INL/EXT-07-12903
Rev. 2

Preliminary Hazard Analysis for the Remote-Handled Low-Level Waste Disposal Facility

February 2010

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Idaho National Laboratory

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February 2010

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http://www.inl.gov

Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

BEA Nuclear Safety Engineering

Preliminary Hazard Analysis for the Remote-Handled Low-Level Waste Disposal Facility

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ABSTRACT

The need for remote-handled low-level waste (LLW) disposal capability has been identified. A new onsite, remote-handled LLW disposal facility has been identified as the highest ranked alternative for providing continued, uninterrupted remote-handled LLW disposal capability for remote-handled LLW that is generated as part of the nuclear mission of the Idaho National Laboratory and from spent nuclear fuel processing activities at the Naval Reactors Facility. Historically, this type of waste has been disposed of at the Radioactive Waste Management Complex. Disposal of remote-handled LLW in concrete disposal vaults at the Radioactive Waste Management Complex will continue until the facility is full or until it must be closed in preparation for final remediation of the Subsurface Disposal Area (approximately at the end of Fiscal Year 2017).

This document supports the conceptual design for the proposed remote-handled LLW disposal facility by providing an initial nuclear facility hazard categorization and by identifying potential hazards for processes associated with onsite handling and disposal of remote-handled LLW.

NOTE:
This document analyzes the hazards for processes associated with onsite handling and disposal of remote-handled low-level waste. A new on-site facility has been identified as an alternative for providing continued remote-handled low-level waste disposal capability in support of ongoing Department of Energy missions at the Idaho site. However, a decision has not been made by the Department of Energy to develop a new onsite disposal facility. The decision, following all required analyses and evaluation of the impacts of all viable alternatives, will be made in accordance with the National Environmental Policy Act of 1969. Use of words indicating requirements or specifying intention, such as “shall” or “will,” are used for the convenience of discussion or to indicate requirements or activities that are conditioned on a decision to develop a new onsite disposal facility. Such usage should not be construed to mean that a final selection of an alternative has been made.

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ACRONYMS

ATR	Advanced Test Reactor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CVAS	cask-to-vault adapting structure
DOE	Department of Energy
DSA	documented safety analysis
HC	hazard category
INL	Idaho National Laboratory
LLW	low-level waste
MAR	material at risk
MFC	Materials and Fuels Complex
NPH	natural phenomenon hazard
NRF	Naval Reactors Facility
PDSA	preliminary documented safety analysis
PHA	preliminary hazards analysis
RH	remote-handled
RSWF	Radioactive Scrap and Waste Facility
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SIH	standard industrial hazard
SSC	structure, system, and component

Preliminary Hazard Analysis for the Remote-Handled Low-Level Waste Disposal Facility

1. INTRODUCTION

This preliminary hazards analysis (PHA) for the Remote-Handled Low-Level Waste (LLW) Disposal Facility is based on INL/EXT-07-12901, *Conceptual Design Report for the Remote-Handled Low-Level Waste Facility*, and other associated documents. The purpose of this PHA is to identify major hazards in the proposed facility and process areas associated with the proposed operations. These hazards vary from standard industrial hazards (SIHs) to handling and storage of highly radioactive materials. The PHA also identifies top-level safety requirements and provides a basis for systems, structures, and components (SSCs) classification (i.e., determine unmitigated hazard probabilities and consequences).

2. BACKGROUND

The Idaho National Laboratory (INL) Site routinely generates contact-handled (<200 mrem/hr on contact) and remote-handled (> 200 mrem/hr on contact) LLW from facility operations and decontamination and decommissioning of inactive facilities. Historically, INL has disposed of its LLW in a disposal facility located at the Radioactive Waste Management Complex (RWMC). This facility includes disposal pits and concrete vaults. As part of ongoing cleanup activities at INL, closure of the RWMC is proceeding under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 USC 9601 et seq. 2006). Disposal of LLW in the disposal pit ceased on September 30, 2008, and all contact-handled LLW and the portion of INL's remote-handled LLW that had been disposed of in the pit are being disposed offsite. Disposal of remote-handled LLW in concrete disposal vaults at RWMC will continue until the facility is full or until it is closed in preparation for final remediation of the Subsurface Disposal Area (SDA).

On July 1, 2009, the Department of Energy (DOE) approved a mission need statement for the INL Remote-Handled LLW Disposal Project to develop replacement remote-handled LLW disposal capability in support of INL's nuclear energy mission and the Naval Nuclear Propulsion Program (DOE/ID-11364, "Mission Need Statement for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Project"). The continuing nuclear mission of INL, associated ongoing and planned operations, and Naval spent fuel activities at the Naval Reactors Facility (NRF) require continued capability to appropriately dispose of remote-handled LLW. Development of a new onsite disposal facility has been identified as the highest ranked alternative for providing continued, uninterrupted INL remote-handled LLW disposal capability (INL/EXT-09-17152, "Remote-Handled Low-Level Waste Disposal Project Alternatives Analysis").

This PHA lists and analyzes safety requirements that should be considered in the implementation of the design for the Remote-Handled LLW Disposal Facility, as required by DOE O 413.3A, "Program and Project Management for the Acquisition of Capital Assets." This PHA is intended to be a living document with ongoing revisions as the design for the facility matures and the design process continues. This will ensure that Integrated Safety Management System requirements are incorporated into facility design and carried through into disposal operations in accordance with DOE O 413.3A.

The proposed Remote-Handled LLW Disposal Facility will be designed and constructed to support disposal of two remote-handled LLW waste streams generated at the Idaho Site: 1) remote-handled resins from the NRF and Advanced Test Reactor (ATR) Complex and 2) activated metals from NRF, ATR, and the Materials and Fuels Complex (MFC). Other remote-handled LLW waste streams have been generated at INL in the past, may be generated in the future, or may be actively generated having an existing disposal pathway; however, the proposed facility is being developed based on the identified resin and activated metal waste streams. Volumetric projections and characteristics of these waste streams provide an upper bound for remote-handled LLW that may be disposed at the proposed facility. A summary of these waste streams is provided in Table 1.

Table 1. Remote-handled low-level waste resins and activated metals waste streams.

Waste Stream	Generator	Description
Resins	INL ATR Complex	ATR produces ion exchange resins from pool and reactor operations. Until September 30, 2008, the waste was disposed of in the RWMC pit. Since closure of the RWMC pit, the waste is being disposed of offsite at NTS.
	NRF	NRF produces ion exchange resins from pool operations. Currently, the waste is disposed of in the RWMC vaults in liners transported using a 55-ton cask.
Activated Metals	INL ATR Complex	ATR produces activated metals during reactor core change-out operations approximately every eight years. These components require an approximate eight-year decay time and are in storage at the ATR Complex. Previous disposal has been at RWMC using a cask that is no longer in use. The CNS 3-60B cask has been identified as a potentially useful cask for this application.
	NRF	NRF produces activated metals during routine operations. Currently, waste is disposed of in the RWMC vaults in 55-ton scrap cask liners.
	INL MFC	MFC will generate activated metals during waste segregation operations for waste removed from the storage at the Radioactive Scrap Waste Facility. The CNS 3-60B cask has been identified as a potentially useful cask for this application.

Ion-exchange resins from pool and reactor operations are generated at the ATR Complex (approximately 36 m^3/yr) and from pool operations at NRF (approximately 8 m^3/yr). ATR ion-exchange resin is generated approximately four to six times annually from reactor loop and reactor ion-exchange systems. The generation rate depends on reactor operations and also varies during the years when core internal change-outs are performed. The ion exchange resin waste stream has typical contact dose rates up to 15 R/hr.

ATR also produces about 3 m^3 of activated metals during reactor core internal change-out operations, approximately every eight years. These components require decay time before they can be handled for disposal and are currently in temporary storage at the ATR Complex. NRF produces approximately 35 m^3/yr of activated metals from the examination of test components and during routine operations removing irradiated non-fuel components from spent fuel modules. In addition, an estimated 60 m^3 of activated metals are expected from new INL programs and from processing of remote-handled waste stored at the Radioactive Scrap and Waste Facility (RSWF) at MFC. The activated metals waste stream has typical contact dose rates up to 30,000 R/hr.

3. FACILITY DESCRIPTION

The vault configuration for the proposed Remote-Handled LLW Disposal Facility is anticipated to be similar to the existing vault design and configuration that is currently present at RWMC. The facility includes concrete vaults, vault plugs, access roads, and support infrastructure. Each stacked cylinder will be placed on a concrete base and will have a separate removable concrete plug placed on top of the cylinder to serve as a radiation shield and a water barrier (see Figure 1).

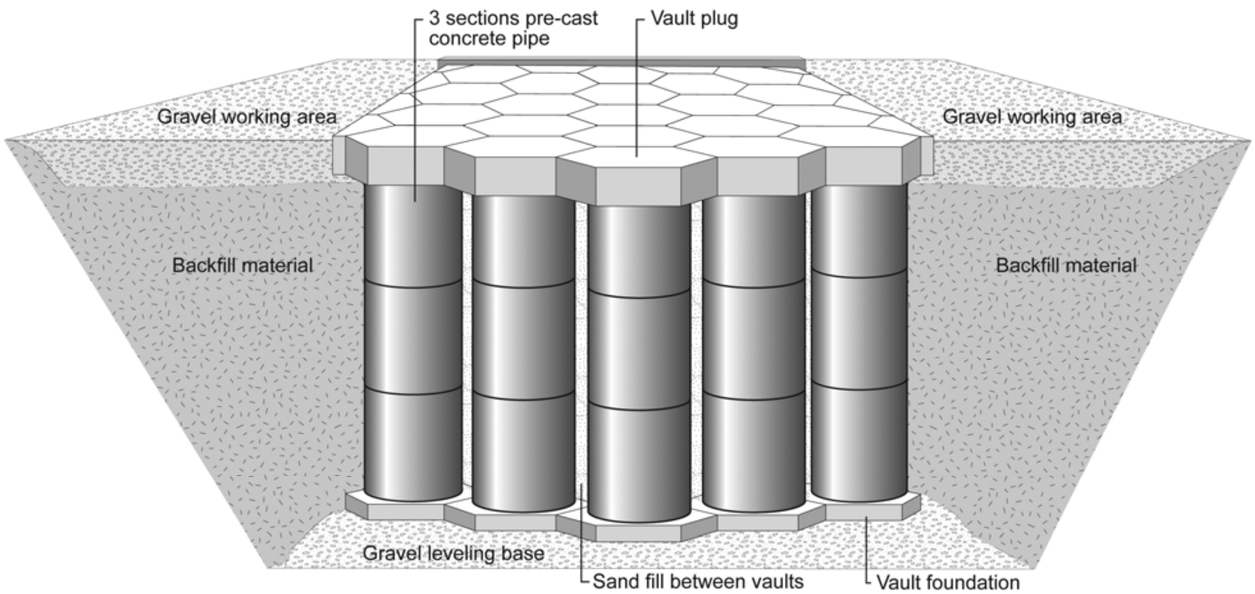

Figure 1. Conceptual layout of proposed concrete vault system.

The proposed facility layout is based on the assumption that the facility would be a stand-alone facility and would provide its own administration buildings and infrastructure to support disposal operations. If a site is selected that is located in the vicinity of an existing facility, then new construction of some of the infrastructure components may not be needed (i.e., the administration building).

The facility would be laid out in a manner to allow trucks entering the disposal facility to have straight access to the unloading area next to the disposal vaults. The crane and other miscellaneous equipment required for completion of the cask-to-vault transfer operation will be staged before arrival of the waste containers. Figure 2 illustrates the facility configuration and includes a photo that shows the equipment currently staged for operation at RWMC. The new facility will use these same methods and will set up the necessary equipment in a similar configuration.

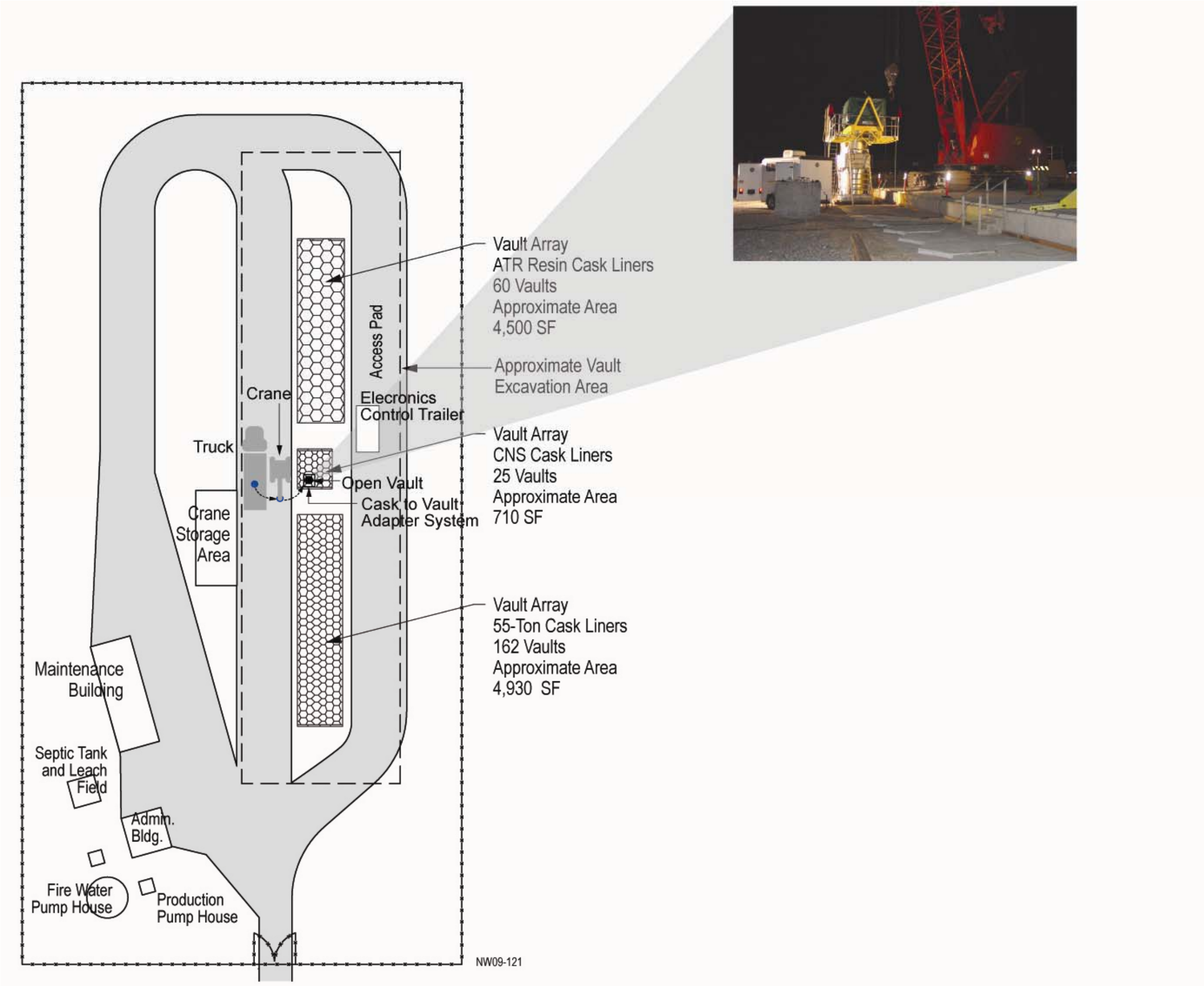

Figure 2. Remote-Handled LLW Disposal Facility operational configuration.

The total number of vaults that will be constructed will depend on the depth of surficial sediment at the specific site that is selected for the facility. The general layout in the conceptual design shows the areal extent of the vaults, as determined using a vault depth that can accommodate disposal of two liners per vault. In this configuration, a minimum of 160 vaults will be needed for NRF waste, 60 vaults for ATR resins, and 23 vaults for activated metals from ATR processing of co-mingled, remote-handled LLW currently stored in RSWF and new INL programs. If the selected site has sufficient surficial sediment to accommodate three liners per vault, the total number of required vaults would be reduced by one-third.

The following are major components of the proposed facility:

- Vaults—The vaults will be aligned vertically to allow multiple remote-handled LLW containers to be stacked on top of the previous one inserted in a vertical orientation. Vaults used to dispose of NRF waste will be designed to interface with the existing cask-to-vault adapting structure (CVAS) and the 55-ton scrap cask. Remaining vaults will be designed to interface with the applicable cask and associated transfer system. All handling equipment consistent with the current configuration and practices will be utilized.

- Vault plugs—A removable concrete plug will be set in place on top of each of the stacked cylinder vaults. The plug will serve as a radiation shield for placed waste and also will act as a water barrier to prevent surface water intrusion into the concrete vaults.

- Crane—The Manitowac 3,900 W, Series 2 crane that is currently in use at RWMC will be disassembled, refurbished, and transported to the new disposal facility. This crane is a mobile two-track crane with a total weight of 262,225 lb (118,943 kg) and a lifting capacity of approximately 140 tons (127,000 kg). If it is determined that the existing crane will not be available, a new crane with similar lifting capacity will need to be procured for the facility.

- Waste liner (container)—Remote-handled LLW will be packaged into steel liners (i.e., waste containers) at the generating facilities. One liner at a time is shipped within a shielded cask from the generating facility to the disposal facility. Upon cask arrival at the appropriate vault array location, the liner will be transferred directly from the bottom-unloading cask into the concrete vault. These liners perform an important safety function as a contamination barrier.

- CVAS—The CVAS currently located at RWMC will be transferred to the new disposal facility. This system is currently owned by NRF. All supporting equipment and components, such as the lifting rigging and control trailer, also will be made available for use. Similar CVAS will be required to accommodate the configuration of other INL-generated remote-handled LLW.

- Staging and Storage Area—Staging and storage pads will be provided within the facility for operating equipment. These pads will be constructed using pit run gravel with a crushed gravel top surface. Areas will be provided for storage of the crane; the CVAS components, including the working platform; the bearing pad; the shield plug; and the electrical control trailer.

- Administrative and other supporting infrastructure—Additional support and administrative structures and services are included in the conceptual design, which include the following:

  Administration building

  Electrical distribution

  Maintenance enclosure

  Temporary cask holding area

  Equipment decontamination

  Access roads

  Video monitoring

  Firewater supply

Additional details of these listed facility components may be found in INL/EXT-07-12901, *Conceptual Design Report for the Remote Handled Low-Level Waste Disposal Facility*.

4. PROCESS OPERATION

This section describes the overall process used for disposal of remote-handled LLW in concrete vaults at the INL. Figure 3 shows the general process that is currently being used for NRF remote-handled LLW disposal in the vaults at RWMC. It is assumed that all future waste received from NRF will be received and disposed of using this same, or similar, sequence of activities.

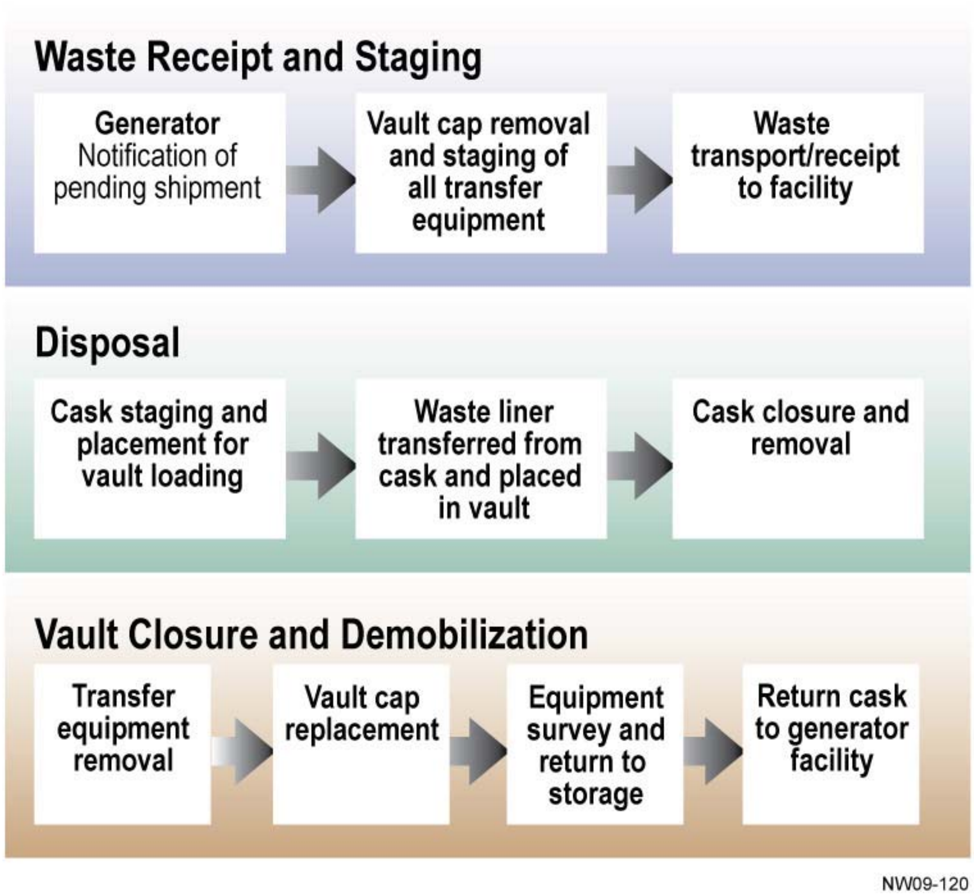

Figure 3. Facility process diagram.

Remote-handled LLW to be disposed at the proposed disposal facility will be packaged in waste liners that are transported to the disposal facility via shielded cask systems. The liners will normally consist of cylindrical containers designed specifically for the cask systems used. It is assumed that remote-handled LLW will be transported from NRF to the proposed disposal facility utilizing the existing 55-ton scrap cask (or similar) and, for purposes of this PHA, the existing RWMC method of cask liner placement will be utilized (see Figure 4).

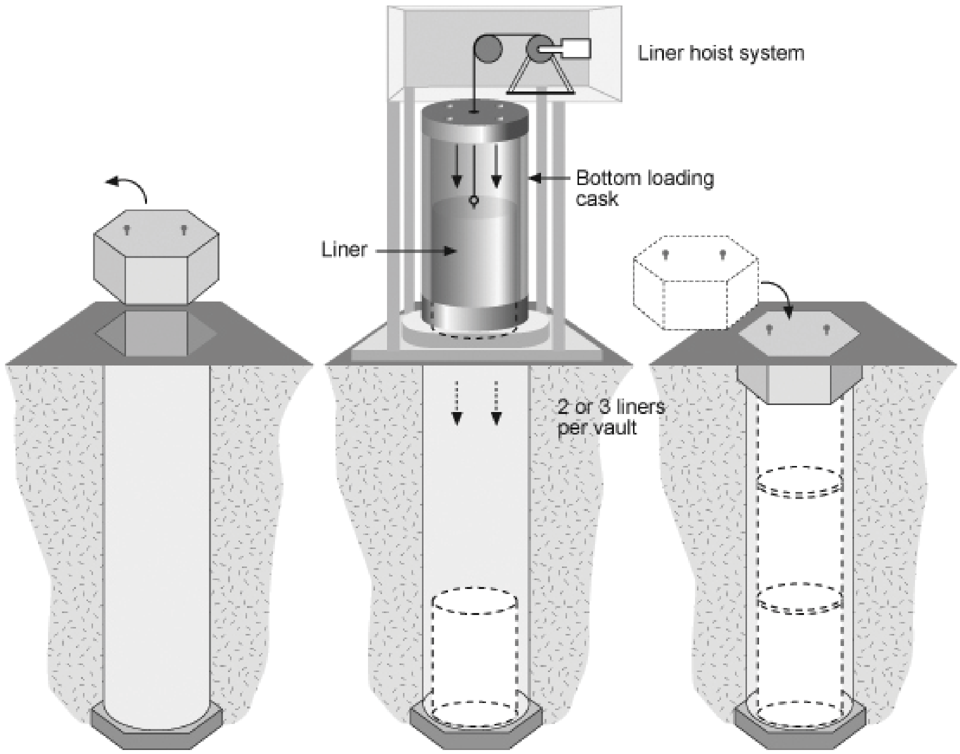

Figure 4. Cask liner placement method at the Radioactive Waste Management Complex.

Existing 75-in.-diameter liners will be used for packaging and disposal of the ATR resins. These liners will be transported to the proposed disposal facility utilizing the NuPac 14-210L cask, which is currently being used to transport ATR resins to the Nevada Test Site. New cask-handling equipment will be procured/designed for cask liners anticipated for remote-handled LLW activated metals generated at ATR, RSWF, and from future missions. It is assumed that the Chem-Nuclear Systems (CNS) 3-60B cask and liner system will be used for shipment of the activated metal waste. Any deviations from this assumption will be defined as the project matures. Such changes are not anticipated to change the basic design of the facility or operational aspects of waste disposal operations, but rather the number of vaults of a specific configuration/size that would be needed. Each of these cask systems (the NuPac 14-210L and CNS 3-60B) are top loading casks, requiring “open-air” transfer of the liner from the cask to the disposal vaults at the proposed disposal facility.

Only one waste liner will be transported in a cask at any one time. The operational system associated with the cask and transfer system used by other INL generators will be determined once specific liner designs and cask systems are finalized. No safety and health monitoring or surveillance, other than normal radiological surveys, are anticipated to be required as a part of normal operations.

The current NRF waste liner placement process consists of the following steps:

1. Once waste is transported to the site (utilizing the NRF 55-ton scrap cask), a crane is used to remove the top plug on the vault and to position the CVAS on top of the open vault.

2. The 55-ton scrap cask is removed from the transporter and placed on the CVAS using the crane.

3. Using a remote-operated hoisting system, the cask liner is unloaded from the bottom of the cask and lowered into the disposal vault.

4. The cask is then closed, and the hoisting system with the associated equipment is removed from the top of the vault.

5. The vault is then closed.

The specific operational systems and placement procedures that will be used in association with the other cask systems used for disposal of the remote-handled LLW at the proposed facility will be determined once the generating facilities identify their specific liner configurations. It is assumed that the following general operational sequence would be used for placement of the waste liners into the associated disposal vaults:

1. Once waste is transported to the site, a crane will be used to remove the top plug on the vault and prepare the vault opening for liner placement.

2. Using the crane, the liner will be removed from the cask using the associated liner handling equipment and positioned over the disposal vault.

3. The liner will be lowered into the disposal vault.

4. The transfer equipment will be removed and the vault plug replaced.

5. PRELIMINARY HAZARD CATEGORIZATION

Remote-handled LLW is considered as any waste container with a contact dose equivalent rate (including neutron and beta radiation) >200 mrem/hr at contact. If internally or externally shielded, the >200 mrem/hr limit applies to the expected dose equivalent rate without shielding. Should shielded containers be designed for placement in the proposed Remote-Handled LLW Disposal Facility, such containers will not have any Resource Conservation and Recovery Act-regulated metals used as shielding. For the purposes of this analysis, types of remote-handled LLW at the INL would include NRF, ATR, and RSWF activated metals and NRF and ATR generated resins placed in waste liners. Following guidance from LWP-18002, “INL Facility Categorization,” preliminary hazard categorization was performed for the proposed facility.

Radiological characteristics are defined by radionuclide composition, fissile material content, and external dose rate. Radionuclide composition affects the following:

- Hazard categorization of the facility
- Radioactive classification of the waste
- Container type and transportation method
- Disposal location.

External dose rate dictates shielding requirements for the facility vault plugs and for packages transported to and from the facility.

Table 2 below is a list showing potential isotopes found in IWTS waste stream 2534: “NRF 55-ton scrap cask insert with remote-handled low level waste. (1997)” This waste stream provides a conservative upper bound for all remote-handled LLW waste streams identified for disposal at the proposed facility. The data in this table is given as the upper levels anticipated in this waste stream. It is understood that this represents the maximum of a range of each isotope and is not indicative of every shipment made to the Remote-Handled LLW Disposal Facility.

Table 2. Maximum isotope activity.

Isotope	Maximum Ci/m^3	HC-3 TQ, Ci	HC-2 TQ, Ci	Fraction HC-3/m^3	Fraction HC-2/m^3
Ag-108m	2.455E-03	2.0E+02		1.23E-05	
Ag-110m	1.932E-04	2.6E+02	5.3E+05	7.43E-07	3.65E-10
Ar-39	2.198E-03	4.0E+04		5.50E-08	
Ba-133	3.654E-06	1.1E+03	4.0E+06	3.32E-09	9.14E-13
Be-10	1.065E-05	1.04E+02		1.02E-07	
Bi-212	4.275E-06	2.0E+03		2.14E-09	
C-14	5.000E+00	4.2E+02	1.4E+06	1.19E-02	3.57E-06
Ca-45	2.838E-03	1.1E+03	4.7E+06	2.58E-06	6.04E-10
Cd-109	5.666E-05	1.8E+02	2.9E+05	3.15E-07	1.95E-10
Cd-113m	1.151E-05	1.18E+01		9.75E-07	
Cd-115m	8.479E-07	2.2E+02		3.85E-09	
Ce-141	6.132E-05	1.0E+03	3.3E+06	6.13E-08	1.86E-11
Ce-144	5.592E-02	1.0E+02	8.2E+04	5.59E-04	6.82E-07
Cl-36	2.500E-02	3.4E+02	1.4E+03	7.35E-05	1.79E-05
Co-57	3.865E-02	6.0E+03		6.44E-06	
Co-58	4.014E+01	9.0E+02		4.46E-02	
Co-60	1.000E+04	2.8E+02	1.9E+05	3.57E+01	5.26E-02
Cr-51	1.670E+00	2.2E+04	1.0E+08	7.59E-05	1.67E-08
Cs-134	1.807E-01	4.2E+01	6.0E+04	4.30E-03	3.01E-06
Cs-137	3.000E-01	6.0E+01	8.9E+04	5.00E-03	3.37E-06
Eu-152	2.050E-01	2.0E+02	1.3E+05	1.03E-03	1.58E-06
Eu-154	9.909E+00	2.0E+02	1.1E+05	4.95E-02	9.01E-05
Eu-155	3.458E+00	9.4E+02	7.3E+05	3.68E-03	4.74E-06
Fe-55	3.850E+03	5.4E+03	1.1E+07	7.13E-01	3.50E-04
Fe-59	2.313E-01	6.0E+02	1.8E+06	3.86E-04	1.29E-07
Gd-153	4.943E-03	1.0E+03	1.4E+06	4.94E-06	3.53E-09
H-3	5.000E+00	1.6E+04	3.0E+05	3.13E-04	1.67E-05
Hf-175	5.916E-02	2.0E+03		2.96E-05	
Hf-181	9.591E-02	7.6E+02	2.2E+06	1.26E-04	4.36E-08
Hg-203	1.586E-06	3.6E+02	4.3E+05	4.41E-09	3.69E-12
I-129	7.000E-07	6.0E-02		1.17E-05	
In-113m	4.327E+00	3.0E+04		1.44E-04	
In-114m	1.129E-02	2.2E+02	3.7E+05	5.13E-05	3.05E-08
Ir-192	2.480E-02	9.4E+02	1.2E+06	2.64E-05	2.07E-08
Kr-85	2.454E-02	2.0E+04	2.8E+07	1.23E-06	8.76E-10
Lu-177	1.426E-05	3.4E+03		4.19E-09	
Mn-54	9.972E+00	8.8E+02		1.13E-02	
Mo-93	1.360E-02	2.0E+03		6.80E-06	
Nb-93m	2.379E+00	2.0E+03		1.19E-03	
Nb-94	2.000E+00	2.0E+02	8.6E+04	1.00E-02	2.33E-05
Nb-95	4.875E+01	9.6E+02		5.08E-02	
Nb-95m	4.761E-01	5.60E+03		8.50E-05	
Ni-59	5.000E+02	1.18E+04		4.24E-02	

Table 2. (continued).

Isotope	Maximum Ci/m^3	HC-3 TQ, Ci	HC-2 TQ, Ci	Fraction HC-3/m^3	Fraction HC-2/m^3
Ni-63	5.500E+04	5.4E+03	4.5E+06	1.02E+01	1.22E-02
Os-185	5.888E-05	1.1E+03		5.35E-08	
P-33	2.621E-04	9.4E+01	3.0E+04	2.79E-06	8.74E-09
Pa-233	9.849E-06	4.6E+03		2.14E-09	
Pb-212	4.275E-06	3.2E+02		1.34E-08	
Pm-147	1.503E-01	1.0E+03	8.4E+05	1.50E-04	1.79E-07
Pm-148m	7.395E-06	3.6E+02		2.05E-08	
Po-210	1.319E-04	1.9E+00	3.5E+02	6.94E-05	3.77E-07
Pr-144	5.592E-02	1.04E+06		5.38E-08	
Ra-224	4.275E-06	2.0E+02	9.9E+03	2.14E-08	4.32E-10
Rb-87	2.975E-06	6.0E+02		4.96E-09	
Re-188	8.959E-03	2.2E+04		4.07E-07	
Rh-103m	3.837E-04	1.04E+07		3.69E-11	
Ru-103	3.837E-04	1.56E+03		2.46E-07	
Ru-106	5.118E-02	1.0E+02	6.5E+03	5.12E-04	7.87E-06
S-35	1.172E-01	7.8E+01	2.5E+04	1.50E-03	4.69E-06
Sb-124	6.22E-02	3.6E+02	1.3E+06	1.73E-04	4.78E-08
Sb-125	5.780E+01	1.2E+03		4.82E-02	
Sc-46	7.205E-03	3.6E+02	1.4E+06	2.00E-05	5.15E-09
Se-75	4.642E-03	3.2E+02	3.4E+05	1.45E-05	1.37E-08
Se-79	2.975E-06	3.6E+02		8.26E-09	
Sm-145	3.089E-03	3.6E+03		8.58E-07	
Sm-151	3.282E+01	1.0E+03	9.9E+05	3.28E-02	3.32E-05
Sn-113	4.328E+00	1.3E+03	3.2E+06	3.33E-03	1.35E-06
Sn-119m	7.886E+01	1.86E+03		4.24E-02	
Sn-121	1.510E-01	4.6E+04		3.28E-06	
Sn-121m	2.500E-01	1.78E+03		1.40E-04	
Sn-123	1.362E-02	3.2E+02		4.26E-05	
Sr-85	9.640E-05	1.44E+04		6.69E-09	
Sr-89	2.073E-02	3.4E+02	7.7E+05	6.10E-05	2.69E-08
Sr-90	5.000E+00	1.6E+01	2.2E+04	3.13E-01	2.27E-04
Ta-182	1.196E+02	6.2E+02		1.93E-01	
Tb-160	1.614E-06	5.6E+02	1.3E+06	2.88E-09	1.24E-12
Tc-99	6.000E-03	1.7E+03	3.8E+06	3.53E-06	1.58E-09
Te-123m	8.257E-03	4.0E+02		2.06E-05	
Te-125m	1.323E+01	7.2E+02		1.84E-02	
Te-127m	2.085E-04	4.0E+02	1.5E+05	5.21E-07	1.39E-09
Te-129	3.280E-06	2.2E+05		1.49E-11	
Te-129m	4.275E-06	4.0E+02	1.4E+05	1.07E-08	3.05E-11
Th-228	4.275E-06	1.0E+00	9.2E+01	4.28E-06	4.65E-08
Th-234	4.420E-06	2.8E+03		1.58E-09	
U-232	5.369E-06	8.2E-01		6.55E-06	
U-234	4.419E-06	4.2E+00	2.2E+02	1.05E-06	2.01E-08
U-237	2.335E-06	1.44E+04		1.62E-10	
U-238	4.419E-06	4.2E+00	2.4E+02	1.05E-06	1.84E-08
W-181	2.669E-02	1.3E+04		2.05E-06	
W-185	1.301E-01	1.38E+03		9.43E-05	
Y-90	5.000E+00	1.42E+03		3.52E-03	
Y-91	1.078E-01	3.6E+02	6.5E+05	2.99E-04	1.66E-07
Zn-65	3.908E-02	2.4E+02	1.6E+06	1.63E-04	2.44E-08

Table 2. (continued).

Isotope	Maximum Ci/m^3	HC-3 TQ, Ci	HC-2 TQ, Ci	Fraction HC-3/m^3	Fraction HC-2/m^3
Zr-93	3.231E-02	6.2E+01	8.9E+04	5.21E-04	3.63E-07
Zr-95	2.268E+01	7.0E+02	1.5E+06	3.24E-02	1.51E-05
	Sum of the Fractions/m^3			HC-3 4.75E+01	HC-2 6.57E-02

The data in Table 3 is very conservative; these values are shown as maximum curie quantities per cubic meter of waste. However, projected remote-handled LLW generation for disposal is significant (1,649 m^3 by the year 2037) giving a substantial isotope inventory in the facility.

While it is likely that no single radionuclide in a single waste container would exceed the associated DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE O 5480.23, Nuclear Safety Analysis Reports," HC-2 Table A.1 threshold quantities values, the summation of waste containers or cumulative facility inventory of radionuclide activity to HC-2 threshold quantities values ratios warrants a preliminary HC-2 designation. DOE-STD-1027 supplemental guidance provides for facility categorization being modified in the final hazard categorization process considering: 1) alternative release fractions, or 2) change in material subject to an accident due to facility features which preclude bringing material together or causing harmful interaction from a common severe phenomenon (facility segmentation). This position will be further evaluated during the development of the preliminary documented safety analysis and documented safety analysis per NS-18101, "INL Safety Analysis Process," to determine if modification to the facility hazard category is appropriate based on alternative release fractions or the facility segmentation consideration. If either approach to hazard category modification is successful, the facility could be categorized as a HC-3 nuclear facility based on the contents of a single vault and using the isotope values shown above.

6. IDENTIFICATION OF PRIMARY FACILITY HAZARDS

This PHA was completed after a thorough review of the conceptual design report for the proposed disposal facility and discussions with the project manager and other personnel associated with the project. From the review of the facility conceptual design report and previous lessons learned, an analysis for potential hazards was performed. The results of this analysis are found in Table 3, which represent hazards and initiators that should be considered as the design progresses and the safety basis documentation is being prepared. This table lists identified hazards, causes of the hazards, and possible preventative and mitigative responses. The table is not intended to be all-inclusive and may be updated, as required. In addition, some hazards in the table may extend beyond the scope outlined in the conceptual design report. This presentation of potential hazards will be used in future analysis to determine whether further accident evaluation is warranted. At the time the safety basis documentation is developed, some potential accidents may be eliminated from further consideration. They are included here because operational experience suggests that further consideration should be given. This list will be periodically reviewed and updated as additional hazards are identified in the facility design process.

Table 3. Preliminary hazards identified for the Remote-Handled LLW Disposal Facility.

Hazard	Initiator	Location	Operation	Likelihood[a]	Scenario	Unmitigated Consequence Category[b]	Preventive Features	Mitigative Features
Loss of Confinement								
Remote-handled waste	Transfer cask drop	Facility storage vault array location	Entry of truck or forklift to disposal area Crane operations	A	Damage to cask and release of radiological material Loss of shielding resulting in a direct radiation exposure hazard	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Employee training Equipment inspection and maintenance programs Control vehicle speed Hoisting and rigging program	Solid waste form Robust transfer cask Immediate worker evacuation
Remote-handled waste	Inner waste liner drop	Storage vault array	Remote-handled waste transfer	U	Damage to inner waste liner and release of radiological material	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	CVAS Employee training Equipment inspection and maintenance programs Hoisting and rigging program	Solid waste form Waste liner integrity Immediate worker evacuation
Remote-handled waste	Corrosion induced waste liner failure	Storage vault array	Passive vault storage	U	No anticipated release	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Radiation protection program Facility design	Vault storage completely enclosed underground Vault storage designed to minimize potential water infiltration
Direct Radiation Hazards								
Remote-handled waste	Transfer cask drop	Facility storage vault array location	Entry of truck or forklift to disposal area Crane operations	A	Damage to cask and loss of shielding, resulting in a direct radiation exposure hazard	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Employee training Equipment inspection and maintenance programs Control vehicle speed Hoisting and rigging program	Immediate worker evacuation Robust transfer cask
Direct radiation exposure	Normal facility operations	Storage vault array	Open air liner transfers	A	Normal operations moving resin liners from transport cask to storage vault	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Employee training Radiation protection program Control distance from liners	Use of temporary shielding

Table 3. (continued).

Hazard	Initiator	Location	Operation	Likelihood[a]	Scenario	Unmitigated Consequence Category[b]	Preventive Features	Mitigative Features
Natural Phenomena Hazards								
Remote-handled waste	Natural phenomena hazards (e.g., tornado, flood, range fire, lightning, or volcanoes)	Storage vault array	Passive vault storage	U	No anticipated release	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Facility design	Vault storage completely enclosed underground Appropriate facility siting
Remote-handled waste	Loss of shield plug integrity due to severe seismic event	Storage vault array	Passive vault storage	EU	Direct radiation exposure to workers	Off-site public: N Collocated Worker: N Facility Worker: H Environment: N	Vault shield plug Surveillance program	Immediate worker evacuation Emergency response procedures
Externally Initiated Events								
Remote-handled waste	External events (e.g., plane crash, vehicle crash, or adjacent building fire/explosion)	Storage vault array	Passive vault storage	EU	No anticipated release	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Facility design	Vault storage completely enclosed underground Appropriate facility siting
Fire or Explosion								
Combustible remote-handled waste	Transfer vehicle fire resulting in cask/container failure	Facility roadway	Entry of truck or forklift into the disposal area	U	Damage to cask or waste container, resulting in release and dispersal of radiological material	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Employee training Equipment maintenance and inspection Robust casks and waste containers function as fire barrier	Facility fire suppression system INL fire department response
Combustible remote-handled waste	Waste container drop resulting in container breach and fire	Storage vault array	Crane operation, including waste container placement	U	Damage to waste container, resulting in release and dispersal of radiological material	Off-site public: N Collocated Worker: N Facility Worker: N Environment: N	Employee training Equipment maintenance and inspection Robust waste containers function as fire barrier	Suppression system INL fire department response

a. Likelihood defined as A=Anticipated (10^{-2} to 10^{-1}/yr) ; U=Unlikely(10^{-4} to 10^{-2}/yr); EU=Extremely Unlikely(10^{-6} to 10^{-4}/yr); BEU=Beyond Extremely Unlikely (<10^{-6}/yr)

b. Consequence categories defined as N=Negligible; L=Low; M=Moderate; H=High

Consequence evaluation of the postulated accident scenarios associated with the proposed facility requires a qualitative evaluation of those hazards. This evaluation encompasses internal events, man-made external events, accident initiators at nearby facilities, and natural phenomenon hazards (NPHs). Sabotage and terrorism are not addressed in the analysis. Internal events occur as a result of facility operations and encompass all operational modes.

Hazard identification involves determining the following for the facility:

1. The material at risk (MAR) (i.e., the type and amount of radioactive and hazardous material that is potentially releasable) including the form and location of the material.

2. Potential energy sources and initiating events that could directly result in injury to workers or affect the inventory of radioactive and hazardous materials.

With respect to MAR, the IWTS material profile associated with the highest radioactive waste stream identified at this point identifies a maximum of 10,000 Ci /m^3 of Co-60 in the waste stream. Standard waste disposal liners for this waste stream are approximately 2.66 m^3, giving a potential MAR for the purpose of qualitative analysis of 26,600 Ci of Co-60 for each liner. The other isotope found in significant quantity is Ni-63; however, the inhalation and direct radiation dose from Co-60 is far greater than that of Ni-63, so Co-60 at the maximum levels is used as a conservative estimate of dose consequences. Initial calculations indicate that the bounding MAR is from the NRF waste stream shown above in Table 2 for both intake/ingestion and direct radiation exposure accidents.

Hazardous chemical inventories for construction and operation of the Remote-Handled LLW Disposal Facility are very low in comparison to other INL operations and commensurate with existing RWMC remote-handled LLW operations. No chemicals found in the Occupational Safety and Health Act substance specific standards have been identified that would create a potential for exposure triggering medical surveillance during construction or operation. Additionally, no highly hazardous chemicals listed in 29 CFR 1910.119, “Process Safety Management of Highly Hazardous Chemicals,” (Appendix A, List of Highly Hazardous Chemicals, or Toxics and Reactives) will be generated, used, or disposed of at this facility.

A qualitative hazard evaluation is performed for the hazards that can result in an uncontrolled release of radioactive or hazardous material and affect the off-site public, collocated workers, facility workers, or the environment. In performing this qualitative evaluation of hazardous events, location, hazard, initiating conditions, likelihood, unmitigated consequences, and preventive and mitigative features are considered.

The likelihood category reflects a qualitative estimate of whether the hazardous event is anticipated (A), unlikely (U), extremely unlikely (EU), or beyond extremely unlikely (BEU) using the definitions in Table 3. The likelihood of a hazardous event is generally the frequency of the initiating event or cause. No credit is taken for controls (i.e., design or administrative) which prevent the event. For an internal event (i.e., events initiated by equipment failure or human error), this generally results in a likelihood category of anticipated (i.e., 10^{-2} to 10^{-1} per year) since the frequency can depend on the facility design and operation. The likelihood category is based on available data, operating experience, and/or engineering judgment. If there is uncertainty in the likelihood category, the higher likelihood category is conservatively assumed.

The consequence category reflects a qualitative estimate of potential consequences to the off-site public, collocated workers, facility workers, and environment from the hazardous event. A consequence category of high (H), moderate (M), low (L), or negligible (N) is assigned for each receptor and the environment based on the unmitigated quantity of radioactive and/or hazardous material potentially released and the energy source for dispersion. Unmitigated means that a material’s quantity, form, location, dispersibility, and interaction with available energy sources are considered, but no credit is taken for safety features (e.g., ventilation system, fire suppression) which could mitigate a hazard. If there is uncertainty in the consequence category, the more severe consequence category is conservatively assumed.

Safety-class SSCs are hazard controls for which credit is taken, either preventive or mitigative, to meet the evaluation guidelines for the off-site public. Based on the results in this PHA, evaluation guidelines for the public are not challenged for unmitigated releases. Therefore, no safety-class SSCs are identified for this facility.

Safety-significant SSCs are hazard controls for which credit is taken to prevent or mitigate postulated anticipated or unlikely accidents that could result in consequences to collocated or facility workers exceeding 25 rem. Based on the results in this PHA, it is concluded that the potential exists for an accident which could result in direct radiation exposure exceeding these guidelines to the facility worker. The 5-ft-thick concrete shield plugs are identified as a component which would protect the facility worker from those consequences. The shield plugs may, therefore, be designated as safety-significant SSCs for design and facility planning purposes. As the facility design matures, further analyses will be performed evaluating the direct radiation exposure to the facility worker from specific material being stored.

7. CONCLUSIONS

This PHA is a tool that will provide the safety analysis and design teams a frame of reference as their activities commence. It identifies potential hazards and initiators that should be considered as the design process begins and that will continue to be considered through approval of the final DSA. Having a common frame of reference at the onset helps avoid potential late design modifications and will result in a safer facility.

Based on the preliminary hazard categorization, the proposed Remote-Handled LLW Disposal Facility will have a sufficient radionuclide inventory to be a HC-2 facility. The final hazard categorization will consider the possibility of reducing the categorization to HC-3 based on alternative release fractions or facility segmentation. The list of potential hazards identified in Table 3 is intended to be an “outline” for the development of a hazards analysis and facility safety basis documents. It incorporates extensive experience and lessons learned from other facility nuclear safety designs and operations. The current stage of the conceptual design process does not require detailed analysis of accidents. Detailed analyses will be completed in conjunction with development of the PDSA. At this time, it is prudent to establish the thought processes necessary to develop accidents scenarios for the PDSA.

As the project design matures, generation of other safety documents and analyses will be required. These supporting documents, other than operational procedures, will include, as appropriate, a fire hazard analysis, PDSA, DSA (DOE approval required) to supplement the INL’s standardized DSA, hoisting and rigging plan, engineering design files, as low as reasonably achievable reviews, radiation work permits, operational job safety analyses, construction project safety and health plan, and industrial hygiene exposure assessments prepared in accordance with the associated INL procedures.

8. REFERENCES

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