to describe an uncontrolled nuclear chain reaction. U.S. Nuclear Regulatory Commission regulations at 10 CFR 71 require that the casks used to ship spent nuclear fuel and high-level radioactive waste be able to survive accident conditions, such as immersion in water, without undergoing a criticality. To meet this requirement, casks are typically designed so that even if water were to fill the cask and the cask contained unirradiated nuclear fuel (the most reactive case from the perspective of a criticality), a criticality would not occur.

K.2.4.10 Aircraft Crash

An aircraft crash into a spent nuclear fuel or high-level radioactive waste cask would be extremely unlikely because the probability of a crash into such a relatively small object, whether stationary or moving, is extremely remote. Nevertheless, DOE analyzed the consequences of an accident in which a large commercial aircraft or a military aircraft is hypothesized to directly hit a cask (DIRS 155970-DOE 2002, Section J.3.3.1). The analysis showed that the heavy shield wall of a cask could not be breached by the penetrating force of the aircraft's center shaft. With the exception of engines, the relatively light structures of an aircraft would be much less capable of causing damage to a cask. A resulting fire would not be sustainable or able to engulf a cask long enough to breach the integrity of the cask.

System malfunctions or material failures that could result in either an accidental release of ordnance or release of a practice weapon were discussed in the *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999), and the *Final Environmental Impact Statement, Withdrawal of Public Lands for Range Safety and Training Purposes, Naval Air Station Fallon, Nevada* (DIRS 148199-USN 1998). The Special Nevada Report (DIRS 153277-SAIC 1991) states that the probability of dropped ordnance resulting in injury, death, or property damage ranges from about 1 in 1 billion to 1 in 1 trillion per dropped ordnance incident, with an average of about 1 in 10 billion per dropped ordnance incident. Less than one accidentally dropped ordnance incident is estimated per year for all flight operations over the Nellis Air Force Range (now called the Nevada Test and Training Range) and Naval Air Station Fallon. All of these analyses are incorporated in the Rail Alignment EIS by reference. Spent nuclear fuel transportation would not affect the risk from dropped ordnance or aircraft crashes. The Rail Alignment EIS does not evaluate radiological consequences of an impact of accidentally dropped ordnance on a shipping cask because the probability of such an event (about 1 in 10 billion per year) is so extremely low that it is not reasonably foreseeable.

Accordingly, DOE believes there would be no need for associated mitigation measures and no impacts on military operations.

K.2.4.11 Baltimore Tunnel Fire

On July 18, 2001, a freight train carrying hazardous (non-nuclear) materials derailed and caught fire while passing through the Howard Street railroad tunnel in downtown Baltimore, Maryland. The possible impacts of this fire were evaluated by the Nuclear Regulatory Commission in *Spent Nuclear Fuel Transportation Package Response to the Baltimore Tunnel Fire Scenario* (DIRS 182014-Adkins et al. 2006, all).

This study evaluated the response of the three transportation casks, the HOLTEC Model No. HI-STAR 100, the TransNuclear Model No. TN-68, and the Nuclear Assurance Corporation (NAC) Legal Weight Truck (LWT), to the conditions that existed during the fire. This study concluded that larger transportation packages resembling the HI-STAR 100 and TN-68 would withstand a fire with thermal conditions similar to those that existed in the Baltimore tunnel fire event with only minor damage to peripheral components. This is due to their sizable thermal inertia and design specifications in compliance with currently imposed regulatory requirements.

For the TN-68 and the NAC LWT, the maximum temperatures predicted in the regions of the lid and the vent and drain ports exceed the seals' rated service temperatures, making it possible for a small release to occur, due to crud that might spall off the surfaces of the fuel rods. While a release is not expected to occur for these conditions, any release that could occur would be very small due to a number of factors. These include (1) the tight clearances maintained between the lid and cask body by the closure bolts, (2) the low pressure differential between the cask interior and exterior, (3) the tendency of such small clearances to plug, and (4) the tendency of crud particles to settle or plate out.

The radiological consequences of the package responses to the Baltimore tunnel fire were also evaluated. The analysis indicates that the regulatory dose rate limits specified in 10 CFR 71.51 for accident conditions would not be exceeded by releases or direct radiation from any of these packages in this fire scenario. All three packages are designed to maintain regulatory dose rate limits even with a complete loss of neutron shielding. While highly unlikely, the NAC LWT could experience some decrease in gamma shielding due to slump in the lead as a consequence of this fire scenario, but a conservative analysis shows that the regulatory dose rate limits would not be exceeded.

The results of this evaluation also strongly indicate that neither spent nuclear fuel particles nor fission products would be released from a spent fuel shipping cask carrying intact spent nuclear fuel involved in a severe tunnel fire such as the Baltimore Tunnel Fire. None of the three cask designs analyzed for the Baltimore Tunnel fire scenario (TN-68, HI-STAR 100, and NAC LWT) experienced internal temperatures that would result in rupture of the fuel cladding. Therefore, radioactive material (spent nuclear fuel particles or fission products) would be retained within the fuel rods.

There would be no release from the HI-STAR 100, because the inner welded canister remains leak tight. While a release is unlikely, the potential releases calculated for the TN-68 rail cask and the NAC LWT truck cask indicate that any release of crud from either cask would be very small—less than an A_2 quantity. The release of an A_2 quantity is approximately equivalent to a radiation dose of 5 rem.

The Nuclear Regulatory Commission also evaluated the response of the NAC LWT cask to the conditions present during the Caldecott Tunnel fire in *Spent Fuel Transportation Package Response to the Caldecott Tunnel Fire Scenario* (DIRS 181841-Adkins et al. 2007, all). This fire took place on April 7, 1982, when a tank truck and trailer carrying 8,800 gallons of gasoline was involved in an accident in the Caldecott Tunnel on State Route 24 near Oakland, California. The tank trailer overturned and subsequently caught fire. This event is one of the most severe of the five major highway tunnel fires involving shipments of hazardous material that have occurred world-wide since 1949.

This study concluded that small transportation casks similar to the NAC LWT cask would probably experience degradation of some seals in this severe accident scenario. The maximum temperatures predicted in the regions of the cask lid and the vent and drain ports exceed the rated service temperature of the tetrafluoroethylene (TFE) or Viton seals, making it possible for a small release to occur due to crud that might spall off the surfaces of the fuel rods. However, any release is expected to be very small due to a number of factors. These include (1) the metallic lid seal does not exceed its rated service temperature and therefore can be assumed to remain intact, (2) the tight clearances maintained by the lid closure bolts, (3) the low pressure differential between the cask interior and exterior, (4) the tendency for solid particles to plug small clearance gaps and narrow convoluted flow paths such as the vent and drain ports, and (5) the tendency of crud particles to settle or plate out and consequently not be available for release.

The radiological consequences of the package response to the Caldecott Tunnel fire were also evaluated. The results of this evaluation strongly indicate that neither spent nuclear fuel particles nor fission products would be released from a spent fuel shipping cask involved in a severe tunnel fire such as the Caldecott Tunnel fire. The NAC LWT cask design analyzed for the Caldecott Tunnel fire scenario does not reach internal temperatures that could result in rupture of the fuel cladding. Therefore, radioactive material (spent nuclear fuel particles or fission products) would be retained within the fuel rods. The potential release calculated for the NAC LWT cask in this scenario indicates that any release of crud from the cask would be very small—less than an A_2 quantity.

K.2.5 SEVERE TRANSPORTATION ACCIDENTS

In addition to analyzing the radiological risks of transporting spent nuclear fuel and high-level radioactive waste, the consequences of severe transportation accidents were assessed. Severe transportation accidents with frequencies of about 1×10^{-7} per year are considered to be maximum reasonably foreseeable transportation accidents.

In the Rail Alignment EIS, DOE assumed that these severe accidents could occur anywhere along the rail alignment. There are no urban areas along the Caliente rail alignment or the Mina rail alignment. However, there are suburban areas and rural areas. Suburban areas are defined as areas with a population density between 139 and 3,326 people per square mile. Rural areas were defined as areas with a population density less than 139 people per square mile. For the Caliente rail alignment, using alignment-specific 2000 Census population data escalated to the year 2067, the average population density in suburban areas along the rail alignment ranged from 223 to 226 people per square kilometer (see Table K-30). The average population density in rural areas, escalated to the year 2067, ranged from 0.346 to 0.585 people per square kilometer (see Table K-30). For the Mina rail alignment, using alignment-specific 2000 census population data escalated to the year 2067, the average population density in suburban areas along the rail alignment ranged from 542 to 589 people per square kilometer (see Table K-31). The average population density in rural areas, escalated to the year 2067, ranged from 3.94 to 4.33 people per square kilometer (see Table K-31). Radiation doses were estimated out to 80 kilometers (50 miles) using these population densities.

DOE used the following assumptions to estimate the consequences of these accidents (DIRS 157144-Jason Technologies 2001, Section 5.3.3.3):

- A release height of the plume of 10 meters (33 feet) for both fire- and impact-related accidents. In the case of an accident with a fire, a 10-meter release height with no plume rise from the buoyancy of the plume due to fire conditions yields higher estimates of consequences than accounting for the buoyancy of the plume from the fire (DIRS 157144-Jason Technologies 2001, p. 176).

- A breathing rate for individuals of 10,400 cubic meters per year (367,000 cubic feet per year). This breathing rate was estimated from data contained in ICRP Publication 23 (DIRS 101074-ICRP 1975, page 346).
- All material released is assumed to be aerosolized and respirable (DIRS 157144-Jason Technologies 2001, p. 177). The deposition velocity for respirable material was 0.01 meters/sec.
- A short-term exposure time to airborne contaminants of 2 hours.
- A long-term exposure time to contamination deposited on the ground of 1 year, with no interdiction or cleanup.
- Consequences were determined using low wind speeds and stable atmospheric conditions (a wind speed of 0.89 meters per second and Class F stability). The severe accident scenario calculation methodology does not include a probabilistic component that includes the atmospheric stability, therefore stable conditions were assumed. Atmospheric conditions affect the dispersion of radionuclides that could be released from a severe accident. The atmospheric concentrations estimated from these atmospheric conditions would be exceeded only 5 percent of the time. Using these atmospheric conditions instead of neutral atmospheric conditions and moderate wind speeds reduces the probability associated with an accident scenario and increases the consequences associated with an accident scenario.
- Consequences were determined for a single rail cask containing 21 pressurized water reactor spent nuclear fuel assemblies.
- The spent nuclear fuel assembly has a burnup of 60 MWd/MTHM, an enrichment of 4 percent, and a decay time of 10 years (DIRS 169061-BSC 2004, all). The radionuclide inventory for a single spent nuclear fuel assembly is listed in Table K-13.

Table K-30. Projected population densities along the Caliente rail alignment in 2067.

Alignment	Escalated urban population density (people/km^2)[a,b]	Escalated suburban population density (people/km^2)	Escalated rural population density (people/km^2)
Highest population	--	224	0.585
Shortest distance	--	223	0.528
Longest distance	--	226	0.353
Lowest population	--	--	0.346

a. To convert people/km^2 to people/mile^2, multiply by 2.589988.
b. Note that there are no urban areas along the rail alignments.

Table K-31. Projected population densities along the Mina rail alignment in 2067.

Alignment	Escalated urban population density (people/km^2)[a,b]	Escalated suburban population density (people/km^2)	Escalated rural population density (people/km^2)
Highest population	--	549	4.19
Shortest distance	--	589	4.25
Longest distance	--	542	4.33
Lowest population	--	589	3.94

a. To convert people/km^2 to people/mile^2, multiply by 2.589988.
b. Note that there are no urban areas along the rail alignments.

DOE estimated radiation doses using the RISKIND computer code (DIRS 101483-Yuan et al. 1995, all) and determined them for the inhalation, groundshine, immersion, and resuspension pathways. RISKIND has been verified and validated for estimating radiation doses from transportation accidents involving radioactive material (DIRS 101845-Maheras and Pippen 1995, all; DIRS 102060-Biwer et al. 1997, all). Radiation doses were estimated using the ICRP inhalation dose coefficients (DIRS 172935-ICRP 2001, all) and the EPA groundshine and immersion dose coefficients (DIRS 175544-EPA 2002, all). These dose coefficients are based on the recommendations by the International Commission on Radiological Protection in ICRP Publication 60 (DIRS 101836-ICRP 1991, all) and incorporate the dose coefficients from ICRP Publication 72 (DIRS 152446-ICRP 1996, all). Table K-32 lists these dose coefficients. The dose coefficients include radioactive progeny (DIRS 176975-BMI 2006, Table 2). The lung absorption type and the value for the fractional absorption from the small intestine (f_1) for each radionuclide are listed in DIRS 176975-BMI 2006, Table 4.

DOE used release fraction and conditional probability data to estimate the consequences of severe transportation accidents (DIRS 152476-Sprung et al. 2000, p. 7-76). The following list describes the 20 accident severity categories involving releases of radioactive material from steel-lead-steel rail casks.

- Case 20: Case 20 is a long-duration (many hours), high-temperature fire that would engulf a cask.
- Cases 19, 18, 17, and 16: Case 19 is a high-speed (more than 120 miles per hour) impact into a hard object such as a train locomotive severe enough to cause failure of cask seals and puncture through the cask's shield wall. The impact would be followed by a very long duration (many hours), high-temperature engulfing fire. Case 18, Case 17, and Case 16 are accidents that would also involve very long duration fires, failures of cask seals, and punctures of cask walls. However, these accidents would be progressively less severe in terms of impact speeds. The impact speeds range from 90 to 120 miles for Case 18, 60 to 90 miles per hour for Case 17, and 30 to 60 miles per hour for Case 16.
- Cases 15, 12, 9, and 6: Case 15 is a high-speed (more than 120 miles per hour) impact into a hard surface such as granite severe enough to cause failure of cask seals. The impact would be followed by a long duration (many hours), high-temperature engulfing fire. Case 12, Case 9, and Case 6 are also accidents that would involve long duration fires, and failures of cask seals. However, these accidents would be progressively less severe in terms of impact speeds ranging from 90 to 120 miles for Case 12, 60 to 90 miles per hour for Case 9, and 30 to 60 miles per hour for Case 6.

Table K-32. RISKIND dose coefficients (page 1 of 3).

Radionuclide	Groundshine pathway dose conversion factor (rem-m^2/Ci-s)[a]	Immersion pathway dose conversion factor (rem-m^3/Ci-s)[b]	Inhalation pathway dose conversion factor (rem/Ci)	Ingestion pathway dose conversion factor (rem/Ci)
Ac-227 plus progeny	1.73E-03	6.45E-02	3.30E+08	4.47E+06
Am-241	8.62E-05	2.50E-03	1.55E+08	7.40E+05
Am-242m plus progeny	7.71E-05	2.80E-03	1.37E+08	7.04E+05
Am-243 plus progeny	7.47E-04	3.26E-02	1.52E+08	7.43E+05
Be-10	1.26E-05	5.11E-04	1.30E+05	4.07E+03
C-14	4.74E-08	9.62E-06	2.29E+01	2.15E+03
Cd-113m	6.55E-06	3.35E-04	1.15E+05	8.51E+04
Ce-144 plus progeny	6.72E-04	1.27E-02	1.33E+05	1.94E+04
Cf-252	1.94E-06	1.35E-05	7.40E+07	3.33E+05
Cl-36	4.14E-05	6.14E-04	2.70E+04	3.44E+03

Table K-32. RISKIND dose coefficients (page 2 of 3).

Radionuclide	Groundshine pathway dose conversion factor (rem-m^2/Ci-s)[a]	Immersion pathway dose conversion factor (rem-m^3/Ci-s)[b]	Inhalation pathway dose conversion factor (rem/Ci)	Ingestion pathway dose conversion factor (rem/Ci)
Cm-242	2.60E-06	1.49E-05	1.92E+07	4.44E+04
Cm-243	4.37E-04	1.96E-02	1.15E+08	5.55E+05
Cm-244	2.38E-06	1.26E-05	9.99E+07	4.44E+05
Cm-245	2.98E-04	1.30E-02	1.55E+08	7.77E+05
Cm-246	2.13E-06	1.15E-05	1.55E+08	7.77E+05
Cm-247 plus progeny	1.19E-03	5.50E-02	1.44E+08	7.03E+05
Cm-248	1.63E-06	8.73E-06	5.55E+08	2.85E+06
Co-58	3.42E-03	1.65E-01	7.77E+03	2.74E+03
Co-60	8.51E-03	4.40E-01	1.15E+05	1.26E+04
Co-60 (crud)	8.51E-03	4.40E-01	1.15E+05	1.26E+04
Cs-134	5.48E-03	2.62E-01	2.44E+04	7.03E+04
Cs-135	9.95E-08	3.52E-05	2.55E+03	7.40E+03
Cs-137 plus progeny	2.03E-03	9.45E-02	1.70E+04	4.81E+04
Eu-154	4.33E-03	2.13E-01	1.96E+05	7.40E+03
Eu-155	1.98E-04	7.96E-03	2.55E+04	1.18E+03
Fe-55	0.00E+00	0.00E+00	1.41E+03	1.22E+03
Fe-55 (crud)	0.00E+00	0.00E+00	1.41E+03	1.22E+03
Fe-59	4.07E-03	2.08E-01	1.37E+04	6.66E+03
H-3	0.00E+00	0.00E+00	9.99E+01	6.66E+01
I-129	7.25E-05	1.05E-03	1.33E+05	4.07E+05
Kr-85	3.89E-05	8.88E-04	0.00E+00	0.00E+00
Mn-54	2.92E-03	1.42E-01	5.55E+03	2.63E+03
Nb-93m	2.52E-06	1.13E-05	1.89E+03	4.44E+02
Nb-94	5.51E-03	2.66E-01	4.07E+04	6.29E+03
Nb-95	2.69E-03	1.29E-01	5.55E+03	2.15E+03
Ni-59	0.00E+00	0.00E+00	4.81E+02	2.33E+02
Ni-63	0.00E+00	0.00E+00	1.78E+03	5.55E+02
Np-237 plus progeny	7.81E-04	3.50E-02	8.51E+07	4.10E+05
Pa-231	1.40E-04	5.81E-03	1.26E+08	2.63E+06
Pb-210 plus progeny	1.38E-04	1.12E-03	1.66E+07	7.00E+06
Pd-107	0.00E+00	0.00E+00	2.18E+03	1.37E+02
Pm-147	1.04E-07	3.21E-05	1.81E+04	9.62E+02
Pu-238	2.32E-06	1.30E-05	5.92E+07	8.51E+05
Pu-239	1.05E-06	1.29E-05	5.92E+07	9.25E+05
Pu-240	2.22E-06	1.27E-05	5.92E+07	9.25E+05
Pu-241	6.36E-09	2.35E-07	6.29E+05	1.78E+04
Pu-242	1.84E-06	1.08E-05	5.55E+07	8.88E+05

Table K-32. RISKIND dose coefficients (page 3 of 3).

Radionuclide	Groundshine pathway dose conversion factor (rem-m^2/Ci-s)[a]	Immersion pathway dose conversion factor (rem-m^3/Ci-s)[b]	Inhalation pathway dose conversion factor (rem/Ci)	Ingestion pathway dose conversion factor (rem/Ci)
Ra-226 plus progeny	6.24E-03	3.10E-01	1.31E+07	1.04E+06
Ra-228 plus progeny	3.47E-03	1.66E-01	9.68E+06	2.55E+06
Rh-102	7.47E-03	3.59E-01	6.29E+04	9.62E+03
Ru-106 plus progeny	1.28E-03	3.92E-02	1.04E+05	2.59E+04
Sb-125 plus progeny	1.53E-03	6.95E-02	2.06E+04	4.80E+03
Se-79	6.11E-08	1.46E-05	4.07E+03	1.07E+04
Sm-151	1.31E-08	9.14E-08	1.48E+04	3.63E+02
Sn-126 plus progeny	7.28E-03	3.33E-01	1.05E+05	1.88E+04
Sr-90 plus progeny	4.13E-04	3.30E-03	1.39E+05	1.14E+05
Tc-99	2.40E-07	1.06E-04	1.48E+04	2.37E+03
Th-228 plus progeny	5.32E-03	2.83E-01	1.60E+08	5.30E+05
Th-229 plus progeny	1.28E-03	5.16E-02	3.18E+08	2.27E+06
Th-230	2.36E-06	5.51E-05	5.18E+07	7.77E+05
Th-232	1.68E-06	2.69E-05	9.25E+07	8.51E+05
U-232	2.99E-06	4.37E-05	1.37E+08	1.22E+06
U-233	2.22E-06	5.25E-05	3.55E+07	1.89E+05
U-234	2.17E-06	2.27E-05	3.48E+07	1.81E+05
U-235 plus progeny	5.76E-04	2.57E-02	3.15E+07	1.75E+05
U-236	1.86E-06	1.43E-05	3.22E+07	1.74E+05
U-238 plus progeny	4.50E-04	6.63E-03	2.96E+07	1.79E+05
Zr-93	0.00E+00	0.00E+00	3.70E+04	4.07E+03

a. To convert rem-m^2/Ci-s to rem-ft^2/Ci-s, multiply by 10.763910.
b. To convert rem-m^3/Ci-s to rem-ft^3/Ci-s, multiply by 35.314667.

- Cases 14, 11, 8, and 5: Case 14 is a high-speed (more than 120 miles per hour) impact into a hard surface such as granite severe enough to cause failure of cask seals. The impact would be followed by a high-temperature engulfing fire that burned for hours. Case 11, Case 8, and Case 5 are also accidents that would involve fires that would burn for hours, and failures of cask seals. However, these accidents would be progressively less severe in terms of impact speeds ranging from 90 to 120 miles for Case 11, 60 to 90 miles per hour for Case 8, and 30 to 60 miles per hour for Case 5.

- Cases 13, 10, 7, and 4: Case 13 is a high-speed (more than 120 miles per hour) impact into a hard surface such as granite severe enough to cause failure of cask seals. The impact would be followed by an engulfing fire lasting more than ½ hour up to a few hours. Case 10, Case 7, and Case 4 are accidents that would involve long duration fires, and failures of cask seals. However, these accidents are progressively less severe in terms of impact speeds ranging from 90 to 120 miles for Case 10, 60 to 90 miles per hour for Case 7, and 30 to 60 miles per hour for Case 4.

- Cases 3, 2, and 1: Case 3 is a high-speed (more than 120 miles per hour) impact into a hard surface such as granite severe enough to cause failure of cask seals—no fire. Case 2 and Case 1 are accidents that would also not involve fire but would have progressively lower impact speeds - 90 to 120 miles for Case 2 and 60 to 90 miles per hour for Case 1.

Each of the 20 accident cases listed above has an associated conditional probability of occurrence (DIRS 152476-Sprung et al. 2000, p. 7-76). These conditional probabilities were combined with the distances along the Caliente and Mina rail alignments and the accident rates discussed in Section K.2.5.1 to estimate the frequency of occurrence for each accident case. These frequencies are listed in Table K-33.

Cases 1, 4, and 20 have frequencies greater than 1×10^{-7} per year. Case 20 is estimated to have the highest consequences of these three accident cases (DIRS 155970-DOE 2002, Table J-22). Therefore, Case 20 is considered to be the maximum reasonably foreseeable transportation accident. Table K-34 lists the release fractions and conditional probabilities for this accident (DIRS 152476-Sprung et al. 2000, p. 7-76).

Table K-33. Annual frequencies for accident severity cases.

Accident severity case	Annual frequency (accidents per year)
1	1×10^{-7}
2	$7 \times 10^{-9} - 8 \times 10^{-9}$
3	6×10^{-11}
4	4×10^{-7}
5	1×10^{-8}
6	$1 \times 10^{-9} - 2 \times 10^{-9}$
7	$8 \times 10^{-10} - 9 \times 10^{-10}$
8	$2 \times 10^{-11} - 3 \times 10^{-11}$
9	3×10^{-12}
10	6×10^{-11}
11	2×10^{-12}
12	2×10^{-13}
13	5×10^{-13}
14	1×10^{-14}
15	2×10^{-15}
16	$5 \times 10^{-12} - 6 \times 10^{-12}$
17	3×10^{-15}
18	2×10^{-16}
19	2×10^{-18}

K.2.6 TRANSPORTATION SABOTAGE

In the Rail Alignment EIS, DOE assumed that a sabotage event could occur anywhere along the Caliente or Mina rail alignment. Radiation doses have been estimated out to 80 kilometers (50 miles) from each rail alignment using the population densities listed in Tables K-30 and K-31.

DOE used the following assumptions to estimate the consequences of transportation sabotage events (DIRS 157144-Jason Technologies 2001, Section 5.3.4.2):

- A breathing rate for individuals of 10,400 cubic meters per year (367,000 cubic feet per year). This breathing rate was estimated from data contained in ICRP Publication 23 (DIRS 101074-ICRP 1975, p. 346).
- A short-term exposure time to airborne contaminants of 2 hours.
- A long-term exposure time to contamination deposited on the ground of 1 year, with no interdiction or cleanup.
- Because it is not possible to estimate the specific atmospheric conditions that would exist during a sabotage event, consequences were determined using moderate wind speeds and neutral atmospheric conditions (a wind speed of 4.47 meters per second and Class D stability).
- The release of both respirable and nonrespirable material was evaluated. The deposition velocity for respirable material was 0.01 meter per second. The deposition velocity for nonrespirable material was 0.1 meter per second.
- It is expected that in a sabotage event, there would be an initial explosive release involving releases of radioactive material at varying release heights. For 4 percent of the release, a release height of 1 meter was estimated; for 16 percent of the release, a release height of 16 meters was estimated; for 25 percent of the release, a release height of 32 meters was estimated; for 35 percent of the release, a release height of 48 meters was estimated; and for 20 percent of the release, a release height of 64 meters was estimated.

DOE plans to operate the repository using a primarily canistered approach that calls for packaging most commercial spent nuclear fuel in TAD canisters, which would hold 21 pressurized-water reactor spent nuclear fuel assemblies. In the Rail Alignment EIS, DOE chose to estimate the consequences of a rail sabotage event based on the radionuclide inventory in 26 pressurized-water reactor spent nuclear fuel assemblies, which overestimated consequences by about 24 percent in comparison to the inventory in 21 pressurized-water reactor spent nuclear fuel assemblies. The radionuclide inventory for a single spent nuclear fuel assembly in this cask is listed in Table K-13.

In the Yucca Mountain FEIS, DOE evaluated the consequences of sabotage events using the release fraction data contained in Luna et al. (1999) (DIRS 104918-Luna, Neuhauser, and Vigil 1999, all; DIRS 155970-DOE 2002, Section 6.2.4.2.3). For rail casks, a sabotage event using the high energy density device denoted HEDD1 yielded the largest radiation doses. Additional data from sabotage experiments conducted in Germany were used by DOE to update the release fractions for HEDD1 (DIRS 181279-Luna 2006, all) used to estimate the consequences of sabotage events in the Rail Alignment EIS. Table K-35 lists these release fractions.

Radiation doses for the sabotage event scenario were estimated using the RISKIND computer code (DIRS 101483-Yuan et al. 1995, all). RISKIND has been verified and validated for estimating radiation doses from releases of radioactive material during transportation (DIRS 101845-Maheras and Pippen 1995, all; DIRS 102060-Biwer et al. 1997, all). Radiation doses were determined for the inhalation, groundshine, immersion, and resuspension pathways. Radiation doses were estimated using the ICRP inhalation dose coefficients (DIRS 172935-ICRP 2001, all) and the EPA groundshine and immersion dose coefficients (DIRS 175544-EPA 2002, all). These dose coefficients are based on the recommendations by the International Commission on Radiological Protection in ICRP Publication 60 (DIRS 101836-ICRP 1991, all) and incorporate the dose coefficients from ICRP Publication 72 (DIRS 152446-ICRP 1996, all). These dose coefficients are listed in Table K-33.

Table K-34. Conditional probabilities and release fractions for severe accident cases.[a]

Severe accident case	Conditional probability	Release fraction				
		Inert gas	Cesium	Ruthenium	Particulates	Crud
20	4.91×10^{-5}	0.84	1.7×10^{-5}	2.5×10^{-7}	2.5×10^{-7}	9.4×10^{-3}

a. Source: DIRS 152476-Sprung et al. 2000, p. 7-76.

Table K-35. Release fractions for transportation sabotage event.[a]

Material	Release fraction					
	Particulates	Ruthenium[b]	Cesium[c]	Iodine[c]	Gas	Crud
Respirable	7.19×10^{-7}	7.19×10^{-7}	7.15×10^{-6}[d]	7.15×10^{-6}[d]	4.05×10^{-4}[d]	5.17×10^{-7}
Nonrespirable	1.75×10^{-4}	1.75×10^{-4}				5.16×10^{-8}

a. Source: DIRS 181279-Luna 2006, all.
b. Ruthenium is modeled as particulate.
c. Cesium and iodine are modeled as volatiles.
d. All cesium, iodine, and gases were assumed to be respirable.

K.2.7 RESULTS FOR THE CALIENTE RAIL ALIGNMENT

K.2.7.1 Incident-Free Impacts

This section presents the radiological impacts of incident-free transportation for workers and members of the public. Impacts are presented for rail workers and escorts en route to the repository, for workers located at the Maintenance-of-Way Trackside Facility and at sidings, for workers at the Staging Yard, and for members of the public along the rail alignment and near the Staging Yard under the Proposed Action and the Shared-Use Option.

K.2.7.1.1 Workers and Members of the Public En Route to the Repository

K.2.7.1.1.1 Workers. During the shipment of spent nuclear fuel and high-level radioactive waste from the Caliente or Eccles Interchange Facility to the repository, workers would be exposed to direct radiation from 9,495 shipping casks.

Table K-36 lists the collective radiation doses and impacts for these workers. Because dedicated trains would be used for transporting spent nuclear fuel and high-level radioactive waste from Caliente or Eccles to the repository and under normal circumstances there would be no en route stops between the Staging Yard and the repository, therefore there would be no radiation doses at stops for rail workers (engineers and conductors) or escorts. Because rail workers would be working in the cab of the locomotive and situated at a distance of at least 150 feet from the nearest cask, and would be shielded from radiation by the locomotive, there would be no radiation doses for these workers while en route to the repository.

The collective radiation dose for these workers is estimated to be 310 to 320 person-rem, with longer alignments having higher estimated radiation doses. The radiation doses would be the same for the Proposed Action and the Shared-Use Option. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.19 or about 1 chance in 5. For perspective, in the United States the lifetime risk of dying from cancer is about 1 in 5.

For workers who could be exposed to radiation when cask trains pass by the Maintenance-of-Way Trackside facility, the collective radiation dose was estimated to be 0.035 person-rem. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 2.1×10^{-5} or about 1 chance in 40,000. The impacts for these workers would be the same for the Proposed Action and the Shared-Use Option. In addition, the impacts for these workers would not depend on the length of the rail alignment.

For workers exposed when a train containing loaded casks passed a train containing empty casks or other materials at a siding, the collective radiation dose is estimated to be 0.0024 person-rem for the Proposed Action and 0.0051 person-rem for the Shared-Use Option. The radiation dose is higher for the Shared-Use Option because there would be increased rail traffic and therefore more opportunities for a train to be passed at a siding and workers exposed. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 1.4×10^{-6} for the Proposed Action and 3.0×10^{-6} for the Shared-Use Option, corresponding to about 1 chance in 700,000 and about 1 chance in 300,000.

The total collective radiation dose for all workers exposed en route to the repository is estimated to range from 310 to 320 person-rem. The radiation dose for escorts accounts for over 99 percent of the total radiation dose to workers. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.19.

Table K-37 lists the maximally exposed individual radiation doses and impacts for all workers. The maximally exposed worker would be an escort. This worker is estimated to receive a radiation dose of 25 rem over the 50 years of operation, based on a 0.5 rem per year administrative dose limit for repository facilities (DIRS 174942-BSC 2005, Section 4.9.3.3) and a person working for up to 50 years escorting shipments. The probability of a latent cancer fatality for this worker is estimated to be 0.015 or about 1 chance in 60.

An individual worker at the Maintenance-of-Way Trackside facility was estimated to receive a radiation dose of 8.8×10^{-4} rem over 50 years of operations and assuming that the worker was exposed to all loaded casks that passed the facility. The probability of a latent cancer fatality for this worker is estimated to be 5.3×10^{-7}, or about 1 chance in 1,800,000.

An individual worker at a siding passed by loaded cask trains was estimated to receive a radiation dose of 2.4×10^{-4} rem for the Proposed Action and 5.1×10^{-4} rem for the Shared-Use Option over 50 years of operations and assuming that the worker was exposed to all loaded casks that passed a siding. The probability of a latent cancer fatality for this worker is estimated to be 1.4×10^{-7} (1 chance in 7,100,000) for the Proposed Action and 3.0×10^{-7} (1 chance in 3,300,000) for the Shared-Use Option.

K.2.7.1.1.2 Members of the Public. During the shipment of spent nuclear fuel and high-level radioactive waste from the Caliente or Eccles Interchange Facility to the repository, members of the public along the rail alignment could be exposed to direct radiation from 9,495 shipping casks.

Table K-36 lists the collective radiation doses and impacts for members of the public. Because dedicated trains would be used for transporting spent nuclear fuel and high-level radioactive waste from Caliente or Eccles to the repository and there would be no en route stops under normal circumstances, there would be no radiation doses at stops for members of the public. In addition, because two trains could not share the single railroad track simultaneously, there would be no on-link radiation doses for members of the public.

The collective radiation dose for members of the public exposed along the rail alignment (off-link) is estimated to range from 0.087 to 0.21 person-rem, with rail alignments having higher exposed populations also having higher estimated radiation doses. These radiation doses are based on the population in the year 2000 escalated to the year 2067. The radiation doses for members of the public would be the same for the Proposed Action and the Shared-Use Option. In the exposed population, the probability of a latent cancer fatality is estimated to range from 5.2×10^{-5} to 1.3×10^{-4}, or about 1 chance in 19,000 to about 1 chance in 7,000. For perspective, in the United States the lifetime risk of dying from cancer is about 1 in 5.

Table K-37 lists the maximally exposed individual radiation doses and impacts for members of the public. The maximally exposed individual would be a resident who lives 18 meters (60 feet) from the rail line. This individual would be exposed to each of 9,495 shipping casks as they passed by en route to the repository. The radiation dose for this individual is estimated to be 0.0078 rem over the course of a shipping campaign of 50 years. The probability of a latent cancer fatality for this individual is estimated to be 4.7×10^{-6} or 1 chance in 200,000.

K.2.7.1.2 Workers and Members of the Public at the Staging Yard

K.2.7.1.2.1 Workers. When shipping casks arrive at the Staging Yard, the railcars containing the shipping cask would be removed from the train, an inspection conducted, and the railcar transferred to the train to be transported to the repository. The escorts that had accompanied the shipping cask from its point of origin would also be present during this inspection. These railcar handling, escort, and inspection workers would be exposed to direct radiation from 9,495 shipping casks over 50 years of transporting spent nuclear fuel and high-level radioactive waste to the repository. Noninvolved workers at the Staging Yard would also be exposed to direct radiation from the casks.

Table K-38 lists the collective radiation doses and impacts for these workers. Because operations at the three potential Staging Yard locations at Caliente-Indian Cove, Caliente-Upload, and Eccles-North would be similar, the radiation doses to workers at each Staging Yard would be the same. In addition, the

Table K-36. Incident-free collective radiation doses and latent cancer fatalities for en route workers and members of the public for the Caliente rail alignment (page 1 of 2).

Rail alignment	Interchange location	Collective radiation dose (person-rem)										
		En route rail workers[a]	En route rail workers at stops	En route escorts	En route escorts at stops	MOW[b] Trackside Facility workers	Workers located at sidings	Total en route workers	Off-link public along route	On-link public along route	Stops public along route	Total public along route
Proposed Action												
Highest population	Caliente	0.0E+0	0.0E+0	3.2E+2	0.0E+0	3.5E-2	0.0024	3.2E+2	2.1E-1	0.0E+0	0.0E+0	2.1E-1
Shortest distance	Caliente	0.0E+0	0.0E+0	3.1E+2	0.0E+0	3.5E-2	0.0024	3.1E+2	1.8E-1	0.0E+0	0.0E+0	1.8E-1
Longest distance	Eccles	0.0E+0	0.0E+0	3.2E+2	0.0E+0	3.5E-2	0.0024	3.2E+2	1.1E-1	0.0E+0	0.0E+0	1.1E-1
Lowest population	Eccles	0.0E+0	0.0E+0	3.1E+2	0.0E+0	3.5E-2	0.0024	3.1E+2	8.7E-2	0.0E+0	0.0E+0	8.7E-2
Shared-Use Option												
Highest population	Caliente	0.0E+0	0.0E+0	3.2E+2	0.0E+0	3.5E-2	0.0051	3.2E+2	2.1E-1	0.0E+0	0.0E+0	2.1E-1
Shortest distance	Caliente	0.0E+0	0.0E+0	3.1E+2	0.0E+0	3.5E-2	0.0051	3.1E+2	1.8E-1	0.0E+0	0.0E+0	1.8E-1
Longest distance	Eccles	0.0E+0	0.0E+0	3.2E+2	0.0E+0	3.5E-2	0.0051	3.2E+2	1.1E-1	0.0E+0	0.0E+0	1.1E-1
Lowest population	Eccles	0.0E+0	0.0E+0	3.1E+2	0.0E+0	3.5E-2	0.0051	3.1E+2	8.7E-2	0.0E+0	0.0E+0	8.7E-2

Table K-36. Incident-free collective radiation doses and latent cancer fatalities for en route workers and members of the public for the Caliente rail alignment (page 2 of 2).

Alignment	Interchange Location	Latent cancer fatalities										
		En route rail workers[a]	En route rail workers at stops	En route escorts	En route escorts at stops	MOW[b] Trackside Facility workers	Workers located at sidings	Total en route workers	Off-link public along route	On-link public along route	Stops public along route	Total public along route
Proposed Action												
Highest population	Caliente	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	1.4E-6	1.9E-1	1.3E-4	0.0E+0	0.0E+0	1.3E-4
Shortest distance	Caliente	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	1.4E-6	1.9E-1	1.1E-4	0.0E+0	0.0E+0	1.1E-4
Longest distance	Eccles	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	1.4E-6	1.9E-1	6.4E-5	0.0E+0	0.0E+0	6.4E-5
Lowest population	Eccles	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	1.4E-6	1.9E-1	5.2E-5	0.0E+0	0.0E+0	5.2E-5
Shared-Use Option												
Highest population	Caliente	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	3.0E-6	1.9E-1	1.3E-4	0.0E+0	0.0E+0	1.3E-4
Shortest distance	Caliente	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	3.0E-6	1.9E-1	1.1E-4	0.0E+0	0.0E+0	1.1E-4
Longest distance	Eccles	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	3.0E-6	1.9E-1	6.4E-5	0.0E+0	0.0E+0	6.4E-5
Lowest population	Eccles	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	3.0E-6	1.9E-1	5.2E-5	0.0E+0	0.0E+0	5.2E-5

a. Rail workers are engineers and conductors.
b. MOW = Maintenance-of-Way.

Table K-37. Incident-free maximally exposed individual radiation doses and latent cancer fatalities for en route workers and members of the public for the Caliente rail alignment.

Severe accident case	Radiation dose (rem)	Latent cancer fatalities
Proposed Action		
Workers		
Escort (one year of operation)	0.50	0.00030
Escort (50 years of operations)	25	0.015
Worker at Maintenance-of-Way Trackside Facility	8.8E-04	5.3E-07
Worker at siding	2.4E-4	1.4E-7
Members of the public		
Resident near rail line	7.8E-3	4.7E-6
Shared-Use Option		
Workers		
Escort (one year of operation)	0.50	0.00030
Escort (50 years of operations)	25	0.015
Worker at Maintenance-of-Way Trackside Facility	8.8E-04	5.3E-07
Worker at siding	5.1E-4	3.0E-7
Members of the public		
Resident near rail line	7.8E-3	4.7E-6

Table K-38. Incident-free collective radiation doses and latent cancer fatalities at the Caliente and Eccles Staging Yards for workers and members of the public.

	Collective radiation dose (person-rem)			
Staging Yard location	Involved workers at Staging Yard	Noninvolved workers at Staging Yard	Total workers at Staging Yard	Public near Staging Yard
Proposed Action and Shared-Use Option				
Caliente-Indian Cove	2.4E+2	1.2E+1	2.5E+2	2.6E-2
Caliente-Upland	2.4E+2	1.2E+1	2.5E+2	6.4E-3
Eccles-North	2.4E+2	1.2E+1	2.5E+2	3.9E-3
	Latent cancer fatalities			
Staging Yard location	Involved workers at Staging Yard	Noninvolved workers at Staging Yard	Total workers at Staging Yard	Public near Staging Yard
Proposed Action and Shared-Use Option				
Caliente-Indian Cove	1.4E-1	7.4E-3	1.5E-1	1.6E-5
Caliente-Upland	1.4E-1	7.4E-3	1.5E-1	3.9E-6
Eccles-North	1.4E-1	7.4E-3	1.5E-1	2.4E-6

radiation dose to workers at the Staging Yard would be the same for the Proposed Action and the Shared-Use Option because the number of shipping casks handled at the Staging Yard would be the same for the Proposed Action and the Shared-Use Option.

The collective radiation dose for involved workers at the Staging Yard is estimated to be 240 person-rem. These radiation doses are in large part dependent on the time that a cask spent in the Staging Yard, which is estimated to be 2 hours, and on the close proximity of the inspector to the cask, which is estimated to be 1 meter. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.14.

The collective radiation dose for noninvolved workers at the Staging Yard is estimated to be 12 person-rem. These radiation doses are in large part dependent on the time that a noninvolved worker is assumed to spend in the Staging Yard, which is estimated to be 2 hours, at an estimated distance of 100 meters from the casks. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.0074.

The total collective radiation dose for involved and noninvolved workers at the Staging Yards is estimated to be 250 person-rem. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.15.

Table K-39 lists the maximally exposed individual radiation doses and impacts for workers at each potential Staging Yard location. The maximally exposed worker would be an inspector, rail worker, or escort. This individual is estimated to receive a radiation dose of 25 rem over the 50 years of operation, based on a 0.5 rem per year administrative dose limit at repository facilities (DIRS 174942-BSC 2005, Section 4.9.3.3) for a person working for up to 50 years at the Staging Yard. The probability of a latent cancer fatality for this worker is estimated to be 0.015 or about 1 chance in 60.

Table K-39. Incident-free maximally exposed individual radiation doses and latent cancer fatalities at the Caliente and Eccles Staging Yards for workers and members of the public.

Proposed Action and Shared-Use Option	Radiation dose (rem)	Latent cancer fatalities
Workers		
Escort, rail worker, or inspector (one year of operation)	0.50	0.00030
Escort, rail worker, or inspector (50 years of operations)	25	0.015
Members of the public - resident near Staging Yard		
Caliente-Indian Cove	3.0E-6	1.8E-9
Caliente-Upland	2.7E-3	1.6E-6
Eccles-North	3.4E-6	2.1E-9

K.2.7.1.2.2 Members of the Public. Members of the public near the Caliente-Indian Cove, Caliente-Upland, or Eccles-North Staging Yard could be exposed to direct radiation from 9,495 shipping casks over 50 years of transporting spent nuclear fuel and high-level radioactive waste to the repository.

Table K-38 lists the collective radiation doses and impacts for these members of the public. The collective radiation dose for members of the public is estimated to range from 0.0039 to 0.026 person-rem. These radiation doses are based on the population in the year 2000 escalated to the year 2067. The highest radiation dose is for the Caliente-Indian Cove Staging Yard location, which also has the highest exposed population. The lowest radiation dose is for the Eccles-North Staging Yard location, which has the lowest exposed population. In the exposed populations around the Staging Yards, the probability of a latent cancer fatality is estimated to range from 2.4×10^{-6} to 1.6×10^{-5}, or about 1 chance in 400,000 to about 1 chance in 60,000.

Table K-39 lists the maximally exposed individual radiation doses and impacts for members of the public near the potential Staging Yard locations at Caliente-Indian Cove, Caliente-Upland, and Eccles-North. The maximally exposed individual at the Caliente-Indian Cove Staging Yard would be a resident who lives 1,600 meters (5,200 feet) from the Staging Yard. This individual would be exposed to each of the 9,495 shipping casks for a period of 2 hours per cask. The radiation dose for this individual is estimated to be 3.0×10^{-6} rem over the shipping campaign of 50 years. The probability of a latent cancer fatality for this individual is estimated to be 1.8×10^{-9}, or about 1 chance in 550,000,000.

The maximally exposed individual at the Caliente-Upland Staging Yard would be a resident who lives 400 meters (1,300 feet) from the Staging Yard. This individual would be exposed to each of the 9,495 shipping casks for a period of 2 hours per cask. The radiation dose for this individual is estimated to be 2.7×10^{-3} rem over the shipping campaign of 50 years. The probability of a latent cancer fatality for this individual is estimated to be 1.6×10^{-6}, or about 1 chance in 600,000.

The maximally exposed individual at the Eccles-North Staging Yard would be a resident who lives 1,500 meters (4,900 feet) from the Staging Yard. This individual would be exposed to each of the 9,495 shipping casks for a period of 2 hours per cask. The radiation dose for this individual is estimated to be 3.4×10^{-6} rem over the shipping campaign of 50 years. The probability of a latent cancer fatality for this individual is estimated to be 2.1×10^{-9}, or about 1 chance in 480,000,000.

K.2.7.1.3 Summary of Incident-Free Impacts

Table K-40 lists the incident-free collective radiation doses and impacts for workers en route to the repository, workers and members of the public located along the rail alignment route, involved and noninvolved workers at the Staging Yards, and members of the public near the Staging Yards for the Proposed Action and the Shared-Use Option.

The total collective radiation dose for en route workers and workers along the rail alignment route is estimated to range from 310 to 320 person-rem. For involved and noninvolved workers at the Staging Yards, the total collective radiation dose is estimated to be 250 person-rem. The total collective radiation dose for all workers (en route, along the rail alignment, and at the Staging Yards) is estimated to be 560 to 570 person-rem. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.34. The impacts for these workers would be the same for the Proposed Action and the Shared-Use Option.

The total collective radiation dose for members of the public along the Caliente rail alignment exposed to radiation from cask trains en route to the repository was estimated to range from 0.087 to 0.21 person-rem. For members of the public near the Staging Yards, the total collective radiation dose is estimated to range from 0.0039 to 0.026 person-rem. The total collective radiation dose for all members of the public (along the rail alignment route and near the Staging Yards) is estimated to range from 0.091 to 0.24 person-rem. These radiation doses are based on the population in the year 2000 and escalated to the year 2067, and vary depending upon the location of the Staging Yard. The radiation doses are highest for those rail alignments and Staging Yard locations where the exposed populations are the highest. In the exposed population, the probability of a latent cancer fatality is estimated to range from 5.5×10^{-5} to 1.4×10^{-4}. The impacts for these members of the public would be the same for the Proposed Action and the Shared-Use Option.

The total collective radiation dose for all workers and members of the public is estimated to be 560 to 570 person-rem. Over 99 percent of the radiation dose is to workers, less than 1 percent of the radiation dose is to members of the public. In the exposed population of workers and members of the public, the probability of a latent cancer fatality 0.34.

Table K-40. Summary of incident-free collective radiation doses and latent cancer fatalities for workers and members of the public for the Caliente rail alignment.

Rail alignment	Staging Yard location	Collective radiation dose (person-rem)						
		Total workers en route and along route	Total workers at Staging Yard	Total workers	Total public along route	Total public near Staging Yard	Total public	Total public and worker
Proposed Action and Shared-Use Option								
Highest population	Caliente-Indian Cove	3.2E+2	2.5E+2	5.7E+2	2.1E-1	2.6E-2	2.4E-1	5.7E+2
Highest population	Caliente-Upland	3.2E+2	2.5E+2	5.7E+2	2.1E-1	6.4E-3	2.2E-1	5.7E+2
Shortest distance	Caliente-Indian Cove	3.1E+2	2.5E+2	5.6E+2	1.8E-1	2.6E-2	2.1E-1	5.6E+2
Shortest distance	Caliente-Upland	3.1E+2	2.5E+2	5.6E+2	1.8E-1	6.4E-3	1.9E-1	5.6E+2
Longest distance	Eccles-North	3.2E+2	2.5E+2	5.7E+2	1.1E-1	3.9E-3	1.1E-1	5.7E+2
Lowest population	Eccles-North	3.1E+2	2.5E+2	5.6E+2	8.7E-2	3.9E-3	9.1E-2	5.6E+2
Highest population	Caliente-Indian Cove	1.9E-1	1.5E-1	3.4E-1	1.3E-4	1.6E-5	1.4E-4	3.4E-1
Highest population	Caliente-Upland	1.9E-1	1.5E-1	3.4E-1	1.3E-4	3.9E-6	1.3E-4	3.4E-1
Shortest distance	Caliente-Indian Cove	1.9E-1	1.5E-1	3.4E-1	1.1E-4	1.6E-5	1.2E-4	3.4E-1
Shortest distance	Caliente-Upland	1.9E-1	1.5E-1	3.4E-1	1.1E-4	3.9E-6	1.1E-4	3.4E-1
Longest distance	Eccles-North	1.9E-1	1.5E-1	3.4E-1	6.4E-5	2.4E-6	6.6E-5	3.4E-1
Lowest population	Eccles-North	1.9E-1	1.5E-1	3.4E-1	5.2E-5	2.4E-6	5.5E-5	3.4E-1

K.2.7.2 Transportation Accident Risks

This section presents the radiological transportation accident risks of shipping spent nuclear fuel and high-level radioactive waste from the Interchange Facility at Caliente or Eccles to the repository for the Proposed Action and the Shared-Use Option. Transportation risks were quantified in terms of dose risk, which is the sum of the products of the probabilities (dimensionless) and consequences (collective radiation doses in units of person-rem) of all potential transportation accidents. Transportation risks were also quantified in terms of latent cancer fatalities.

Table K-41 lists the dose risks for the four rail alignments evaluated in the Rail Alignment EIS. The dose risks are estimated to range from 1.1×10^{-3} to 2.2×10^{-3} person-rem. The rail alignments that have the higher exposed populations also have the higher dose risks. Also, because the number of shipping casks transported from Caliente or Eccles to the repository would be the same for the Proposed Action and for the Shared-Use Option, the dose risks are the same for the Proposed Action and Shared-Use Option. In the exposed populations along the rail alignments, the probability of a latent cancer fatality is estimated to range from 6.7×10^{-7} to 1.3×10^{-6}, or about 1 chance in 1,400,000 to about 1 chance in 700,000.

K.2.7.3 Severe Transportation Accidents

This section presents the consequences of severe transportation accidents, known as maximum reasonably foreseeable transportation accidents, that could occur during the shipment of spent nuclear fuel and high-level radioactive waste to the repository from the Interchange Facility at Caliente or Eccles for the Proposed Action and the Shared-Use Option.

Because it is not possible to forecast the atmospheric conditions that might exist during a severe accident, consequences were determined using low wind speeds and stable atmospheric conditions (a wind speed of 0.89 meters per second and Class F stability). The severe accident scenario calculation methodology does not include a probabilistic component that includes the atmospheric stability, therefore stable conditions were assumed. The atmospheric concentrations estimated from these conditions would be exceeded only 5 percent of the time.

For the four rail alignments described in Table K-30, there were no urban areas as defined in U.S. Census Bureau population data. However, there were suburban areas and rural areas. Using alignment-specific 2000 census population data escalated to the year 2067, the average population density in suburban areas along the alignments ranged from 223 to 226 people per square kilometer (577 to 585 people per square mile) near Caliente and Goldfield. The average population density along rural areas, escalated to the year 2067, ranged from 0.346 to 0.585 people per square kilometer (0.896 to 1.51 people per square mile).

Table K-42 lists the impacts of the maximum reasonably foreseeable accident. This accident has a frequency of about 6×10^{-7} per year. If the maximum reasonably foreseeable accident were to occur in a suburban area, the population radiation dose would be 770 person-rem. The probability of a latent cancer fatality in the exposed population is estimated to be 0.46. If the maximum reasonably foreseeable accident were to occur in a rural area, the collective radiation dose would be 2 person-rem. The probability of a latent cancer fatality in the exposed population is estimated to be 1.2E-3.

In either a suburban area or rural area, the radiation dose from the maximum reasonably foreseeable transportation accident for the maximally exposed individual located 330 meters from the accident would be 34 rem. The probability of an LCF for that individual is estimated to be 0.020.

Table K-41. Radiological transportation accident risks for the Caliente rail alignment.

Rail alignment	Staging Yard location	Dose risk[a] (person-rem)	Latent cancer fatalities (LCFs)
Proposed Action and Shared-Use Option			
Highest population	Caliente	2.2E-3	1.3E-6
Shortest distance	Caliente	1.9E-3	1.1E-6
Longest distance	Eccles	1.3E-3	7.6E-7
Lowest population	Eccles	1.1E-3	6.7E-7

a. Dose risk is the sum of the products of the probabilities and consequences in person-rem of all potential transportation accidents.

The radiation dose to a first responder would range from 0.14 to 2.0 rem. The probability of an LCF for this first responder is estimated to range from 8.2×10^{-5} to 0.0012.

Recovering rail casks loaded with spent nuclear fuel or high-level radioactive waste would use methods commonly used to recover railcars and locomotives following accidents. The capability to lift such weights exists and would be deployed as required. Railroads use emergency response contractors with

Table K-42. Consequences of the maximum reasonably foreseeable accident in suburban and rural areas along the Caliente rail alignment.[a]

	Suburban area[b]	Rural area[c]
Proposed Action and Shared-Use Option		
Population radiation dose (person-rem)	770	2.0
Latent cancer fatalities	0.46	1.2E-3
Maximally exposed individual (rem)	34	34
Probability of latent cancer fatality	0.020	0.020
First responder radiation dose (rem)	0.14 – 2.0	0.14 – 2.0
Probability of latent cancer fatality	$8.2 \times 10^{-5} - 0.0012$	$8.2 \times 10^{-5} - 0.0012$

a. Consequences based on low wind speeds and stable atmospheric conditions.
b. Population density in the suburban area is 226 people per square kilometer; to convert people per square kilometer to people per square mile, multiply by 2.589988.
c. Population density in the rural area is 0.585 people per square kilometer; to convert people per square kilometer to people per square mile, multiply by 2.589988.

the capability to lift derailed locomotives that could weigh as much as 150 tons. Difficult recoveries of equipment as heavy as spent nuclear fuel casks have been accomplished and DOE anticipates that if such a recovery was necessary, it would be accomplished using methods and equipment similar to those used in prior difficult recoveries.

K.2.7.4 Transportation Sabotage

This section presents the consequences of a sabotage event for shipments of spent nuclear fuel and high-level radioactive waste to the repository from the Interface with the Union Pacific Mainline on the Caliente alternative segment or the Eccles alternative segment.

For the four rail alignments described in Table K-30, there were no urban areas as defined in U.S. Census Bureau population data. However, there were suburban areas and rural areas. Using alignment-specific 2000 census population data escalated to the year 2067, the average population density in suburban areas along the alignments ranged from 223 to 226 people per square kilometer (577 to 586 people per square mile), near Caliente and Goldfield. The average population density along rural areas, escalated to the year 2067, ranged from 0.346 to 0.585 people per square kilometer (0.896 to 1.51 people per square mile).

Table K-43 lists the consequences of a potential sabotage event. The consequences would be the same for the Proposed Action and the Shared-Use Option. If the sabotage event occurred in a suburban area, the collective radiation dose is estimated to be 1,800 person-rem. In the exposed population, the number of latent cancer fatalities is estimated to be 1.1.

If the sabotage event occurred in a rural area, the collective radiation dose is estimated to be 4.7 person-rem. In the exposed population, the risk of a latent cancer fatality is estimated to be 0.0028.

If the sabotage event were to occur in either a suburban area or rural area, the maximally exposed individual would be located 100 meters (330 feet) from the sabotage event, at the location of maximum downwind air concentration. The radiation dose for the maximally exposed individual is estimated to be 27 rem. The probability of a latent cancer fatality for this individual is estimated to be 0.016.

Table K-43. Consequences of a sabotage event in suburban and rural areas along the Caliente rail alignment.[a]

	Suburban area[b]	Rural area[c]
Proposed Action and Shared-Use Option		
Population radiation dose (person-rem)	1,800	4.7
Latent cancer fatalities	1.1	0.0028
Maximally exposed individual (rem)	27	27
Probability of latent cancer fatality	0.016	0.016

a. Consequences based on moderate wind speeds and neutral atmospheric conditions.
b. Population density in the suburban area is 226 people per square kilometer; to convert people per square kilometer to people per square mile, multiply by 2.589988.
c. Population density in the rural area is 0.585 people per square kilometer; to convert people per square kilometer to people per square mile, multiply by 2.589988.

K.2.8 RESULTS FOR THE MINA RAIL ALIGNMENT

K.2.8.1 Incident-Free Impacts

This section presents the radiological impacts of incident-free transportation for workers and members of the public. Impacts for the Proposed Action and the Shared-Use Option are presented for rail workers and escorts en route to the repository, for workers located at the Maintenance-of-Way Trackside Facility and at sidings, for workers at the Staging Yard at Hawthorne, and for members of the public along the rail alignment and near the Staging Yard at Hawthorne.

K.2.8.1.1 Workers and Members of the Public En Route to the Repository

K.2.8.1.1.1 Workers. During the shipment of spent nuclear fuel and high-level radioactive waste from Hazen, Nevada to the repository, workers would be exposed to direct radiation from 9,495 shipping casks.

Table K-44 lists the collective radiation doses and impacts for these workers. Because dedicated trains would be used for transporting spent nuclear fuel and high-level radioactive waste from Hazen to the repository and under normal circumstances there would be no en route stops between Hazen and the repository, therefore there would be no radiation doses at stops for rail workers (engineers and conductors) or escorts. Because rail workers would be working in the cab of the locomotive and situated at a distance of at least 150 feet from the nearest cask, and would be shielded from radiation by the locomotive, there would be no radiation doses for these workers while en route to the repository.

The collective radiation dose for workers is estimated to be 310 to 340 person-rem, with longer alignments having higher estimated radiation doses. The radiation doses would be the same for the Proposed Action and the Shared-Use Option. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.18 to 0.20 or about 1 chance in 5. For perspective, in the United States the lifetime risk of dying from cancer is about 1 in 5.

For workers who could be exposed to radiation when cask trains pass by the Maintenance-of-Way Trackside Facility, the collective radiation dose is estimated to be 0.035 person-rem. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 2.1×10^{-5} or about 1 chance in 40,000. The impacts for these workers would be the same for the Proposed Action and the Shared-Use Option. In addition, the impacts for these workers would not depend on the length of the rail alignment.

For workers exposed when a train containing loaded casks passed a train containing empty casks or other materials at a siding, the collective radiation dose is estimated to be 0.0013 person-rem for the Proposed Action and 0.0028 person-rem for the Shared-Use Option. The radiation dose is higher for the Shared-Use Option because there would be increased rail traffic and therefore more opportunities for a train to be passed at a siding and workers exposed. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 7.7×10^{-7} for the Proposed Action and 1.7×10^{-6} for the Shared-Use Option, corresponding to about one chance in 1,200,000 to about one chance in 500,000.

The total collective radiation dose for all workers exposed en route to the repository is estimated to range from 310 to 340 person-rem. The radiation dose for escorts accounts for over 99 percent of the total radiation dose to workers. In the exposed population of workers, the probability of a latent cancer fatality is estimated to range from 0.18 to 0.20.

Table K-45 lists the maximally exposed individual radiation doses and impacts for all workers. The maximally exposed worker would be an escort. This worker is estimated to receive a radiation dose of 25 rem over the 50 years of operation, based on a 0.5 rem per year administrative dose limit for repository facilities (DIRS 174942-BSC 2005, Section 4.9.3.3) and a person working for up to 50 years escorting shipments. The probability of a latent cancer fatality for this worker is estimated to be 0.015 or about 1 chance in 60.

An individual worker at the Maintenance-of-Way Trackside Facility was estimated to receive a radiation dose of 8.8×10^{-4} rem over 50 years of operations and assuming that the worker was exposed to all loaded casks that passed the facility. The probability of a latent cancer fatality for this worker is estimated to be 5.3×10^{-7}, or about 1 chance in 1,800,000.

An individual worker at a siding passed by loaded cask trains was estimated to receive a radiation dose of 1.3×10^{-4} rem for the Proposed Action and 2.8×10^{-4} rem for the Shared-Use Option over 50 years of operations and assuming that the worker was exposed to all loaded casks that passed a siding. The probability of a latent cancer fatality for this worker is estimated to be 7.7×10^{-8} (1 chance in 12,000,000) for the Proposed Action and 1.7×10^{-7} (1 chance in 5,800,000) for the Shared-Use Option.

K.2.8.1.1.2 Members of the Public. During the shipment of spent nuclear fuel and high-level radioactive waste from Hazen, Nevada, to the repository, members of the public along the rail alignment could be exposed to direct radiation from 9,495 shipping casks.

Table K-44 lists the collective radiation doses and impacts for members of the public along the rail alignment. Because dedicated trains would be used for transporting spent nuclear fuel and high-level radioactive waste from Hazen to the repository and there would be no en route stops under normal, circumstances, there would be no radiation doses at stops for members of the public. In addition, because two trains could not share the single railroad track simultaneously, there would be no on-link radiation doses for members of the public.

The collective radiation dose for members of the public exposed along the rail alignment (off-link) is estimated to be 1.4 person-rem, for all rail alignments. These radiation doses are based on the population in the year 2000 escalated to the year 2067. The radiation doses for members of the public would be the same for the Proposed Action and the Shared-Use Option. In the exposed population, the probability of a latent cancer fatality is estimated to range from 8.1×10^{-4} to 8.5×10^{-4}, or about 1 chance in 1,000. For perspective, in the United States the lifetime risk of dying from cancer is about 1 in 5.

Table K-45 lists the maximally exposed individual radiation doses and impacts for members of the public. The maximally exposed individual would be a resident who lives 18 meters (60 feet) from the rail line. This individual would be exposed to each of 9,495 shipping casks as they passed by en route to the repository. The radiation dose for this individual is estimated to be 0.0078 rem over the course of a shipping campaign of 50 years. The probability of a latent cancer fatality for this individual is estimated to be 4.7×10^{-6} or 1 chance in 200,000.

K.2.8.1.2 Workers and Members of the Public at the Staging Yard

K.2.8.1.2.1 Workers. When shipping casks arrive at the Staging Yard at Hawthorne, the railcars containing the shipping cask would be removed from the train, an inspection conducted, and the railcar transferred to the train to be transported to the repository. The escorts that had accompanied the shipping cask from its point of origin would also be present during this inspection. These railcar handling, escort, and inspection workers would be exposed to direct radiation from 9,495 shipping casks over 50 years of transporting spent nuclear fuel and high-level radioactive waste to the repository. Noninvolved workers at the Staging Yard would also be exposed to direct radiation from the casks.

Table K-46 lists the collective radiation doses and impacts for these workers. The radiation dose to workers at the Staging Yard would be the same for the Proposed Action and the Shared-Use Option because the number of shipping casks handled at the Staging Yard would be the same for the Proposed Action and Shared-Use Option.

The collective radiation dose for involved workers at the Staging Yard is estimated to be 240 person-rem. These radiation doses are in large part dependent on the time that a cask spent in the Staging Yard, which is estimated to be 2 hours, and on the close proximity of the inspector to the cask, which is estimated to be 1 meter. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.14.

The collective radiation dose for noninvolved workers at the Staging Yard is estimated to be 10 person-rem. These radiation doses are in large part dependent on the time that a noninvolved worker is assumed to spend in the Staging Yard, which is estimated to be 2 hours, at an estimated distance of 100 meters from the casks. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.0063.

Table K-44. Incident-free collective radiation doses and latent cancer fatalities for en route workers and members of the public for the Mina rail alignment (page 1 of 2).

Rail alignment	Interchange location	Collective radiation dose (person-rem)										
		En route rail workers[a]	En route rail workers at stops	En route escorts	En route escorts at stops	MOW[b] Trackside Facility workers	Workers located at sidings	Total en route workers	Off-link public along route	On-link public along route	Stops public along route	Total public along route
Proposed Action												
Highest population	Hazen	0.0E+0	0.0E+0	3.2E+2	0.0E+0	3.5E-2	0.0013	3.2E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Shortest distance	Hazen	0.0E+0	0.0E+0	3.1E+2	0.0E+0	3.5E-2	0.0013	3.1E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Longest distance	Hazen	0.0E+0	0.0E+0	3.4E+2	0.0E+0	3.5E-2	0.0013	3.4E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Lowest population	Hazen	0.0E+0	0.0E+0	3.3E+2	0.0E+0	3.5E-2	0.0013	3.3E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Shared-Use Option												
Highest population	Hazen	0.0E+0	0.0E+0	3.2E+2	0.0E+0	3.5E-2	0.0028	3.2E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Shortest distance	Hazen	0.0E+0	0.0E+0	3.1E+2	0.0E+0	3.5E-2	0.0028	3.1E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Longest distance	Hazen	0.0E+0	0.0E+0	3.4E+2	0.0E+0	3.5E-2	0.0028	3.4E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0
Lowest population	Hazen	0.0E+0	0.0E+0	3.3E+2	0.0E+0	3.5E-2	0.0028	3.3E+2	1.4E+0	0.0E+0	0.0E+0	1.4E+0

Table K-44. Incident-free collective radiation doses and latent cancer fatalities for en route workers and members of the public for the Mina rail alignment (page 2 of 2).

		Latent cancer fatalities										
Alignment	Interchange location	En route rail workers[a]	En route rail workers at stops	En route escorts	En route escorts at stops	MOW[b] Trackside Facility workers	Workers located at sidings	Total en route workers	Off-link public along route	On-link public along route	Stops public along route	Total public along route
Proposed Action												
Highest population	Hazen	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	7.7E-7	1.9E-1	8.5E-4	0.0E+0	0.0E+0	8.5E-4
Shortest distance	Hazen	0.0E+0	0.0E+0	1.8E-1	0.0E+0	2.1E-5	7.7E-7	1.8E-1	8.2E-4	0.0E+0	0.0E+0	8.2E-4
Longest distance	Hazen	0.0E+0	0.0E+0	2.0E-1	0.0E+0	2.1E-5	7.7E-7	2.0E-1	8.3E-4	0.0E+0	0.0E+0	8.3E-4
Lowest population	Hazen	0.0E+0	0.0E+0	2.0E-1	0.0E+0	2.1E-5	7.7E-7	2.0E-1	8.1E-4	0.0E+0	0.0E+0	8.1E-4
Shared-Use Option												
Highest population	Hazen	0.0E+0	0.0E+0	1.9E-1	0.0E+0	2.1E-5	1.7E-6	1.9E-1	8.5E-4	0.0E+0	0.0E+0	8.5E-4
Shortest distance	Hazen	0.0E+0	0.0E+0	1.8E-1	0.0E+0	2.1E-5	1.7E-6	1.8E-1	8.2E-4	0.0E+0	0.0E+0	8.2E-4
Longest distance	Hazen	0.0E+0	0.0E+0	2.0E-1	0.0E+0	2.1E-5	1.7E-6	2.0E-1	8.3E-4	0.0E+0	0.0E+0	8.3E-4
Lowest population	Hazen	0.0E+0	0.0E+0	2.0E-1	0.0E+0	2.1E-5	1.7E-6	2.0E-1	8.1E-4	0.0E+0	0.0E+0	8.1E-4

a. Rail workers were engineers and conductors.
b. MOW = Maintenance-of-Way.

Table K-45. Incident-free maximally exposed individual radiation doses and latent cancer fatalities for en route workers and members of the public for the Mina rail alignment.

Severe accident case	Radiation dose (rem)	Latent cancer fatalities
Proposed Action		
Workers		
Escort (one year of operation)	0.50	0.00030
Escort (50 years of operations)	25	0.015
Worker at Maintenance-of-Way Trackside Facility	8.8E-04	5.3E-07
Worker at siding	1.3E-4	7.7E-8
Members of the public		
Resident near rail line	7.8E-3	4.7E-6
Shared-Use Option		
Workers		
Escort (one year of operation)	0.50	0.00030
Escort (50 years of operations)	25	0.015
Worker at Maintenance-of-Way Trackside Facility	8.8E-04	5.3E-07
Worker at siding	2.8E-4	1.7E-7
Members of the public		
Resident near rail line	7.8E-3	4.7E-6

Table K-46. Incident-free collective radiation doses and latent cancer fatalities at the Staging Yard at Hawthorne for workers and members of the public.

	Collective radiation dose (person-rem)			
Staging Yard location	Involved workers at Staging Yard	Noninvolved workers at Staging Yard	Total workers at Staging Yard	Public near Staging Yard
Proposed Action and Shared-Use Option				
Mina - Hawthorne	2.4E+2	1.0E+1	2.5E+2	0.0E+0
	Latent cancer fatalities			
Staging Yard location	Involved workers at Staging Yard	Noninvolved workers at Staging Yard	Total workers at Staging Yard	Public near Staging Yard
Proposed Action and Shared-Use Option				
Mina - Hawthorne	1.4E-1	6.3E-3	1.5E-1	0.0E+0

The total collective radiation dose for involved and noninvolved workers at the Staging Yard is estimated to be 250 person-rem. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.15.

Table K-46 lists the maximally exposed individual radiation doses and impacts for workers at the Staging Yard. The maximally exposed worker would be an inspector, rail worker, or escort. This individual is estimated to receive a radiation dose of 25 rem over the 50 years of operation, based on a 0.5 rem per year administrative dose limit at repository facilities (DIRS 174942-BSC 2005, Section 4.9.3.3) for a person working for up to 50 years at the Staging Yard. The probability of a latent cancer fatality for this worker is estimated to be 0.015 or about 1 chance in 60.

K.2.8.1.2.2 Members of the Public. Members of the public near the Staging Yard at Hawthorne could be exposed to direct radiation from 9,495 shipping casks over 50 years of transporting spent nuclear fuel and high-level radioactive waste to the repository.

Tables K-46 and K-47 list the radiation doses and impacts for these members of the public. Based on 2000 census data, there is no resident population within 800 meters of the Staging Yard. Therefore, the collective radiation dose for members of the public is estimated to zero. There is, however, a business located 660 meters (2,100 feet) from the Staging Yard. The radiation dose for a person at this business is estimated to be 0.00018 rem, assuming that an individual was exposed to each of the 9,495 shipping casks for a period of 2 hours per cask. The probability of a latent cancer fatality for this individual is estimated to be 1.1×10^{-7}, or about 1 chance in 9,000,000.

Table K-47. Incident-free maximally exposed individual radiation doses and latent cancer fatalities at the Staging Yard at Hawthorne for workers and members of the public.

	Radiation dose (rem)	Latent cancer fatalities
Proposed Action and Shared-Use Option		
Workers		
Escort, rail worker, or inspector (one year of operation)	0.50	0.00030
Escort, rail worker, or inspector (50 years of operations)	25	0.015
Members of the public		
Business near Staging Yard	1.8E-4	1.1E-7

K.2.8.1.3 Summary of Incident-Free-Impacts

Table K-48 lists the incident-free collective radiation doses and impacts for workers en route to the repository, workers and members of the public located along the rail alignment route, involved and noninvolved workers at the Staging Yard at Hawthorne, and members of the public near the Staging Yard at Hawthorne for the Proposed Action and the Shared-Use Option.

The total collective radiation dose for en route workers and workers along the rail alignment route is estimated to range from 310 to 340 person-rem. For involved and noninvolved workers at the Staging Yard at Hawthorne, the total collective radiation dose is estimated to be 250 person-rem. The total collective radiation dose for all workers (en route, along the rail alignment, and at the Staging Yard) is estimated to be 550 to 580 person-rem. In the exposed population of workers, the probability of a latent cancer fatality is estimated to be 0.33 to 0.35. The impacts for these workers would be the same for the Proposed Action and the Shared-Use Option.

The total collective radiation dose for members of the public along the Mina rail alignment exposed to radiation from cask trains en route to the repository was estimated to be 1.4 person-rem. Since there are no members of the public near the Staging Yard at Hawthorne, the total collective radiation dose for members of the public near the Staging Yards is zero. The total collective radiation dose for all members of the public (along the rail alignment route and near the Staging Yard) is estimated be 1.4 person-rem. These radiation doses are based on the population in the year 2000 and escalated to the year 2067. In the exposed population, the probability of a latent cancer fatality is estimated to range from 8.1×10^{-4} to

Table K-48. Summary of incident-free collective radiation doses and latent cancer fatalities for workers and members of the public for the Mina rail alignment.

Rail alignment	Staging Yard location	Collective radiation dose (person-rem)						
		Total workers en route and along route	Total workers at Staging Yard	Total workers	Total public along route	Total public near Staging Yard	Total public	Total public and worker
Proposed Action and Shared-Use Option								
Highest population	Hawthorne	3.2E+2	2.5E+2	5.7E+2	1.4E+0	0.0E+0	1.4E+0	5.7E+2
Shortest distance	Hawthorne	3.1E+2	2.5E+2	5.5E+2	1.4E+0	0.0E+0	1.4E+0	5.5E+2
Longest distance	Hawthorne	3.4E+2	2.5E+2	5.8E+2	1.4E+0	0.0E+0	1.4E+0	5.8E+2
Lowest population	Hawthorne	3.3E+2	2.5E+2	5.8E+2	1.4E+0	0.0E+0	1.4E+0	5.8E+2
Highest population	Hawthorne	1.9E-1	1.5E-1	3.4E-1	8.5E-4	0.0E+0	8.5E-4	3.4E-1
Shortest distance	Hawthorne	1.8E-1	1.5E-1	3.3E-1	8.2E-4	0.0E+0	8.2E-4	3.3E-1
Longest distance	Hawthorne	2.0E-1	1.5E-1	3.5E-1	8.3E-4	0.0E+0	8.3E-4	3.5E-1
Lowest population	Hawthorne	2.0E-1	1.5E-1	3.5E-1	8.1E-4	0.0E+0	8.1E-4	3.5E-1

8.5×10^{-4}. The impacts for these members of the public would be the same for the Proposed Action and the Shared-Use Option.

The total collective radiation dose for all workers and members of the public is estimated to range from 550 to 580 person-rem. Over 99 percent of the radiation dose is to workers, less than 1 percent of the radiation dose is to members of the public. In the exposed population of workers and members of the public, the probability of a latent cancer fatality is estimated to range from 0.33 to 0.35.

K.2.8.2 Transportation Accident Risks

This section presents the radiological transportation accident risks of shipping spent nuclear fuel and high-level radioactive waste from Hazen, Nevada to the repository for the Proposed Action and the Shared-Use Option. Transportation risks were quantified in terms of dose risk, which is the sum of the products of the probabilities (dimensionless) and consequences (collective radiation doses in units of person-rem) of all potential transportation accidents. Transportation risks were also quantified in terms of latent cancer fatalities.

Table K-49 lists the dose risks for the four rail alignments evaluated in the Rail Alignment EIS. The dose risks are estimated to range from 1.2×10^{-2} to 1.3×10^{-2} person-rem. The rail alignments that have the higher exposed populations also have the higher dose risks. Also, because the number of shipping casks transported from Mina to the repository would be the same for the Proposed Action and for the Shared-Use Option, the dose risks are the same for the Proposed Action and Shared-Use Option. In the exposed populations along the tail alignments, the probability of a latent cancer fatality is estimated to range from 7.4×10^{-6} to 7.7×10^{-6}, or about 1 chance in 100,000.

K.2.8.3 Severe Transportation Accidents

This section presents the consequences of severe transportation accidents, known as maximum reasonably foreseeable transportation accidents, that could occur during the shipment of spent nuclear fuel and high-level radioactive waste to the repository from Hazen, Nevada, for the Proposed Action and the Shared-Use Option.

Because it is not possible to forecast the atmospheric conditions that might exist during a severe accident, consequences were determined using low wind speeds and stable atmospheric conditions (a wind speed of 0.89 meters per second and Class F stability). The severe accident scenario calculation methodology does not include a probabilistic component that includes the atmospheric stability, therefore stable conditions were assumed. The atmospheric concentrations estimated from these conditions would be exceeded only 5 percent of the time.

For the four rail alignments described in Table K-31, there were no urban areas as defined in U.S. Census Bureau population data. However, there were suburban areas and rural areas. Using alignment-specific 2000 census population data escalated to the year 2067, the average population density in suburban areas along the alignments ranged from 542 to 589 people per square kilometer (1,400 to 1,530 people per square mile), near Silver Springs, Nevada. The average population density along rural areas, escalated to the year 2067, ranged from 3.94 to 4.33 people per square kilometer (10.2 to 11.2 people per square mile).

Table K-50 lists the impacts of the maximum reasonably foreseeable accident. This accident has a frequency of about 7×10^{-7} per year. If the maximum reasonably foreseeable accident were to occur in a suburban area, the population radiation dose would be 2000 person-rem. In the exposed population, it is estimated that there could be 1.2 latent cancer fatalities. If the maximum reasonably foreseeable accident

Table K-49. Radiological transportation accident risks for the Mina rail alignment.

Rail alignment	Staging Yard location	Dose risk[a] (person-rem)	Latent cancer fatalities (LCFs)
Proposed Action and Shared-Use Option			
Highest population	Mina	1.3E-2	7.7E-6
Shortest distance	Mina	1.2E-2	7.4E-6
Longest distance	Mina	1.3E-2	7.6E-6
Lowest population	Mina	1.2E-2	7.4E-6

a. Dose risk is the sum of the products of the probabilities and consequences in person-rem of all potential transportation accidents.

Table K-50. Consequences[a] of severe accident case scenarios in suburban and rural areas for the Mina rail alignment.

	Suburban area[b]	Rural area[c]
Proposed Action and Shared-Use Option		
Population radiation dose (person-rem)	2,000	15
Latent cancer fatalities	1.2	8.9×10^{-3}
Maximally exposed individual (rem)	34	34
Probability of latent cancer fatality	0.020	0.020
First responder radiation dose (rem)	0.14 – 2.0	0.14 – 2.0
Probability of latent cancer fatality	8.2×10^{-5} – 0.0012	8.2×10^{-5} – 0.0012

a. Consequences based on low wind speeds and stable atmospheric conditions.
b. Population density in the suburban area is 589 people per square kilometer. To convert people per square kilometer to people per square mile, multiply by 2.589988.
c. Population density in the low population density rural area is 4.33 people per square kilometer. To convert people per square kilometer to people per square mile, multiply by 2.589988.

were to occur in a rural area, the collective radiation dose would be 15 person-rem. The probability of a latent cancer fatality in the exposed population is estimated to be 8.9E-3.

In either a suburban area or rural area, the radiation dose from the maximum reasonably foreseeable transportation accident for the maximally exposed individual located 330 meters from the accident would be 34 rem. The probability of an LCF for that individual is estimated to be 0.020.

The radiation dose to a first responder would range from 0.14 to 2.0 rem. The probability of an LCF for this first responder is estimated to range from 8.2×10^{-5} to 0.0012.

Recovering rail casks loaded with spent nuclear fuel or high-level radioactive waste would use methods commonly used to recover railcars and locomotives following accidents. The capability to lift such weights exists and would be deployed as required. Railroads use emergency response contractors with the capability to lift derailed locomotives that could weigh as much as 150 tons. Difficult recoveries of equipment as heavy as spent nuclear fuel casks have been accomplished and DOE anticipates that if such a recovery was necessary, it would be accomplished using methods and equipment similar to those used in prior difficult recoveries.

K.2.8.4 Transportation Sabotage

This section presents the consequences of a potential sabotage event for shipments of spent nuclear fuel and high-level radioactive waste to the repository from Hazen, Nevada, for the Proposed Action and the Shared-Use Option.

For the four rail alignments described in Table K-31, there were no urban areas as defined in U.S. Census Bureau population data. However, there were suburban areas and rural areas. Using alignment-specific 2000 census population data escalated to the year 2067, the average population density in suburban areas along the alignments ranged from 542 to 589 people per square kilometer (1,400 to 1,530 people per square mile), near Silver Springs, Nevada. The average population density along rural areas, escalated to the year 2067, ranged from 3.94 to 4.33 people per square kilometer (10.2 to 11.2 people per square mile).

Table K-51 lists the consequences of a potential sabotage event. The consequences would be the same for the Proposed Action and the Shared-Use Option. If the sabotage event occurred in a suburban area, the collective radiation dose is estimated to be 4,700 person-rem. In the exposed population, the number of latent cancer fatalities is estimated to be 2.8.

If the sabotage occurred in a rural area, the collective radiation dose is estimated to be 35 person-rem. In the exposed population, the risk of a latent cancer fatality is estimated to be 0.021.

If the sabotage event were to occur in either a suburban area or rural area, the maximally exposed individual would be located 100 meters (330 feet) from the sabotage event, at the location of maximum downwind air concentration. The radiation dose for the maximally exposed individual is estimated to be 27 rem. The probability of a latent cancer fatality for this individual is estimated to be 0.016.

Table K-51. Consequences of a sabotage event in suburban and rural areas – Mina rail alignment.[a]

	Suburban area[b]	Rural area[c]
Proposed Action and Shared-Use Option		
Population radiation dose (person-rem)	4,700	35
Latent cancer fatalities	2.8	0.021
Maximally exposed individual (rem)	27	27
Probability of latent cancer fatality	0.016	0.016

a. Consequences based on moderate wind speeds and neutral atmospheric conditions.
b. Population density in the suburban area is 589 people per square kilometer; to convert people per square kilometer to people per square mile, multiply by 2.589988.
c. Population density in the low population density rural area is 4.33 per square kilometer; to convert people per square kilometer to people per square mile, multiply by 2.589988.

K.3 Transportation Topical Areas

This section discusses additional topics identified during the scoping process for the Nevada Rail Corridor SEIS, the Rail Alignment EIS, and the Repository SEIS.

K.3.1 COST OF CLEANUP

According to the Nuclear Regulatory Commission report *Reexamination of Spent Fuel Shipment Risk Estimates* (DIRS 152476-Sprung et al. 2000, pp. 7 to 76), in more than 99.99 percent of accidents radioactive material would not be released from the cask. After initial safety precautions had been taken, the cask would be recovered and removed from the accident scene. Because no radioactive material would be released, based on reported experience with two previous accidents (DIRS 156110-FEMA 2000, Appendix G, Case 4 and Case 5), the economic costs of these accidents would be minimal.

For the 0.01 percent of accidents severe enough to cause a release of radioactive material from a cask, a number of interrelated factors would affect costs of cleaning up resulting radioactive contamination after the accident. Factors included are the severity of the accident and the initial level of contamination; the weather at the time and following; the location and size of the affected land area and how the land is used; the standard established for the allowable level of residual contamination following cleanup and the decontamination method used; and the technical requirements for and location for disposal of contaminated materials.

Because it would be necessary to specify each of the factors to estimate clean up costs, any estimate for a single accident would be highly uncertain and speculative. Nonetheless, to provide a gauge of the costs that could be incurred, DOE examined past studies of costs of cleanup following hypothetical accidents that would involve uncontrolled releases of radioactive materials.

A study of the impacts of transporting radioactive materials conducted by the Nuclear Regulatory Commission in 1977 estimated that costs could range from about $1 million to $100 million for a transportation accident that involved a 600-curie release of a long-lived radionuclide (DIRS 101892-NRC 1977, Table 5-11). These estimates would be about 3 times higher if escalated for inflation from 1977 to the present. In 1980, Finley et al. estimated that costs could range from about $90 million to $2 billion for a severe spent nuclear fuel transportation accident in an urban area (DIRS 155054-Finley et al 1980, Table 6-9). Sandquist et al. (DIRS 154814-Sandquist et al 1985, Table 3-7) estimated that costs could range from about $200,000 to $620 million. In this study, Sandquist estimated that contamination would affect between 0.063 to 4.3 square kilometers (16 to 1,100 acres). A study by Chanin and Murfin (DIRS 152083-Chanin and Murfin 1996, Chapter 6) estimated the costs of cleanup following a transportation accident in which plutonium would be dispersed. This study developed cost estimates for cleaning up and remediating farmland, urban areas, rangeland, and forests. The estimates ranged from $38 million to $400 million per square kilometer that would need to be cleaned up. The study also evaluated the costs of expedited cleanups in urban areas for light, moderate, and heavy contamination levels. These estimates ranged from $89 million to $400 million per square kilometer.

The National Aeronautics and Space Administration studied potential accidents for the Cassini mission, which used a plutonium powered electricity generator. The Agency estimated costs of cleaning up radioactive material contamination on land following potential launch and reentry accidents. The estimate for the cost following a launch accident ranged from $7 million to $70 million (DIRS 155551-NASA 1995, Chapter 4) with an estimated contaminated land area of about 1.4 square kilometers (350 acres). The Agency assumed cleanup costs would be $5 million per square kilometer if removal and disposal of contaminated soil were not required and $50 million per square kilometer if those activities were required. For a reentry accident that would occur over land, the study estimated that the contaminated land area could range from about 1,500 to 5,700 square kilometers (370,000 to 1.4 million acres) (DIRS 155551-NASA 1995, Chapter 4) with cleanup costs possibly exceeding a total of $10 billion. In a more recent study of potential consequences of accidents that could involve the Cassini mission, NASA estimated that costs could range from $7.5 million to $1 billion (DIRS 155550-NASA 1997, Chapter 4). The contaminated land area associated with these costs ranged from 1.5 to 20 square kilometers (370 to 4,900 acres). As in the 1995 study, these estimates were based on cleanup costs in the range of $5 million to $50 million per square kilometer.

Using only the estimates provided by these studies, the costs of cleanup following a severe transportation accident involving spent nuclear fuel where radioactive material was released could be in the range from $300,000 (after adjusting for inflation from 1985 to the present) to $10 billion. Among the reasons for this wide range are different assumptions made regarding the factors that must be considered: 1) the severity of the assumed accident and resulting contamination levels, 2) accident location and use of affected land areas, 3) meteorological conditions, 4) cleanup levels and decontamination methods, and 5) disposal of contaminated materials. However, the extreme high estimates of costs are based on assumptions that all factors combine in the most disadvantageous way to create a "worst case." Such worst cases are not reasonably foreseeable. Conversely, estimates as low as $300,000 may also not be realistic for all of the direct and indirect costs of cleaning up following an accident severe enough to cause a release of radioactive materials.

To gauge the range of costs that it could expect for severe accidents in transporting spent nuclear fuel to a Yucca Mountain repository, DOE considered the amount of radioactive material that could be released in the maximum reasonably foreseeable accident and compared this to the estimates of releases used by the various studies discussed above. During the maximum reasonably foreseeable accident, about 30 curies (mostly cesium) would be released. This is about 50 times less than used by Sandquist in his study (1,630 curies) and 20 times less than the release used in the estimates provided by the Nuclear Regulatory Commission in 1977 (600 curies). The estimated frequency for an accident this severe to occur is about 6 or 7 times in 10 million years. Based on the prior studies (where estimated releases exceeded those estimated in this appendix for a maximum reasonably foreseeable accident) and the amount of radioactive material that could be released in a maximum reasonably foreseeable accident, the Department believes that the cost of cleaning up following such an accident could be a few million dollars. Nonetheless, as stated above, the Department also believes that estimates of such costs contain great uncertainty and are speculative; they could be less or 10 times greater depending on the contributing factors.

For perspective, the current insured limit of responsibility for an accident involving releases of radioactive materials to the environment is $10.26 billion (see Appendix L).

Opposing View: Costs of Cleanup

The State of Nevada has provided analyses that assert that the costs of cleanup could be much higher than the estimates discussed in the Rail Alignment EIS, up $189.7 billion for accidents involving rail casks (DIRS 181756-Lamb, Resnikoff and Moore 2001, p. 48) and up to $299.4 billion for sabotage involving a rail cask (DIRS 181892-Lamb, Hintermann and Resnikoff 2002, p. 15).

DOE believes that these extremely high estimates of costs are based on assumptions that all factors combine in the most disadvantageous way to create a "worst case." Such worst cases are not reasonably foreseeable.

K.3.2 UNIQUE LOCAL CONDITIONS

In scoping comments on the Rail Alignment EIS, the State of Nevada stated that the unique local conditions in Nevada require special consideration in the transportation accident analysis. In the Rail Alignment EIS, DOE does analyze a range of accidents that reflect the range of reasonably foreseeable "real-life conditions." Real-life conditions that would involve various types of collisions, various natural disasters, specific locations (such as mountain passes), or various infrastructure accidents (such as track failure) in effect constitute a combination of cask failure mechanisms, impact velocities, and temperature ranges, which the Rail Alignment EIS does evaluate. Because it is impossible to predict what real-life conditions might be involved in any accidents that could occur, DOE has described the maximum reasonably foreseeable accident in terms of cask failure mechanisms and accident forces, and to ensure that the analysis accounts for all reasonably foreseeable real-life conditions. Accident scenarios are modeled in this fashion to accommodate the almost infinite number of variables that any given accident could involve.

K.3.3 COMPREHENSIVE RISK ASSESSMENT

The State of Nevada recommended that comprehensive risk assessment should be used as a substitute for probabilistic risk assessment in the transportation analysis.

The methods used to calculate transportation impacts are state-of-the-art. As a consequence, DOE believes that the Rail Alignment EIS adequately analyzes the environmental impacts that could result from shipping spent nuclear fuel and high-level waste. DOE believes the Rail Alignment EIS fulfills all legal obligations required for an EIS and a "comprehensive risk assessment" is neither required nor necessary.

K.3.4 USE OF NUREG/CR-6672 TO ESTIMATE ACCIDENT RELEASES

The evaluations of the radiological impacts of transportation accidents presented in the Yucca Mountain FEIS (DIRS 155970-DOE 2002, Chapter 6) are based on data presented in NUREG/CR-6672 *Reexamination of Spent Nuclear Fuel Shipment Risk Estimates* (DIRS 152476-Sprung et al. 2000) on conditional probabilities for the occurrence of severe accidents and on corresponding fractions of cask contents that could be released in such accidents.

In September of 1977, the Nuclear Regulatory Commission (NRC or the Commission) issued a generic EIS (*Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170 [DIRS 101892-NRC 1977]). That EIS addressed environmental impacts associated with the transport of all types of radioactive material by all transport modes (road, rail, air, and water), and provided the basis under NEPA for the NRC to issue general licenses for transportation of radioactive material under 10 CFR 71. Based in part on the findings of NUREG-0170, the Commission concluded that "present regulations are adequate to protect the public against unreasonable risk from the transport of radioactive materials" (46 *Federal Register* 21629, April 13, 1981) and stated that "regulatory policy concerning transportation of radioactive materials be subject to close and continuing review."

In 1996 the NRC decided to reexamine the risks associated with the shipment of spent power reactor fuel by truck and rail to determine whether the estimates of environmental impacts in NUREG-0170 remained valid. According to the Commission, the reexamination was initiated (1) because many spent fuel shipments are expected to be made during the next few decades, (2) because these shipments will be made to facilities along routes and in casks not specifically examined by NUREG-0170, and (3) because the risks associated with these shipments can be estimated using new data and improved methods of analysis. In 2000, the Commission published the results of the reexamination in a report prepared by the Sandia National Laboratories, *Reexamination of Spent Nuclear Fuel Shipment Risk Estimates* (NUREG/CR-6672).

Some have been critical of NUREG/CR-6672; for example, see *Review of NUREG/CR-6672, Reexamination of Spent Fuel Shipment Risk Estimates* (DIRS 181884-Lamb and Resnikoff 2000, all) and *Worst Case Credible Nuclear Transportation Accidents: Analysis for Urban and Rural Nevada* (DIRS 181756-Lamb, Resnikoff, and Moore 2001, Appendix A). However, the Commission has stated that many of the purported methodological flaws appear to be related to differing views regarding assumptions and that critical comments do not appear to recognize that many of the assumptions used overstated risks (DIRS 181603-Shankman 2001).

Supporting the NRC's assessment, in its review of NUREG/CR-6672 (see *Going the Distance? The Safe Transport of Spent Nuclear and High-Level Radioactive Waste in the United States* [DIRS 182032-National Research Council 2006]), the National Academy of Sciences Committee on Transportation of Radioactive Waste noted that the conservative assumptions used were reasonable for producing bounding estimates of accident consequences.

Conversely, the Committee indicated less confidence regarding the analysis of overall transport risks presented in the report. Here the Committee noted that the truck and rail routes used in the analyses were based on realistic, not bounding, characteristics. The Committee considered "many other uncertainties" and ultimately concluded that the overall results of the "Sandia analyses are likely to be neither realistic nor bounding and 'probably' overestimate transport risks."

Based on the review by the National Academy of Sciences and NRC comments, DOE has concluded that NUREG/CR-6672 represents the best available information for use in estimating the consequences of transportation accidents involving spent nuclear fuel and high-level waste and has used NUREG/CR-6672 in the Rail Alignment EIS.

K.4 Glossary

absorbed dose	A measure of the energy deposited in a medium by ionizing radiation. It is equal to the energy deposited per unit mass of medium
alpha particle	A positively charged particle ejected spontaneously from the nuclei of some ***radioactive*** elements. It is identical to a helium ***nucleus*** and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). See ***ionizing radiation.***
atomic number	The number of ***protons*** in an atom's ***nucleus***.
beta particle	A negatively charged ***electron*** or positively charged positron emitted from a ***nucleus*** during ***decay***. Beta decay usually refers to a ***radioactive*** transformation of a ***nuclide*** by electron emission, in which the ***atomic number*** increases by 1 and the mass number remains unchanged. In positron emission, the atomic number decreases by 1 and the mass number remains unchanged. See ***ionizing radiation.***
burnup	The total energy released per initial unit mass of nuclear fuel as a result of irradiation. The commonly used units of burnup are megawatt-days per metric ton of heavy metal (MWd/MTHM).
collective dose	See ***population dose***.
committed effective dose equivalent	Dose delivered to specified organs or tissues over a specified period of time following an acute intake of a radionuclide by ingestion, inhalation, or dermal absorption. Time period over which committed doses are calculated normally is 50 year for intakes by adult or from age at intake to age 70 for intakes by other age groups.
conditional probability	the probability of an accident of a given severity category, given that an accident occurs.
cosmic radiation	A variety of high-energy particles including ***protons*** that bombard the Earth from outer space. They are more intense at higher altitudes than at sea level, where the Earth's atmosphere is most dense and provides the greatest protection.
decay (radioactive)	The process in which one ***radionuclide*** spontaneously transforms into one or more different radionuclides called ***decay products***.
decay product	A ***nuclide*** resulting from the radioactive decay of a parent isotope or precursor nuclide.
decay time	The time since the spent nuclear fuel has been discharged from the reactor.

dose (radioactive)	The amount of ***radioactive*** energy taken into (absorbed by) living tissues. See ***effective dose equivalent***.
dose equivalent	(1) The number (corrected for background) zero and above that is recorded as representing an individual's ***dose*** from external ***radiation*** sources or internally deposited ***radioactive*** materials; (2) the product of the absorbed dose in ***rads*** and a quality factor; (3) the product of the absorbed dose, the quality factor, and any other modifying factor. The ***dose equivalent*** quantity is used for comparing the biological effectiveness of different kinds of radiation (based on the quality of radiation and its spatial distribution in the body) on a common scale; it is expressed in ***rem***.
dose rate	The ***dose*** per unit time.
effective dose equivalent	Often 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.
electron	A stable elementary particle that is the negatively charged constituent of ordinary matter.
enrichment	The fraction of atoms of a specified isotope in a mixture of isotopes of the same element when this fraction exceeds that in the naturally occurring mixture. By convention, uranium enrichment is given on a weight basis.
gamma ray	The most penetrating type of radiant nuclear energy. It does not contain particles and can be stopped by dense materials such as concrete or lead. See ***ionizing radiation.***
hormesis	A dose response phenomenon characterized by a low dose stimulation, high dose inhibition, resulting in either a J-shaped or an inverted U-shaped dose response.
ion	An atom or group of atoms that carries a positive or negative charge as a result of having lost or gained one or more electrons.
ionizing radiation	(1) ***Alpha particles***, ***beta particles***, ***gamma rays***, ***X-rays***, ***neutrons***, high-speed ***electrons***, high-speed ***protons***, and other particles capable of producing ions. (2) Any ***radiation*** capable of displacing electrons from an atom or molecule, thereby producing ions.
irradiation	***Exposure*** to ***radiation***.
millirem	A unit of radiation dose that is equivalent to one one-thousandth of a rem.
neutron radiation	See ***ionizing radiation***.
nucleus	The central, positively charged, dense portion of an atom. Also known as ***atomic nucleus***.
nuclide	An atomic ***nucleus*** specified by its ***atomic weight***, ***atomic number***, and energy state; a ***radionuclide*** is a ***radioactive*** nuclide.
person-rem	A unit used to measure the ***radiation exposure*** to an entire group and to compare the effects of different amounts of radiation on groups of people; it is the product of the average ***dose equivalent*** (in ***rem***) to a given organ or tissue multiplied by the number of persons in the population of interest.

photon	Quantum of electromagnetic radiation, having no charge or mass, that exhibits both particle and wave behavior, such as a ***gamma*** or ***x-ray***.
proton	An elementary particle that is the positively charged component of ordinary matter and, together with the ***neutron***, is a building block of all ***atomic*** nuclei.
population dose	A summation of the ***radiation doses*** received by individuals in an exposed population; equivalent to ***collective dose***; expressed in ***person-rem***.
rad	A unit of absorbed radiation dose in terms of energy. One rad equals 100 ergs of energy absorbed per gram of tissue.
radiation	The emitted particles or ***photons*** from the nuclei of radioactive atoms. Some elements are naturally ***radioactive***; others are induced to become radioactive by ***irradiation*** in a reactor. Naturally occurring radiation is indistinguishable from induced radiation.
radioactive	Emitting ***radioactivity***.
radionuclide	See ***nuclide***.
release fraction	The fraction of material released during an accident.
rem	A unit of ***dose equivalent***. The dose equivalent in rems equals the absorbed dose in ***rads*** in tissue multiplied by the appropriate quality factor and possibly other modifying factors. Derived from roentgen equivalent man, referring to the dosage of ionizing ***radiation*** that will cause the same biological effect as one roentgen of ***X-ray*** or ***gamma ray*** exposure. One rem equals 0.01 sievert.
source term	Types and amounts of ***radionuclides*** that are the source of a potential release of ***radioactivity***.
subatomic particles	Any particle smaller than an atom.
total dose	The radiation dose to an individual or a group of people.
X-rays	Penetrating electromagnetic ***radiation*** having a wavelength much shorter than that of visible light. X-rays are identical to ***gamma rays*** but originate outside the ***nucleus***, either when the inner orbital ***electrons*** of an excited atom return to their normal state or when a metal target is bombarded with high-speed electrons.

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APPENDIX L

SUPPLEMENTAL TRANSPORTATION INFORMATION

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SUPPLEMENTAL TRANSPORTATION INFORMATION

L.1 Introduction

The U.S. Department of Energy (DOE or the Department) developed this appendix to provide general background information on transportation-related topics. Although this information is not essential for analysis of potential impacts from the transportation of spent nuclear fuel and high-level radioactive waste to a repository at Yucca Mountain, Nevada, it will help readers to understand how the transportation system would operate within the regulatory framework for the transportation of these materials. Section L.2 discusses transportation regulations, Section L.3 describes the components of a transportation system, and Section L.4 discusses operational practices. Section L.5 describes cask safety and testing. Section L.6 discusses emergency response, and Section L.7 describes available assistance for state, local, and American Indian tribal governments for emergency response planning. Section L.8 discusses DOE plans for transportation security, and Section L.9 describes potential liability under the Price-Anderson Act.

Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the component elements of which have not been separated by reprocessing. In this document, the term refers to the special nuclear material, byproduct material, source material, and other radioactive materials associated with fuel assemblies and includes commercial spent nuclear fuel (including mixed-oxide fuel) from civilian nuclear power reactors, and DOE spent nuclear fuel from DOE and non-DOE production reactors, naval reactors, test and experimental reactors, and research reactors. Naval spent nuclear fuel shipments to the repository would be conducted under the authority of Presidential Executive Order 12344 and Public Law 106-65 and would be in compliance with applicable sections of the Code of Federal Regulations (CFR).

Most nuclear power reactors use solid uranium dioxide ceramic pellets of low-enriched uranium for fuel. The pellets are sealed in strong metal tubes, which are bundled together to form a nuclear fuel assembly. Depending on the type of reactor, typical fuel assemblies can be as long as 4.9 meters (16 feet) and weigh up to 540 kilograms (1,200 pounds). After a period in a reactor, the fuel is no longer efficient for the production of power and the assembly is removed from the reactor. After removal, the assembly (now called spent nuclear fuel) is highly radioactive and requires heavy shielding and remote handling to protect workers and the public.

High-level radioactive waste is the highly radioactive material that resulted from the reprocessing of spent nuclear fuel; it includes liquid waste that was produced directly in reprocessing and any solid material from such liquid waste that contains fission products in sufficient concentrations. High-level radioactive waste also includes other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, has determined by rule to require permanent isolation. Immobilized surplus weapons-usable plutonium is part of the high-level radioactive waste inventory. All high-level radioactive waste would be in a solid form before DOE would ship it to Yucca Mountain.

L.2 Transportation Regulations

The shipment of spent nuclear fuel and high-level radioactive waste is highly regulated. For transportation of these materials to Yucca Mountain, DOE would meet or exceed U.S. Department of Transportation and NRC rules. DOE would also work with states, local government officials, federally recognized American Indian tribes, utilities, the transportation industry, and other interested parties in a cooperative manner to develop the transportation system.

The Hazardous Materials Transportation Act, as amended (49 United States Code [U.S.C.] 1801 *et seq.*), directs the U.S. Department of Transportation to develop transportation safety standards for hazardous materials, including radioactive materials. Title 49 of the Code of Federal Regulations contains U.S. Department of Transportation standards and requirements for the packaging, transporting, and handling of radioactive materials for all modes of transportation. NRC sets additional design and performance standards for packages that carry materials with higher levels of radioactivity.

The Nuclear Waste Policy Act, as amended (42 U.S.C. 10101 *et seq.*; NWPA), requires that all shipments of spent nuclear fuel and high-level radioactive waste to Yucca Mountain be in NRC-certified casks and in accordance with NRC regulations related to advance notification of state and local governments. In addition, DOE has committed to notification of American Indian tribal governments for these shipments (DIRS 171934-DOE 2002, p. 23). NRC rules do not require notification of local authorities, which is the responsibility of the individual state governments. This section discusses the key regulations that govern the transportation of spent nuclear fuel and high-level radioactive waste.

L.2.1 PACKAGING

The primary means for the protection of people and the environment during radioactive materials shipment is the use of radioactive materials packages that meet U.S. Department of Transportation and NRC requirements. Packages are selected based on activity, type, and form of the material to be shipped. All spent nuclear fuel and high-level radioactive waste shipments to Yucca Mountain would be in Type B casks, which have the most stringent design standards to prevent release of radioactive materials under normal conditions of transport and during hypothetical accidents (Section L.4.10 discusses accident conditions). NRC regulates and certifies the design, manufacture, testing, and use of Type B packages under regulations in 10 CFR Part 71. All shippers must properly package radioactive materials so that external radiation levels do not exceed regulatory limits. The packaging protects handlers, transporters, and the public from exposure to dose rates in excess of recognized safe limits. Regulations in 10 CFR 71.47 and 49 CFR 173.441 prescribe the external radiation standards for all packages. For shipments to the repository, the limiting radiation dose limit would be 10 millirem per hour at any point 2 meters (6.6 feet) from the outer edge of the railcar or truck trailer.

L.2.2 MARKING, LABELING, AND PLACARDING

U.S. Department of Transportation regulations in 49 CFR require that shippers meet specific hazard communication requirements in marking and labeling packages that contain radioactive materials and other hazardous materials. Markings, labels, and placards identify the hazardous contents to emergency responders in the event of an incident.

Markings provide the proper shipping name, a four-digit hazardous materials number, the shipper's name and address, gross weight, and type of packaging; other important information labels on opposite sides of a package identify the contents and radioactivity level. Shippers of radioactive materials use one of three labels—Radioactive White I, Yellow II, or Yellow III—as shown in Figure L-1. The use of a particular label is based on the radiation level at the surface of the package and the transport index. The transport index, determined in accordance with 49 CFR 173.403, is a number on the label of a package that indicates the degree of control the carrier must exercise during shipment. Packaging that previously contained Class 7 (radioactive) materials and has been emptied of its contents as much as practicable is exempted from marking requirements. However, 49 CFR 173.428 requires the application of an Empty label (not shown) to the cask.

Figure L-1 also shows a Fissile label, which shippers must apply to each package with fissile material (a material that is capable of sustaining a chain reaction of nuclear fission). Such labels, where applicable, must be affixed adjacent to the labels for radioactive materials. The Fissile label includes the Criticality Safety Index, which indicates how many fissile packages can be grouped together on a conveyance.

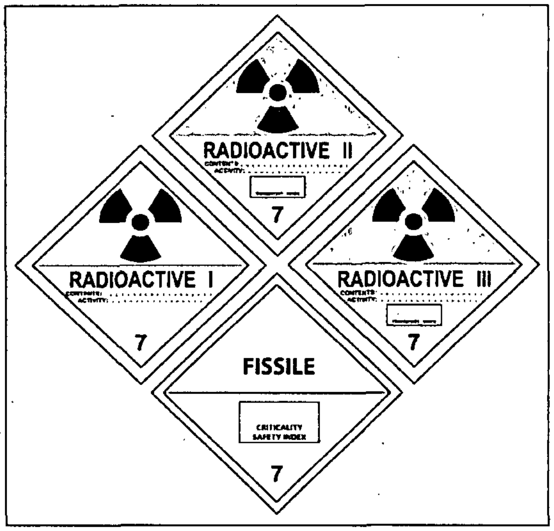

Figure L-1. Radioactive material shipment labels.

Shipments of spent nuclear fuel and high-level radioactive waste are usually classified as Highway Route-Controlled Quantities of Radioactive Materials, and 49 CFR 172.403(c) requires Radioactive Yellow-III labels for them regardless of the radiation dose rate. For Radioactive Yellow III shipments, 49 CFR 172.504 requires radioactive hazard communication placards (Figure L-2) on each side and each end of a freight container, transport vehicle, or railcar. In addition, for Highway Route-Controlled Quantities of Radioactive Materials shipments the placard must be on a white square background with a black border (49 CFR 172.507 through 172.527). In addition to the placard, a vehicle might have a United Nations Identification Number near the placard. The United Nations assigns these four-digit numbers, which shippers commonly use throughout the world to aid in the quick identification of materials in bulk containers. The number appears on either an orange plane or on a plain white square-on-point configuration similar to a placard. The usual identification number for spent nuclear fuel is UN3328.

Figure L-2. Radioactive hazard communication placard.

L.2.3 SHIPPING PAPERS

The shipper prepares shipping papers and gives them to the carrier. These documents contain additional details about the cargo and include a signed certification that the material is properly classified and in proper condition for transport. Shipping papers also contain emergency information that includes contacts and telephone numbers. Highway carriers must keep shipping papers readily available during transport for inspection by appropriate officials such as state or federal inspectors.

L.2.4 ROUTING

U.S. Department of Transportation regulations classify spent nuclear fuel and high-level radioactive waste as Highway Route-Controlled Quantities of Radioactive Materials shipments. Carriers of these materials are required to use preferred routes, which include interstate highway systems or alternative routes selected by state or tribal routing authorities in accordance with U.S. Department of Transportation regulations. Preferred routes generally use beltways and bypasses around cities to avoid highly populated urban centers.

States and tribes can designate alternative preferred routes by following U.S. Department of Transportation regulations for designation and performing a comparative route analysis that adequately considers overall risk to the public. Factors for the analysis can include accident rates, traffic counts, distance, vehicle speeds, population density, land use, timeliness, and availability of emergency response capabilities. States must also document required consultation with affected neighboring jurisdictions. U.S. Department of Transportation highway routing regulations preempt any conflicting routing requirements that state, local, or tribal governments might issue, such as prohibitions on radioactive waste shipments through local nuclear-free zones.

No federal routing rules govern spent nuclear fuel and high-level radioactive waste shipments by rail. Because railroads are privately owned and operated, route selection would involve discussions between DOE and the chosen railroad companies and other stakeholders. Key factors for selection of rail routes include time and distance in transit, the track class and capacity, operational input from carriers, and infrastructure capabilities.

The U.S. Department of Homeland Security and U.S. Department of Transportation issued rulemaking proposals in relation to railroad routing for radioactive materials shipments for security purposes on December 21, 2006; Section L.2.9 discusses the proposals.

L.2.5 ADVANCE NOTIFICATION

DOE Manual 460.2-1, *Radioactive Material Transportation Practices* (DIRS 171934-DOE 2002, all), which implements DOE Order 460.1B, Packaging and Transportation Safety, and NRC regulations (10 CFR 71.97 and 73.37), requires written notice to governors, or their designees, before shipment of spent nuclear fuel and high-level radioactive waste through their states. If sent by regular mail, the notice must be postmarked at least 7 days before the shipment; for messenger service, it must arrive 4 days before. The notification must contain the name, address, and telephone number of the shipper, the carrier, and the receiver; a description of the shipment; a list of the routes within the state; the estimated date and time of departure from the point of origin; the estimated date and time of entry into the state; and a statement on safeguarding schedule information. Federal regulations allow states to release certain advance information to local officials on a need-to-know basis. As required by Section 180 of the NWPA, all shipments to a repository would comply with NRC regulations on advance notification of state and local governments. In the event of a change in schedule that differs more than 6 hours from what was in the notification to the governor or their designee, DOE would provide the state with the new schedule by telephone. Although current regulations do not require notification of tribal authorities, DOE policy is to inform tribes of spent nuclear fuel and high-level radioactive waste shipments that would pass through their jurisdictions (DIRS 171934-DOE 2002, p. 23).

NRC issued an Advance Notice of Proposed Rulemaking (64 *Federal Register* [*FR*] 71331) on December 21, 1999, to invite early input from affected parties and the public on advance notification to American Indian tribes of spent nuclear fuel and high-level waste shipments. Although the Commission approved a rulemaking plan, it put the rulemaking on hold pending review of Commission rules in response to the events of September 11, 2001. NRC is coordinating the schedule for this rulemaking with other security rulemaking activities. The current schedule would result in a proposed rule in about 2010.

L.2.6 RAILROAD SAFETY PROGRAM

The Rail Safety Act of 1970 (Public Law 91-458) authorized states to work with the Federal Railroad Administration to enforce federal railroad safety regulations. States can enforce federal standards for track, signal and train control, motive power and equipment, and operating practices. In 1992, the State Safety Participation regulations (49 CFR Part 212) were revised to permit states to perform hazardous materials inspections of rail shipments. The Grade Crossing Signal System Safety regulations (49 CFR Part 234) were revised to authorize federal and state signal inspectors to ensure that railroad owners or operators were properly testing, inspecting, and maintaining automated warning devices at grade crossings. Before state participation can begin, each state agency must enter into a multiyear agreement with the Federal Railroad Administration for the exercise of specified authority. This agreement can delegate investigative and surveillance authority in relation to all or any part of federal railroad safety laws.

L.2.7 PERSONNEL TRAINING

U.S. Department of Transportation regulations require proper training for anyone involved in the preparation or transportation of hazardous materials, including radioactive materials. In accordance with 49 CFR Part 397, Subpart D, operators of vehicles that transport Highway Route-Controlled Quantities of Radioactive Materials receive special training that covers the properties and hazards of the materials, associated regulations, and applicable emergency procedures. In addition, DOE Orders require that driver or crew training covers operation of the specific package tie-down systems, cask recovery procedures, use of radiation detection instruments, use of satellite tracking systems and other communications equipment, adverse weather and safe parking procedures, public affairs awareness, first responder awareness (29 CFR 1910.120 [q]), and radiation worker "B" (or equivalent) training.

The U.S. Department of Transportation also requires training specific to the mode of transportation. Highway carriers are responsible for the development and maintenance of a qualification and training program that meets Department of Transportation requirements. Rail carriers must comply with Federal Railroad Administration regulations. Rail carriers are responsible for training and qualification of their crews, which includes application of 49 CFR Part 240 for locomotive engineer certification. If DOE decided to provide federal rail crews for waste shipments on the national rail system, the carriers would require a pilot, who would be an engineer familiar with the rail territory, unless the federal engineer was qualified on that route. The Federal Railroad Administration requires recurrent and function-specific training for personnel who perform specific work, such as train crews, dispatchers, and signal maintainers. In addition, the regulations require that each employee receives training that specifically addresses the job function.

L.2.8 OTHER REQUIREMENTS

Organizations that represent different transportation modes often establish mode-specific standards. For example, all North American shipments by rail that change carriers must meet Association of American Railroads interchange rules. Equipment in interchanges must also meet the requirements of the *Association of American Railroads Field Manual of the A.A.R. Interchange Rules* (DIRS 175727-AAR 2005, all).

On May 1, 2003, the Association released Standard S-2043, *Performance Specification for Trains Used To Carry High-Level Radioactive Material* (DIRS 166338-AAR 2003, all) to establish performance guidelines and specifications for trains that carry spent nuclear fuel or high-level radioactive waste. These guidelines apply to the individual railcars within the train, and they promote communication between railroads, spent nuclear fuel and high-level radioactive waste shippers, and railcar suppliers. The objectives of this standard are (1) to provide a cask, railcar, and train system that ensures safe transportation of casks in the railroad operating environment and allows timetable speeds with limited restrictions and (2) to use the best available technology to minimize the chances of derailment in transportation. This standard reflects the current technical understanding of the railroad industry in relation to optimum vehicle performance through application of current and prospective new railcar technologies. On December 20, 2005, the Association adopted two appendixes to AAR S-2043: Appendix A, "Maintenance Standards and Recommended Practices for Trains Used To Carry High-Level Radioactive Material," and Appendix B, "Operating Standard for Trains Used To Carry High-Level Radioactive Material" (DIRS 166338-AAR 2003, all). Changes and additions to this standard can be expected as specific vehicles are developed. All future changes will be based on the achievement of optimum performance within acceptable expectations for safe operations.

Association of American Railroads Circular No. OT-55, *Recommended Railroad Operating Practices for Transportation of Hazardous Materials* (DIRS 155658-AAR 2000, all), provides recommendations on operating practices that are adopted by Association of American Railroads and American Short Line and Regional Railroad Association members in the United States for these shipments. The current revision of the circular became effective July 17, 2006; its recommendations cover road operating practices, yard operating practices, storage and separation distances, transportation community awareness and emergency response program implementation, criteria for shipper notification, time-sensitive materials, and special provisions for spent nuclear fuel and high-level radioactive waste.

The Commercial Vehicle Safety Alliance has developed inspection procedures and out-of-service criteria for commercial highway vehicles that transport shipments of transuranic elements and Highway Route-Controlled Quantities of Radioactive Materials shipments (Section L.4.9). Under these procedures, each state through which a shipment passed would inspect each shipment to the repository, and a shipment would not begin or continue until inspectors determined that the vehicle and its cargo were free of defects.

Trucks that carry spent nuclear fuel or high-level radioactive waste and weigh over 36,300 kilograms (80,000 pounds) would exceed federal commercial vehicle weight limits for nondivisible loads (which cannot be separated into smaller loads). Most states require transportation companies to obtain permits when their vehicles exceed weight limits to control time and place of movement. Local jurisdictions also often require overweight permits. The criteria for the permitting process are not uniform among different jurisdictions. A number of factors affect issuance of these permits including traffic volumes and patterns, protection of state highways and structures such as bridges, zoning and general characteristics of the route, and safety of the motoring public.

L.2.9 PROPOSED RAIL REGULATIONS

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration, in consultation with the Federal Railroad Administration, has proposed revision of the current requirements in the Hazardous Materials Regulations applicable to the safe and secure transportation of hazardous materials by rail at 49 CFR Parts 172 and 174 (71 *FR* 76834; December 21, 2006). The proposed rulemaking includes "Radioactive Materials" and "Class 7- Highway Route-Controlled Quantities of Radioactive Materials." The proposal would require rail carriers to compile annual data on specified shipments of hazardous materials, to use the data to analyze safety and security risks along rail transportation routes where those materials are transported, to assess alternative routes, and to make routing decisions based on those assessments. The Pipeline and Hazardous Materials Safety Administration has also proposed clarifications of the current security plan requirements to address en route storage, delays in transit, delivery notification, and additional security inspection requirements for hazardous materials shipments.

The Transportation Security Administration has proposed new security requirements for 49 CFR Parts 1520 and 1580 for freight railroad carriers; intercity, commuter, and short-haul passenger train service providers; rail transit systems; and rail operations at certain, fixed-site facilities that ship or receive specified hazardous materials by rail (71 *FR* 76852; December 21, 2006). The proposal would codify the scope of the existing inspection program and require regulated parties to allow Transportation Safety Administration and Department of Homeland Security officials to enter, inspect, and test property, facilities, and records relevant to rail security. This proposed rule would also require regulated parties to designate rail security coordinators and to report significant security concerns to the Department of Homeland Security.

In addition, the Transportation Security Administration has proposed that freight rail carriers and certain facilities that handle hazardous materials be able, on request, to report location and shipping information to the Administration and that they should implement chain-of-custody requirements to ensure a positive and secure exchange of specified hazardous materials (71 *FR* 76852, December 21, 2006). The proposal would clarify and extend the sensitive security information protections to cover certain information associated with rail transportation.

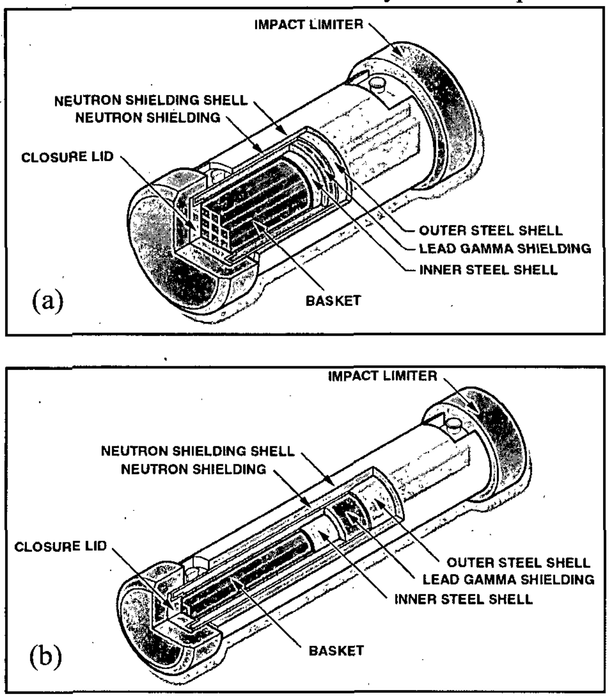

Figure L-3. Generic rail cask (a) and truck cask (b) for spent fuel.

L.3 Transportation System Components

The DOE transportation system would consist of hardware (shipping containers, handling equipment, railcars, and truck trailers), a transportation operations center, a Cask Maintenance Facility, and the Nevada rail line.

L.3.1 SHIPPING CONTAINERS

As required by the NWPA, the designs of the shipping casks for transportation of the spent nuclear fuel and high-level radioactive waste would be NRC-certified. The casks would be sealed containers that could weigh up to 180 metric tons (200 tons). The casks would consist of layers of steel and lead or other materials, which would provide shielding against the radiation from the waste and prevent the materials from escaping to the environment in the event of an incident.

The open end of the cylindrical cask would be sealed with a heavy lid. Impact limiters on each end of the cask would absorb most of the impact force and provide protection of the container and its contents in the event of an incident. Figure L-3 illustrates generic rail and truck casks.

DOE would procure NRC-certified casks from private industry. As required by Section 137 of the NWPA, DOE would use private industry to the fullest extent possible for each aspect of transportation. The Department has a preference for maximizing the use of existing cask designs rather than developing new ones. Existing cask designs would have to be modified to accommodate TAD canisters before NRC certification.

L.3.2 RAILCARS

The trains DOE would use to transport spent nuclear fuel and high-level radioactive waste to the repository would typically use locomotives, escort cars, one or more loaded cask railcars, and buffer railcars that would separate the cask railcars from occupied locomotives and escort railcars.

L.3.3 TRANSPORTATION OPERATIONS CENTER

The functions of a transportation operations center would include coordination between shipping sites and the repository, planning and scheduling of shipments, coordination with carriers, notifications to states and American Indian tribes, monitoring and tracking of shipments, en route communications, emergency management, and security coordination.

L.3.4 CASK MAINTENANCE FACILITY

Owners of rail and highway transportation casks and the associated equipment (for example, personnel barriers and impact limiters) must maintain them in proper condition to satisfy the requirements in their NRC certificates of compliance. The Cask Maintenance Facility would periodically remove casks from service and perform maintenance and inspection. The activities at the Cask Maintenance Facility would include but not be limited to testing, repair, minor decontamination, and approved modifications. The Cask Maintenance Facility would also serve as the primary recordkeeping facility for the cask fleet equipment.

L.3.5 TRANSPORT SERVICES

The U.S. freight railroad system consists of seven Class 1 railroads (mainline), 31 regional railroads, and over 500 local railroads (line-haul railroads smaller than regional railroads). Some origin sites of spent nuclear fuel and high-level radioactive waste have rail services, while others do not. DOE would use short-line or Class 1 railroads to transport casks from the origin sites. There are numerous short-line railroads that operate one or more relatively small sections of track that connect to the Class 1 rail network. Origin sites without rail service would require alternative intermodal delivery from the origin site to a nearby rail transfer facility, either by barge using a nearby dock or by heavy-haul truck using local highways.

At some sites with limited cask handling capability, DOE could use overweight trucks for smaller casks. After loading and preparation, DOE would pick up the cask and deliver it directly to the repository using the public highway network.

DOE would construct a branch rail line to transport casks from a Union Pacific mainline railroad in Nevada to the repository site, and the Department would contract the operation and maintenance of the branch rail line.

L.4 Operational Practices

DOE has adopted as policy the practices that were developed in consultation with stakeholders and are outlined in DOE Manual 460.2-1 (DIRS 171934-DOE 2002, all). The Manual establishes 14 standard transportation practices for Departmental programs to use in the planning and execution of shipments of radioactive materials including radioactive waste. It provides a standardized process and framework for planning and for interacting with state and tribal authorities and transportation contractors and carriers.

L.4.1 STAKEHOLDER INTERACTIONS

The 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) guides state and tribal government interactions, some of which are already underway. During planning and actual transportation operations, stakeholders are and would be involved in planning for route identification, funding approaches for emergency response planning and training, understanding safeguards and security requirements, operational practices, communications, and information access.

DOE is working collaboratively with states through State Regional Group committees, whose members are state officials responsible for transportation policy, law enforcement, emergency response, and oversight of hazardous materials shipments, and with American Indian tribal governments to assist them to prepare for the shipments.

In addition to coordination with State Regional Groups and tribal governments, a national cooperative effort is underway as part of the Transportation External Coordination Working Group, which involves a broad range of stakeholder organizations that routinely interact with DOE to provide input and recommendations on transportation planning and program information. DOE works with states, tribes, and industry to guide and focus emergency training, coordination with local officials, and other activities to prepare for shipments to the repository.

DOE is preparing a comprehensive national spent fuel transportation plan that accommodates stakeholder concerns to the extent practicable. The plan will outline the challenges and strategies for the development and implementation of the system required to transport the waste to Yucca Mountain.

L.4.2 ROUTE PLANNING PROCESS

An initial step in the planning process to ship spent nuclear fuel and high-level radioactive waste to Yucca Mountain is to identify a national suite of routes, both rail and highway. Stakeholder groups in the DOE program are participating in this process by examining potential routing criteria in the route identification process. State Regional Groups, tribal governments, transportation associations, industry, federal agencies, and local government organizations are some of the groups that work collaboratively with DOE in this process. DOE is performing and would perform the work through a Topic Group of the Transportation External Coordination Working Group, which would seek broader public input and collect comments on routing criteria and the process for development of a set of routes. The process includes consideration of industry practices, DOE requirements, and analysis of regional routes that states have previously evaluated in the process to identify a preliminary set of routes. Public involvement is an essential element of a safe, efficient, and flexible transportation system.

L.4.3 PLANNING AND MOBILIZATION

DOE would use the methods and requirements this section describes to establish the baseline operational organization and practices for route identification, fleet planning and acquisition, carrier interactions, and operations.

DOE would develop a Transportation Operations Plan to provide the basis for planning shipments. This plan would describe the operational strategy and delineate the steps to ensure compliance with applicable regulatory and DOE requirements. It would include information on organizational roles and responsibilities, shipment materials, projected shipping windows, estimated numbers of shipments, carriers, packages, sets of routes, prenotification procedures, safe parking arrangements, tracking systems, security arrangements, public information, and emergency preparedness, response, and recovery.

The Department would develop individual site plans to include the information necessary to ship from specific sites that included roles and responsibilities of the participants in the shipping campaign, shipment materials, schedules, number of shipments, types and number of casks and other equipment, carriers, routes, in-transit security arrangements, safe parking arrangements for rail and truck shipments, communications including prenotification, public information, tracking, contingency planning, and emergency preparedness, response, and recovery.

In addition, DOE would issue an Annual Shipment Projection at least 6 months to a year in advance of the beginning of a shipment year and would identify the sites from which it would ship spent nuclear fuel and high-level radioactive waste in a given calendar year, the expected characteristics and quantities of waste to be delivered by each site, types of casks, and anticipated numbers of casks and shipments. The Annual Shipment Projection would not define specific shipment schedules or routes, but DOE would use it for schedule and route planning.

L.4.4 DEDICATED TRAIN SERVICE POLICY

On July 18, 2005, in a policy statement (DIRS 182833-Golan 2005, all), DOE decided that dedicated train service would be the usual manner of rail shipment of commercial and DOE spent nuclear fuel and high-level radioactive waste to Yucca Mountain. Dedicated indicates train service for one commodity (in this case, spent nuclear fuel and high-level radioactive waste). Past and current shipping campaigns have used dedicated train service to address issues of safety, security, cost, and operations. Analyses indicate that the primary benefit of dedicated train service would be significant cost savings over the lifetime of transportation operations. The added cost of dedicated train service would be offset by reductions in fleet size and its attendant operations and maintenance costs. In addition, the shorter times in transit and shorter layovers at switching yards would enhance safety and security. Use of dedicated train service would provide greater operational flexibility and efficiency because of the reduced transit time and greater predictability in routing and scheduling.

L.4.5 TRACKING AND COMMUNICATION

DOE would provide authorized state and tribal governments with the capability and training to monitor shipments to the repository through their jurisdictions using a satellite tracking system, such as the Transportation Tracking and Communication System, that would provide continuous, centralized monitoring and communications capability (DIRS 172433-DOE 2003, p. 5). Trained personnel could use such a system to monitor shipment progress and communicate with the dispatch center. A transportation operations center would be in contact with the carriers and the escorts throughout each shipment. In addition, all truck and rail escort cars would have communications equipment. The train control center would manage rail communications and signaling on the branch Nevada rail line.

DOE would develop detailed backup procedures to ensure safe operations in the event that the tracking system was temporarily unavailable. The procedures would be based on a telephone call-in system for operators to report shipment locations to DOE on a regular basis and before crossing state and tribal borders.

L.4.6 TRANSPORTATION OPERATIONAL CONTINGENCIES

DOE would obtain weather forecasts along routes as part of preshipment planning, notification, and dispatching. At the time of departure, current weather conditions, the weather forecast, and expected travel conditions would have to be acceptable for safe operations. If these conditions were not acceptable, DOE could delay the shipment until travel conditions became acceptable or reroute the shipment.

Shipments would not travel during severe weather or other adverse conditions that could make travel hazardous. DOE would obtain route conditions and construction information that could temporarily affect the planned route through consultation with the railroads and states along the planned route.

DOE would receive input from states and tribes on weather conditions through the satellite tracking system known as TRANSCOM, which they would also use to monitor shipments. Rail carriers use train control and monitoring systems to identify the locations of trains and to make informed decisions to avoid or minimize potentially adverse weather or track conditions. Truck dispatch centers and the transportation operations center would coordinate on weather conditions while shipments were en route.

Continuous communications with a transportation operations center would provide advance warning of potential adverse conditions along the route. If the shipment encountered unanticipated severe weather, the operators would contact this center to coordinate routing to a safe stopping area if it became necessary to delay the shipment until conditions improved.

L.4.7 CARRIER PERSONNEL QUALIFICATIONS

Carriers would develop and maintain qualification and training programs that met U.S. Department of Transportation requirements for drivers, operators, and security personnel. For truck drivers, qualifications include being at least 21 years of age, meeting physical standards, having a commercial driver's license, and successfully completing a road driving test in the shipment vehicle. In addition, drivers must have training on the properties and hazards of the shipment materials as well as the procedures to follow in the event of an emergency. Locomotive engineers must meet the Locomotive Engineer Certification requirements of 49 CFR Part 240, which include completion of an approved training program (Section L.2.7 addresses other training requirements),

L.4.8 NOTICE OF SHIPMENTS

The NRC requires advance notice, en route status, and other pertinent shipment information on DOE shipments (10 CFR Parts 71 and 73). Section L.2.5 addresses advance notification requirements. DOE and other stakeholders would use this information to support coordination of repository receipt operations, to support emergency response capabilities, to identify weather or road conditions that could affect shipments, to identify safe stopping locations, to schedule inspections, and to coordinate appropriate public information programs.

L.4.9 INSPECTIONS

To ensure safety, DOE would inspect shipments when they left their point of origin and when they arrived at the repository to verify vehicle safety and radiological safety of the shipping casks. These inspections would include radiological surveys of radioactive material packages to ensure that they met the radiation level limits of 49 CFR 173.441 and surface contamination limits of 49 CFR 173.443. DOE would inspect rail shipments in accordance with 49 CFR 174.9 and the Federal Railroad Administration High-Level Nuclear Waste Rail Transportation Inspection Policy in Appendix A of *Safety Compliance Oversight Plan for Rail Transportation of High-Level Radioactive Waste and Spent Nuclear Fuel* (DIRS 156703-DOT 1998, all), which includes motive power, signals, track conditions, manifests, and crew credentials. DOE would inspect highway shipments using the enhanced standards of the Commercial Vehicle Safety Alliance, which provide uniform inspection procedures for radiological requirements, drivers, shipping papers, vehicles, and casks (DIRS 175725-CVSA 2005, all).

Although DOE would minimize the number of stops to the extent practicable, under federal regulations states and tribes could order additional inspections when shipments entered their respective jurisdictions. DOE would attempt to coordinate those inspections with normal crew change locations whenever possible.

L.4.10 PROCEDURES FOR OFF-NORMAL CONDITIONS

Off-normal conditions are potentially adverse conditions that do not relate to accidents, incidents, or emergencies. They include but are not limited to mechanical breakdowns, fuel problems, tracking system failure, and illness, injury, or other incapacity of a member of the truck, train, or escort crew. DOE would require carriers to provide operators with specific written procedures that define detailed actions for off-normal events. Procedures would address notifications, deployment of appropriate hazard warnings, security, medical assistance, operator or escort replacement, and maintenance, repair, replacement, or recovery of equipment, as appropriate. Procedures would also cover selection of alternative routes and safe parking areas.

L.4.11 POSTSHIPMENT RADIOLOGICAL SURVEYS

DOE would visually inspect and radiologically survey the external surfaces of a cask after shipment in accordance with U.S. Department of Transportation, DOE, and NRC regulations. Receiving facility operators would survey each cask and transporter on arrival (before unloading) and determine if there was radiological contamination in excess of the applicable limits. The inspections would include the cask, tie-downs, and associated hardware to determine if physical damage occurred during transit.

L.4.12 SHIPMENT OF EMPTY TRANSPORT CASKS

Except before their first use, shipments of all empty transportation casks would comply with the requirements of the NRC certificate of compliance or 49 CFR 173.428, which addresses empty radioactive materials packages, whichever was applicable. DOE would ship casks that did not meet the criteria for "empty" in accordance with the applicable U.S. Department of Transportation hazardous materials regulations. Advance shipment notifications and en route inspections would not apply to the shipment of empty transportation casks; however, DOE would use dedicated train service to realize the cost benefits of a decreased fleet requirement.

L.5 Cask Safety

The purpose of the NRC regulations for transportation of spent nuclear fuel and high-level radioactive waste (10 CFR Part 71) is to protect the public health and safety from normal and off-normal conditions of transport and to safeguard and secure shipments of these materials. Over the years, NRC has amended its regulations to be compatible with the latest editions of the International Atomic Energy Agency and other standards (see 69 FR 3698, January 26, 2004).

In addition to the standard testing discussed below, NRC has committed to a package performance study for the full-scale testing of a spent nuclear fuel package of the kind DOE would likely use. The Commission approved the proposed test in June 2005 (DIRS 182896-Viette-Cook 2005, all; DIRS 182897-Reyes 2005, all). According to the proposal, the package would contain surrogate fuel elements and be mounted on a railcar placed at 90 degrees to a simulated rail crossing. The rail package would be subjected to a collision with a locomotive and several freight cars at 96 kilometers (60 miles) per hour. NRC is formulating the study to give the public greater confidence in the movement of spent nuclear fuel, to provide information on the methods and processes of transportation system qualification, and to validate the applicability of NRC regulations.

Regulations in 10 CFR Part 71 require that casks for shipping spent nuclear fuel and high-level radioactive waste must be able to meet specified radiological performance criteria for normal transport and for transport under severe accident conditions. Meeting these requirements is an integral part of the safety assurance process for transportation casks. The ability of a design to withstand these conditions can be demonstrated by comparing designs to similar casks, engineering analyses (such as computer-simulated tests), or by scale-model or full-scale testing. As shown in Figure L-4, these hypothetical accident conditions include, in sequence, a 9-meter (30-foot) drop onto an unyielding flat surface, a 1-meter (40-inch) drop onto a vertical steel bar, exposure of the entire package to fire for 30 minutes, and immersion in 0.9 meter (3 feet) of water. In addition, an undamaged cask must be able to survive submersion in the equivalent pressure of 15 and 200 meters (50 and 650 feet) of water.

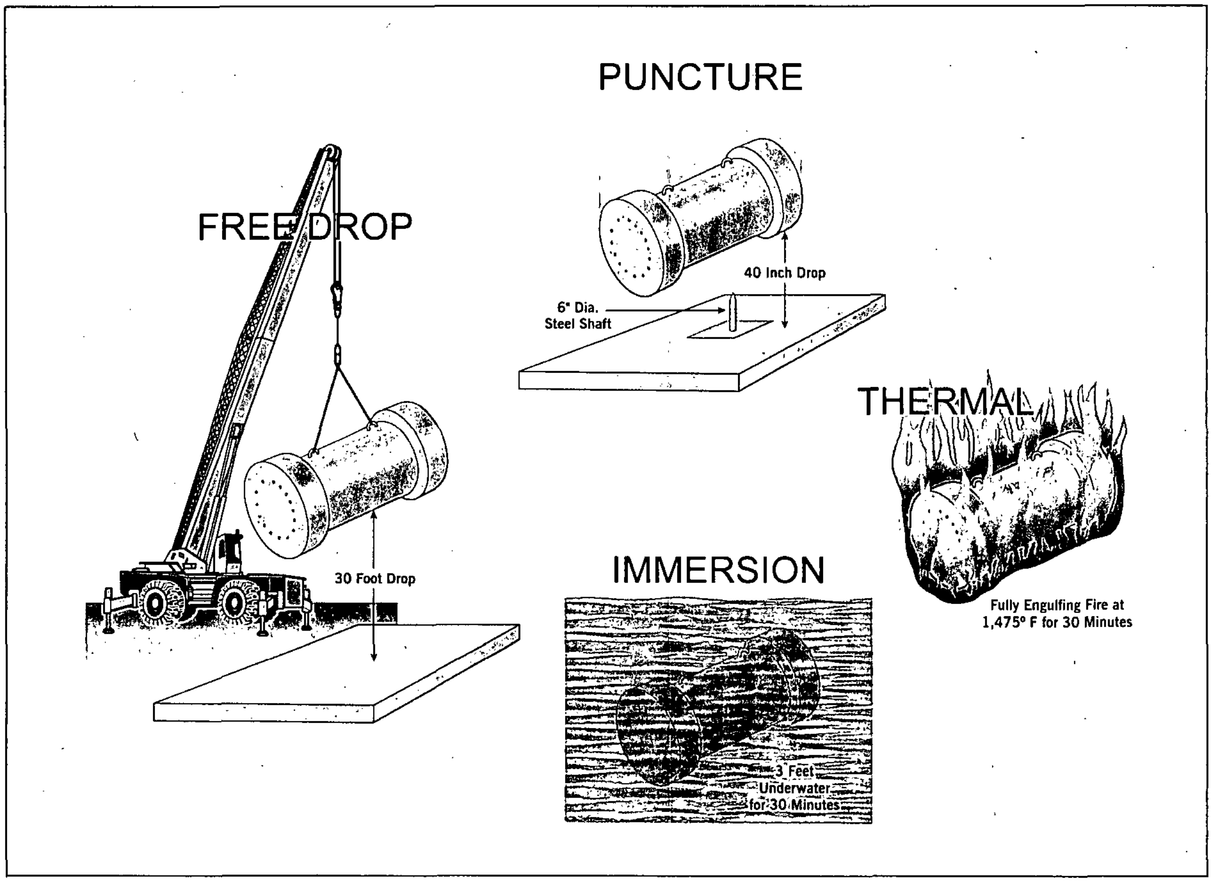

Figure L-4. Hypothetical accident conditions.

For most accidents more severe than those the hypothetical accident conditions simulate, NRC studies (DIRS 152476-Sprung et al. 2000, all; DIRS 181841-Adkins et al. 2007, all; DIRS 182014-Adkins et al. 2006, all) show that the radiological criteria for containment, shielding, and subcriticality would still be satisfied. The studies also show that for the few severe incidents in which these criteria could be exceeded, only containment and shielding would be affected, and the regulatory criteria could be exceeded only slightly. Based on the analyses of the *Final Environmental Impact Statement for a Geological Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (DIRS 155970-DOE 2002, all), casks would continue to contain spent nuclear fuel and high-level radioactive waste fully in more than 99.99 percent of all incidents (of the thousands of shipments over the last 30 years, none has resulted in an injury due to the release of radioactive materials). The following sections discuss each of these packaging performance criteria.

L.5.1 NINE-METER DROP ONTO AN UNYIELDING SURFACE

The first set of accident conditions in the sequence simulates impact and evaluation of a 9-meter (30-foot) free fall onto an unyielding surface with the cask striking the target in the most damaging orientation. The free fall results in a final velocity of 48 kilometers (30 miles) per hour. Although this velocity is less than the expected speed of interstate highway traffic, it is severe because the target surface is unyielding. This results in the cask absorbing all the energy of the drop, which is approximately equivalent to a 96-kilometer (60-mile)-per-hour impact with a medium hardness surface (such as shale or other relatively soft rock) and a 150-kilometer (90-mile)-per-hour impact with a soft surface (such as tillable soil).

L.5.2 ONE-METER DROP ONTO A STEEL BAR

The second set of accident conditions simulates a cask hitting a rod or bar-like object that could be present in an accident. This requires evaluation for a 1-meter (40-inch) drop onto a 15-centimeter (6-inch)-diameter rod on an unyielding surface. The cask must be in the orientation in which maximum damage would be likely. In addition, the bar must be long enough to cause maximum damage to the cask. This evaluates several impacts in which different parts of a cask strike the bar either by simulation or physical testing.

L.5.3 FIRE

The third set of accident conditions simulates a fire that occurs after the two impacts. This involves a hydrocarbon fire with an average flame temperature of 800°C (1,475°F) and requires the cask to be fully engulfed in the flame for 30 minutes.

L.5.4 WATER IMMERSION

The final set of accident conditions in the sequence is shallow immersion. The cask must be immersed in 0.9 meter (3 feet) of water. The purpose of this test is to ensure that water cannot leak into the cask after having passed through the challenges.

An undamaged version of the cask must also be able to survive immersion in the equivalent of 15 meters (50 feet) of water at a pressure of about 1,500 grams per square centimeter (22 pounds per square inch) to test for leakage. Furthermore, shipping casks for more than 1 million curies of radioactivity must be able to survive water pressure of about 20,000 grams per square centimeter (290 pounds per square inch) for 1 hour without collapsing, buckling, or leaking. That pressure is equivalent to a depth of about 200 meters (650 feet).

L.5.5 ACCEPTANCE CRITERIA

To be judged successful in meeting all but the 200-meter (650-foot) submersion requirement, a cask must not release more than limited amounts of radioactive material in 1 week. These release limits are set for each radionuclide based on dispersivity and toxicity. In addition, the cask must not emit radiation at a dose rate of greater than 1 rem per hour at a distance of 1 meter (3.3 feet) from the cask surface. Last, the contents of the cask must not be capable of undergoing a nuclear chain reaction, or criticality, as a result of the hypothetical accident conditions.

L.5.6 USE OF MODELS

Manufacturers can demonstrate the ability of a cask to survive these hypothetical accident conditions in several ways. They can subject a full-size model of the cask to the sequences, use smaller models of the casks (typically half- or quarter-scale), compare the cask design to previously licensed designs, or analyze the hypothetical accident scenarios with computer models. NRC approves what level of physical testing or analysis is necessary for each cask design. Because NRC generally accepts the results of scale-model testing, more expensive full-scale testing rarely occurs, although NRC sometimes requires such tests for specific cask components. For example, NRC could accept quarter-scale drop tests for a particular cask design but full-scale tests of the cask's impact limiters. Computer analysis could be sufficient for meeting the hypothetical fire and criticality control criteria.

L.6 Emergency Response

L.6.1 ROLES AND RESPONSIBILITIES

States and tribes along shipping routes have the primary responsibility for the protection of the public and environment in their jurisdictions. If an emergency that involved a DOE radioactive materials shipment occurred, incident command would be established based on the procedures and policies of the state, tribe, or local jurisdiction. When requested by civil authorities, DOE would provide technical advice and assistance including access to teams of experts in radiological monitoring and related technical areas. DOE staffs eight Regional Coordinating Offices 24 hours a day, 365 days a year with teams of nuclear engineers, health physicists, industrial hygienists, public affairs specialists, and other professionals (Section L.6.2 contains further detail on the DOE role). Under NWPA Section 180(c), DOE must provide technical assistance and funds to states for training for public safety officials of appropriate units of local government and American Indian tribes through whose jurisdiction DOE plans to transport spent nuclear fuel or high-level radioactive waste. Training must cover procedures for safe routine transportation of these materials as well as for emergency response situations.

DOE would require selected carriers to provide drivers and train crews with specific written procedures that defined detailed actions for an emergency or incident that involved property damage, injury, or the release or potential release of radioactive materials. Procedures would comply with U.S. Department of Transportation guidelines for emergency response in the 2004 *Emergency Response Guidebook* (DIRS 175728-DOT 2004, all) and would address emergency assistance to injured crew or others who were involved in identification and assessment of the situation, notification and communication requirements, securing of the site and controlling access, and technical help to first responders.

L.6.2 FEDERAL COORDINATION

The Department of Homeland Security coordinates the overall Federal Government response to radiological Incidents of National Significance in accordance with Homeland Security Presidential Directive 5 (DIRS 182271-DHS 2003, all) and the *National Response Plan* (DIRS 175729-DHS 2004, all). Based on Directive 5 criteria, an Incident of National Significance is an actual or potential high-impact event that requires a coordinated and effective response by, and appropriate combination of, federal, state, local, tribal, nongovernmental, or private-sector entities to save lives and minimize damage, and to provide the basis for long-term community recovery and mitigation activities.

In Directive 5, the President designates the Secretary of Homeland Security as the Principal Federal Official for domestic incident management and empowers the Secretary to coordinate federal resources used in response to terrorist attacks, major disasters, or other emergencies in specific cases (DIRS 182271-DHS 2003, all). The Directive establishes a single, comprehensive National Incident Management System that unifies federal, state, territorial, tribal, and local lines of government into one coordinated effort. This system encompasses much more than the Incident Command System, which is nonetheless a critical component of the National Incident Management System. That system also provides a common foundation for training and other preparedness efforts, communicating and sharing information with other responders and with the public, ordering resources to assist with a response effort, and integrating new technologies and standards to support incident management. The Incident Command System uses as its base the local first responder protocols; that use does not eliminate the required agreements and coordination among all levels of government.

In Directive 5 (DIRS 182271-DHS 2003, all), the President directed the development of the new *National Response Plan* (DIRS 175729-DHS 2004, all) to align federal coordination structures, capabilities, and resources into a unified approach to domestic incident management. The Plan is built on the template of the National Incident Management System. The Plan provides a comprehensive, all-hazards approach to domestic incident management. All federal departments and agencies must adopt the National Incident Management System and use it in their individual domestic incident management and emergency prevention, preparedness, response, recovery, and mitigation activities, as well as in support of all actions taken to assist state or local entities.

DOE supports the Department of Homeland Security as the coordinating agency for incidents that involve the transportation of radioactive materials by or for DOE. DOE is otherwise responsible for the radioactive material, facility, or activity in the incident. DOE is part of the Unified Command, which is an application of the Incident Command System for when there is more than one agency with incident jurisdiction or when incidents cross political jurisdictions. DOE coordinates the federal radiological response activities as appropriate. Agencies work together through the designated members of the Unified Command, often the senior person from agencies or disciplines that participate in the Unified Command, to establish a common set of objectives and strategies.

DOE, as the transporter of radiological material, would notify state and tribal authorities and the Homeland Security Operations Center. The Department of Homeland Security and DOE coordinate federal response and recovery activities for the radiological aspects of an incident. DOE reports information and intelligence in relation to situational awareness and incident management to the Homeland Security Operations Center.

The Department of Homeland Security and DOE are responsible for coordination of security activities for federal response operations. While spent nuclear fuel and high-level radioactive waste shipments are in transit, state, local, and tribal governments could provide security for a radiological transportation incident that occurred on public lands. The Department of Homeland Security, with DOE as the coordinating agency, approves issuance of all technical data to state, local, and tribal governments.

The Interagency Modeling and Atmospheric Assessment Center, is responsible for production, coordination, and dissemination of consequence predictions for an airborne hazardous material release. The Center generates the single federal prediction of atmospheric dispersions and their consequences using the best available resources.

Federal monitoring and assessment activities are coordinated with state, local, and tribal governments. Federal agency plans and procedures for implementation of this activity are designed to be compatible with the radiological emergency planning requirements for state and local governments, specific facilities, and existing memoranda of understanding and interagency agreements.

DOE maintains national and regional coordination offices at points of access to federal radiological emergency assistance. Requests for Radiological Assessment Program teams go directly to the DOE Emergency Operations Center in Washington, D.C. If the situation requires more assistance than a team can provide, DOE alerts or activates additional resources. DOE can respond with additional resources including the Aerial Measurement System to provide wide-area radiation monitoring and Radiation Emergency Assistance Center/Training Site medical advisory teams. Some participating federal agencies have radiological planning and emergency responsibilities as part of their statutory authority, as well as established working relationships with state counterparts. The monitoring and assessment activity, which DOE coordinates, does not alter these responsibilities but complements them by providing coordination of the initial federal radiological monitoring and assessment response activities.

The U.S. Department of Homeland Security and DOE, as the coordinating agency, oversee the development of Federal Protective Action Recommendations. In this capacity, they provide advice and assistance to state, tribal, and local governments, which can include advice and assistance on measures to avoid or reduce exposure of the public to radiation from a release of radioactive material and advice on emergency actions such as sheltering and evacuation.

State, local, and tribal governments are encouraged to follow closely the *National Response Plan* (DIRS 175729-DHS 2004, all), the Nuclear/Radiological Incident Annex, and the National Incident Management System protocols and procedures. As established, all federal, state, local and tribal responders agree to and follow the Incident Command System.

L.7 Technical Assistance and Funding for Training of State and American Indian Public Safety Officials

The NWPA requires DOE to provide technical assistance and funds to states and American Indian tribes for training public safety officials of appropriate units of local governments through whose jurisdictions the Department plans to transport spent nuclear fuel or high-level radioactive waste. Section 180(c) further provides that training must cover procedures for safe routing and emergency response situations. Section 180(c) encompasses all modes of transportation, and funding would come from the Nuclear Waste Fund. Once implemented, this program would provide funding and technical assistance to train firefighters, law enforcement officers, and other public safety officials in preparation for repository shipments through their jurisdictions.

To implement this requirement in the 1990s, DOE published four Federal Register notices to solicit public comment on its approach to implementing Section 180(c). DOE responded to the comments in subsequent notices through April 1998. In 2004, the changes in homeland security and DOE transportation practices made it timely for DOE to renew efforts to develop Section 180(c) policy and implementation procedures. DOE evaluated changes in emergency preparedness and funding for responders since 1998 as well as emergency preparedness grant programs that began after September 11, 2001. The evaluation considered programs the Department of Homeland Security and the Federal Emergency Management Agency developed and relevant DOE funding and emergency response training efforts such as the Waste Isolation Pilot Plant and Foreign Research Reactor transportation programs.

The revisitation of Section 180(c) implementation began with the formation of a Transportation External Coordination Working Group Topic Group in April 2004. DOE also worked with State Regional Groups and the Tribal Issues Topic Group of the Transportation External Coordination Working Group to solicit stakeholder input on the policy. Topic Group members wrote issue papers on specific Section 180(c) topics such as allowable activities, funding allocation method, timing and eligibility, and definitions. From these materials, DOE developed a draft policy that it issued in a Federal Register notice on July 23, 2007 (72 *FR* 40139) to request additional comments from stakeholders and the public. DOE plans to conduct a pilot test of the program and then issue the final Section 180(c) policy.

Under the proposed policy, DOE would make two grants available to eligible state and tribal governments. An initial assessment and planning grant would be available about 4 years before shipments through a jurisdiction began. Once the state or tribe completed the assessment and planning grant activities, they would be eligible for the training grant every year that shipments traveled through their jurisdiction.

L.8 Transportation Security

Transportation safeguards and security are among the highest DOE priorities as it plans for shipments of spent nuclear fuel and high-level radioactive waste to Yucca Mountain. DOE would build the security program for the shipments on the successful security program it developed and has successfully used in past decades for shipments of spent nuclear fuel to DOE facilities from foreign and domestic reactors.

An effective security program must protect members of the public near transportation routes as well as minimize potential threats to workers, and it must include security elements appropriate to each phase of transportation. DOE would continually test security procedures to identify improvements in the security system throughout transportation operations. The key elements of a secure transportation program include physical security systems, information security, materials control and accounting, personnel security, security program management, and emergency response capabilities.

DOE is working closely with other federal agencies including NRC and the Department of Homeland Security to understand and mitigate potential threats to shipments. In addition to domestic efforts, the Department is a member of the International Working Group on Sabotage for Transport and Storage Casks, which investigates the consequences of a potential act of sabotage and explores opportunities to enhance the physical protection of casks. As a result of these efforts, DOE would modify its methods and systems as appropriate between now and the time of shipments.

In coordination with other federal agencies, DOE is working with other stakeholders including state, local, and tribal governments; industry associations such as the Association of American Railroads, and technical advisory and oversight organizations such as the National Academies of Science and the Nuclear Waste Technical Review Board. This enables DOE to take advantage of the experience and practical recommendations of experts on a broad range of security-related technical, procedural, and operational matters.

L.9 Liability

The Price-Anderson Act (Section 170 of the Atomic Energy Act, as amended [42 U.S.C. 2011 *et seq.*]) provides indemnification for liability for nuclear incidents that apply to the proposed Yucca Mountain repository. The following sections address specific details or provisions of the Act.

L.9.1 THE PRICE-ANDERSON ACT

In 1957, Congress enacted the Price-Anderson Act as an amendment to the Atomic Energy Act to encourage the development of a commercial nuclear industry and to ensure prompt and equitable compensation in the event of a nuclear incident. The Price-Anderson Act establishes a system of financial protection for persons who could be liable for and persons who could be injured by a nuclear incident. The purposes of the Act are (1) to encourage growth and development of the nuclear industry through the increased participation of private industry and (2) to protect the public by ensuring that funds are available to compensate victims for damages and injuries sustained in the event of a nuclear incident. Congress renewed and amended the indemnification provisions in 1966, 1969, 1975, and 1988. The 1988 Price-Anderson Amendments Act extended the Act for 14 years until August 1, 2002 (Public Law 100-408, 102 Stat. 1066). Since then, Congress has extended the Act until December 31, 2025, and increased liability to $10.26 billion for an extraordinary nuclear occurrence (that is, any nuclear incident that causes substantial damage), subject to increase for inflation.

L.9.2 INDEMNIFICATION UNDER THE PRICE-ANDERSON ACT

For each shipper, DOE must include an agreement of indemnification in each contract that involves the risk of a nuclear incident. This indemnification (1) provides omnibus coverage of all persons who could be legally liable, (2) fully indemnifies all legal liability up to the statutory limit on such liability (currently $10.26 billion for a nuclear incident in the United States), (3) covers all DOE contractual activity that could result in a nuclear incident in the United States, (4) is not subject to the usual limitation on the availability of appropriated funds, and (5) is mandatory and exclusive.

L.9.3 COVERED AND EXCLUDED INDEMNIFICATION

The Price-Anderson Act indemnifies liability arising out of, or resulting from, a nuclear incident or precautionary evacuation, including all reasonable additional costs incurred by a state or a political subdivision of a state, in the course of responding to a nuclear incident or a precautionary evacuation. It excludes (1) claims under state or federal worker compensation acts of indemnified employees or persons who are at the site of, and in connection with, the activity where the nuclear incident occurs, (2) claims that arise out of an act of war, and (3) claims that involve certain property on the site.

L.9.4 PRICE-ANDERSON ACT DEFINITION OF A NUCLEAR INCIDENT

A nuclear incident is any occurrence, including an extraordinary nuclear occurrence, that causes bodily injury, sickness, disease, death, loss of or damage to property, or loss of use of property, that arises out of or results from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material (42 U.S.C. 2014).

L.9.5 PROVISIONS FOR PRECAUTIONARY EVACUATION

A precautionary evacuation is an evacuation of the public within a specified area near a nuclear facility or the transportation route in the case of an incident that involves transportation of source material, special nuclear material, byproduct material, spent nuclear fuel, high-level radioactive waste, or transuranic waste. It must be the result of an event that is not classified as a nuclear incident but poses an imminent danger of injury or damage from the radiological properties of such nuclear materials and causes an evacuation. The evacuation must be initiated by an official of a state or a political subdivision of a state who is authorized by state law to initiate such an evacuation and who reasonably determined that such an evacuation was necessary to protect the public health and safety.

L.9.6 AMOUNT OF INDEMNIFICATION

The Price-Anderson Act establishes a system of private insurance and federal indemnification to ensure compensation for damage or injuries suffered by the public in a nuclear incident. The current amount of $10.26 billion reflects a threshold level beyond which Congress would review the need for additional payment of claims in the case of a nuclear incident with catastrophic damage. The limit for incidents that occur outside the United States is $500 million, and the nuclear material must be owned by, and used by or under contract with, the United States.

L.9.7 INDEMNIFICATION OF TRANSPORTATION ACTIVITIES

DOE indemnifies any nuclear incident that arises in the course of any transportation activities in connection with a DOE contractual activity, including transportation of nuclear materials to and from DOE facilities.

L.9.8 COVERED NUCLEAR WASTE ACTIVITIES

The indemnification specifically includes nuclear waste activities that DOE undertakes in relation to the storage, handling, transportation, treatment, disposal of, or research and development on spent nuclear fuel, high-level radioactive waste, or transuranic waste. It would cover liability for incidents that could occur while wastes were in transit from nuclear power plants, at a storage facility, or at Yucca Mountain.

If a DOE contractor or other indemnified person was liable for the nuclear incident or a precautionary evacuation that resulted from its contractual activities, that person would be indemnified for that liability. While DOE tort liability would be determined under the Federal Tort Claims Act (28 U.S.C. Sections 1346(b), 1402(b), 2401(b), and 2671 through 2680), the Department would use contractors to transport spent nuclear fuel and high-level radioactive waste and to construct and operate a repository. Moreover, if public liability arose out of activities that the Nuclear Waste Fund supported, the Fund would pay compensation up to the maximum amount of protection. The NWPA established the fund to support federal activities for the disposal of spent nuclear fuel and high-level radioactive waste.

L.9.9 INDEMNIFICATION FOR STATE, AMERICAN INDIAN, AND LOCAL GOVERNMENTS

State, American Indian, and local governments are persons in the sense that they might be indemnified if they incur legal liability. The Price-Anderson Act defines a person as including "(1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, government agency other than [DOE or the Nuclear Regulatory] Commission, any state or any political subdivision of, or any political entity within a state, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing" (42 U.S.C. 2214). A state or a political subdivision of a state could be entitled to indemnification for legal liability, which would include all reasonable additional costs of responding to a nuclear incident or an authorized precautionary evacuation. In addition, indemnified persons could include contractors, subcontractors, suppliers, shippers, transporters, emergency response workers, health professional personnel, workers, and victims.

L.9.10 PROCEDURES FOR CLAIMS AND LITIGATION

Numerous provisions ensure the prompt availability and equitable distribution of compensation, which would include emergency assistance payments, consolidation and prioritization of claims in one federal court, channeling of liability to one source of funds, and waiver of certain defenses in the event of a large incident. The Price-Anderson Act authorizes payments for immediate assistance after a nuclear incident. In addition, it provides for the establishment of coordinated procedures for the prompt handling, investigation, and settlement of claims that result from a nuclear incident.

L.9.11 FEDERAL JURISDICTION OVER CLAIMS

The U.S. District Court for the district in which a nuclear incident occurred would have original jurisdiction "with respect to any [suit asserting] public liability...without regard to the citizenship of any party or the amount in controversy" [42 U.S.C. 2210(n)]. If a case was brought in another court, it would be removed to the U.S. District Court with jurisdiction upon motion of a defendant, NRC, or DOE.

L.9.12 CHANNELING LIABILITY TO ONE SOURCE OF FUNDS

The Price-Anderson Act channels the indemnification (that is, the payment of claims that arise from the legal liability of any person for a nuclear incident) to one source of funds. This economic channeling eliminates the need to sue all potential defendants or to allocate legal liability among multiple potential defendants. Economic channeling results from the broad definition of indemnified persons to include any person who could be legally liable for a nuclear incident. Therefore, regardless of individual legal liability for a nuclear incident that resulted from a DOE contractual activity or NRC-licensed activity, the indemnity will pay the claim.

In the hearings on the original Act, "the question of protecting the public was raised where some unusual incident, such as negligence in maintaining an airplane motor, should cause an airplane to crash into a reactor and thereby cause damage to the public. Under this bill, the public is protected and the airplane company can also take advantage of the indemnification and other proceedings" (DIRS 155789-DOE 1999, p. 12).

L.9.13 LEGAL LIABILITY UNDER STATE TORT LAW

The Price-Anderson Act does not define legal liability, but the legislative history clearly indicates that state tort law determines the covered legal liabilities (DIRS 155789-DOE 1999, p. A-6). In 1988, public liability action was defined to state explicitly that "the substantive rules for decision in such action shall be derived from the law of the state in which the nuclear incident involved occurs, unless such law is inconsistent with the provisions of [Section 2210 of Title 42]" (42 U.S.C. 2014).

L.9.14 PROVISIONS WHERE STATE TORT LAW MAY BE WAIVED

The Price-Anderson Act includes provisions to minimize protracted litigation and to eliminate the need to prove the fault of or to allocate legal liability among various potential defendants. Certain provisions of state law may be superseded by uniform rules that the Act prescribes, such as a limitation on punitive damages. In the case of an extraordinary nuclear occurrence, the Act imposes strict liability by requiring the waiver of any defenses in relation to conduct of the claimant or fault of any indemnified person. Such waivers would result, in effect, in strict liability, the elimination of charitable and governmental immunities, and the substitution of a 3-year discovery rule in place of statutes of limitations that would normally bar all suits after a specified number of years.

L.9.15 COVERAGE AVAILABLE FOR INCIDENTS IF THE PRICE-ANDERSON ACT DOES NOT APPLY

If an incident does not involve the actual release of radioactive materials or a precautionary evacuation is not authorized, Price-Anderson Act indemnification does not apply. If the indemnification does not apply, liability is determined under state law, as it would be for any other type of transportation incident. Private insurance could apply. As noted above, however, the Act would cover all DOE contracts for transportation of spent nuclear fuel and high-level radioactive waste to a repository for nuclear incidents and precautionary evacuations. Indemnified persons under that DOE contractual activity would include the contractors, subcontractors, suppliers, state, American Indian, and local governments, shippers and transporters, emergency response workers, and all other workers and victims.

Carriers would have private insurance to cover liability from a nonnuclear incident and for environmental restoration for such incidents. The Motor Carrier Act (42 U.S.C. 10927) and its implementing regulations (49 CFR Part 387) require all motor vehicles that carry spent nuclear fuel or high-level radioactive waste to maintain financial responsibility of at least $5 million. Federal law does not require rail, barge, or air carriers of radioactive materials to maintain liability coverage, but these carriers often voluntarily cover such insurance. Private insurance policies often exclude coverage of nuclear incidents. Therefore, private insurance policies generally apply only to the extent that the Price-Anderson Act is not applicable.

L.10 National Academy of Sciences Findings and Recommendations

In 2006, the National Academy of Sciences Committee on Transportation of Radioactive Waste issued *Going the Distance? The Safe Transport of Spent Nuclear and High-Level Radioactive Waste in the United States* (DIRS 182032-National Research Council 2006, all). The following sections provide the findings and recommendations from this report that are relevant to the Rail Alignment EIS along with a discussion of the DOE position on or approach to the aspects of the findings and recommendations.

L.10.1 TRANSPORTATION SAFETY AND SECURITY

Principal Academy Finding on Transportation Safety

> The committee could identify no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. Transport by highway (for small-quantity shipments) and by rail (for large-quantity shipments) is, from a technical viewpoint, a low-radiological-risk activity with manageable safety, health, and environmental consequences when conducted with strict adherence to existing regulations. However, there are a number of social and institutional challenges to the successful initial implementation of large-quantity shipping programs that will require expeditious resolution as described in this report. Moreover, the challenges of sustained implementation should not be underestimated.

DOE agrees that the transportation of spent nuclear fuel and high-level radioactive waste has a low radiological risk with manageable safety. DOE also agrees that there are social and institutional challenges, but the Department believes it would meet these challenges successfully through a process that has transportation safety as its priority.

Principal Academy Finding on Transportation Security

> Malevolent acts against spent fuel and high-level waste shipments are a major technical and societal concern, especially following the September 11, 2001, terrorist attacks on the United States. The committee judges that some of its recommendations for improving transportation safety might also enhance transportation security. The Nuclear Regulatory Commission is undertaking a series of security studies, but the committee was unable to perform an in-depth technical examination of transportation security because of information constraints.

Academy Recommendation

> An independent examination of the security of spent fuel and high-level waste transportation should be carried out prior to the commencement of large-quantity shipments to a federal repository or to interim storage. This examination should provide an integrated evaluation of the threat environment, the response of packages to credible malevolent acts, and operational security requirements for protecting spent fuel and high-level waste while in transport. This examination should be carried out by a technically knowledgeable group that is independent of the government and free from institutional and financial conflicts of interest. This group should be given full access to the necessary classified documents and Safeguards Information to carry out this task. The findings and recommendations from this examination should be made available to the public to the fullest extent possible.

Transportation safeguards and security are among DOE's highest priorities as it plans for shipments of spent nuclear fuel and high-level radioactive waste to the proposed repository. The Department would build the security program for the repository shipments on the security program that it has developed and successfully used in past decades for shipments of spent nuclear fuel to DOE facilities from foreign and domestic reactors.

An effective security program must protect members of the public near transportation routes as well as potential threats to workers, and it must include security elements appropriate to each phase of transportation. Continual testing of security procedures would result in improvements in the security system through completion of transportation operations for Yucca Mountain. The most important elements of a secure transportation program include physical security systems, information security, materials control and accounting, personnel security, security program management, and emergency response capabilities.

DOE is working closely with other Federal agencies including the NRC, and the U.S. Department of Homeland Security, and the Transportation Security Agency to understand and eliminate potential threats to repository shipments. In addition to its domestic efforts, the Department is a member of the International Working Group on Sabotage for Transport and Storage Casks, which is investigating the consequences of a potential act of sabotage and is exploring opportunities to enhance the physical protection of casks. As a result of these efforts, DOE would modify its methods and systems as appropriate between now and the time of shipments.

In coordination with other Federal agencies, DOE is working with other stakeholders including state, tribal, and local governments; industry associations such as the Association of American Railroads and technical advisory and oversight organizations such as the National Academy of Sciences and the Nuclear Waste Technical Review Board. This allows DOE to take advantage of the experience and practical recommendations of experts on a broad range of security-related technical, procedural, and operational matters.

L.10.2 TRANSPORTATION RISK

Academy Finding

> There are two types of transportation risk: health and safety risks and social risks. The health and safety risks arise from the potential exposure of transportation workers as well as other people who travel, work, or live near transportation routes to radiation that may be emitted or released from these loaded packages. Social risks arise from social processes and human perceptions and can have both direct socioeconomic impacts and perception-based impacts.
>
> There are two potential sources of radiological exposures from transporting spent fuel and high-level waste: (1) radiation shine from spent fuel and high-level waste transport packages under normal transport conditions; and (2) potential increases in radiation shine and release of radioactive materials from transport packages under accident conditions that are severe enough to compromise fuel element and package integrity. The radiological risks associated with the transportation of spent fuel and high-level waste are well understood and are generally low, with the possible exception of risks from releases in extreme accidents involving very long duration, fully engulfing fires. While the likelihood of such extreme accidents appears to be very small, their occurrence cannot be ruled out based on historical accident data for other types of hazardous material shipments. However, the likelihood of occurrence and consequences can be reduced further through relatively simple operational controls and restrictions and route-specific analyses to identify and mitigate hazards that could lead to such accidents.

Academy Recommendation

To address radiological risk, the NAS stated there were clear transportation operations and safety advantages to be gained from shipping older (i.e. radiologically and thermally cooler) spent fuel first.

Transportation planners and managers should undertake detailed surveys of transportation routes to identify potential hazards that could lead to or exacerbate extreme accidents involving very long duration, fully engulfing fires. Planners and managers should also take steps to avoid or mitigate such hazards before the commencement of shipments or shipping campaigns.

The Rail Alignment EIS evaluated the radiological risks of transportation accidents and found these risks to be very low, as did the Yucca Mountain FEIS. In addition, NRC has evaluated the response of spent nuclear fuel casks to the environments that existed during the Baltimore tunnel fire and the Caldecott tunnel fire, which would be representative of long duration, fully engulfing fires. These evaluations show that releases of radioactive material during these types of events, if they occurred at all, would be very small. Based on recommendations from the NRC, the Association of American Railroads has modified its operating standards to prohibit trains that carry flammable materials from being in a tunnel at the same time as a train that carries spent fuel. This administrative adjustment addresses some of the concerns of the Academy.

An initial step in the planning process to ship spent nuclear fuel and high-level radioactive waste to the Yucca Mountain repository would be to identify a national suite of rail and highway routes. Stakeholder groups in the DOE transportation program are participating in this process by examining routing criteria that DOE could use in the route identification process. State Regional Groups, American Indian tribes, transportation associations, industry, Federal agencies, and local government organizations are some of the groups that work collaboratively with DOE in this process.

Academy Finding

The social risks for spent fuel and high-level waste transportation pose important challenges to the successful implementation of programs for transporting spent fuel and high-level waste in the United States. Such risks have received substantially less attention than health and safety risks, and some are difficult to characterize. Current research and practice suggest that transportation planners and managers can take early proactive steps to characterize, communicate, and manage the social risks that arise from their operations. Such steps may have additional benefits: they may increase the openness and transparency of transportation planning and programs; build community capacity to mitigate these risks; and possibly increase trust and confidence in transportation programs.

Academy Recommendation

Transportation implementers should take early and proactive steps to establish formal mechanisms for gathering high-quality and diverse advice about social risks and their management on an ongoing basis. The committee makes two recommendations for the establishment of such mechanisms for the Department of Energy's program to transport spent fuel and high-level waste to a federal repository at Yucca Mountain: (1) expand the membership and scope of an existing advisory group (Transportation External Coordination Working Group; see Chapter 5) to obtain outside advice on social risk, including impacts and management; and (2) establish a transportation risk advisory group that is explicitly designed to provide advice on characterizing, communicating, and mitigating the social, security, and health and safety risks that arise from the transportation of spent fuel and high-level waste to a federal repository or interim storage. This group should be comprised of risk experts and practitioners drawn from the relevant technical and social science disciplines and should be convened under the Federal Advisory Committee Act or a similar arrangement to enhance the openness of its operations. Its members should receive security clearances to facilitate access to appropriate transportation security information. The existing federal Nuclear Waste Technical Review Board, which will cease operations no later than one year after the Department of Energy begins disposal of spent fuel or high-level waste in a repository, could be broadened to serve this function.

DOE has reviewed the Academy recommendation on involving social scientists in the Transportation External Coordination Working Group and on expert panels, and the Department has contacted some panel members to explore opportunities for future studies. DOE has sponsored studies by social scientists in the past on risk perception about transportation of radioactive materials and adjusted its programs to focus on local officials and support for emergency planning and training as a result. The Department needs to update this study and is in the process of reviewing literature to understand gaps in research to address some of the most pressing transportation issues. In addition, DOE has proposed a topic group within the Transportation External Coordination Working Group to address social risks. The Working Group membership has not yet indicated if that is an area they want to focus on at this time.

L.10.3 CURRENT CONCERNS ABOUT TRANSPORTATION OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

L.10.3.1 Package Performance

Academy Finding

Transportation packages play a crucial role in the safety of spent fuel and high-level radioactive waste shipments by providing a robust barrier to the release of radiation and radioactive material under both normal transport and accident conditions. International Atomic Energy Agency package performance standards and associated Nuclear Regulatory Commission regulations are adequate to ensure package containment effectiveness over a wide range of transport conditions, including most credible accident conditions. However, recently published work suggests that extreme accident scenarios involving very long duration, fully engulfing fires might produce thermal loading conditions sufficient to compromise containment effectiveness. The consequences of such thermal loading conditions for containment effectiveness are the subject of ongoing investigations by the Nuclear Regulatory Commission and other parties, and this work is improving the understanding of package performance. Nonetheless, additional analyses and experimentation are needed to demonstrate a bounding-level understanding of package performance in response to very long duration, fully engulfing fires for a representative set of package designs.

Academy Recommendation

The Nuclear Regulatory Commission should build on recent progress in understanding package performance in very long duration fires. To this end, the agency should undertake additional analyses of very long duration fire scenarios that bound expected real world accident conditions for a representative set of package designs that are likely to be used in future large-quantity shipping programs. The objectives of these analyses should be to:

- Understand the performance of package barriers (spent fuel cladding and package seals);
- Estimate the potential quantities and consequences of any releases of radioactive material; and
- Examine the need for regulatory changes (e.g., package testing requirements) or operational changes (e.g., restrictions on trains carrying spent fuel) either to help prevent accidents that could lead to such fire conditions or to mitigate their consequences.

Strong consideration should also be given to performing well-instrumented tests for improving and validating the computer models used for carrying out these analyses, perhaps as part of the full-scale test planned by the Nuclear Regulatory Commission for its package performance study. Based on the results of these investigations, the Commission should implement operational controls and restrictions on spent fuel and high-level radioactive waste shipments as necessary to reduce the chances that such fire conditions might be encountered in service. Such effective steps might include, for example, additional operational restrictions on trains carrying spent fuel and high-level radioactive waste to prevent co-location with trains carrying flammable materials in tunnels, in rail yards, and on sidings.

As Section L.10.2 notes, NRC has addressed operating restrictions for tunnels by working with the Association of American Railroads to adjust rail operating practices. In addition, DOE has committed to supporting the NRC Package Performance Study to better understand severe accidents.

Academy Finding

The committee strongly endorses the use of full-scale testing to determine how packages will perform under both regulatory and credible extra-regulatory conditions. Package testing in the United States and many other countries is carried out using good engineering practices that combine state-of-the-art structural analyses and physical tests to demonstrate containment effectiveness. Full-scale testing is a very effective tool both for guiding and validating analytical engineering models of package performance and for demonstrating the compliance of package designs with performance requirements. However, deliberate full-scale testing of packages to destruction through the application of forces that substantially exceed credible accident conditions would be marginally informative and is not justified given the considerable costs for package acquisitions that such testing would require.

Academy Recommendation

Full-scale package testing should continue to be used as part of integrated analytical, computer simulation, scale-model, and testing programs to validate package performance.

> Deliberate full-scale testing of packages to destruction should not be required as part of this integrated analysis or for compliance demonstrations.

DOE would use NRC-certified casks for transportation of spent nuclear fuel and high-level radioactive waste to the proposed repository. Cask vendors would supply these NRC-certified casks to DOE under contractual requirements. To obtain the certificate, the vendors would conduct testing as NRC specifies.

L.10.3.2 Route Selection for Research Reactor Spent Fuel Transport

Academy Finding

> The Department of Energy's procedures for selecting routes within the United States for shipments of foreign research reactor spent fuel appear on the whole to be adequate and reasonable. These procedures are risk informed; they make use of standard risk assessment methodologies in identifying a suite of potential routes and then make final route selections by taking into account security, state and tribal preferences, and information from states and tribes on local transport conditions. The Department of Energy's procedures reflect the agency's position (which is consistent with Department of Transportation regulations) that the states are competent and responsible for selecting highway routes. For rail route selection, the Department of Energy's practice of negotiating routes with carriers in consultation with states is analogous to its interaction with states on highway routing.

Academy Recommendation

> The Department of Energy should continue to ensure the systematic, effective involvement of states and tribal governments in its decisions involving routing and scheduling of foreign and DOE research reactor spent fuel shipments.

For shipments to the repository, DOE would use its 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) to guide interactions with state and tribal governments. During planning and actual transportation operations, DOE would involve these stakeholders in route identification, funding approaches for emergency response planning and training, understanding safeguards and security requirements, operational practices, and communications and information access.

DOE is working collaboratively with states through State Regional Group committees (whose members are state officials responsible for transportation policy, law enforcement, emergency response, and oversight of hazardous materials shipments) and with American Indian tribal governments to assist them to prepare for the shipments.

In addition to State Regional Group and tribal coordination, a national cooperative effort is underway as part of the Transportation External Coordination Working Group and its various Topic Groups, which involves a broad range of stakeholder organizations that routinely interact with DOE to provide input and recommendations on transportation planning and program information. States, tribes, and industry are working with DOE to guide and focus emergency training, coordination with local officials, and other transportation activities to prepare for shipments to the repository.

Academy Finding

> Highway routes for shipment of spent nuclear fuel are dictated by DOT regulations (49 CFR Part 397). The regulations specify that shipments normally must travel by the

fastest route using highways designated by the states or the federal government. They do not require the carrier or shipper to evaluate risks of portions of routes that meet this criterion. These regulations are a satisfactory means of ensuring safe transportation, provided that the shipper actively and systematically consults with the states and tribes along potential routes and that states follow the route designation procedures prescribed by the DOT.

Academy Recommendation

DOT should ensure that states that designate routes for shipment of spent nuclear fuel rigorously comply with its regulatory requirement that such designations be supported by sound risk assessments. DOT and DOE should ensure that all potentially affected states are aware of and prepared to fulfill their responsibilities regarding highway route designations.

DOE is working collaboratively with states through State Regional Group committees (whose members are state officials responsible for transportation policy, law enforcement, emergency response, and oversight of hazardous materials shipments) and with American Indian tribal governments to assist them to prepare for the shipments.

As part of the routing discussions, DOE has provided training to officials of these stakeholders on its routing model (TRAGIS; DIRS 181276-Johnson and Michelhaugh 2003, all) and the risk model (RADTRAN 5; DIRS 150898-Neuhauser and Kanipe 2000, all). If states or tribes choose to designate alternative highway routes, technical assistance is available from the experts at the national laboratories who manage these two models. In addition, State Regional Group staff support their states with routing assistance as part of the cooperative efforts DOE supports.

L.10.4 FUTURE CONCERNS FOR TRANSPORTATION OF SPENT FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

L.10.4.1 Mode for Transporting Spent Fuel and High-Level Radioactive Waste to a Federal Repository

Academy Finding

Transport of spent fuel and high-level waste by rail has clear safety, operational, and policy advantages over highway transport for large-quantity shipping programs. The committee strongly endorses DOE's selection of the "mostly rail" option for the Yucca Mountain transportation program for the following reasons:

- It reduces the total number of shipments to the federal repository by roughly a factor of five, which reduces the potential for routine radiological exposures, conventional traffic accidents, and severe accidents.
- Rail shipments have a greater physical separation from other vehicular traffic and reduced interactions with people along transportation routes, which also contributes to safety.
- Operational logistics are simpler and more efficient.
- There is a clear public preference for this option.

The committee does not endorse the development of an extended truck transportation program to ship spent fuel cross-country or within Nevada should DOE fail to complete construction of the Nevada rail spur or procure the necessary rail equipment by the time the federal repository is opened.

Academy Recommendation

DOE should fully implement its mostly rail decision by completing construction of the Nevada rail spur, obtaining the needed rail packages and conveyances, and working with commercial spent fuel owners to ensure that facilities are available at plants to support this option. These steps should be completed before DOE commences the large-quantity shipment of spent fuel and high-level waste to a federal repository to avoid the need to procure infrastructure and construct facilities to support an extended truck transportation program. DOE should also examine the feasibility of further reducing its needs for cross-country truck shipments of spent fuel through the expanded use of intermodal transportation (i.e., combining heavy-haul truck, legal-weight truck, and barge) to allow the shipment of rail packages from plants that do not have direct rail access.

In the Rail Alignment EIS, DOE analyzed the intermodal transfer of rail casks for generator sites that do not have direct rail access. The SEIS analysis identified nine such sites from which DOE would ship spent nuclear fuel or high-level radioactive waste using 2,650 truck shipments. In addition, DOE's transportation operational planning recognizes the value of barge and some heavy-haul truck shipments to maximize rail use to ship to the repository. DOE would address all modes of transportation in future transportation campaign plans.

L.10.4.2 Route Selection for Transportation to a Federal Repository

Academy Finding

DOE has not made public a specific plan for selecting rail and highway routes for transporting spent fuel and high-level waste to a federal repository. DOE also has not determined the role of its program management contractors in selecting routes or specific plans for collaborating with affected states, tribes, and other parties.

Academy Recommendation

DOE should identify and make public its suite of preferred highway and rail routes for transporting spent fuel and high-level waste to a federal repository as soon as practicable to support state, tribal, and local planning, especially for emergency responder preparedness. DOE should follow the practices of its foreign research reactor spent fuel transport program of involving states and tribes in these route selections to obtain access to their familiarity with accident rates, traffic and road conditions, and emergency responder preparedness within their jurisdictions. Involvement by states and tribes may improve the public acceptability of route selections and may reduce conflicts that can lead to program delays.

An initial step in the DOE planning process to ship spent nuclear fuel and high-level radioactive waste to the proposed Yucca Mountain repository would be to identify a national suite of routes, both rail and highway, that DOE could use. Stakeholder groups are participating with DOE in this process by examining routing criteria the Department could use in the route identification process. State Regional Groups, American Indian tribes, transportation associations, industry, federal agencies, and local government organizations are some of the groups that work collaboratively with DOE in this process. The work would be conducted through a topic group of the Transportation External Coordination Working Group. Broader public input would also be sought to collect comments on routing criteria and the process for developing a set of routes. Industry practices, DOE requirements, and analyses of regional routes that were evaluated by state organizations would be included in the process to identify a preliminary set of routes. Public involvement is central to contributing to a safe, efficient, and flexible transportation system.

L.10.4.3 Use of Dedicated Trains for Transport to a Federal Repository

Academy Finding

Studies carried out to date on transporting spent fuel by dedicated versus general trains have failed to show a clear radiological risk based advantage for either option. However, the committee finds that there are clear operational, safety, security, communications, planning, programmatic, and public preference advantages that favor dedicated trains. The committee strongly endorses DOE's decision to transport spent fuel and high-level waste to a federal repository using dedicated trains.

Academy Recommendation

DOE should fully implement its dedicated train decision before commencing the large-quantity shipment of spent fuel and high-level waste to a federal repository to avoid the need for a stop gap shipping program using general trains.

DOE made a decision to use dedicated trains for its usual mode of shipment, which offers benefits that include efficient use of casks and rail cars, lower dwell time in rail yards and, in combination with other service features, direct service from origin to destination. DOE agrees with the Academy's recommendation.

L.10.4.4 Acceptance Order for Commercial Spent Fuel Transport to a Federal Repository

Academy Finding

The order for accepting commercial spent fuel that is mandated by the Nuclear Waste Policy Act (NWPA) was not designed with the transportation program in mind. In fact, the acceptance order prescribed by the NWPA could require DOE to initiate its transportation program with long cross-country movements of younger (i.e., radiologically and thermally hotter) spent fuel from multiple commercial sites. There are clear transportation operations and safety advantages to be gained from shipping older (i.e., radiologically and thermally cooler) spent fuel first and for initiating the transportation program with relatively short, logistically simple movements to gain experience and build operator and public confidence.

Academy Recommendation

DOE should negotiate with commercial spent fuel owners to ship older fuel first to a federal repository or federal interim storage, except in cases (if any) where spent fuel storage risks at specific plants dictate the need for more immediate shipments of younger fuel. Should these negotiations prove to be ineffective, Congress should consider legislative remedies. Within the context of its current contracts with commercial spent fuel owners, DOE should initiate transport through a pilot program involving relatively short, logistically simple movements of older fuel from closed reactors to demonstrate the ability to carry out its responsibilities in a safe and operationally effective manner. DOE should use the lessons learned from this pilot activity to initiate its full-scale transportation program from operating reactors.

The terms of the "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste" (10 CFR Part 961) require DOE to assign priority to those generator sites whose fuel was discharged earliest. This is usually called the "Oldest Fuel First" priority. DOE must pick up fuel from sites that were designated by those generators as those with the oldest fuel regardless of the location. At sites that were designated by the generators who own the oldest spent nuclear fuel, DOE must pick up fuel the generators have selected and that has cooled for at least 5 years.

Regardless of which fuel DOE would ship first, it would conduct the shipments safely in NRC-certified casks for that type of fuel.

L.10.4.5 Emergency Response Planning and Training

Academy Finding

Emergency responder preparedness is an essential element of safe and effective programs for transporting spent fuel and high-level waste. Emergency responder preparedness has so far received limited attention from DOE, states, and tribes for the planned transportation program to the federal repository. DOE has the opportunity to be innovative in carrying out its responsibilities for emergency responder preparedness. Emergency responders are among the most trusted members of their communities. Well-trained responders can become important emissaries for DOE's transportation program in local communities and can enhance community preparedness to respond to other kinds of emergencies.

Academy Recommendation

DOE should begin immediately to execute its emergency responder preparedness responsibilities defined in Section 180(c) of the Nuclear Waste Policy Act. In carrying out these responsibilities, DOE should proceed to (1) establish a cadre of professionals from the emergency responder community who have training and comprehension of emergency response to spent fuel and high-level waste transportation accidents and incidents; (2) work with the Department of Homeland Security to provide consolidated "all-hazards" training materials and programs for first responders that build on the existing national emergency response platform; (3) include trained emergency responders on the escort teams that accompany spent fuel and high-level waste shipments; and (4) use emergency responder preparedness programs as an outreach mechanism to communicate broadly about plans and programs for transporting spent fuel and high-level waste to a federal repository with communities along planned shipping routes.

The NWPA requires DOE to provide technical assistance and funds to states and American Indian tribes for training public safety officials of appropriate units of local governments through whose jurisdictions the Department plans to transport spent nuclear fuel or high-level radioactive waste. Section 180(c) further provides that training cover procedures required for safe routing transportation of these materials, as well as procedures for dealing with emergency response situations. Section 180(c) indicates that funding for work under this subsection would come from the Nuclear Waste Fund. Once implemented, this program would provide the increment of funding and technical assistance necessary to train fire fighters, law enforcement officers, and other public safety officials in preparation for repository shipments through their jurisdictions.

To implement this requirement in the 1990s, DOE published four *Federal Register* notices soliciting public comments on its approach to implementing Section 180(c). Comments received in response to these notices were addressed in each subsequent Federal Register notice with the last notice issued in April 1998. In 2004, the changes in homeland security and DOE's transportation practices made it timely for DOE to renew efforts to develop Section 180(c) policy and implementation procedures. Changes in emergency preparedness and funding for responders since 1998 were reviewed and evaluated as well as emergency preparedness grant programs initiated after September 11, 2001. Programs developed by Department of Homeland Security and the Federal Emergency Management Agency were considered. Relevant DOE funding and emergency response training efforts such as the Waste Isolation Pilot Plant and Foreign Research Reactor transportation programs were also evaluated.

DOE's revisiting of Section 180(c) implementation began with the formation of the Transportation External Coordination Working Group 180(c) Topic Group in April 2005. DOE also worked with the state regional groups and the Tribal Issues Topic Group of the Transportation External Coordination Working Group to solicit stakeholder input on the policy. Topic Group members wrote issue papers on specific Section 180(c) topics such as allowable activities, funding allocation method, timing and eligibility, and definitions. From these materials, DOE developed a draft policy which it issued in a Federal Register Notice on July 23, requesting additional comments from stakeholders and the public. DOE plans to conduct a pilot to test the program, and then issue the final Section 180(c) Policy.

Under the proposed policy, two grants would be made available to eligible state and tribal governments. An initial assessment and planning grant would be available about four years prior to shipments commencing through a jurisdiction. Once the state or tribe completes the assessment and planning grant activities, they would be eligible for the training grant every year that shipments travel through their jurisdiction.

L.10.4.6 Information Sharing and Openness

Academy Finding

There is a conflict between the open sharing of information on spent fuel and high-level waste shipments and the security of transportation programs. This conflict is impeding effective risk communication and may reduce public acceptance and confidence. Post-September 11, 2001, efforts by transportation planners, managers, and regulators to further restrict information about spent fuel shipments make it difficult for the public to assess the safety and security of transportation operations.

Academy Recommendation

The Department of Energy, Department of Homeland Security, Department of Transportation, and Nuclear Regulatory Commission should promptly complete the job of developing, applying, and disclosing consistent, reasonable, and understandable criteria for protecting sensitive information about spent fuel and high-level waste transportation. They should also commit to the open sharing of information that does not require such protection and should facilitate timely access to such information: for example, by posting it on readily accessible Web sites.

Interactions with state and tribal governments would be guided by the Office of Civilian Radioactive Waste Management 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). During planning and actual transportation operations, states, tribes, industry, and other key stakeholders would be involved in route identification, funding approaches for emergency response planning and training, understanding safeguards and security requirements, operational practices, and communications and information access.

In addition to key stakeholder organizations and groups, the public has access to transportation information through the DOE web page and through the Transportation External Coordination Working Group web page. These two mechanisms allow program information that should be shared reach a broad audience.

L.10.4.7 Organizational Structure of the Federal Transportation Program

Academy Finding

Successful execution of DOE's program to transport spent fuel and high-level waste to a federal repository will be difficult given the organizational structure in which it is embedded, despite the high quality of many current program staff. As currently structured, the program has limited flexibility over commercial spent fuel acceptance order (Section 5.2.4); it also has limited control over its budget and is subject to the annual federal appropriations process, both of which affect the program's ability to plan for, procure, and construct the needed transportation infrastructure. Moreover, the current program may have difficulty supporting what appears to be an expanding future mission to transport commercial spent nuclear fuel for interim storage or reprocessing. In the committee's judgment, changing the organizational structure of this program will improve its chances for success.

Academy Recommendation

The Secretary of Energy and the U.S. Congress should examine options for changing the organizational structure of the Department of Energy's program for transporting spent fuel and high-level waste to a federal repository. The following three alternative organizational structures, which are representative of progressively greater organizational change, should be specifically examined: (1) a quasi-independent DOE office reporting directly to upper-level DOE management; (2) a quasi-government corporation; or (3) a fully private organization operated by the commercial nuclear industry. The latter two options would require changes to the Nuclear Waste Policy Act. The primary objectives in modifying the structure should be to give the transportation program greater planning authority; greater budgetary flexibility to make the multiyear commitments necessary to plan for, procure, and construct the necessary transportation infrastructure; and greater flexibility to support an expanding future mission to transport spent fuel and high-level waste for interim storage or reprocessing. Whatever structure is selected, the organization should place a strong emphasis on operational safety and reliability and should be responsive to social concerns.

The NWPA defines the Federal Government's responsibilities for disposal of spent nuclear fuel and high-level radioactive waste. The NWPA created the Office of Civilian Radioactive Waste Management within DOE to carry out these responsibilities, which include the development of a transportation system. The Act requires the Office to maximize use of the private sector to implement its transportation responsibilities. That collaborative development effort is underway, and would continue until the law changed.

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APPENDIX M

CULTURAL RESOURCES PROGRAMMATIC AGREEMENT

QA:N/A

MOL.20060531.0087

**PROGRAMMATIC AGREEMENT
AMONG
THE U.S. DEPARTMENT OF INTERIOR BUREAU OF LAND MANAGEMENT, NEVADA (BLM);
THE U.S. DEPARTMENT OF ENERGY (DOE);
SURFACE TRANSPORTATION BOARD (STB);
AND
THE NEVADA STATE HISTORIC PRESERVATION OFFICE (SHPO)
REGARDING THE NEVADA RAIL PROJECT (NRP)**

WHEREAS, Congress directed the United States Department of Energy (DOE) to characterize and evaluate the suitability of Yucca Mountain as a potential site for a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste, and if appropriate, construct and operate the facility; and

WHEREAS, on July 23, 2002, the President signed into law (PL107–200) a joint resolution of the U.S. House of Representatives and the U.S. Senate designating the Yucca Mountain site in Nye County, Nevada, for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste; and

WHEREAS, in the event the Nuclear Regulatory Commission authorizes construction of the repository and receipt and possession of spent nuclear fuel and high-level radioactive waste at Yucca Mountain, DOE would be responsible for transporting these materials to the Yucca Mountain Repository as part of its obligations under the Nuclear Waste Policy Act; and

WHEREAS, on April 8, 2004, DOE selected the mostly rail transportation scenario analyzed in the "Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada," as the transportation mode both on a national basis and in the State of Nevada; and

WHEREAS, on April 8, 2004, DOE selected the Caliente rail corridor in which to examine potential alignments for construction of a rail line; and

WHEREAS, the BLM and DOE have determined that the proposed NRP in Southern Nevada may have an effect upon properties eligible for inclusion in the National Register of Historic Places (NRHP), and have consulted with the Nevada SHPO pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA); and

WHEREAS, BLM may issue a rail line right-of-way for the NRP across BLM managed lands; and

WHEREAS, this Programmatic Agreement (PA) covers all aspects of the planning, construction, and operation of the NRP, including but not limited to the rail alignment, sidings, staging area, borrow, ballast, or quarry pits, access roads, the construction zone, extra work areas, and all ancillary facilities;

WHEREAS, the Advisory Council on Historic Preservation was offered the opportunity to participate as a consulting party to this Agreement and declined; and

NOW THEREFORE, the consulting parties agree that construction of the NRP shall be administered in accordance with the following stipulations to ensure that historic properties will be treated to avoid or mitigate effects to the extent practicable, regardless of surface ownership, and to satisfy DOE and BLM Section 106 responsibilities for all aspects of the undertaking.

I. ROLES AND RESPONSIBILITIES

The consulting parties: BLM; SHPO; STB; and DOE, agree that DOE will be the Lead Federal Agency for implementing this PA. The consulting parties agree that the consultation and compliance portions of the current *BLM/SHPO Statewide Protocol* will be used to implement this PA (Appendix E, State Protocol Agreement as amended through January 2005). The relevant portions of that protocol are incorporated by reference.

DOE, in consultation with BLM, is responsible for administering this PA. This includes but is not limited to: ensuring that the consulting parties carry out their responsibilities; overseeing all cultural resource work; assembling all submissions to the SHPO, including reports, determinations of eligibility and effect, and treatment or data recovery plans; and for seeking SHPO concurrence with all agency compliance decisions. Stipulation E.9 delegates BLM lead responsibilities to the Ely Field Office (EFO) authorized officer.

DOE will be responsible for reviewing reports and making determinations of eligibility, developing treatment options, and determining effects of the NRP on private land. BLM will be responsible for reviewing reports and making determinations of eligibility, developing treatment options, and determining effects of the NRP on public land.

II. AREA OF POTENTIAL EFFECT

The Area of Potential Effect (APE) shall be defined to include all potential direct and indirect effects to cultural resources and properties of traditional religious and cultural importance from any activities associated with the undertaking, regardless of land ownership.

The proposed rail alignment, and all access roads and work areas or other facilities for this project located outside the rail alignment, will be managed according to the provisions of this PA. The APE for the rail line will be 200 feet from the center line of the alignment or the actual ROW application submitted to BLM, whichever is greater. The APE for access roads outside of the alignment will be a minimum of 100 feet wide with at least 50 feet on either side of centerline. The minimum APE for any construction areas or other temporary use areas, outside of the alignment, will be the footprint of the area plus 100 feet outward in all directions from the perimeter of each area. The APE for assessing indirect effects on historic properties outside of the rail line alignment will extend at least one mile in all directions from the perimeter of the direct effects APE.

DOE, in coordination with BLM, may amend the APE as needed, or as requested by the SHPO, by amending this PA under the provisions of Section J. The initial study area is described and presented in Appendix A.

STIPULATIONS

DOE, in cooperation with the other consulting parties, shall ensure that the following stipulations are carried out:

A. Identification

1. DOE funds all appropriate cultural resource identification activities (Appendix D), including inventory, records research, informant interviews, archaeological, historic, or ethnographic report preparation, monitoring, and curation based on the APE for all activity areas, or portions thereof, in a manner consistent with the BLM/SHPO Statewide Protocol.

2. Each consulting party (DOE, BLM, and SHPO) will identify interested persons and tribes to DOE. Upon concurrence from the consulting parties, DOE will involve identified interested persons, tribes, or affected ethnic groups in all activities associated with the undertaking, as appropriate.

3. Required identification activities shall be completed regardless of the ownership (federal or private) of the lands involved, and DOE shall be responsible for gaining access to privately held lands by applying all reasonable means available including obtaining right of entry through courts.

4. Previously recorded sites will be updated using the Nevada IMACS site form. Sites recorded ten years previously will be re-evaluated for National Register significance.

5. In cooperation with the BLM, DOE, in accordance with the *American Indian and Alaska Native Tribal Government Policy* (DOE, 2000), shall make a good faith effort to consult with tribes and identified interested persons, or affected ethnic groups, to identify properties of traditional religious and cultural importance, and to inform the consulting parties of their eligibility and suggest appropriate treatment to avoid adverse effects to historic properties in accordance with the consultation procedures as specified in Appendix C.

6. Prior to initiating identification efforts, the consulting parties, including DOE and its cultural resource consultants, the BLM State Office, all appropriate BLM field Offices and the SHPO, will meet to finalize identification efforts, including the treatment of isolates, historic mining complexes, and linear resources. The results of those meetings which materially affect the nature of this Agreement are automatically appended to this Agreement.

B. Eligibility

1. DOE on private land, BLM on public land, and in consultation with SHPO, shall evaluate all cultural resources located within the APE for eligibility to the NRHP. Eligibility will be determined prior to the initiation of activities, within a construction segment, that may affect cultural resources. Eligibility will be determined in a manner compatible with the BLM/SHPO Statewide Protocol.

2. DOE, in consultation with BLM and SHPO, shall consult with appropriate tribes to evaluate the eligibility of properties of traditional religious and cultural importance. Consultation procedures are specified in Appendix C.

3. To the extent practicable, eligibility determinations shall be based on inventory information. If the information gathered in the inventory is inadequate to determine eligibility, DOE, through its cultural resource consultants, shall conduct limited subsurface testing or other evaluative techniques to determine eligibility.

   As needed, DOE, in consultation with the other consulting parties, will develop testing plans and submit them to the SHPO for concurrence. DOE shall provide identified tribes and interested parties with the same review opportunity as afforded the SHPO. Any proposed testing shall be limited to disturbing no more than 25 percent of the surface area of the resource being evaluated.

4. If any of the consulting parties, identified tribe or interested parties disagree regarding eligibility, DOE shall notify all consulting parties of the dispute and seek to resolve it among the parties. If the dispute cannot be resolved, DOE shall seek a formal determination of eligibility from the *Keeper of the National Register*. The Keeper will take 45 calendar days to make a determination or request additional information. The Keeper's determination will be considered final.

C. Treatment

1. In avoiding or mitigating effects, DOE on private land, BLM on public land and in consultation with SHPO, shall determine the precise nature of effects to historic properties identified in the APE. DOE, in consultation with BLM, shall develop a comprehensive treatment or data recovery plan and seek SHPO concurrence on the consolidated plan. At the same time, DOE shall provide identified tribes and interested parties with the same review timeframe as afforded the SHPO.

2. To the extent practicable, the consulting parties shall ensure that DOE avoids effects to historic properties through project design, or redesign, relocation of facilities, or by other means in a manner consistent with the BLM/SHPO Statewide Protocol. When avoidance is not practical, DOE, in consultation with the consulting parties, identified interested persons, and appropriate tribes, shall ensure that an appropriate Treatment or Data Recovery Plan designed to lessen or mitigate project-related effects to historic properties is developed and implemented.

3. For properties eligible under Criteria (a) through (c), mitigation other than data recovery may be considered in the Treatment Plan (e.g., Historic American Buildings Survey/Historic American Engineering recordation, oral history, historic markers, exhibits, interpretive brochures or publications, etc.). Where appropriate, Treatment Plans shall include provisions (content and number of copies) for a publication for the general public.

4. When data recovery is proposed, DOE, in consultation with BLM and SHPO, shall ensure that a Data Recovery Plan is developed and implemented that is consistent with the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation* (48 FR 44716), and *Treatment of Historic Properties: A Handbook* (Advisory Council on Historic Preservation 1980).

5. DOE, through its cultural resource consultants, shall implement and complete the fieldwork portions of any final Treatment or Data Recovery Plan prior to initiating any activities in any construction segment (Stipulation G) that may affect historic properties located within the area covered by the plan.

6. DOE shall ensure that all records and materials resulting from identification and treatment efforts are curated in accordance with 36 CFR 79 in a BLM-approved facility in Nevada. Materials covered by Native American Graves Protection and Repatriation Act (NAGPRA) will be handled in accordance with 43 CFR 10. All materials collected will be maintained in accordance with 36 CFR 79 or 43 CFR 10 until the final treatment report is complete and collections are curated or returned to their owners. DOE will encourage private owners to donate collections from their lands to an appropriate curation facility.

7. DOE shall ensure that all final archaeological reports resulting from actions pursuant to this PA will be provided to the consulting parties, tribes and other interested persons. All such reports shall be consistent with contemporary professional standards and the Secretary of the Interior's Standards for *Final Reports of Data Recovery Programs* (48 FR 44716-44740).

8. The consulting parties agree that visual impacts to landscapes or other historic properties that are mitigated to BLM Class II Visual Resource Management standards (substantially unnoticeable) shall be considered to have no adverse affect.

9. Any dispute concerning treatment will be resolved according to Stipulation I.

D. Discovery Situations

1. Human Remains

   a. If anyone associated with the NRP encounters what appears to be human remains during construction or other project related activities, all activity will halt in the immediate vicinity of the discovery, and all project related activities will be kept at least 200 feet away from the discovery in all directions.

   b. The BLM, DOE, and SHPO will be notified of the find as soon as possible.

   c. The BLM shall notify its law enforcement staff, who will inform and work with local law enforcement and coroner, to determine if the human remains are associated with a crime.

d. Once it has been determined that the discovery is not the result of a crime scene, the BLM and DOE shall comply with the 43 CFR 10 on public land and Nevada Revised Statutes (NRS) 383 on private land.

2. Other Situations

a. Prior to initiating any activities within the APE, DOE will identify who will be responsible for notifying BLM of any discoveries. In addition to the stipulations here, the process detailed in Appendix B will be followed in all discovery situations, including human remains and other NAGPRA objects.

b. As soon as there is a discovery or unanticipated impact situation, all NRP related activities will halt in the immediate vicinity of the discovery. Once in a safe condition, activities would be directed away from an area at least 200 feet in all directions from the point of discovery. DOE will immediately notify BLM, the SHPO and other landowner as appropriate of the situation.

c. DOE shall notify the SHPO, BLM, tribes, and interested parties as appropriate within one working day of being notified of the discovery or unanticipated impact, and consider their initial comments on the situation. DOE will also initiate the procedures outlined in Appendix B. Within two working days after initial notification, the BLM for public lands, and DOE for private lands, shall notify all consulting parties, tribes, and interested parties, of the decision to either allow NRP activities to proceed or to require further evaluation or mitigation.

d. If, in consultation with the consulting parties, BLM determines that mitigation for discoveries or unanticipated impacts is required, DOE shall solicit comments from the consulting parties, tribes, and interested persons, as appropriate, to develop mitigating measures. The consulting parties, tribes, and interested persons, as appropriate, will be allowed two working days to provide DOE with comments to be considered when BLM or DOE, depending on land status, decides on the nature and extent of mitigative efforts. Within seven working days of initial notification, the BLM or DOE, depending on land status, will inform all consulting parties of the nature of the mitigation required, and ensure that such mitigative actions are implemented before allowing NRP activities to resume.

e. DOE, in consultation with BLM, may consider the following types of activities as categorical exclusions meaning SHPO consultations are not required:

1) Conducting non-archaeological data collection and monitoring activities, not associated with proposed undertakings, that involve new surface disturbance less than one square meter. Such activities include but are not limited to forage trend monitoring, stream gauges, weather gauges, research geophysical sensors, photoplots, traffic counters, animal traps, or other similar devices.
2) Installing facilities such as recreational, special designation, regulatory, or information signs, visitor registers, kiosks, cattle guards, gates, temporary corrals, or portable sanitation devices in previously disturbed areas outside of known historic properties.

3) Decisions and enforcement actions (that do not involve cultural resources) to ensure compliance with laws, regulations, orders, and all other requirements imposed as conditions of approval, when the original approval was subject to the NHPA Section 106 process.

3. DOE shall ensure that reports of mitigation efforts for discovery situations are completed in a timely manner and conform to the Secretary of Interior's *Format Standards for Final Reports of Data Recovery Programs* (42 FR 5377-79). Drafts of such reports shall be submitted to the SHPO for review and comment as set forth in Stipulation H.2 of this PA.

4. Any disputes or objections arising during a discovery situation that cannot be resolved by DOE, BLM and SHPO shall be handled in accordance with Stipulation I.

5. NRP related activities in the area of the discovery will be halted on public land until DOE is notified by the BLM Authorized Officer in writing that mitigation is complete and activities can resume.

E. Other Considerations, including but not limited to

1. DOE shall ensure that all stipulations of this PA are carried out by BLM, SHPO, and all contractors, subcontractors, cultural resource consultants, or other personnel involved with this undertaking.

2. DOE shall ensure that ethnographic, historic, architectural, and archaeological work conducted pursuant to this PA is carried out by or under the direct supervision of persons meeting qualifications set forth in the Secretary of the Interior's *Professional Qualification Standards* dated June 20, 1997 (62 FR 33707-33723), which are part of the larger Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation* (48 FR 44716) and who have been permitted for such work by the consulting parties.

3. DOE, in cooperation with BLM and SHPO, shall ensure that all its personnel and all the personnel of its contractors, subcontractors, and cultural resource consultants are trained and directed not to engage in the illegal collection of historic and prehistoric materials. DOE shall cooperate with the BLM to ensure compliance with the Archaeological Resources Protection Act of 1979 (16 U.S.C. 470) on Federal lands and with NRS 381 for private lands.

4. DOE shall bear the expense of identification, evaluation, monitoring and treatment of all cultural resources directly or indirectly affected by NRP-related activity. Such costs shall include, but not be limited to, pre-field planning, fieldwork, post-fieldwork analysis, research and report preparation, interim and summary report preparation, publications for the general public, and the cost of curating project documentation and artifact collections.

5. Identification, evaluation, and treatment efforts may extend beyond the geographic limits of the APE when the resources being considered extend beyond the APE.

6. Properties of traditional religious and cultural importance will be identified, evaluated,

and treated through consultation with appropriate tribes or interested persons. DOE may contract for data gathering to assist in identifying, evaluating, and treating these properties. However, formal consultation, as needed, will be done by DOE in consultation with the other consulting parties. Identification, evaluation, and treatment efforts for properties of traditional religious and cultural importance shall be consistent with the BLM/SHPO Statewide Protocol and Appendix C.

7. Information on the location and nature of all cultural resources and will be made available consistent with the provisions of the Archaeological Resources Protection Act, the NHPA, and their associated implementing regulations. All information considered proprietary by tribes, will be held confidential by the consulting parties to the extent provided by Federal law.

8. DOE shall ensure that any human remains, grave goods, items of cultural patrimony, and sacred objects encountered during the undertaking are treated with the respect due such materials. In coordination with this PA, human remains and associated grave goods found on Federal land will be handled according to the provisions of the NAGPRA and its implementing regulations (43 CFR 10). Human remains and associated grave goods on private land will be handled according to the provisions of Nevada Revised Statutes NRS 383.

9. The lead and point of contact for BLM will be the EFO authorized officer. All DOE/SHPO activities will be coordinated through the EFO and all other BLM Field Offices (Las Vegas and Tonopah) will coordinate their determinations, comments, issues, and other matters through the EFO to ensure consistency among Field Offices. The EFO will consolidate all BLM comments and other communications into a single BLM communication. DOE will not interact with the BLM offices without explicit approval of the EFO. Any issues that cannot be resolved by the EFO will be referred to the BLM State Office for resolution.

F. Monitoring

1. Consulting parties may monitor actions carried out pursuant to this PA. To the extent practicable, all monitoring activities will be done so as to minimize the number of monitors involved in the undertaking.

2. Areas that DOE, in consultation with the SHPO, BLM, tribes, or interested party, identifies as sensitive historic properties or religiously or culturally important in a monitoring plan will be monitored by an appropriate professional or tribal representative during construction or operational activities that may impact the area. Monitors shall be empowered to stop work in the specific area of concern to protect resources and work will not proceed in identified sensitive areas without a monitor present.

G. Notices to Proceed

After compliance with Stipulation A.3, the BLM, in consultation with the other consulting parties may issue Notices to Proceed to DOE for individual construction segments, as defined by the Treatment Plan, which includes the approach for effects mitigation, under any of the following conditions:

1. DOE, BLM and SHPO have determined that there are no cultural resources within the APE for the construction segment; or

2. DOE, BLM and SHPO have determined that there are no historic properties within the APE for the construction segment; or

3. DOE, after consultation with the BLM, SHPO, tribes, and interested persons has implemented an adequate Treatment Plan for the construction segment, and

    a. The fieldwork phase of the treatment option has been completed; and

    b. DOE and BLM have accepted a letter summary description of the fieldwork performed and a reporting schedule for that work.

H. Time Frames

1. Reports: BLM, shall review and comment on any report submitted by DOE within 30 calendar days of receipt. DOE will consolidate all comments and send them to SHPO as needed.

2. SHPO Consultation: After review by the other consulting parties, DOE shall submit the results of all identification, evaluation, and treatment efforts, including Treatment or Data Recovery Plans to the SHPO for a 30-calendar-day review and comment period.

3. Consultation with Tribes or Interested Parties: Concurrent with SHPO review, DOE shall submit the results of all identification and evaluation efforts, including discovery situations, and Treatment Plans to tribes and other identified interested persons for a 30-calendar-day review and comment period.

4. If any consulting party to this PA, tribe, or other interested person fails to respond to DOE within 30 calendar days of the receipt of a submission, DOE shall presume concurrence with the findings and recommendations as detailed in the submission and proceed accordingly.

5. Reports: A draft final report of all identification, evaluation, treatment or other mitigative activities will be due to the BLM from DOE within nine months after the completion of the fieldwork associated with the activity, unless otherwise negotiated. Negative inventories will be documented on BLM Negative Inventory Forms and sent to BLM and SHPO in a timely manner.

6. Curation: All reports, records, photographs, maps, field notes, artifacts, and other materials collected or developed for any identification, evaluation, or treatment activities will be curated in a facility in accordance with 36 CFR 79 approved by the consulting parties at the time the final report associated with that activity is accepted by DOE, unless materials and artifacts must be returned to the owner.

7. Discovery Situations: As specified in Stipulation D.

I. Dispute Resolution

1. Should any party to this PA object to any action carried out or proposed with respect to the implementation of this PA, DOE shall consult with the objecting party to resolve the objection. If after initiating such consultation DOE determines that the objection cannot be resolved through consultation, DOE shall forward all documentation relevant to the objection to the State Director of the Bureau of Land Management. Such documentation shall include DOE's proposed response to the objection, with the expectation that within 30 days after receipt of all pertinent documentation, the State Director shall:

   a. Advise DOE that the BLM concurs in DOE's proposed final decision, whereupon DOE will respond to the objection accordingly; or,

   b. Provide DOE with an alternative to resolve the objection.

   The BLM State Director's decision shall be considered final.

2. In consultation with DOE, any determination made by the BLM State Director will be understood to pertain only to the subject of the dispute. DOE's responsibility to carry out actions required by this PA that are not subject of the dispute shall remain unchanged.

J. Amendment

Any consulting party to this PA may request that this PA be amended, whereupon the consulting parties will consult to consider such amendment.

K. Termination

Any consulting party to this PA may terminate the PA by providing 30 calendar days' advance written notice with cause to the other consulting parties, provided that the consulting parties will consult during the period prior to termination to seek agreement on amendments or other actions that would avoid termination.

L. Execution

1. Execution and implementation of this PA evidences that the consulting parties have satisfied their Section 106 responsibilities for all actions associated with the construction and installation of the NRP.

2. In the event that this PA is terminated, DOE in cooperation with BLM, shall follow the requirements of 36 CFR800 for the management of historic properties.

3. This PA shall become effective on the date of the last signature below and shall remain in effect until terminated as provided in Stipulation K, or until undertaking is completed, or a maximum five (5) years from the effective date.

CONSULTING PARTIES:

BUREAU OF LAND MANAGEMENT

By: for Wenker Date: 3/10/06

Title: BLM Nevada State Director

CONSULTING PARTIES:

DEPARTMENT OF ENERGY

By: T Gary Lanthrum Date: 9 FEB 2006

Title: Director, Office of National Transportation

CONSULTING PARTIES:

NEVADA STATE HISTORIC PRESERVATION OFFICE

By: Alice M. Baldrica Date: 4/17/06

Title: Deputy Nevada State Historic Preservation Officer

CONSULTING PARTIES:

SURFACE TRANSPORTATION BOARD

By: ______________________ Date: Feb. 8, 2006

Title: Chief, Section of Environmental Analysis

APPENDIX N

DISTRIBUTION LIST

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APPENDIX N

DISTRIBUTION LIST

N.1 United States Congress

The U.S. Department of Energy (DOE) is providing copies of the Nevada Rail Corridor SEIS and Rail Alignment EIS to federal, state, and local elected and appointed officials and agencies of government; American Indian groups; national, state, and local environmental and public interest groups; and other organizations and individuals listed below. DOE will provide copies to other interested organizations or individuals on request.

N.1.1 UNITED STATES SENATORS FROM NEVADA

The Honorable John E. Ensign
U.S. Senator
United States Senate

The Honorable Harry Reid
Senate Majority Leader
United States Senate

N.1.2 UNITED STATES REPRESENTATIVES FROM NEVADA

The Honorable Shelley Berkley
1st District Representative
U.S. House of Representatives

The Honorable Dean A. Heller
2nd District Representative
U.S. House of Representatives

The Honorable Jon C. Porter, Sr.
3rd District Representative
U.S. House of Representatives

N.1.3 UNITED STATES SENATE COMMITTEES

The Honorable Jeff Bingaman
Chairman
Senate Committee on Energy & Natural Resources

The Honorable Thad Cochran
Ranking Member
Senate Committee on Appropriations

The Honorable James Inhofe
Ranking Member
Senate Committee on Environment & Public Works

The Honorable Carl Levin
Chairman
Senate Committee on Armed Services

The Honorable Robert C. Byrd
Chairman
Senate Committee on Appropriations

The Honorable Pete V. Domenici
Ranking Member
Senate Committee on Energy & Natural Resources

The Honorable Daniel K. Inouye
Chairman
Senate Committee on Commerce, Science & Transportation
Subcommittee on Surface Transportation & Merchant Marine

The Honorable John S. McCain
Vice Chairman
Senate Armed Services Committee

The Honorable Bernard Sanders
Senate Committee on Environment & Public Works

The Honorable John Warner
Senate Committee on Armed Services
Senate Committee on Environment & Public Works

The Honorable Trent Lott
Senate Committee on Commerce, Science & Transportation
Subcommittee on Surface Transportation & Merchant Marine Infrastructure, Safety & Security

The Honorable Ted Stevens
Vice Chairman
Senate Committee on Commerce, Science & Transportation

N.1.4 UNITED STATES HOUSE OF REPRESENTATIVES COMMITTEES

The Honorable Joe Barton
Ranking Minority Member
House Committee on Energy & Commerce

The Honorable John D. Dingell
Chairman
House Committee on Energy & Commerce

The Honorable David Hobson
Ranking Member
House Committee on Appropriations
Subcommittee on Energy & Water Development

The Honorable David Obey
Chairman
House Committee on Appropriations

The Honorable Peter J. Visclosky
House Committee on Appropriations
Subcommittee on Energy & Water Development

The Honorable Rick Boucher
House Committee on Energy & Commerce
Subcommittee on Energy & Air Quality

The Honorable Ralph M. Hall
House Committee on Energy & Commerce
Subcommittee on Energy & Air Quality

The Honorable Duncan Hunter
Ranking Member
House Committee on Armed Services

The Honorable Jerry Lewis
Ranking Member
House Committee on Appropriations

The Honorable Ike Skelton
Chairman
House Committee on Armed Services

N.2 Federal Agencies

Dr. Mark Abkowitz
U.S. Nuclear Waste Technical Review Board

Dr. William Howard Arnold
U.S. Nuclear Waste Technical Review Board

Dr. Daryle Busch
U.S. Nuclear Waste Technical Review Board

Dr. George Milton Hornberger
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Dr. Ronald Latanision
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Dr. Thure Cerling
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N.3 State of Nevada

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The Honorable Rod R. Blagojevich
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The Honorable Mike Beebe
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Governor of Tennessee

The Honorable Felix Camacho
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The Honorable Jon S. Corzine
Governor of New Jersey

The Honorable Charlie Crist
Governor of Florida

The Honorable Mitch Daniels
Governor of Indiana

The Honorable Chet Culver
Governor of Iowa

The Honorable Jim Doyle
Governor of Wisconsin

The Honorable James H. Douglas
Governor of Vermont

The Honorable Ernie Fletcher
Governor of Kentucky

The Honorable Michael F. Easley
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The Honorable Jennifer M. Granholm
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The Honorable David D. Freudenthal
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The Honorable Dave Heineman
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The Honorable Christine O. Gregoire
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The Honorable John Hoeven
Governor of North Dakota

The Honorable Charles Bradford "Brad" Henry
Governor of Oklahoma

The Honorable Timothy "Tim" M. Kaine
Governor of Virginia
The Honorable Linda Lingle
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The Honorable Jon M. Huntsman, Jr.
Governor of Utah
The Honorable Ted Kulongoski
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The Honorable Joe Manchin, III
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The Honorable Frank Murkowski
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The Honorable Ruth Ann Minner
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The Honorable John H. Lynch
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The Honorable Martin O'Malley
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The Honorable Sarah H. Palin
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The Honorable Timothy Pawlenty
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The Honorable Rick Perry
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The Honorable Edward G. Rendell
Governor of Pennsylvania

The Honorable Robert "Bob" R. Riley
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The Honorable Bill Ritter, Jr.
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The Honorable Arnold Schwarzenegger
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The Honorable Kathleen Sebelius
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The Honorable Ted Strickland
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The Honorable Eliot Spitzer
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The Honorable Janet Napolitano
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The Honorable C. L. Butch Otter
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Paiute Indian Tribe of Utah

Ms. Rebecca Van Lieshout
Coordinator, Tribal EPA
Forest County Potawatomi Community of Wisconsin

Mr. Ken Watteron
Timbisha Shoshone Tribe

Mr. Richard Wilder
Tribal Representative
Fort Independence
The Honorable Charles Wood
Chairman
Chemehuevi Indian Tribe
Genia Williams
Tribal Chairperson
Walker River Paiute Tribe

N.6 Environmental and Public Interest Groups

Ms. Beth Gallegos
Citizens Against Contamination

Mr. Robert Holden
Director
National Congress of American Indians (NCAI)
Emergency Management & Radioactive Programs

Mr. Toney Johnson
Citizens Against Nuclear Trash

Mr. David Albright
President
Institute for Science and International Security

Ms. Kathryn Landreth
State Director
Nevada Field Office
The Nature Conservancy

Mr. Thomas A. Schatz
President
Council for Citizens Against Government Waste

Mr. David Beckman
Natural Resources Defense Council
Los Angeles Office

Ms. Joan B. Claybrook
President
Public Citizen

Mr. John Flicker
Chief Executive Officer
National Audubon Society

Dave Lochbaum, Ph.D.
Sr. Nuclear Safety Engineer
Union of Concerned Scientists

Mr. Paul R. Portney
President & Senior Fellow
Resources for the Future

Mr. John Tanner

Mr. Jim Riccio
Greenpeace International

Ms. Meg Power
Senior Advisor
National Community Action Foundation

Mr. Fred Krupp
President
National Headquarters
Environmental Defense

Mr. Albert (Brandt) Petrasek
State and Tribal Government Working Group

Ms. Carolyn Hanson
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Mr. Mark Wenzler
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Legislative Office

Mr. John H. Adams
President
Natural Resources Defense Council

Ms. Carol Browner
Chairman of the Board
National Audubon Society

Mr. Larry Fahn
President, Board of Directors
Sierra Club

Mr. Pete Litster
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Shundahai Network

Mr. Steven J. McCormick
President & Chief Executive Officer
The Nature Conservancy

Ms. Sara Szynelski
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Energy Communities Alliance

Ms. Joni Arends

Coalition 21

Mr. John M. Bailey
Institute for Local Self-Reliance

Ms. Mavis Belisle
Director
Peace Farm

Mr. David Bradley
Executive Director
National Community Action Foundation

Mr. Jim C. Bridgman
Program Director
Alliance for Nuclear Accountability

Mr. David Brunner
Chief Operating Officer
National Fish & Wildlife Foundation

Ms. Jodi Dart
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Ms. Anna M. Frazier
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Dine CARE

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Indigenous Environmental Network

Ms. Lisa Gover
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National Tribal Environmental Council (NTEC)

Ms. Thea Harvey
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Economists for Peace & Security at the Levy Institute

Mr. Daniel Hirsch
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Environmental Defense Institute

Dr. Robert D. Bullard
Director
Clark Atlanta University
Environmental Justice Resource Center

Ms. Kateri Callahan
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Alliance to Save Energy

Ms. Laura Carlsen
Director, Americas Program
International Relations Center

Mrs. Nina Carter
Executive Director, Washington State Office
National Audubon Society

Mr. Thomas Cassidy
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The Nature Conservancy

Ms. Christine Chandler
Responsible Environment Action League

Ms. Janet Feldman
Sierra Club

Mr. Bob Fulkerson
Progressive Leadership Alliance of Nevada

Ms. Susan Gordon
Director
Alliance for Nuclear Accountability

Ms. Nicole Graysmith
Legal Aid of North Carolina
Environmental Poverty Law Project

Ms. Janet Greenwald
Citizens for Alternatives to Radioactive Dumping (CARD)

Mr. Don Hancock

Reverend Mac Legerton
Center for Community Action

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Senior Director for Congressional & Federal Affairs
National Wildlife Foundation

Mr. Michael McCally
Physicians for Social Responsibility

Ms. Elizabeth Merritt
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Center for Biological Diversity

Mr. Roger Rivera
President
National Hispanic Environmental Council

Nick Roth
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Mr. Paul Schwartz
National Campaign Director
Clean Water Action

Ms. Alice Slater
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Global Resource Action Center for the Environment

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The Nature Conservancy
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Tri-Valley CAREs

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STAND, Inc.

Mr. Ronald Lamb
Coalition for Health Concern

Mr. Lloyd Leonard
League of Women Voters

Mr. Kevin Martin
Executive Director
Peace Action Education Fund

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Executive Director
Harambee House, Inc.
Projects: ACA-Net & Citizens for Environmental Justice

Mr. Allen Metscher
Citizens Advisory Council

Mr. Richard Moore
Executive Director
Southwest Network for Environmental & Economic Justice

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Mr. Gerald Pollet
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The Wilderness Society
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Ms. Kassie Siegel
Air Climate and Energy Director
Center for Biological Diversity

Jennifer Olaranna Viereck
Healing Ourselves & Mother Earth

Women's Action for New Directions

Ms. Gail Small
Executive Director
Native Action

Mr. Derek Stack
Executive Director
Great Lakes United

Ms. Peggy Maze Johnson, Executive Director
Citizens Alert

N.7 Other Groups and Individuals

Mr. Ralph Anderson
Project Manager, Plant Support
Nuclear Energy Institute

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Commissioner
Tempiute Grazing Association

Mr. Steven Kerekes
Director, Media Relations
Nuclear Energy Institute

Mr. William Ramsey
Executive Director
Troutman Sanders

Dr. Budhi Sagar
Technical Director
Southwest Research Institute
Center for Nuclear Waste Regulatory Analyses

Dr. Stephen Wells
President
Desert Research Institute

Ms. Barbara Bauman Tyran
Director, Washington Relations
Electric Power Research Institute
Ms. Anna Aurilio
Director, Washington, DC Office
U.S. Public Interest Research Group

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University of Nevada, Las Vegas
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Abigail C. Johnson Consulting

Ms. Mary Olson
Radioactive Waste Project & NIX MOX Campaign
Nuclear Information & Resource Service

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University of Nevada, Las Vegas
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Public Education

Admiral, Retired Frank L. "Skip" Bowman

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Natural Resources Defense Council, Inc.
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Director, Climate Center
Natural Resources Defense Council
Washington Office

Mr. Ace Robison
Consultant

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Executive Director
CERM, Desert Research Institute
Center for Environmental Remediation & Monitoring

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Nuclear Energy Institute

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Director, Spent Nuclear Fuel Management
Nuclear Energy Institute

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Director, Environmental Activities
Edison Electric Institute

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Center for Applied Research

President & Chief Executive Officer
Nuclear Energy Institute

Mr. Tom Barry
Senior Policy Analyst & Co-founder
International Relations Center

Mr. Kevin Kamps
Nuclear Information & Resource Service

Mr. Paul Leventhal
Founding President
Nuclear Control Institute

Arjun Makhijani, Ph.D.
President
Institute for Energy & Environmental Research (IEER)

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Nuclear Energy Institute

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Washington Representative
American Petroleum Institute

Mr. Vincent Scoccia
Nye Regional Medical Center

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Mr. Patrick Cummins
Air Quality Project Manager
Western Regional Air Partnership

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National Governors' Association (NGA)
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Assistant Vice President, Environment & Hazardous Materials
Association of American Railroads (AAR)

Ms. Shauna Larsen
Government Relations Representative
American Public Power Assoc.

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Region III President
International Association of Emergency Managers
c/o General Physics Corporation

Mr. Robert E. Marvin
Director
FRA/State Rail Safety Participation Program
c/o Transportation Division
Ohio Public Utilities Commission

Mr. William T. Pound
Executive Director
National Conference of State Legislatures

Mr. Jim B. Reed
Transportation Program Director
National Conference of State Legislators (NCSL)

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Senior Policy Analyst
Council of State Governments-Midwest Office (CSG/MW)

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National Governors' Association

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Western Interstate Energy Board
Mr. Robert Thompson
Energy Communities Alliance

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International Association of Fire Fighters (IAFF)
Hazardous Materials Training Department
Safety & Operations Dept.

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President & CEO
The Aspen Institute
Program on Energy, the Environment & the Economy

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Executive Director
Western Interstate Energy Board (WIEB)

Mr. William Mackie
Program Manager
Western Governors' Association

Mr. Brian J. O'Connell
Director, Nuclear Waste Program
National Assoc. of Regulatory Utility Commissioners (NARUC)

Mr. Duane Parde
Executive Director
American Legislative Exchange Council (ALEC)

Mr. Randy Rawson
President
American Boiler Manufacturers Association

Ms. Eileen Supko
Senior Consultant
Energy Resources International, Inc.

Mr. James S. Tulenko
President
American Nuclear Society

Mr. George D. Turner
President & Chief Executive Officer
American Nuclear Insurers

Arden L. Bement, Ph.D.
Director
National Science Foundation
Mr. Anthony DeSouza
Director, Board on Earth Studies & Natural Sciences
National Academy of Sciences

Ms. Julie Ufner
Associate Legislative Director
National Association of Counties (NACo)

N.8 Reading Rooms and Libraries

Esmeralda County Yucca Mountain Oversight Office
Goldfield, NV

Nye County Department of Natural Resources and Federal Facilities
Pahrump, NV
U.S. Department of Energy Headquarters
Office Public Reading Room
Washington, D.C.

Ms. Susan Beard
Librarian
Northern Arizona University
Cline Library

Ms. Michelle Born
Librarian
Clark County Library
Main Branch
Reference Department

Mr. Bert Chapman
Purdue University
Hesse Library - Documents Department

Ms. Pauline Conner
Administrator
Savannah River Operations
University of South Carolina-Aiken, Gregg-Graniteville Library
Public Reading Room

Ms. Kathy Edwards
Nevada State Library & Archives

Lincoln County Nuclear Waste Project Office
Caliente, NV

Pahrump Yucca Mountain Information Center
Pahrump, NV

The University of Nevada Libraries
Business and Government Information Center
Reno, NV

Mr. Dan Barkley
University of New Mexico
Zimmerman Library

Ms. Jan Bennett
Public Affairs Representative
Entergy Nuclear Vermont Yankee

Ms. Carol Brown
Office of Intergovernmental Affairs
City of Chicago

Mr. Hui Hua Chua
Michigan State University

Ms. Kay Collins
University of California, Irvine
Langson Library

Ms. Sherry DeDecker
University of California, Santa Barbara
Davidson Library - Government Information Center

Ms. Amy Sue Goodin
Associate Director of Research
University of New Mexico
Institute for Public Policy

Ms. Heather Elliott
Clearinghouse Coordinator, Nevada State Clearinghouse
Department of Administration
State of Nevada

Ms. Sandra Groleau
Bates College Library

Ms. Paige Harper
University of Florida
Documents Department

Ms. Deanna Harvey
Strategic Petroleum Reserve Project
Management Office
SPRPMO/Reading Room

Mr. John Horst
National Renewable Energy Lab
Public Reading Room

Librarian, Government Documents
University of New Hampshire
Dimond Library

Librarian
San Jose State University
Martin Luther King, Jr. Library
Government Publications Department

Librarian
University of Colorado, Boulder
Library - Government Publications

Librarian
University Library, California State University
Government Documents

Librarian
Susanville District Library

Librarian
Sparks Branch Library

Librarian
Fishlake Branch Library

Librarian
Carson City Library
Reference Department
Librarian
Laughlin Branch Library

Librarian
Needles Library

Public Reading Room

Ms. Verna Graybill
Librarian
Northwestern Oklahoma State University
J.W. Martin Library Depository

Mr. Michele Hayslett
North Carolina State University Libraries
Government Information Services – RISD

Mr. Mark Holt
Library of Congress

Ms. Alisa Huckle
Mr. Brent Jacobson
Idaho Operations Office
INEEL Technical Library
U.S. DOE Public Reading Room

Mr. Walter Jones
University of Utah
Marriott Library, Special Collections

Librarian
University of Notre Dame
Hesburgh Library - Government Documents
Center

Librarian
University of California, Riverside
Rivera Library - Government Publications
Department

Librarian
U.S. Geological Survey
Serial Records Unit
National Center

Librarian
Spring Valley Library

Librarian
Billinghurst Middle School Library

Librarian
Inyo County Free Library

Librarian
New Mexico State University

Librarian
Round Mountain Public Library

Librarian
University of Wisconsin, Madison
Wendt Library - Technical Reports Center

Librarian
University of Texas, San Antonio
Library - Government Documents Department

Mrs. Pat Loper
Great Basin College Library

Mr. Joseph Milazzo
Southern Methodist University
Fondren Library East
Government Information

Ms. Janice Parthree
U.S. Department of Energy
Richland Operations Center
Public Reading Room
Mr. Tim D. Petrosky
Public Affairs Director
Consumer Energy
Big Rock Point

Mr. William H. Schalk
Communications Manager
American Electric Power Company
Cook Visitor Information Center

Ms. Susie Skarl
Head, Government Publications
University of Nevada, Las Vegas
Lied Library

Ms. Barbara Sullivan
Center for Health, Environment and Justice
CHEJ Library

Ms. T. Twyford
Librarian
Tecopa Library

Mr. John Walters
Branson Library - Documents

Librarian
North Las Vegas Public Library
Librarian
Brainerd Memorial Library

Librarian
University of Rhode Island
Library - Government Publications Office

Librarian
University of Maryland, Baltimore County
Albin O. Kuhn Library and Gallery -
Government Documents

Mr. David Mienke
Alliant Utilities, Inc.
Duane Arnold Energy Center

Mr. Gary Morell
College Hill Library
Rocky Flats Field Office

Mr. Walter Perry
U.S. Department of Energy Information Center
Oak Ridge Operations Office

Ms. Angela Riley
Community Relations Representative
TXU Electric & Gas
Comanche Peak Visitors Center

Mr. John Shuler
Richard J. Daley Library
Documents, Maps and Microforms Department
University of Illinois at Chicago

Mr. Bobby St. John
Media Coordinator
Washington TRU Solutions

Mr. Tim Sutherland
Indiana University
Northwest Library, Documents Department
Mr. Carl E. Unger
Senior Communications Representative
Public Information Center
Arizona Public Service Company
Palo Verde Nuclear Generating Station

Utah State University
Merrill Library

Ms. Judy Weiss
U.S. Department of Energy
Oakland Operations Office

Mr. Joel Yudken
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Mr. Robert A. Apel
Newcrest Resources, Inc.

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Mr. Jonathan M. Brown
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New Mexico Energy Minerals & Natural Resources Dept.

Mr. John M. Engler
President
National Association of Manufacturers

Mr. Michael Govan
Dia Art Foundation

Ms. Arlene Grider
President
Independence Chamber of Commerce

Ms. Sharon Kerrick
Manager
American Nuclear Society (ANS)
Outreach & Volunteer Dept.

Ms. Elaine Watson
Boise State University
Library - Government Documents

Ms. Beryl A. Zundel
Sunrise Library

Mr. Bill Zimmerman
U.S. Department of Energy
Bonneville Power Administration
BPA-CILL-1

Mr. David Blee
Executive Director
U.S. Transport Council

Mr. Dennis P. Bryan
Converse Consultants

Mr. John J. Castellani
President
Business Roundtable

Mr. Thomas Donohue
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U.S. Chamber of Commerce

Mr. Glenn L. English, Jr.
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National Rural Electric Cooperative Assoc.

Mr. Irwin Forman
Formarts Corp.

Mr. Robert Alan Kemp
NV Central, Great Basin, NV Northern Railroads

Mr. Thomas R. Kuhn
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