CNWRA 2001-001
Revision 1

REVIEW AND EVALUATION OF SITE CHARACTERISTICS OF NAVAL REACTORS SPENT FUEL ISFSI SITE AT INEEL

Prepared for

U.S. Nuclear Regulatory Commission
Contract NRC–02–97–009

Prepared by

Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas

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ACRONYMS/ABBREVIATIONS

AE	Architectural Engineering
amsl	above mean sea level
CBR	California Bearing Resistence
CNWRA	Center for Nuclear Waste Regulatory Analyses
CSR	cyclic stress ratio
cfs	cubic feet per second
DE	Design Earthquake
DNR	Division of Naval Reactors
DOE	U.S. Department of Energy
DSHA	Deterministic Seismic Hazard Assessment
ESRP	Eastern Snake River Plain
FDF	Flood Diversion Facility
HLW	High-Level Nuclear Waste
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
ISFSI	Independent Spent Fuel Storage Installation
LOFT	Loss of Fluid Test
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
OSS	Overpack Storage Slab
PHA	Peak Horizontal Acceleration
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PSHA	Probabilistic Seismic Hazard Assessment
RAI	Request for Additional Information
SAR	Safety Analysis Report
SER	Safety Evaluation Report
SPT	Standard Penetration Tests
SSC	Structures, Systems, and Components
SSE	Safe Shutdown Earthquake
SSI	Soil Structure Interaction
TAN	Test Area North
TMI-2	Three Mile Island Unit 2
URSGWCFS	URS Greiner Woodward-Clyde Federal Services
USGS	U.S. Geological Survey
WCC	Woodward-Clyde Consultants
WCFS	Woodward-Clyde Federal Services
YM	Yucca Mountain

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QUALITY OF DATA, ANALYSES, AND CODE DEVELOPMENT

DATA: No CNWRA-generated original data are contained in this report.

ANALYSES AND CODES: No CNWRA computer analysis results were used in this report.

INTRODUCTION

On December 28, 1999, the U.S. Department of Energy (DOE), Division of Naval Reactors (DNR) (herein referred to as DOE-DNR), submitted to the U.S. Nuclear Regulatory Commission (NRC) a safety analysis report (SAR) (Bechtel Bettis, Inc., 1999) for the dry storage of naval reactors' spent fuel at an independent spent fuel storage Installation (ISFSI) at the Idaho National Engineering and Environmental Laboratory (INEEL). The ISFSI will be constructed at the Naval Reactors Facility (NRF) on the site of INEEL The facility will not be licensed by the NRC, however, the DOE-DNR requested that the NRC review the SAR and make a determination whether the facility provides protection to the public comparable to a facility licensed by the NRC under 10 CFR Part 72. On March 21, 2000, the NRC directed the Center for Nuclear Waste Regulatory Analyses (CNWRA) to assist the NRC in reviewing portions of the SAR of the NRF ISFSI. Specific areas reviewed by the CNWRA include the site characteristics of surface and subsurface hydrology, meteorology, geology, and seismology; and a soil-structure interaction analysis of the overpack storage slab, which are contained in Chapter 2 of NUREG–1567 (U.S. Nuclear Regulatory Commission, 2000) Standard Review Plan for Spent Fuel Dry Storage Facilities. The format of this chapter has been arranged according to a slightly modified version of Chapter 2 of NUREG–1567.

The NRF SAR does not discuss directly the NRF ISFSI site characteristics. Instead, this NRF SAR primarily refers to Chapter 2, Site Characteristics, of the Three Mile Island Unit 2 (TMI-2) SAR (U.S. Department of Energy, 1996) and assumes that the site characteristics described in TMI-2 generally apply to both the Idaho National Technology and Engineering Center, where the TMI-2 ISFSI site is located, and to the NRF site. The NRF SAR also refers to several other reports and the references therein such as URS Greiner Woodward-Clyde Federal Services et al. (2000, 1999); Woodward-Clyde Federal Services (1998); and Paul C. Rizzo Associates, Inc., (2000, 1998, 1994). Furthermore, the DOE also provided responses (U.S. Department of Energy, 2000a,b) to the NRC request for additional information. This report is based on the review of those documents. The staff evaluation is also based on the assumption that the NRF ISFSI SAR is intended to meet the applicable requirements of 10 CFR Part 72 for spent fuel storage.

This report (CNWRA 2001-001) addresses only Chapter 2, Principal Design Criteria, of the Naval Spent Fuel Canister Storage Safety Analysis Report. This report is intended to provide supplemental information to the NRC staff Safety Evaluation Report for the Naval Spent Fuel Canister System Storage Facility.

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EXECUTIVE SUMMARY

By letter dated December 28, 1999, as supplemented, the U.S. Department of Energy (DOE), Division of Naval Reactors (DNR) (herein referred to as the DOE-DNR), submitted to the U.S. Nuclear Regulatory Commission (NRC) Revision 5 of a Safety Analysis Report (SAR) for dry storage of Naval spent fuel at the Naval Reactors Facility in Idaho. The dry storage facility will not be licensed by the NRC; however, the DOE-DNR requested that the NRC review the SAR and make a determination that the facility provides protection to the public comparable to a facility licensed under 10 CFR Part 72. On February 25, 2000, the DOE-DNR submitted Revision 6 to the SAR. Furthermore, the DOE-DNR also provided responses to the NRC request for additional information (RAI). This report documents the review and evaluation of site characteristics of surface and subsurface hydrology, meteorology, geology, and seismology, and the soil structure interaction analysis of the overpack storage slab. These specific areas are contained in Chapter 2 of NUREG–1567, Standard Review Plan for Spent Fuel Dry Storage Facilities (U.S. Nuclear Regulatory Commission, 2000).

The site characteristics, including soil structure interaction analysis, were evaluated against the regulatory standards in 10 CFR Part 72 for independent storage of spent fuel. The NRC staff reviewed the SAR using the guidance in Chapter 2 of NUREG–1567. Based on the statements and representations in Revision 6 of the SAR and the responses to RAIs, the staff concluded that the description of site characteristics, including soil structure interaction analysis, meet the requirements of 10 CFR Part 72.

Reference

U.S. Nuclear Regulatory Commission. *Standard Review Plan for Spent Fuel Dry Storage Facilities.* Final Report. NUREG–1567. Washington, DC: U.S. Nuclear Regulatory Commission. 2000.

2 PRINCIPAL DESIGN CRITERIA

2.1 Conduct of Review

The Naval Reactors Facility (NRF) Independent Spent Fuel Storage Installation (ISFSI) Safety Analysis Report (SAR) (Bechtel Bettis, Inc., 1999) assumed that the information presented in Chapter 2, Site Characteristics, of the Three Mile Island Unit 2 (TMI-2) ISFSI SAR (U.S. Department of Energy, 1996a) and several other reports and the references therein, such as those by the URS Greiner Woodward-Clyde Federal Services (URSGWCFS) and its consultants (1999, 2000), Woodward-Clyde Federal Services (WCFS) (1998) and Paul C. Rizzo Associates, Inc. (1994, 1998, 2000) as sufficient to characterize the proposed NRF ISFSI site including the determination of the storage pad zero period accelerations. The NRF ISFSI site is located at the NRF on Idaho National Engineering and Environmental Laboratory (INEEL).

The staff evaluated site characteristics by reviewing Chapter 2, Site Characteristics, of the TMI-2 SAR (U.S. Department of Energy, 1996a); U.S. Department of Energy (DOE) responses to the TMI-2 request for additional information (RAI) (Wilcynski, 1997; Hagers, 1998a,b); documents cited in the TMI-2 ISFSI SAR; DOE responses to NRF SAR RAI (U.S. Department of Energy, 2000a,b); and other relevant literature for application to the proposed NRF ISFSI. The staff also used the results of an independent investigation of seismic ground motion at the TMI-2 ISFSI site based on a survey of existing literature, state of the knowledge in probabilistic seismic hazard assessment (PSHA) and deterministic seismic hazard assessment (DSHA), and analyses of existing U.S. Nuclear Regulatory Commission (NRC) regulations and regulatory guidance documents (Chen and Chowdhury, 1998). This independent investigation was conducted by the Center for Nuclear Waste Regulatory Analyses for preparation of the TMI-2 ISFSI Safety Evaluation Report (SER) (Brach, 1999a).

Chapter 2, Site Characteristics, of the TMI-2 ISFSI SAR; DOE responses to the TMI-2 and NRF RAIs; and documents cited in chapter 2 of the TMI-2 SAR discuss the geographical location of the TMI-2 ISFSI at the Idaho Nuclear Technology and Engineering Center (INTEC) on the INEEL, and meteorological, hydrological, seismological, geological, and volcanological characteristics of the site and surrounding vicinity. The SAR also describes the population distribution within and around the INEEL, land and water use, and associated site activities.

Section 2.2.5, Seismic Design, of the NRF SAR, uses the mean rock outcrop peak ground acceleration value for the NRF ISFSI site based on the probabilistic PSHA conducted by the URSGWCFS and its consultants (1999, 2000). Section 2.2.5, Seismic Design, of the NRF SAR also uses the information provided in a report by Paul C. Rizzo Associates, Inc. (2000) as a basis for adopting storage pad surface zero period accelerations. The review was conducted to ensure that the NRF ISFSI site has been characterized adequately and the calculation of the storage pad surface zero period accelerations is adequate.

2.1.1 Geography and Demography

This section contains the review of Section 2.1, Geography and Demography, of the TMI-2 ISFSI SAR (U.S. Department of Energy, 1996a) for relevance and adequacy to evaluation of the proposed NRF ISFSI. Subsections that have been discussed include (i) site location, (ii) site description, (iii) population distribution and trends, and (iv) land and water uses.

2.1.1.1 Site Location

The staff have reviewed information presented in Section 2.1.1, Site Location, of the TMI-2 ISFSI SAR and responses to RAIs regarding the TMI-2 site for relevance to the NRF ISFSI. The NRF ISFSI site location, as presented by the DOE-Division of Naval Reactors (DNR), is adequately described in relation to political boundaries of the INEEL (see figure 1-4 of NRF ISFSI SAR). Specific location and accompanying topographic maps provided in the SAR for the NRF ISFSI site are acceptable. The NRF ISFSI site will be located within the relatively large DOE research complex [the INEEL is 59 km (37 mi) north to south and 56 km (35 mi) east to west, encompassing about 2,300 km^2 (890 mi^2) of southeastern Idaho]. A topographic map to a 0.3-m (1-ft) contour interval was provided for the NRF ISFSI proposed site. The exact site location of the NRF ISFSI in latitude and longitude is Latitude: 43° 39' 02" North and Longitude: 112° 54' 51" West and was provided by the DOE-DNR. Additional NRF ISFSI site maps presenting the detail near the proposed NRF ISFSI site and site plots establishing orientation of buildings, roads, railroads, streams, ponds, drainage ways, transmission lines, and neighboring structures were provided. A general location map of the NRF ISFSI was provided that encompasses more than an 8-km (5-mi) radius about the proposed NRF ISFSI. Buffering of the NRF ISFSI from the public will be provided by the size of the INEEL, however, the proposed NRF ISFSI will be located significantly nearer an INEEL boundary (8.9 km or 5.5 mi) than is the TMI-2 pad site (13.6 km or 8.5 mi) at the INTEC. Discussion and presentation of location of nearby population (see Section 2.1.1.3, Population Distribution and Trends) were also provided.

2.1.1.2 Site Description

The staff have reviewed information presented in Section 2.1.2, Site Description, of the TMI-2 ISFSI SAR and responses to RAIs regarding the site. The DOE-DNR has clearly delineated the site boundary and controlled area (INEEL boundary) on maps of appropriate scale and legibility for safety evaluations. A description of the proposed NRF ISFSI site is acceptable. Distances, provided in the NRF ISFSI SAR and the corresponding responses to the RAIs, to nearby facilities and cities are based on the location of the NRF ISFSI. Although no release of effluents at the NRF ISFSI is anticipated by the DOE-DNR, the site description allows characterization and evaluation of the effect of any unexpected releases of radioactive or other effluent on the local and regional environment. A map that shows the orientation of the NRF ISFSI facility structures with respect to nearby roads, railways, and waterways was provided and allows for the evaluation of the effect of NRF ISFSI traffic on the adjacent transportation links and the potential effect of an accidental release of radioactive or other materials on the nearby transportation infrastructure.

Information was presented by the DOE-DNR in the SAR and responses to RAIs on the physical characteristics of the NRF ISFSI site in terms of relief, drainage, soils, and local vegetation. A description of the character and extent of the soils and vegetation near the NRF ISFSI was provided. The provided information on the relief, drainage, soils, and vegetation at the proposed NRF ISFSI is satisfactory.

2.1.1.3 Population Distribution and Trends

The staff have reviewed the information presented in Section 2.1.3, Population Distribution and Trends, of the TMI-2 ISFSI SAR and responses to RAIs regarding the site . Population data used in the TMI-2 ISFSI SAR were derived from the 1990 U.S. Census. Any information from the 2000 U.S. Census should be added to the population database when it becomes available. The projected growth rate in the region is 1.6 percent from 1990 to 2004 compared to a statewide projection of 1.7 percent. This projected relationship is acceptable. The nearest permanently inhabited city to the proposed NRF ISFSI is at Atomic City, Idaho, with a 1990 population of 30 (estimated at 28 in 1998), located about 25 km (16 mi) southeast from the NRF ISFSI. However, Howe, Idaho, permanent population estimated at 0 in 1998 is located about 16 km (10 mi) northwest of the site and may be home to transients and seasonal residents. In responses to RAIs on the NRF ISFSI, the DOE reports about 25 residences (calculated to be about 60 individuals) primarily within the northwest quadrant about the site located outside the INEEL boundaries but within a 16-km (10-mi) radius of the NRF ISFSI. Future changes in the workforce at INEEL may occur, but because of the relatively low risk of contamination from the proposed NRF ISFSI to the offsite workers at INEEL, no additional consideration is required. It is likely that the effects of the proposed NRF ISFSI on the population distribution and trends in the vicinity of INEEL will be minimal and will occur within the expected changes associated with the normal maturation of INEEL facilities.

2.1.1.4 Land and Water Use

The staff have reviewed the information presented in Section 2.1.4, Uses of Nearby Lands and Waters, of the TMI-2 ISFSI SAR and responses to RAIs regarding the NRF ISFSI site. Currently, grazing is allowed on the INEEL facility with more than half its acreage (300,000–350,000 acres) used for cattle and sheep grazing. Also, a 3.64-km^2 (900-acre) parcel of land is used annually as a winter feed lot for about 6,500 sheep. INEEL operating procedures prohibit grazing within 4.8 km (3 mi) of any nuclear facility, and the Naval Reactors Test Facility is a nuclear reactor facility. No dairy cattle are allowed on the INEEL site. Based on a map provided in the RAIs to the NRF ISFSI SAR, it appears that grazing is allowed outside of 4.8 km (3.0 mi) of the NRF ISFSI. Numbers or seasonality of cattle grazing 4.8 km (3.0 mi) to 8.0 km (5.0 mi) from the NRF ISFSI were not provided. However, the normal operation of the NRF ISFSI is not likely to affect cattle grazing on the INEEL site.

The DOE-DNR has described groundwater withdrawal allocations at the NRF. The NRF pumped approximately 34 million gal. (104 acre-ft/yr) of water in 1999 and the water usages in 2000 and 2001 are expected to be similar. Water usage beyond 2001 is projected to be similar to current usage. This amount of usage is considerably smaller than the combined groundwater withdrawal for the entire INEEL facility averages (approximately 8,000 acre-ft/yr). These withdrawal rates should not adversely affect any nearby permanent human populations.

2.1.2 Nearby Industrial, Transportation, and Military Facilities

The staff have reviewed information presented in Section 2.2, Nearby Industrial, Transportation, and Military Facilities, of the TMI-2 ISFSI SAR and responses to NRF ISFSI RAIs regarding the site. The INEEL is a self-contained research facility with significant buffer space to the nearest non-INEEL industrial, transportation, and military facilities. Based on provided information, it was determined with reasonable assurance that the proposed addition of the NRF ISFSI to the INEEL mission will not affect such facilities adversely during construction, operation, and decommissioning. Likewise, the NRF operating reactors should not be affected adversely by the nearness of the proposed NRF ISFSI.

2.1.3 Meteorology

The staff have reviewed the information presented in Section 2.3, Meteorology, of the TMI-2 ISFSI SAR and the responses to RAIs 2-2 and 2-3 regarding the TMI-2 site for relevance and sufficiency for evaluation of the proposed NRF ISFSI. Subsections that are discussed include (i) regional climatology, (ii) local meteorology, and (iii) onsite meteorological measurement program.

2.1.3.1 Regional Climatology

The staff have reviewed information presented in Section 2.3.1, Regional Climatology, of the TMI-2 ISFSI SAR and the responses to RAIs 2-2 and 2-3 regarding the TMI-2 site for applicability and sufficiency for evaluation of the NRF ISFSI. The regional climate data and discussion presented in the TMI-2 ISFSI SAR are applicable and acceptable to the NRF ISFSI. Reliable data sources have been used and the level of detail provided by the DOE-DNR is appropriate. Long-term data of the National Weather Service have been summarized and data from applicable regional and local meteorological stations have been included. The information on severe weather, particularly tornadoes, is acceptable. Because of the relative nearness of the NRF ISFSI site to the TMI-2 ISFSI site with regard to regional climate, the summarized regional meteorological and climatological data are considered by the staff to be representative of an area that encompasses both sites.

Numerous weather stations onsite (INEEL) and offsite (nearby communities) contain lengthy (> 35 yr) records used in the compilation of the meteorologic information. The (i) influence of terrain on regional climate; (ii) regional temperature, precipitation, atmospheric moisture, and winds; (iii) severe weather, including maximum and minimum temperatures, temperature ranges, freeze-thaw cycle, degree days, design temperature, subsoil temperatures, extreme winds, tornadoes, dust devils, hurricanes and tropical storms, precipitation extremes, thunderstorms and lightning, snow storms and snow accumulation, hail and ice storms, and other phenomena; (iv) station atmospheric pressure; and (v) air density have been acceptably documented by the DOE in the TMI-2 ISFSI SAR. The cited values are applicable and sufficient to describe atmospheric conditions at the NRF ISFSI. The TMI-2 ISFSI SAR summaries of climatological data at the INTEC and elsewhere on INEEL and the accompanying tables, maps, and graphs (e.g., Sagendorf, 1996) provide reasonable assurance that the regional climatology is as described. The DOE-DNR used appropriate values from reliable data sources (i.e., National Oceanic and Atmospheric Administration, 1984; Clawson et al., 1989) for strong wind and windborne missiles in development of the structural design criteria in Chapter 2, Principal Design Criteria, of the NRF SAR, and the cited values are applicable and sufficient to describe such atmospheric conditions at the NRF ISFSI. No additional information about the regional climate is necessary.

2.1.3.2 Local Meteorology

The staff have reviewed the information presented in Section 2.3.2, Local Meteorology, of the TMI-2 ISFSI SAR and responses to RAIs (Wilcynski, 1997; Hagers, 1998a,b) regarding the

TMI-2 site. The DOE-DNR has provided acceptable local meteorologic data based on INEEL measurements at several locations near the INTEC but has not identified any meteorologic data for the NRF. To be complete, any meteorologic data collected at the NRF should be summarized and presented in the NRF SAR as per NUREG–1567 (U.S. Nuclear Regulatory Commission, 2000).

Collection points for meteorologic data at the NRF are not identified. However, meteorological extremes are well-represented in the regional data, and there is consistency between the extreme values reported in Section 2.3.1.3, Severe Weather, of the TMI-2 ISFSI SAR (warmest temperature recorded was 101 °F, and coldest temperature recorded was −40 °F) and those extreme values used to develop structural and thermal design criteria in Chapter 3, Principal Design Criteria, of the TMI-2 ISFSI SAR (−50 °F for low and 103 °F for high) (e.g., Coats and Murray, 1985). Similar temperature values are used in the NRF SAR design evaluations. Additionally, the average temperature values (average maximum temperature of 87 °F in July and 27 °F in January; average minimum temperature of 49 °F in July and 4 °F in January) from section 2.3.1.3 of the TMI-2 ISFSI SAR are consistent with the average temperature conditions considered in the NRF SAR Section 2.2.1, Design Temperatures.

Acceptable topographic maps of the region and the proposed NRF ISFSI are provided in the responses to RAIs for the NRF ISFSI SAR. Although not provided, topographic profiles of the proposed NRF ISFSI site necessary to evaluate particle dispersion can be generated from the provided topographic maps. Based on an evaluation of the topographic maps, the staff concluded the response of slopes in the NRF ISFSI area to the expected precipitation and runoff will not adversely affect the operation or safety of the NRF ISFSI.

2.1.3.3 Onsite Meteorological Measurement Program

Although the DOE-DNR has not directly provided any onsite meteorological measurements at the NRF ISFSI site, it has stated in the responses to NRF ISFSI RAIs that on-site meteorological monitoring has been accomplished at the NRF ISFSI site and that measurements collected at the NRF meteorological tower were used in the calculations of atmospheric dispersion at the TMI-2 site some 8.8 km (5.5 mi) away. The lack of provision of on-site meteorologic data does not constitute an Open Item because the DOE-DNR has stated that such information compiled at the NRF site was used to evaluate the atmospheric dispersion characteristics at the TMI-2 ISFSI, which calculations were found acceptable to the NRC.

Additionally, the DOE-DNR-provided atmospheric dispersion estimates for the TMI-2 ISFSI site are acceptable to determine the likely effects of any airborne radioactive material releases at the NRF site because of site similarity in terms of relief and location. Appropriate dispersion analyses using the data from the NRF ISFSI site meteorological tower were calculated for the TMI-2 site using NRF data. Thus, the analyses from the TMI-2 ISFSI site are also representative of the NRF ISFSI site. In the TMI-2 ISFSI calculations, the DOE used both the Sagendorf et al. (1982) XOQDOQ code, an NRC computer program for the meteorological evaluation of routine effluent releases at nuclear power stations, and MESODIF, a regional-scale variable-trajectory Gaussian puff model developed at the National Oceanic and Atmospheric Administration Air Resources Laboratory at the INEEL (Start and Wendell, 1974). The dispersion estimates for the NRF ISFSI site are expected to be the same as the dispersion estimates for the TMI-2 ISFSI site and the TMI-2 calculations can be used to evaluate the likely effects of any airborne radioactive releases at the NRF ISFSI site.

2.1.4 Surface Hydrology

The staff have reviewed Section 2.4, Surface Hydrology, of the TMI-2 ISFSI SAR and the responses to the RAIs regarding the TMI-2 ISFSI site for relevance and adequacy for evaluation of the proposed NRF ISFSI.

2.1.4.1 Hydrologic Description

The NRF and the INEEL are located in the Pioneer Hydrologic Basin. The Pioneer Hydrologic Basin is a closed topographic basin located on the Snake River Plain. The Pioneer Hydrologic Basin can be described as a high-infiltration zone due to the high permeability of alluvium and the underlying bedrock of the basin. There are no perennial streams in the Pioneer Hydrologic Basin. The basin receives intermittent runoff from the Big Lost River, Little Lost River, and Birch Creek. Most of the water from these streams is diverted for irrigation upstream of the INEEL. In exceptionally wet years, when the Big Lost River may provide surface water flow to the INEEL, flow ends in a series of playas. Birch Creek is usually dry, except during heavy spring runoff when water may flow onto the INEEL. The Little Lost River ends in a playa just off the INEEL site.

The surface water hydrology of the INEEL is mostly affected by the Big Lost River, which discharges an average of 211,000 acre-ft/yr below Mackay Dam located 48 km (30 mi) northwest of Arco, Idaho. The largest recorded annual flow of the Big Lost River, below Mackay Dam, was 476,000 acre-ft/yr in 1984. The surface water at INEEL is restricted to these intermittent streams, playas, and human-induced percolation, infiltration, and evaporation ponds. Surface water that reaches the INEEL is not consumed, and there are no identified future uses of surface water.

Site and Structures

The staff have reviewed information presented in Section 2.1.2, Site Description, of the TMI-2 ISFSI SAR and responses to RAIs regarding the site. The NRF ISFSI site location, as presented by the DOE-DNR, is adequately mapped in relation to political boundaries of the INEEL (see Figure 1-4 of NRF ISFSI SAR). The response to the NRF ISFSI RAIs provided additional information. The specific location and accompanying topographic maps provided in the SAR for the TMI-2 site are now acceptable for application to the proposed NRF ISFSI. The storage pad is to be constructed with a surface elevation of approximately 1,478.2 m (4,849.5 ft). The storage pad is designed to be covered by a light metal building and have a slope no greater than 0.1 percent. There will be no drainage system within the storage pad. The storage pad is to be elevated relative to the surrounding ground surface. The ground surrounding the storage pad is to slope away from the storage pad. Storm water will be directed from the pad to the existing storm sewer system. Sufficient information is provided to close this issue.

Hydrosphere

Little Lost River and Birch Creek seldom reach the INEEL and would have no effect on the proposed NRF ISFSI because they are sufficiently far to the north. The Little Lost River drains the slopes of the Lemhi and Lost River ranges. Water in the Little Lost River is diverted seasonally for irrigation north of Howe, Idaho, and does not flow onto the INEEL. Birch Creek originates from springs below Gilmore Summit in the Beaverhead Mountains and flows in a southeasterly direction onto the Snake River Plain. The water in the creek is diverted north of the INEEL for irrigation and hydropower purposes. In the winter months when the water is not being used for irrigation, flows are returned via a human-induced channel to the main Birch Creek channel within the INEEL boundary. The channel leads to a gravel pit near Playa 4, approximately 6.4 km (4 mi) north of test area north (TAN), where it infiltrates the channel and gravel pit bottom, recharging the Snake River Plain Aquifer.

The Big Lost River is the only stream with potential to affect the proposed NRF ISFSI as described in Section 2.4.2 of the TMI-2 ISFSI SAR. The Big Lost River is located approximately 3 km (1.87 mi) from the NRF ISFSI at its closest point. The elevation of the Big Lost River is approximately 1,477 m (4,845 ft) at this point, per the U.S. Geological Survey (USGS) East of Howe Peak, Idaho, 1973 topographic map. The Big Lost River flows southeast from Mackay Dam through the Big Lost River Basin past Arco, Idaho, and onto the Snake River Plain. Stream flows are often reduced significantly before reaching the INEEL by irrigation diversions and infiltration losses along the river. When flow in the Big Lost River reaches the INEEL, it is routed to the flood diversion facilities (FDFs) or flows northward across the INEEL in a shallow, gravel-filled channel to its terminus in the Big Lost River playas where its flow is lost to evaporation and infiltration recharging the Snake River Plain Aquifer.

Control on the Big Lost River upstream of the NRF ISFSI site includes the Mackay Dam and the INEEL FDF. Mackay Dam, located about 72 km (45 mi) upstream from the INEEL, stores water for irrigation downstream. Mackay Dam is a 436-m (1,430-ft)-long, 24-m (79-ft)-high earthfill dam. The dam has a storage capacity of 44,500 acre-ft and surface area of 5 km^2 (1,241 acres) at a water surface elevation of 1,849 m (6,066.5 ft). The spillway design discharge is 92 m^3/s [3,250 cubic feet per second (cfs)]. The total discharge capacity of Mackay Dam is less than 283 m^3/s (10,000 cfs). The INEEL FDF includes a diversion dam, dikes, and spreading areas located about 16 km (10 mi) upstream from INTEC. The FDF controls or divides the flow in the Big Lost River between the spreading areas to the south and the playas to the north where the water can be temporarily stored. This stored water is lost through evaporation and infiltration. Flow in the diversion channel is uncontrolled at discharges that exceed the capacity of the culverts. The combined diversion capacity of FDF is 262.5 m^3/s (9,269.5 cfs) (Bennett, 1986). The capacity of the spreading areas is about 58,000 acre-ft at an elevation of 1,539 m (5,050 ft) above mean sea level (amsl) (McKinney, 1985). Runoff from the Big Lost River has never exceeded the capacity of the spreading areas and overflowed the weir (Carrigan, 1972).

2.1.4.2 Floods

Based on American National Standards Institute/American Nuclear Society 2.8-1984 (1984), the proposed ISFSI site is not a flood-dry site (i.e., it is located in a floodplain). The analysis presented in the SAR to determine the suitability of the site is summarized in this section.

Flood History

USGS streamflow stations along the Big Lost River upstream of the INEEL suggest a history of low-magnitude floods (Koslow and Tullis, 1983). Flooding in the INEEL is typically associated with peak flows during the spring-summer snowmelt season and occasional flooding in winter caused by ice jams in the stream channel. Stream losses due to the high rate of infiltration and irrigation diversions affect the natural flood peaks significantly. The local runoff from low intensity rainstorms on the INEEL site is also minimal due to the relief and geology. Two large flooding events, associated with unseasonably warm temperatures and rain on frozen ground, occurred in 1965 and 1984. The maximum runoff, due to a record snowpack in the Big Lost River basin in the winter of 1964–1965, occurred in late June of 1965. Because the Mackay Reservoir was full, most of the runoff was discharged downstream to the basin and through the FDF on the INEEL site. During the flood, approximately 51 m^3/s (1,800 cfs) was diverted to the spreading areas from a peak flow of 62.7 m^3/s (2,215 cfs) (Martineau et al., 1990). The water did not reach the end of the Big Lost River channel at the Birch Creek playa during this flood and caused no damage to INEEL facilities.

During the winter of 1983–1984, high streamflows in the Big Lost River and a severe cold spell produced ice jams that caused localized flooding in INEEL. These high streamflows were largely the result of the Borah Peak earthquake October 28, 1983, which created new springs upstream of Mackay Reservoir, reduced the storage behind the dam, and resulted in increased discharge in the downstream channel. The diversion channel capacity at FDF was increased to 255 m^3/s (9,000 cfs) to handle the additional flow in the channel. There was no damage to the INEEL facilities through accumulation of ice in the diversion channel.

Location coordinates, topographic maps, and flood analysis results for the subject site were provided in response to the RAIs.

Flood Design Considerations

Flood Routing Analysis for a Failure of MacKay Dam by Koslow and Van Haaften (1986) was used to evaluate flooding at the NRF. According to Koslow and Van Haaften (1986), a peak water surface water elevation of 1,478.98 m (4,852.29 ft) at the NRF would occur during a probable maximum flood (PMF)-induced overtopping of the MacKay Dam. [Note that this elevation is corrected to the INEL datum from the USGS datum (Koslow and Van Haaften, 1986).] This peak surface water elevation exceeds the proposed storage pad elevation of 1,508.6 m (4949.5 ft) by 0.85 m (2.79 ft). A 0.91-m (3-ft) tall concrete base to the walls surrounding the storage pad provides a revetment to water. The height of the concrete wall would exceed the maximum peak surface water elevation by 0.06 m (0.21 ft). Koslow and Van Haaften (1986) note there is uncertainty in their calculations, but do not estimate the level of uncertainty in the MacKay Dam analyses. However, because of the relatively flat topographic surface of the Big Lost River floodplain near the NRF, significantly larger water discharge during the flood events would be required to significantly increase the peak surface water elevation at the NRF. After reviewing the available information, it was determined that the NRF ISFSI storage pad, if protected by a 0.91-m (3-ft) tall concrete base in the surrounding walls, will not be flooded or inundated by storm runoff.

Effects of Local Intense Precipitation

Detailed [i.e., 0.3-m (1-ft) contour] topographic map, location coordinates, and a site construction description were provided in response to the RAIs.. After reviewing the available information, it was determined that the NRF ISFSI Overpack Storage Slab (OSS), if protected by a 0.9-m (3-ft) tall concrete base in the surrounding walls, completely covered by a roof, and built such that the ground surface upon which the OSS is constructed slopes away from all sides to the surrounding areas, will not be flooded or inundated by the effects of local intense precipitation.

2.1.4.3 Probable Maximum Flood on Streams and Rivers

The PMF represents the maximum flow that can occur due to hydrometeorological factors. It may be caused by an unusually severe storm or some catastrophic event, such as a dam failure. A PMF-induced overtopping failure of the Mackay Dam caused by extreme precipitation [the general storm probable maximum precipitation (PMP)] is used as a bounding scenario for INEEL facilities. Flood Routing Analysis for a Failure of MacKay Dam by Koslow and Van Haaften (1986) was used to evaluate flooding at the NRF. This analysis provides information on the peak water surface, elevation, peak flow, water velocity, and the time of arrival at several downstream locations, including the NRF. After reviewing the available information, it was determined that the NRF ISFSI storage pad, if protected by a 0.91-m (3-ft) tall concrete base in the surrounding walls, will not be flooded or inundated by a PMF-induced flooding of the Big Lost River.

Probable Maximum Precipitation

The general storm PMP used for the analysis resulted from a 48-hr general storm that was preceded 3 days by a storm with a 40-percent magnitude of the 48-hr storm (Koslow and Van Haaften, 1986). This scenario provides a conservative analysis because of no infiltration losses. It may also be representative of actual site conditions in the case of severe frost or a fully saturated watershed. Based on the analysis, the peak flow for the PMF, occurring after 154 hr, is 2,325 m^3/s (82,100 cfs). The Myers envelope curve used by the U.S. Army Corps of Engineers estimates the PMF to be within 1,416–5,663 m^3/s (50,000–200,000 cfs). The highest flow recorded at USGS Howell Station is 125 m^3/s (4,420 cfs) (U.S. Department of Energy, 1996a).

Precipitation Losses

The topography and drainage characteristics along the Big Lost River provide conditions conducive for high-infiltration losses. The precipitation in this area generally does not exceed the infiltration capacity of the soil to create intermittent streams to the Big Lost River.

Runoff Model

Detailed [i.e., 0.3-m (1-ft) contour] topographic map, location coordinates, and details of the storage pad construction were provided in responses to the RAIs. Details of construction of the NRF storage pad and surrounding area were provided. After reviewing the available information, the staff found reasonable assurance that the NRF ISFSI storage pad, if protected by a 0.9-m (3-ft) tall concrete base in the surrounding walls, will not be adversely affected by runoff.

Probable Maximum Flood Flow

The discharge capacity of the spillway on Mackay Dam is not adequate to pass the maximum flow due to PMP safely. This could result in overtopping and subsequent breaching of the dam. This scenario has been analyzed and suggests the inflow is sufficient to raise the water surface 0.3 m (1 ft) above the crest of the dam. This overtopping is projected to develop a trapezoidal breach through the dam in a 1-hr period. The computer code DAMBRK, developed by the National Weather Service, was used in the flood-routing analysis (Koslow and Van Haaften, 1986). The peak flow immediately downstream of the Mackay Dam caused by the PMP-induced overtopping failure is 8,685 m^3/s (306,700 cfs). This peak flow will be attenuated to 2,035 m^3/s (71,850 cfs) at the INEEL Diversion Dam and to 1,892 m^3/s (66,830 cfs) at INTEC. The flood wave will reach the INEEL FDF in about 10 hr with average water velocities of 0.3–0.9 m/s (1–3 ft/s).

Water Level Determinations

The PMF-induced overtopping failure was analyzed by the computer program DAMBRK to obtain peak water surface elevations, flow, velocity, and time of wave arrival as identified in Table 2.2 (Koslow and Van Haaften, 1986). Detailed [i.e., 0.3-m (1-ft) contour] topographic map and location coordinates were provided in responses to the. The responses to the NRF ISFSI RAIs provided an adequate analysis of the effects of PMF-induced overtopping failure of the MacKay Dam.

Coincident Wave Activity

The static and dynamic effects of wave activity would be negligible because the waves did not exceed 0.15 m (0.5 ft) due to wind activity coincident with the largest projected flood crest (Lockheed Martin Idaho Technologies Company, 1994).

2.1.4.4 Potential Dam Failures (Seismically Induced)

The State of Idaho classified the Mackay Dam as a high hazard dam with reference to the U.S. Army Corps of Engineers guidelines for safety inspection of dams (State of Idaho, 1978). Although Mackay Dam is located in a region of historical seismicity, it was built without any seismic design criteria. A seismically induced dam failure analysis was conducted to determine potential effects at the INEEL (Koslow and Van Haaften, 1986). This analysis assumed a postulated seismic failure of Mackay Dam during an inflow to the reservoir equal to the 25-yr recurrence interval flood [peak flow 114 m^3/s (4,030 cfs)]. During this analysis, a trapezoidal breach extending to the bottom of the structure and developing during a 1-hr period was used. The peak flow, immediately downstream of the dam from this hypothetical analysis, was 3,043 m^3/s (107,480 cfs). This peak flow was attenuated to 1,286 m^3/s (45,410 cfs) at the INEEL diversion dam. The leading edge of the flood wave reached the INEEL diversion dam in about 12 hr, with average water velocities of 0.3–0.9 m/s (1–3 ft/s).

Detailed [i.e., 0.3-m (1-ft) contour] topographic map and location coordinates were provided in response to the RAIs. Flood routing analysis for seismically induced failure of MacKay Dam by

Koslow and Van Haaften (1986) was used to evaluate peak flow at the NRF. This analysis provides information on the peak water surface, elevation, peak flow, water velocity, and the time of arrival at several downstream locations, including the NRF. After reviewing the available information, the staff found reasonable assurance that the NRF ISFSI storage pad, if protected by a 0.9-m (3-ft) tall concrete base in the surrounding walls, will not be flooded or inundated by seismically induced failure of MacKay Dam.

Reservoir Description

Mackay Dam, built in 1917, is a 436-m-(1,430-ft)-long, 24-m (79-ft)-high earthfill dam built primarily for irrigation for the Big Lost River Irrigation District. Water from Mackay Dam provides irrigation for about 274 km^3 (67,700 acres) of land and recreational opportunities. The INEEL flood diversion dam, located approximately 10.4 km (6.5 mi) downstream from the western INEEL boundary, was built in 1958 to divert flows from the Big Lost River to protect downstream facilities.

Dam Failure Permutations

Two different scenarios are discussed in the Sections 2.4.3, Probable Maximum Flood on Streams and Rivers, and 2.4.4, Potential Dam Failures (Seismically Induced), of the TMI-2 ISFSI SAR that include overtopping dam failure due to the PMP and a seismically induced dam failure. Additional scenarios examined for dam failure include two hydraulic (piping) failures concurrent with 100- and 500-yr inflow floods to the reservoir. Floodwaters released from the failure of Mackay Dam will overtop the INEEL diversion dam and cause flooding downstream on the INEEL site. The analysis conducted using the DAMBRK code assumes that the INEEL diversion dam begins to fail when flood waters reach 1,544 m (5,065 ft) amsl, an overtopping depth of 0.09 m (0.3 ft) (Koslow and Van Haaften, 1986). The results of the analysis indicate an almost instantaneous failure (in 0.1 hr) of the INEEL diversion dam.

Unsteady Flow Analysis of Potential Dam Failures

Because of the failure of Mackay Dam, the flood would have a high initial velocity just downstream of the dam, however, the average velocity would decrease to approximately 0.3–0.9 m/s (1–3 ft/s) near the FDF in INEEL. The discharge capacity of the FDF is sufficient to handle the flood wave and will be diverted to the spreading areas (Koslow and Van Haaften, 1986). Downstream of the FDF, the remaining water in the Big Lost River channel will continue to spread across the floodplain with a peak water velocity of 0.8 m/s (2.7 ft/s) at the NRF ISFSI.

Water Level at the Installation Site

The maximum flooding condition at the NRF will result from a failure of the Mackay Dam due to the PMP storm. Detailed [i.e., 0.3-m (1-ft) contour] topographic map, location coordinates, and a flood analysis were provided in responses to the RAIs. The responses to the NRF ISFSI RAIs provided an adequate analysis of the effects of PMF-induced overtopping failure of the MacKay Dam.

2.1.4.5 Probable Maximum Surge and Seiche Flooding

Effects from surge and seiche flooding are not potential natural phenomena at the NRF ISFSI due to its remoteness from major water bodies.

2.1.4.6 Probable Maximum Tsunami Flooding

Tsunami flooding at the INEEL is not a potential natural phenomenon due to the inland location of the NRF ISFSI site.

2.1.4.7 Ice Flooding

Detailed (i.e., 0.3-m contour) topographic map and location coordinates were provided in response to the RAIs. Any ice jams would occur upstream of the diversion dam on the Big Lost River. Overflowing banks will not be a concern of the NRF located downstream from the diversion dam.

2.1.4.8 Flood Protection Requirements

Detailed [i.e., 0.3-m (1-ft) contour] topographic map, location coordinates, and a flood analysis were provided in responses to the RAIs. After reviewing the available information, it was determined that the NRF ISFSI storage pad, if protected by a 0.91-m (3-ft) tall concrete base in the surrounding walls, will not be flooded or inundated by a PMF-induced flooding of the Big Lost River.

2.1.4.9 Environmental Acceptance of Effluents

According to the SAR, there will be no liquid effluents associated with the normal operation of the NRF ISFSI. Therefore, the environmental acceptance of effluents will not be an issue at the NRF ISFSI.

2.1.5 Subsurface Hydrology

The staff have reviewed Section 2.5, Subsurface Hydrology, of the TMI-2 ISFSI SAR and the DOE responses to the RAIs regarding the TMI-2 ISFSI site for relevance and adequacy for evaluation of the proposed NRF ISFSI site.

2.1.5.1 Regional Characteristics

The Snake River Plain Aquifer serves as the main water supply source for INEEL. It underlies the INEEL and nearly all the Eastern Snake River Plain (ESRP). The aquifer is about 320 km (200 mi) long and 48–96 km (30–60 mi) wide. The Snake River Plain Aquifer comprises a series of basalt flows with interbedded layers of fluvial, lacustrine, windblown, and pyroclastic sediments. High-permeability zones occur along the upper and lower contacts of successive basaltic flows due to high density of fractures. These fractures cause a large degree of heterogeneity and anisotropy in the hydraulic properties of the aquifer.

Most of the water from Big Lost River entering the INEEL recharges to the Snake River Plain Aquifer. A small amount of recharge occurs from infiltration of precipitation directly on the INEEL site. In some years of high runoff, Birch Creek water flowed onto the INEEL and seeped underground. Groundwater in the aquifer generally flows from the northeast to the southwest. The annual discharge from the aquifer is estimated at 6.5×10^6 acre-ft. Most of the discharge occurs as spring flow. The irrigation activities consume about 2.1×10^6 acre-ft/yr of groundwater from the Snake River Plain Aquifer. It is estimated that about half this water reenters the aquifer as return flow. The regional groundwater surface underlying the INEEL ranges from about 1,402 m (4,600 ft) in the north to about 1,341 m (4,400 ft) near the southwest boundary of the INEEL. The average hydraulic gradient slopes to the south and southwest on the INEEL site. At the INEEL, the depth below the land surface to the regional groundwater table ranges from 61 m (200 ft) in the northeast to 274 m (900 ft) in the west-southwest.

The Snake River Plain Aquifer is the only source of water for the INEEL. The average groundwater withdrawal is approximately 8,000 acre-ft/yr. This amounts to about 1 percent of the flux in the Snake River Plain Aquifer and less than 0.1 percent of the total annual aquifer discharge.

A map with well and borehole locations in the vicinity of NRF, projected water usage rates, driller and geophysical logs for boreholes and wells, and a vertical section constructed with well logs were provided in responses to the RAIs.

2.1.5.2 Site Characteristics

Due to low dissolved solids, groundwater from the Snake River Plain Aquifer is satisfactory for most purposes without any treatment. The major dissolved solids in the groundwater are calcium and magnesium carbonate. The groundwater has a median pH of 8.01. The average depth to the groundwater in the NRF ISFSI area is about 137 m (450 ft), the average aquifer transmissivity is 5.6×10^4 m^3/m (6×10^5 ft^3/ft), the storage coefficient ranges 0.2–0.15, and the effective porosity ranges 0.05–0.10. Projected water usage at NRF is 34 million gal./yr (104 acre-ft/yr). This amount of water will not alter the regional Snake River Plain Aquifer. This item is closed.

2.1.5.3 Contaminant Transport Analysis

The spent nuclear fuel canisters at the NRF ISFSI will not be externally contaminated and the design precludes leaking, so no contamination to the outside of the facility is expected.

Additionally, the contaminants would have to travel through at least 122 m (400 ft) of basalt to reach groundwater. Any small amount of contamination, if released from the site, will have very low probability to reach the groundwater. Because there is a low probability that any contamination will be released from the ISFSI, a transport analysis was not included in the SAR.

2.1.6 Geology and Seismology

Geology and seismology are not discussed directly in the NRF SAR (Bechtel Bettis, Inc., 1999). Instead, this NRF SAR primarily refers to the TMI-2 ISFSI SAR (U.S. Department of Energy, 1996a) and assumes that the site characteristics described in TMI-2 ISFSI SAR generally apply to both the Idaho INTEC, where the TMI-2 ISFSI site is located, and the NRF sites. The only significant difference in geology and seismology between the NRF ISFSI SAR and the TMI-2 ISFSI SAR is that the PSHA has been recalculated in the NRF SAR using new ground motion attenuation relations developed by URSGWCFS and their subcontractors, Pacific Engineering and Analysis and Geomatrix Consultants. Those results are given in URSGWCFS et al. (2000) and references therein, including URSGWCFS et al. (1999), WCFS (1998), and WCFS et al. (1996).

This section contains the review of Section 2.6, Geology and Seismology, of the TMI-2 ISFSI SAR as relevant to the proposed NRF ISFSI site. Subsections that have been discussed include (i) Basic Geology and Seismic Information, (ii) Vibratory Ground Motion, (iii) Subsurface Faulting, (iv) Stability of Subsurface Materials, (v) Slope Stability, (vi) Volcanism, and (vii) Design Ground Motion. Specific information pertaining to the site geological and seismological characteristics were reviewed from WCFS et al. (1996). Much of this information has been previously reviewed by the staff for the TMI-2 ISFSI SER (Brach, 1999a; Chen and Chowdhury, 1998). The areas of review herein correspond to information given in these reports and follow the organization of information given in NUREG–1567 (U.S. Nuclear Regulatory Commission, 2000).

2.1.6.1 Basic Geologic and Seismic Information

Basic geologic and seismic characteristics of the site and vicinity are presented in Section 2.6.1 of the TMI-2 ISFSI SAR, the response to the RAI, and references therein. Information includes the physiographic background and site geomorphology, regional and site geological history, structural geologic conditions, and engineering evaluation of geologic features.

Physiographic Background and Site Geomorphology

The INEEL is located near the northwestern margin of the ESRP in southeastern Idaho (figure 2-1). The Snake River Plain is a topographically subdued physiographic province bordered on the northwest and southeast by the Basin and Range Province, on the northeast by the Yellowstone Plateau, and on the north by Idaho Batholith Provinces. The ESRP is the portion extending from Yellowstone Plateau to the Great Rift. These four physiographic provinces (ESRP, northern Basin and Range, Yellowstone Plateau, and Idaho Batholith) also correspond to defined tectonic or seismotectonic provinces (e.g., Burchfiel et al., 1992).

Each physiographic province has a unique seismogenic potential determined by the nature of the underlying intrinsic tectonic processes. As part of the TMI-2 ISFSI SAR evaluation, the staff reviewed a wealth of relevant information in the literature, including Pierce and Morgan (1992), Malde (1991), Hackett and Smith (1992), Christiansen (1984), and work conducted by DOE subcontractors[1] [Woodward-Clyde Consultants (WCC), 1990, 1992a,b; Woodward-Clyde Federal Services, 1995, 1996a,b].

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[1]Woodward-Clyde Federal Services. *Recommendations for Neotectonic Investigations of the Arco Rift Zone and Southern Lost River Fault Zone, Idaho*. Idaho Falls, ID: EG&G Idaho, Inc. Unpublished final report. 1994.

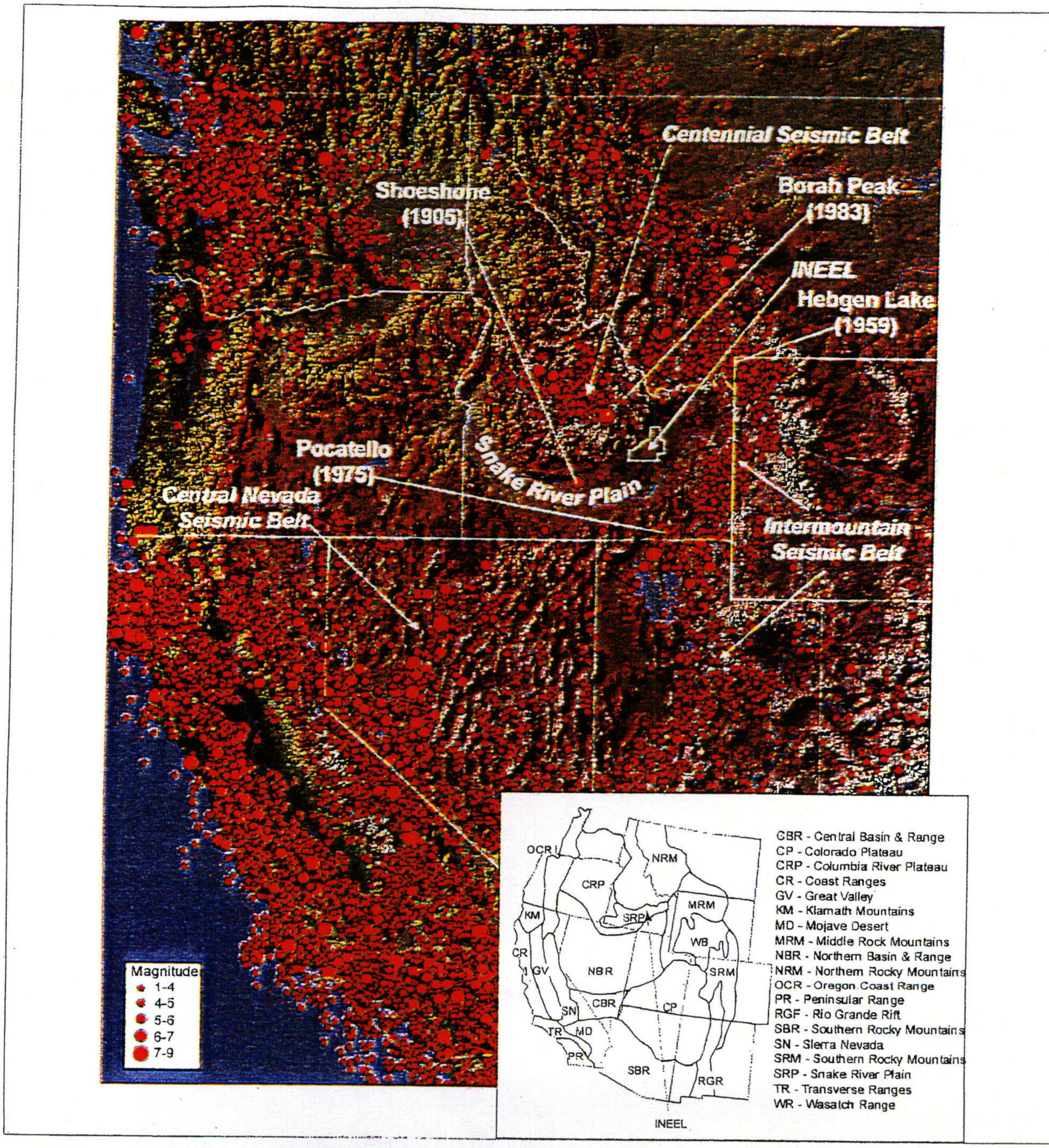

Figure 2-1. Digital elevation model of the western United States showing the distribution of historical earthquakes. The earthquake data come from the compilation by the U.S. Geological Survey. The inset shows the location of seismotectonic provinces in the western United States.

Figure 2-1 shows earthquake epicenters of the Snake River Plain and surrounding areas based on the USGS earthquake catalog of earthquakes for the past 100 yr. Relatively few earthquakes occurred within the Snake River Plain. In contrast, the Snake River Plain is wrapped on its southeastern, eastern, and northern boundaries by two seismic activity belts known as the Intermountain Seismic Belt and the Centennial Tectonic Belt.

In the TMI-2 ISFSI SAR, the geomorphology of the ESRP is characterized as rough, uneven topography due to numerous basalt lava flows that make up the surface rock exposures. Pertinent topographic features include buttes, rivers, sinks, depressions, mounds, and vents for basaltic volcanism that are concentrated in volcanic rift zones and along the central axis of the plain (Kuntz et al., 1992). The site is in a flat-lying area near the Big Lost River in the south central part of the INEEL. Landforms consist of braided channels of the Big Lost River to the west and north of the site and irregular flow lobes of basalt lavas to the east of the site.

The review confirmed the TMI-2 ISFSI site is in a relatively flat and stable location. Results of that review are presented in the NRC SER (Brach, 1999b) and in Chen and Chowdhury (1998). Because the proposed NRF ISFSI is located within the same physiographic and geomorphic setting as the TMI-2 site, the current analyses are adequate and no additional information about the site physiography or geomorphology is necessary.

Regional and Site Geological History

The TMI-2 ISFSI SAR briefly discusses the Paleozoic, Mesozoic, and early Cenozoic history of the region and provides more detailed discussions of the Late Cenozoic and Quaternary history of the area. Precambrian through Mesozoic rocks are dominantly clastic (shales and quartzites) and carbonate (dolomites and limestones) sedimentary rocks. During the Mesozoic and early Cenozoic, large volumes of granitic rock were emplaced by igneous intrusions into the upper crust.

The Snake River Plain is considered the continental scar of a mantle hotspot track. The hotspot now resides beneath the Yellowstone Plateau (Pierce and Morgan, 1992). The hotspot is a mantle plume that impinged on the base of the lithosphere directly underneath north-central Nevada about 17 million yr ago (Pierce and Morgan, 1992). Because the plume is rooted deep in the mantle, it has remained stationary, while the North American Plate drifted southwest across the plume at about 3.6 cm/yr (1.4 in./yr) as a result of plate tectonic movements. This relative movement of the North American Plate over the hotspot, and the subsequent heating and cooling processes, produced the basin of the Snake River Plain that extends from Yellowstone National Park to north-central Nevada.

Geologic processes that produced the Snake River Plain include (i) input of magma and heat into the continental lithosphere and crust from the mantle hotspot, crustal melting, and voluminous silicic volcanism from large calderas; (ii) cooling of the crust, solidification of midcrustal mafic magmas and upper crustal silicic batholiths, and subsidence due to thermal contraction and densification of the crust in the wake of the hotspot as the plate moved to the southwest; and (iii) filling the subsiding elongate basin with basalt lava flows and interbedded terrigenous clastic sediments to depths as great as 1.13–2.25 km (0.7–1.4 mi) in the ESRP (Woodward-Clyde Federal Services, 1996a; Sparlin et al., 1982; Brott et al., 1981; Blackwell, 1989). The TMI-2 ISFSI site is underlain by about 9–18 m (30–60 ft) of Big Lost River alluvial silts, sands, and gravels that lie on an alternating sequence of basalt lava flows and interbedded sediments extending to a depth of about 600–700 m (1,969–2,297 ft). The sediments composed of fine-grained silts, sands, gravels, and clays are up to 60 m (197 ft) thick, depending on the duration of the quiescence between volcanic periods.

The staff review confirmed that the TMI-2 ISFSI SAR adequately described the regional and site geologic history. Results of that review are presented in the NRC SER (Brach, 1999b) and in Chen and Chowdhury (1998). Because the proposed NRF ISFSI is located within the same geologic setting as the TMI-2 site, no additional information about the regional and site geologic history is necessary.

Structural Geologic Conditions

Previous analyses of the structural geologic conditions of the INEEL (e.g., U.S. Department of Energy, 1996a; Chen and Chowdhury, 1998) show that there is no evidence for folding or faulting in the subsurface. Although some basalt lava flows are present in parts of the INEEL area and absent in others, they have not been structurally disrupted. Their discontinuous distribution is due to stratigraphic pinch-outs of lavas that flowed into the Big Lost River valley from vents to the southeast and southwest. Most significant earthquake sources are the Basin and Range faults that lie to the north of the ESRP. Those fault sources are discussed in Section 2.1.6.2, Vibratory Ground Motion. Specific structural geology conditions related to subsurface faulting are discussed in Section 2.1.6.3, Surface Faulting.

The staff review confirmed that the TMI-2 ISFSI SAR adequately described the structural geologic conditions. Results of that review are presented in the NRC SER (Brach, 1999b) and in Chen and Chowdhury (1998). Because the proposed NRF ISFSI is influenced by the same structural geologic conditions as the TMI-2 site, no additional information about the regional and structural geologic conditions is necessary.

Engineering Evaluation of Geologic Features

The TMI-2 ISFSI SAR provided a detailed description of the geological engineering characteristics, including type of rock or sediments, permeability, and seismic wave velocities. These discussions were based on analysis of geophysical logs of wells, examination of drill cores from boreholes, chemical analyses of core samples, and radiometric age determinations of strata. A site-specific shear wave velocity profile is provided. The interlayering of unconsolidated and poorly consolidated sediments within the basalts has engineering significance to the facilities at INEEL because (i) the interbedded sediments have low permeability and high absorption capabilities (Nace et al., 1975), and they retard the downward migration of water and contaminants to the water table; (ii) the low permeability of the sedimentary interbeds commonly causes localized perched water zones beneath some INEEL infiltration ponds and natural infiltration/recharge zones; (iii) the interbeds act as confining or semiconfining layers in the aquifer and affect water flow directions; (iv) the alternating high and low seismic velocities associated with basalts and poorly consolidated sedimentary interbeds cause greater attenuation of earthquake ground motion (Woodward-Clyde Consultants, 1990, 1992a; Woodward-Clyde Federal Services, 1996a); and (v) the unconsolidated sands and clays intercalated within the hard, brittle basalts contribute to difficult drilling and downhole geophysical logging.

The staff review confirmed that the TMI-2 ISFSI SAR provides an adequate engineering evaluation of the geologic features with regard to engineering evaluation of structural geologic conditions. Results of that review are presented in the NRC SER (Brach, 1999b) and in Chen and Chowdhury (1998). Specific engineering properties with respect to stability of subsurface materials are evaluated in section 2.1.6.4. Because the proposed NRF ISFSI is located within the same geologic setting as the TMI-2 site, no additional information or evaluation about the geologic features is necessary.

2.1.6.2 Vibratory Ground Motion

Vibratory ground motion from earthquakes is estimated from the historical seismic record, paleoseismicity, and geological considerations. The analyses include identification of potential seismic sources and their characteristics, correlation of earthquake activity with geologic structures, estimations of maximum earthquake potential, and characteristics of seismic energy wave transmission.

According to 20 CFR 72.122(b)(2), structures, systems, and components (SSCs) important to safety must be designed to withstand the effects of natural phenomena, including earthquakes. For sites west of the Rocky Mountains, such as NRF ISFSI site, 10 CFR Part 72 requires that seismicity be evaluated by techniques described in appendix A of 10 CFR Part 100. This appendix defines the safe shutdown earthquake (SSE) as the earthquake that produces the maximum vibratory ground motion at the site and requires that the SSCs be designed to withstand the ground motion produced by the SSE. This seismic design method uses a DSHA; one that only considers the most significant seismic event and is time-independent (i.e., it does not consider the planned operational period of the facility). Also, 10 CFR 72.102(f)(1) requires that analyses using appendix A methodology should use a design peak horizontal acceleration (PHA) equivalent to that of the SSE for a nuclear power plant. Furthermore, NUREG–0800 (U.S. Nuclear Regulatory Commission, 1997, section 2.5.2.6) states that the 84th-percentile value of ground motion spectrum should be used to calculate the reactor SSE PHA (U.S. Nuclear Regulatory Commission, 1997).

In the TMI-2 ISFSI SAR, the DOE proposed to design the TMI-2 ISFSI at the INEEL based on seismic design criteria contained within the INEEL architectural engineering (AE) (cross sections) standards (U.S. Department of Energy, 1992). In the AE standards related to a reactor or facilities with similar risk, the peak design basis horizontal acceleration for the INTEC is 0.36 g, including effects of soil amplification.

PSHA is now recognized as state of the art in assessing seismic hazard assessments (e.g., Budnitz et al., 1997). Although 10 CFR Part 72 has not yet been explicitly revised to allow use of a PSHA to derive the design earthquake (DE) for an ISFSI, several regulatory developments support a PSHA methodology for ISFSIs, including (i) recent revisions of other NRC regulations to allow for PSHA (10 CFR Parts 50, 60, and 100), (ii) NRC-planned rulemaking for siting and design of dry cask ISFSIs under 10 CFR Part 72, and (iii) NRC acceptance of PSHA for designing SSCs for the TMI-2 ISFSI (Brach, 1999a) and Yucca Mountain (YM) high-level nuclear waste (HLW) repository (U.S. Department of Energy, 1996b).

As part of the TMI-2 ISFSI SER, the NRC granted an exemption from 10 CFR Part 72 regulations and allowed a PSHA approach, including mean ground motions at a 2000-yr mean recurrence interval (U.S. Nuclear Regulatory Commission, 1998). On September 23, 1999, the NRC agreed that a PSHA, following the TMI-2 ISFSI methodology, is also acceptable to the NRF ISFSI (Brach, 1999b).

Methods for calculating ground shaking using a PSHA approach are well established in the scientific literature (e.g., Cornell, 1968; McGuire, 1995). Basic inputs required to conduct the PSHA are (i) interpretation of the seismic sources from which conditional probability distribution functions of earthquake parameters (e.g., maximum magnitude, source-to-site distance, or thickness of seismogenic crust) can be obtained, (ii) earthquake recurrence parameters (e.g., slip rate or activity rate), and (iii) ground motion attenuation. For the NRF ISFSI SAR, only the third component (ground motion attenuation) was modified from the original PSHA (Woodward-Clyde Federal Services, 1996a) used in the TMI-2 ISFSI SAR.

In 2000, URSGWCFS and its subcontractors, Pacific Engineering and Analysis and Geomatrix Consultants Inc., recalculated the hazards at five INEEL facility sites: Test Reactor Area, Radioactive Waste Management Complex, Power Burst Facility, TAN, and the NRF. The seismic hazards at these five facility areas were recalculated based on recently developed attenuation models from the YM project (CRWMS M&O, 1998) and revised site-specific stochastic attenuation relations developed in URSGWCFS et al. (2000). In short, the revised attenuation models used in the URSGWCFS et al. (2000) PSHA led to a lower seismic hazard by 12–23 percent compared to the seismic hazard levels reported in the 1996 PSHA. Therefore, the focus of this review of the seismic hazard is centered on the application of these new ground motion attenuation models to the NRF ISFSI.

Geological and Seismotectonic Settings

As indicated in the TMI-2 ISFSI SAR, the four physiographic provinces in the region also correspond to tectonic or seismotectonic provinces: ESRP, northern Basin and Range, Yellowstone Plateau, and Idaho Batholith (figure 2-1, TMI-2 ISFSI SER). Furthermore, the ESRP is wrapped on its southeastern, eastern, and northern boundaries by two seismically active belts known as the Intermountain Seismic Belt and the Centennial Tectonic Belt. All these are important background zones that contribute to seismic ground motion at the INEEL. Other features significant to seismic ground motion that need separate consideration in seismic hazard analyses include active fault zones in the northern Basin and Range Province and volcanic rift zones in the ESRP.

The staff review confirmed that the TMI-2 ISFSI SAR provides an adequate description of the geologic and seismotectonic settings of the NRF ISFSI site. Results of that review are presented in the NRC SER (Brach, 1999b) and in Chen and Chowdhury (1998). Because the proposed NRF ISFSI is located within the same geologic and seismotectonic as the TMI-2 site, no additional evaluation of the geologic and seismotectonic settings is necessary.

Historical Seismicity

Thousands of earthquakes with magnitudes of 2.5 or greater have occurred within 500 km (310 mi) of the INEEL since the first recorded earthquake in 1884. The staff evaluated the analyses of historical seismicity given in the TMI-2 ISFSI SAR by reviewing information presented by the DOE, research performed by the DOE contractors and subcontractors, and studies in the scientific literature.

There were two significant earthquakes in the region: the 1959 Hebgen Lake earthquake [moment magnitude (M_w) = 7.3, surface wave magnitude (M_s) = 7.5] and the 1983 Borah Peak earthquake (M_w = 6.8, M_s = 7.3). The 1959 Hebgen Lake earthquake was the largest historical earthquake in the intermountain region. The mainshock appears to have consisted of two normal faulting subevents that reactivated the existing Laramide thrust faults. Two faults appear to have ruptured during the earthquake: the Red Canyon fault and the Hebgen fault.

The 1983 Borah Peak earthquake is of particular interest because of its proximity to INEEL. The earthquake produced a surface rupture 37-km (23 mi) long, including all of the nearly 21-km (13-mi) long Thousand Springs segment of the Lost River fault. The magnitude of the 1983 Borah Peak earthquake confirmed the selection of the magnitude of the most significant earthquake in earlier DSHA at the INEEL [e.g., WCC[2] (M_s = 6.75) for Loss of Fluid Test (LOFT); Allied Chemical Corporation,[3] Local magnitude (M_l = 7.75) for INTEC; Agbabian Associates[4] (M_s = 6.75) for LOFT; and WCC[5] (M_s = 6.75) for Transient Reactor Test]. It also has been referenced, together with evidence of paleoseismic study, in selecting magnitude of the most significant earthquake for fault sources in the recent DSHAs [WCC (1990) (M_s = 7.3), WCC (1992) (M_w = 7.0), and WCFS (1996b) (M_w = 7.1)].

Another earthquake used in estimating seismic hazard at INEEL is the 1905 earthquake near Shoshone. There are, however, significant uncertainties in both the location and magnitude of this earthquake. Based on the estimated magnitude of the 1905 Shoeshone earthquake, an M_w = 5.5 earthquake was selected as the maximum magnitude in the Woodward-Clyde Consultants probabilistic study (1992a) and as the average maximum magnitude in the WCFS (1996a) probabilistic studies for the ESRP areal source.

An earthquake of particular interest is the 1975 Pocatello Valley earthquake (M_l = 6.0), because it occurred on a blind fault that was not evident in the surface geology. Therefore, it provided justification and a reference for maximum magnitude for areal sources based on the concept of a random earthquake.

Evaluations of the DOE analyses of historical seismicity by the staff indicate that the analyses and information in the TMI-2 ISFSI SAR provide reasonable assurance that an adequate set of historical seismic data was used in developing seismic recurrence relationships and determining the maximum earthquake potential in hazard analyses. Results of that review are

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[2]Woodward-Clyde Consultants. *A Seismic Hazard Study for the LOFT Reactor Facility at the INEL, Idaho.* Prepared for Energy Research and Development Agency. Unpublished report. 1975.

[3]Allied Chemical Corporation. *Preliminary Safety Analysis Report for the New Waste Calcining Facility.* Prepared for Idaho National Engineering Laboratory. Unpublished report. 1975.

[4]Agbabian Associates. *Evaluation of Seismic Criteria Used in the Design of INEEL Facilities.* Prepared for the Energy Research and Development Administration. Idaho Falls, ID: Idaho National Engineering Laboratory. Unpublished report. 1977.

[5]Woodward-Clyde Consultants. *A Seismic Hazard Study for the TREAT Facility at the INEEL, Idaho.* Prepared for Argonne National Laboratory. Unpublished report. 1979.

presented in the NRC SER (Brach, 1999b) and in Chen and Chowdhury (1998). All significant historical earthquakes were identified and their effects on the TMI-2 ISFSI site evaluated, based on available documents. The review confirmed that the TMI-2 ISFSI SAR provides an adequate description of the historical seismicity at the INEEL. Because the proposed NRF ISFSI is located within the same seismotectonic setting as the TMI-2 ISFSI and because there have been no significant earthquakes since the TMI-2 ISFSI SAR was published, no additional evaluation of the historical seismicity is necessary.

Potential Seismic Sources and Their Characteristics

Site characterization at INEEL is an evolving process that has spanned the nearly 50-yr history of the INEEL facility. For the TMI-2 ISFSI SER, the staff review of literature addressing the regional geological and seismotectonic settings indicated that seismotectonic characteristics and seismic sources significant for seismic hazard evaluation at INEEL have been sufficiently analyzed and identified, mainly by the DOE and its subcontractors such as WCFS. The staff concluded that these studies reflect the state of knowledge in seismic source characterization (Brach, 1999b; Chen and Chowdhury, 1998).

Three types of seismic sources were considered in the PSHA (Woodward-Clyde Federal Services, 1996a): fault zones, an ESRP volcanic rift zone, and regional area source zones. Results from the WCFS (1996a) PSHA show that fault sources and regional areal sources contribute significantly more to the seismic hazard than volcanic source zones. Contributions from the fault sources become most significant at lower probability levels and for longer ground motion periods.

Details of the review of fault sources for the INEEL are given in Chen and Chowdhury (1998) and in the TMI-2 ISFSI SER (Brach, 1999b). Those reviews confirmed fault sources for the TMI-2 ISFSI were adequately characterized. Staff concluded that the TMI-2 ISFSI SAR provides reasonable assurance that all significant sources and capable faults as defined in 10 CFR Part 100, appendix A, have been identified and their characteristics and associated uncertainties adequately described and appropriately included in evaluation of the seismic ground motion hazard. Because the proposed NRF ISFSI is located near the TMI-2 site and no additional information about fault sources has been identified since the TMI-2 ISFSI SER was published in 1998, no additional information about the earthquake source zones is necessary.

Probabilistic Seismic Hazard Assessment

In the INEEL seismic hazard analyses conducted by WCC (1992a), WCFS (1996a,b), and URSGWCFS et al. (2000), the potential ground motions that can be produced at the INEEL by earthquakes were modeled using two approaches. The first approach relied on empirical ground-motion attenuation relationships, derived from California strong motion data. The second approach was based on a stochastic site-specific numerical model. The final hazard was then computed by assigning a 0.4 weight to the first approach—empirical attenuation relationships—and a 0.6 weight to the second approach—stochastic models.

The main difference between the WCFS (1996a) results, used as a basis for the TMI-2 ISFSI SAR, and the URSGWCFS et al. (2000) results, used as the basis for the NRF SAR, was the selection of key parameters in the attenuation relationships and numerical models. For the empirical approach, the California strong-motion attenuation relationships were modified following the approach and results from the DOE expert elicitation for the proposed YM repository (CRWMS M&O, 1998). For the stochastic numerical model for the NRF ISFSI, a key input parameter—the distribution of stress drops associated with normal faulting earthquakes—was modified based on recently published results of average stress drops for earthquakes in extensional tectonic regimes (Becker and Abrahamson, 1998). As a result of the application of these changes to the ground-motion attenuation models, the PSHA results calculated in URSGWCFS et al. (2000) were lower by 12–23 percent compared to the seismic hazard levels reported in the WCFS (1996a) PSHA. Table 2-1 summarizes the differences in PSHA for the NRF site for mean recurrence intervals of 500, 1000, 2000, and 10,000 yr.

Empirical Attenuation Modeling Approach

The underlying technical bases given in URSGWCFS et al. (2000) for the applicability of the YM attenuation relationships are that both the INEEL and YM lie in extensional tectonic environments (i.e., adjacent to or within the Basin and Range). In addition, the analyses of worldwide ground motion from normal faults by Spudich et al. (1997, 1999) suggest that faulting in extensional tectonic regions produces 15–20 percent less ground motion than in compressional tectonic settings for the same magnitude earthquake. The difference is attributed to lower stress drops in extensional tectonic settings compared to compressional or strike-slip settings (Stark et al., 1992; Becker and Abrahamson, 1998).

Based on a review of information cited in the previous paragraph, responses to the RAIs, and the assumptions in the modified approach to ground-motion attenuation in URSGWCFS et al. (2000), staff conclude that the empirical modeling approach used by the DOE reflects the state of current knowledge. The staff have found that the empirical attenuation modeling approach used by the DOE is adequate to accurately predict earthquake-induced ground motion at the NRF ISFSI site.

Table 2-1. Comparison of bedrock peak horizontal accelerations from Probabilistic Seismic Hazard Assessment conducted by Woodward-Clyde Federal Services (1996a) and URS Greiner Woodward-Clyde Federal Services et al. (2000) for the Naval Reactors Facility at the Idaho National Engineering and Environmental Laboratory

Study	(Mean) Horizontal Peak Acceleration (g) Annual Exceedance Probability (Return Period)			
	2×10^{-3} (500 yr)	1×10^{-3} (1,000 yr)	5×10^{-4} (2,000 yr)	1×10^{-4} (10,000 yr)
WCFS (1996a)	0.08	0.11	0.15	0.26
URSGWCFS (2000)	0.07	0.09	0.12	0.20

WCFS—Woodward-Clyde Federal Services
USRGWCFS—URS Greiner Woodward-Clyde Federal Services

Stochastic Modeling Approach

The purpose of the stochastic modeling of earthquake attenuation was to incorporate site-specific information about normal faulting earthquakes, local crustal attenuation, and other local site conditions at the INEEL. This approach was necessary because the INEEL lacks sufficient measured strong-motions from nearby earthquakes to generate reliable site-specific empirical attenuation models. In addition to stress drop, site-specific parameters for crustal attenuation, near-surface attenuation, and near-surface crustal amplification were developed for the stochastic model. These parameters were varied to incorporate the range of uncertainty based on current knowledge of site conditions at the INEEL, as described in WCFS (1996a). Earthquake attenuation relationships (as a function of source-to-site distance earthquake magnitude) were then developed from the resulting spectral accelerations computed using the stochastic models.

Similar to the revision of the California–YM empirical attenuation modeling approach, the revised stochastic modeling of vibratory ground motion given in URSGWCFS et al. (2000) utilizes recent scientific advances in earthquake seismology, particularly with regard to dynamic stress drops associated with earthquakes in extensional tectonic regimes. In the recalculated seismic hazard for the INEEL given in URSGWCFS et al. (2000), the stress drop has four values, the median and three weighted values about the median used to represent the parameter distribution. The median stress drop is 50 bars (0.6 = weight) compared to 75 bars (0.5 weight) used in WCFS (1996a). The distribution around the median is 25 bars (0.2 weight), 75 bars (0.15 weight), and 150 bars (0.05 weight). This revised distribution of stress drops is consistent with recent published values of expected stress drops associated with earthquakes in extensional tectonic settings (Stark et al., 1992; Becker and Abrahamson, 1998; Spudich et al., 1997, 1999).

Based on a review of the information cited in the previous paragraph, responses to the NRF ISFSI RAI and the assumptions in the stochastic modeling approach given in WCFS (1996a) and URSGWCFS et al. (2000), the staff conclude that the stochastic modeling approach used by the DOE reflects the state of current knowledge. The staff have found that the approach is adequate to predict earthquake-induced ground motions at the NRF ISFSI site.

2.1.6.3 Surface Faulting

Surface faulting was discussed in Section 2.6.3, Surface Faulting, of the TMI-2 ISFSI SAR. The possibility of surface faulting was evaluated through discussions of geologic conditions, evidence of site fault offset, earthquakes associated with capable faults, investigation of capable faults, and correlation of epicenters with capable faults.

Surface faulting refers to rupture of the Earth's surface due to tectonic or magmatic activity. The TMI-2 ISFSI SAR identified the southern tip of the Lemhi fault as the only possible structure capable of surface faulting on the INEEL site related to tectonic activities of all capable faults that might affect the TMI-2 ISFSI site. This is because it is conceivable that surface faulting associated with an earthquake on the Howe and Fallert Springs segments of the Lemhi fault could extend southward into the INEEL for a distance of several miles in the area just east of the Big Lost River Sinks. There is no direct evidence, however, of surface faulting at the TMI-2 or NRF ISFSI sites. Other areas in which surface faulting is of concern are in volcanic rift zones related to dike intrusion. For example, areas in and near the Arco and the Lava Ridge-Hells Half Acre volcanic rift zones have the greatest potential for such dike-induced surface faulting. Also, the fissures north of NRF appear to be dike-induced fissures. The potential recurrence of such fissuring is determined by the annual probability of a silicic volcano activity occurring near the TMI-2 site, which is estimated at $<10^{-6}$/yr (Brach, 1999b).

The staff have reviewed the information presented in the SAR and found reasonable assurance that surface or near-surface faulting is not a potential hazard that may have a deleterious effect on the proposed TMI-2 ISFSI. Because the proposed NRF ISFSI is constrained by similar faulting conditions, staff conclude that surface faulting is not a potential safety factor. No additional information about surface faulting is necessary.

2.1.6.4 Stability of Subsurface Materials

Stability of subsurface materials is discussed in Section 2.6.4, Stability of Subsurface Materials and Foundations, of the TMI-2 ISFSI SAR and corresponding responses to RAI 2-14. Safety factors for seismic events are presented in Section 8.2.3, Earthquake Accident Analysis, of the SAR. Stability of subsurface materials is addressed through discussions of surface or subsurface subsidence, previous loading history, weak materials due to rock jointing and weathering, residual stresses, excavation and backfill, groundwater conditions, and liquefaction potential. These discussions are supported by detailed soil geotechnical and rock mechanics testing data. The SAR presents properties of soil and sediments at the INTEC, including soil classification, density information, moisture content, porosity, strength characteristics, P- and S-wave velocities, and critical damping ratios. In response to an RAI for the TMI-2 SAR, an explanation was provided how these testing results relate to safety concerns and how they were used in the design to ensure safety. The response to RAI 2-14 also provided general analysis of foundation stability. Specific indicators of soil stability include gentle surface gradient, unsaturated conditions, low water contents of the soils, high blow counts in standard penetration tests (SPTs), high shear wave velocity, and large grain size. The discussion of these factors and associated data provided reasonable assurance that the subsurface materials at the TMI-2 ISFSI site would be stable with respect to landsliding, slumping, and liquification during earthquake ground shaking.

Most of the characteristics stated previously are similar for the NRF ISFSI site. The site topographic map provided in response to the RAIs indicates that the surface gradient is gentle. The slope around the OSS has a horizontal to vertical ratio of about 233:1 (see discussion in Section 2.1.6.5 of this report). The minimum allowable bearing pressure for the function of the OSS is 24,434 kg/m^2 (5,000 psf). This value gives a safety factor of 2.1 considering a fully loaded OSS and a maximum vertical acceleration of 0.34 g ground motion. In the responses to the RAIs regarding the NRF site, the DOE-DNR indicated that the soils located above the sandy gravel layer, which is at a depth 2.1–3.05 m (7–10 ft) from ground surface, will be excavated and backfilled with engineered material. The backfill material will be compacted to at least 95 percent of the maximum density (Bettis Atomic Power Laboratory, 1999). The base soil (sandy gravel) was estimated to have a minimum bearing capacity of 237 kPa (5,000 psf). This estimate was based on soil gradation tests, California Bearing Resistence (CBR) tests, and soil logs. Furthermore, the DOE-DNR project specifications require conducting CBR tests on the base soil when excavation reaches a specified depth [indicated on the soil boring logs or 3.05 m (10 ft), whichever is less] to make sure that the bearing capacity of the base soil is greater than the minimum value (Bettis Atomic Power Laboratory, 1999). This approach is acceptable. The staff concluded that the compacted backfill material and the base soil should provide a stable foundation for the OSS if the project specifications are properly implemented.

According to the responses to the RAIs, the groundwater is expected to be more than 30.5 m (100 ft) below the surface. Consequently, the soil beneath the site is unsaturated. In the absence of groundwater, there is no potential for liquefaction. The only possibility that the soil beneath the site can get saturated is through flooding. The DOE-DNR indicated in its response that the surface at the NRF site has not been inundated for approximately 10,000 yr and the possibility of failure of the MacKay Dam is less than 10^{-5}. Therefore, the possibility of flooding and subsequent saturation of the soil around and under that OSS is small. The possibility for soil saturation and an earthquake to occur concurrently is even smaller. The staff concurs with the DOE-DNR assessment.

Even for a remote possibility that soil saturation and an earthquake occur at the same time, various field performance data show that liquefaction may not be likely at the NRF ISFSI site. The site geotechnical investigations conducted by Paul C. Rizzo Associates, Inc. (2000) indicated that the soils above the basalt rock have raw SPT blow counts that are in general smaller than those at the TMI-2 ISFSI site. More than one-half of the blow counts in the three boreholes presented are below or near 30. However, most of the low SPT blow counts are associated with the soils above the sandy gravel. As discussed in the previous paragraph, these soils will be excavated and backfilled with engineered material. The compacted backfill material is not subject to liquefaction. The average SPT blow counts for the sandy gravel is approximately 34. In the responses to the RAIs, DOE-DNR estimated that the cyclic stress ratio (CSR) is about 0.26 on the basis of a peak ground acceleration of 0.225 g. By comparing the average blow counts and CSR with a published correlation for assessing liquefaction potential, it can be concluded that liquefaction of the sandy gravel at the NRF ISFSI site has a low probability of occurrence.

2.1.6.5 Slope Stability

The staff have reviewed Section 2.6.5, Slope Stability, of the TMI-2 ISFSI SAR, which states that slopes in the TMI-2 ISFSI sites are gentle, a few feet per mile at the most, and, therefore, pose no threat for instability or landsliding. The staff site visit confirmed that slope stability is not a safety concern at the TMI-2 site.

The NRF ISFSI site is located about 9.66 km (6 mi) north of the TMI-2 ISFSI site. The cross section at the west edge of the OSS, constructed using three core-hole data, indicates a roughly horizontal to vertical ratio of 233:1 [estimated from Figure 5 of Paul C. Rizzo Associates, Inc. (2000)]. Furthermore, the detailed topographic elevation map of the site provided in response to the NRF ISFSI RAI, indicates that the slopes in the area are gentle as well. The OSS is on relatively higher ground. Consequently, there should be no slopes that pose a safety concern at the NRF site. Also, in the responses to the RAIs regarding the NRF site, it is stated that the OSS will be excavated and backfilled with engineered material compacted according to project specifications. The staff concur with the DOE assessment that no stability concerns associated with excavated slopes is expected if the backfilled material is compacted according to approved specifications (Bettis Atomic Power Laboratory, 1999).

2.1.6.6 Volcanism

Volcanism is a fundamental characteristic of the proposed region. Past volcanic activity that affected the site consists of (i) fallout of ash from eruptions of Cascade volcanoes, (ii) deposits from nearby eruptions of older silicic volcanoes, and (iii) basaltic lava flows. Each of these three types of volcanic activity could adversely affect the ISFSI if they occurred during operation of the NRF ISFSI. In accordance with 10 CFR 72.24, 72.40, 72.90, 72.92, 72.98, and 72.122, volcanic hazards must be evaluated to determine whether there is reasonable assurance that unacceptable risks from volcanism are unlikely or can be mitigated.

The staff reviewed information presented in the TMI-2 ISFSI SAR and three responses to RAIs regarding volcanic features of the site. The review also assessed relevant literature cited in the TMI-2 ISFSI SAR and other literature cited in the TMI-2 ISFSI SAR to provide independent evaluation of volcanic features and potential hazards of the site.

Information presented in the TMI-2 ISFSI SAR provides reasonable assurance that the annual probability of a silicic volcano forming close enough to the TMI-2 ISFSI site to have a deleterious effect on the facility is $< 10^{-6}$. The staff review found reasonable assurance that these types of eruptions do not present a credible risk to public health and safety during the proposed operating period of the ISFSI.

In the review of the TMI-2 ISFSI, staff noted that recent (i.e., younger than 10,000 yr) basaltic volcanic activity occurs only in areas more than about 15 km (9.3 mi) from the TMI-2 site. The staff found reasonable assurance that the annual probability of forming a new basaltic volcano at the TMI-2 site is $< 10^{-6}$. This information, however, also shows there is an annual probability around 5×10^{-6} of a distant volcano producing a lava flow that affects the TMI-2 ISFSI site. The staff also found reasonable assurance that a future basaltic lava flow represents an extremely unlikely but credible event that has the potential to adversely affect performance of the TMI-2 facility. To mitigate potential adverse effects of volcanism at the TMI-2 ISFSI, staff recommended that an emergency plan for the lava diversion be explicitly incorporated into the TMI-2 Site Emergency Plan.

The staff have reviewed the information presented in the SAR and have found reasonable assurance that volcanism is not a potential hazard to the proposed NRF ISFSI. Staff, therefore, conclude that the analyses of volcanism presented in the TMI-2 ISFSI SAR provide an adequate assessment for the NRF ISFSI. The NRF site lies approximately 9.7 km (6 mi) north of the TMI-2 site, and is, thus, farther from any basaltic volcano that could affect the site. Because the NRF ISFSI facility is 9.7 km (6 mi) farther away from potential volcanic sources than the TMI-2 ISFSI facility, staff acknowledge that unlike the TMI-2 ISFSI, no additional measures are necessary with regard to emergency planning at the NRF ISFSI facility.

2.1.6.7 Design Ground Motion

The staff have reviewed the information presented in Section 2.2.5, Seismic Design, of the SAR with respect to its SSI analysis (Paul C. Rizzo Associates, Inc., 2000). The investigation described was aimed at determining seismic design ground motions to be adopted for the design of the storage facility, as described in the SAR. These motions were based on performing a three-dimensional dynamic SSI analysis of the OSS proposed for the NRF ISFSI site. For that purpose, the geotechnical conditions were modeled numerically and subjected to a recommended seismic response spectrum for that site.

A wave propagation analysis was performed with the computer code SHAKE91 (Bechtel, Bettis, Inc., 1999) to obtain free-field motions and strain-compatible shear modulus and damping for the soils overlying the bedrock. The acceleration time history used for conducting the analysis was developed using the rock outcrop Design Response Spectra in the horizontal and vertical directions developed by Bechtel BWTX Idaho (1999). The SHAKE91 computer code is a modified version of the program SHAKE, which is an industrial standard program for performing equivalent linear site response analyses for layered soil deposits. Potential nonlinear effects such as the dependency of the soil shear modulus and damping ratio on the shear strain are accounted for in a piecewise linear manner. The analysis is conducted in an iterative manner. At the end of each iteration, the shear modulus and damping ratio are adjusted until the assumed properties are consistent with the calculated strains.

To account for uncertainties associated with the estimated shear modulus, the NRF ISFSI SAR presented three wave-propagation analyses using the (i) shear moduli estimated from the measured shear wave velocities for different soil types, (ii) shear modulus values that are one-half of the estimated shear moduli, and (iii) shear moduli that are twice the estimated values. This approach for considering data uncertainties is acceptable to the staff.

According to the NRF ISFSI SAR and the response to the RAIs, the free-field motions and materials properties obtained from the wave-propagation analysis using SHAKE91 were used for performing dynamic SSI analysis with the computer code SASSI (Bechtel, Bettis, Inc., 1999). The responses to the RAIs include input and output files for both SHAKE91 and SASSI analyses. An evaluation of these files indicates that the geotechnical profiles used in the SHAKE91 and SASSI analyses are the same, and the horizontal control motions used for the SASSI analysis are consistent with the free-field time histories generated from SHAKE91. Although the vertical control motions used for the SASSI analysis are not the same as the output vertical time histories generated from SHAKE91, the control motions appear to contain relatively higher accelerations. Consequently, results from the SASSI analysis should be more conservative and, hence, acceptable.

The dynamic SSI analysis with SASSI presented in the NRF ISFSI SAR ignored overpack sliding and liftoff. The responses to the RAIs stated that the potential nonlinear response of the overpacks, including sliding and rocking, has the effect to decouple some of the mass of the overpacks from the OSS in the SSI analysis. Consequently, the calculated responses, without including overpack sliding and rocking, bound the responses for the cases if the sliding and rocking are considered. Furthermore, the additional mass of another row of overpacks, as compared to the actual system, was added in the SASSI analysis to take advantage of symmetrical conditions for finite element modeling. This extra mass provides an additional conservatism to the analysis results relative to the actual system.

A separate nonlinear dynamic analysis of the overpack sliding and rocking subjected to the design basis event is also provided. The results of the analysis indicated that the maximum sliding is 3.9 cm (1.54 in.) and the maximum rocking is 0.455°. Because the potential rocking is small, it is not likely to affect the response of the OSS subjected to ground motion. The responses to the RAIs indicated that results from shaker table testing showed that no significant rocking occurred, and the amount of sliding was less than the 12 cm (4.7 in.) as calculated in

Section 2.2.5.2.5 of Revision 7 of the SAR. Although the sliding amount 12 cm (4.7 in.) provided in Section 2.2.5.2.5 of Revision 7 of the SAR is significantly larger—the result from the nonlinear dynamic analysis—no pounding between overpacks is expected because the adjacent overpacks are designed to be 45.7 cm (18 in.) apart.

Recommended seismic design ground motions were proposed, based on the findings from the SASSI analysis, which were subsequently adopted in the SAR for the seismic design. The general approach and many aspects of information in that reference are clear and acceptable. Consequently, the staff made a determination that the general requirements given in 10 CFR 72.120 have been satisfied.

2.2 Evaluation Findings

The staff have reviewed the site characteristics, PSHA, and SSI analyses presented in the SAR; and found reasonable assurance that they satisfy the requirements in 10 CFR Part 72.

2.2.1 Geography and Demography

Based on the review of the information presented in the SAR and the responses to the RAIs, the following evaluation findings are made about the proposed NRF ISFSI.

2.2.1.1 Site Location

- The staff have reviewed the information presented in Section 2.1.1, Site Location, of the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that the site location has been adequately indicated and described such that design bases for the NRF ISFSI can be developed.

- The staff have reviewed the information presented in Section 2.1.1, Site Location, of the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that the site location has been adequately indicated and described such that its direct effect on safety or any environmental impact can be assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(e) in that the site location has been adequately described such that any potential radiological and environmental impacts on the region can be evaluated.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.96(a) in that the site location has been adequately indicated and described such that it can be determined there is no candidate HLW repository site at the ISFSI site.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(a) in that the site location has been adequately indicated and described such that the regional extent of external phenomena, human-induced or natural, used as a basis for the design of the ISFSI can be identified.

2.2.1.2 Site Description

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that the site has been adequately described such that design bases for the ISFSI can be developed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that the site has been adequately described such that the direct effect of site conditions on safety and the likely environmental impact of activities at the site can be assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(e) in that the site has been adequately described such that any potential radiological and environmental impacts on the region can be evaluated.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(a) in that the site has been adequately described such that the regional extent of external phenomena, human-induced or natural, used as a basis for the design of the ISFSI can be identified.

2.2.1.3 Population Distribution and Trends

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.98(c)(1) in that the population has been adequately described such that the present and future character and distribution of the population can be investigated.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.100(a) in that the population has been adequately described such that the effects on population in the region resulting from the release of radioactive materials during operation and decommissioning of the ISFSI under normal and accident conditions, considering usual and unusual site characteristics, can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.100(b) in that the population has been adequately described such that the effects on populations in the region during construction, operation, and decommissioning of the proposed ISFSI under normal and accident conditions, considering usual and unusual regional and site characteristics, can be identified.

2.2.1.4 Land and Water Use

- The staff have reviewed the information presented in the SAR and the responses to the RAIs for land use and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.98(b) in that the site land use has been adequately described such that the regional impact on population or the environment because of construction, operation, or decommissioning of the proposed ISFSI can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs regarding water use and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.98(b) in that site water use has been described adequately such that the regional impact on population or the environment because of construction, operation, or decommissioning of the proposed ISFSI can be identified.

2.2.2 Nearby Industrial, Transportation, and Military Facilities

Based on the review of the information presented in the SAR and the responses to the RAIs, the following evaluation findings are made about the proposed NRF ISFSI.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that the nearby industrial, transportation, and military facilities have been adequately described such that design bases for the ISFSI facility can be developed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that the nearby industrial, transportation, and military facilities have been adequately described such that their direct effect on safety and their potential environmental impacts can be assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.94(a) in that the nearby industrial, transportation, and military facilities have been adequately described such that important human-induced events that could affect the proposed ISFSI can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.94(b) in that the information on the nearby industrial, transportation, and military facilities has been adequately collected and described such that the potential occurrence and severity of important human-induced events that could affect the proposed ISFSI can be evaluated for reliability, accuracy, and completeness.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.96(a) in that the nearby industrial, transportation, and military facilities have been adequately described such that it can be determined there is no candidate HLW repository site at the ISFSI site.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.98(a) in that the nearby industrial, transportation, and military facilities have been adequately described such that the regional extent of external phenomena, human-induced or natural, used as a basis for the design of the ISFSI, can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.98(b) in that the nearby industrial, transportation, and military facilities have been adequately described such that the regional impact on population or the environment due to the construction, operation, or decommissioning of the proposed ISFSI can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.100(a) in that the nearby industrial, transportation, and military facilities have been adequately described such that the effects on those facilities in the region resulting from the release of radioactive materials during operation and decommissioning of the proposed ISFSI under normal and accident conditions, considering usual and unusual site characteristics, can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found with reasonable assurance that they satisfy the requirements of 10 CFR 72.100(b) in that the nearby industrial, transportation, and military facilities have been adequately described such that the effects on these facilities in the region during construction, operation, and decommissioning of the ISFSI under normal and accident conditions, considering usual and unusual regional and site characteristics, can be identified.

2.2.3 Meteorology

Based on the review of the information presented in the SAR and the responses to the RAIs, the following evaluation findings are made with respect to the NRF ISFSI.

2.2.3.1 Regional Climatology

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.24(a) in that the regional climatology has been adequately described such that design bases for the ISFSI can be developed.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(a) in that the regional climatology has been adequately described such that the direct effect of site conditions on safety and the likely environmental impact of activities at the site can be assessed.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(b) in that the regional climatology has been adequately described such that the frequency and severity of meteorological events that could affect the safe operation of the proposed ISFSI can be assessed.

2.2.3.2 Local Meteorology

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a) in that the local meteorology has been adequately described such that potential meteorological effects on the ISFSI can be identified and assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(a) in that the local meteorology has been adequately described such that the regional extent of external phenomena, human-induced or natural, used as a basis for the design of the ISFSI can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(b) in that the local meteorology has been adequately described such that the regional impact on population or the environment due to the construction, operation, or decommissioning of the proposed ISFSI can be identified.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(c)(3) in that local meteorology has been adequately described such that any special characteristics that may influence the potential consequences of release of radioactive material during the operational lifetime of the ISFSI can be identified.

2.2.3.3 Onsite Meteorological Measurement Program

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a) in that meteorologic data have been adequately described such that potential meteorological effects on the ISFSI can be identified and assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(a) in that the meteorologic information has been adequately described such that the regional extent of external phenomena, human-induced or natural, used as a basis for the design of the ISFSI can be identified and assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(b) in that the local meteorologic data have been adequately described such that the regional impact on population or the environment due to the construction, operation, or decommissioning of the proposed ISFSI can be identified and assessed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(c)(3) in that the meteorologic data have been adequately described such that any special characteristics that may influence the potential consequences of release of radioactive material during the operational lifetime of the ISFSI can be identified and assessed.

2.2.4 Surface Hydrology

Based on the review of the information presented in the SAR and the responses to the RAIs, the following evaluation findings are made about the proposed NRF ISFSI.

2.2.4.1 Hydrologic Description

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that the basic surface hydrology of the site and the vicinity have been adequately described such that safety of the site can be assessed and design bases for external events can be developed.

2.2.4.2 Floods

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that the surface water flooding that may directly affect the safety or environmental impact has been investigated and assessed sufficiently.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(b) with respect to the frequency and severity of flooding that may directly affect the site.

2.2.4.3 Probable Maximum Flood on Streams and Rivers

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(c). The design basis analysis for flooding is sufficient for all combinations of proposed site and NRF ISFSI design.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(d) in that the information is sufficient to determine if adequate protection is provided from flooding because of the elevation for the NRF ISFSI site.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(f) in that the proposed ISFSI did demonstrate it will avoid any adverse impact associated with the occupancy and modification of floodplains.

2.2.4.4 Potential Dam Failures (Seismically Induced)

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a) in that sufficient information is available to determine if the flooding that can occur in the region of the proposed NRF ISFSI has been adequately identified and its effect on safety and design assessed.

2.2.4.5 Probable Maximum Surge and Seiche Flooding

Surge and seiche flooding are not credible events for the NRF ISFSI site.

2.2.4.6 Probable Maximum Tsunami Flooding

Tsunami flooding is not a credible event for the NRF ISFSI site.

2.2.4.7 Ice Flooding

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a) in that the ice flooding that can occur in the region of the proposed NRF ISFSI has been identified and its effect on safety and design assessed.

2.2.4.8 Flood Protection Requirements

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(b) in that the records of occurrence and severity of flooding are collected and evaluated for reliability, accuracy, and completeness.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(c) in that analysis of the flood protection at the NRF ISFSI site was provided.

2.2.4.9 Environmental Acceptance of Effluents

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.98(c)(2) in that the impact on present and future surface water use in the region is negligible.

2.2.5 Subsurface Hydrology

Based on the review of the information presented in the SAR and the responses to the RAIs, the following evaluation findings are made about the proposed NRF ISFSI.

2.2.5.1 Regional Characteristics

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that the basic subsurface hydrology of the site and the vicinity have been adequately described such that safety of the site can be assessed and design bases for external events developed.

2.2.5.2 Site Characteristics

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(c)(2) in that the impact on present and future groundwater use in the region has been determined adequately.

2.2.5.3 Contaminant Transport Analysis

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that a contaminant transport analysis is not required for the NRF ISFSI to satisfy the requirements of 10 CFR 72.122(b).

2.2.6 Geology and Seismology

Based on the review of the information presented in the SAR and the responses to the RAIs, the following evaluation findings are made about the proposed NRF ISFSI.

2.2.6.1 Basic Geologic and Seismic Information

- The staff have reviewed the information presented in the SAR and found reasonable assurance that the SAR satisfies the requirements of 10 CFR 72.24(a) in that basic geologic and seismic characteristics of the site and vicinity have been adequately described such that safety of the site can be assessed and design bases for external events developed.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that the SAR satisfies the requirements of 10 CFR 72.90(a) in that basic geologic and seismic characteristics that directly affect site conditions and the likely environmental impact of activities at the site can be assessed.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that the SAR satisfies the requirements of 10 CFR 72.102(e) in that it was demonstrated that significant engineered provisions are not necessary to correct site deficiencies and that the geologic characteristics of the ISFSI are stable.

2.2.6.2 Vibratory Ground Motion

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that potential ground vibration during earthquakes has been adequately described such that safety of the site can be assessed and design bases for earthquake ground motion can be developed.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that the earthquake ground motion hazard that directly affects site conditions and the likely environmental impact of activities at the site have been investigated and assessed sufficiently.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(b) with respect to the frequency and severity of seismic events that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(c). The design basis seismic ground motion is adequately determined for each combination of proposed site and ISFSI designs.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a) in that seismic events are adequately identified and the potential effects on safety and design are adequately assessed.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(b) in that records of the occurrence and severity of historical and paleoseismic events are collected for the region and evaluated for reliability, accuracy, and completeness.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(c) in that appropriate methods were adopted for evaluating the DE based on site characteristics and state of knowledge.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.98(b) and (c)(3) in that earthquake ground motion will not influence the potential consequences of a release of radioactive material during the operational lifetime of the proposed ISFSI.

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.102(b) in that seismicity has been evaluated by the techniques consistent with the exemption provided by the NRC (Brach, 1999c).

- The staff have reviewed the information presented in the SAR and corresponding responses to RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.102(f)(2) in that the DE has a value for the horizontal ground motion greater than 0.10 g, the appropriate response spectra were provided.

2.2.6.3 Surface Faulting

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.24(a) in that surface geological structures at the site have been adequately described such that safety of the site can be assessed and design bases for surface faulting events developed.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that the potential of surface faulting that directly affects site conditions and the likely environmental impact of activities at the site have been sufficiently investigated and assessed and satisfy the requirements of 10 CFR 72.90(a).

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(b–d) and 72.92(a–c). There is no known surface faulting near the site that may affect site safety. Therefore, no specific designs or mitigation actions with respect to surface faulting are required.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.98(b) and (c)(3) in that surface faulting will not influence the potential consequences of a release of radioactive material during the operational lifetime of the proposed ISFSI.

2.2.6.4 Stability of Subsurface Materials

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that stability of subsurface materials have been adequately described such that safety of the site can be assessed and design bases for subsurface material stability during external events developed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that subsurface material instability that directly affects site conditions and the likely environmental impact of activities at the site have been investigated and assessed sufficiently.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(b) with respect to the severity of subsurface material instability that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(c), (d), and 72.92(a) in that subsurface material stability information has been provided adequately.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a–c) in that information regarding material instability near the site has been provided adequately.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.102(c) in that liquefaction potential or other soil instability due to vibratory ground motion has been evaluated sufficiently.
- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.102(d) in that soil conditions are adequately described.

2.2.6.5 Slope Stability

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.24(a) in that slopes and slope materials of the site and vicinity have been described adequately such that safety of the site can be assessed and design bases for slope stability during external events developed.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(a) in that slope stability that directly affects site conditions and the likely environmental impact of activities at the site have been investigated and assessed sufficiently.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(b) with respect to the severity of slope instability that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.90(c), (d) and 72.92(a) in that slope stability information has been provided adequately.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.92(a–c) in that adequate slope stability information has been provided.

2.2.6.6 Volcanism

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.24(a) in that volcanic features have been adequately described such that design bases for this external event can be developed.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(a) with regard to volcanic features that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(b) with regard to the frequency and severity of volcanic features that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(c). Volcanism does not pose a hazard to the NRF ISFSI site.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.90(d). Volcanism does not pose a hazard to the NRF ISFSI site.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.92(a) with regard to volcanic features that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.92(b) with regard to volcanic features that may directly affect site safety.

- The staff have reviewed the information presented in the SAR and found reasonable assurance that it satisfies the requirements of 10 CFR 72.92(c). Appropriate measures were adopted to evaluate volcanism of the NRF ISFSI site.

2.2.6.7 Design Ground Motion

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirement of 122(b)(2)(i) in that uncertainties associated with soil shear moduli of soil layers at the NRF ISFSI site have been considered appropriate for developing design ground motion.

- The staff have reviewed the information presented in the SAR and the responses to the RAIs and found reasonable assurance that they satisfy the requirements of 10 CFR 72.120 in that the control motions used in the SSI analyses are consistent with or more conservative than the free-field motions generated from the wave-propagation analyses.

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