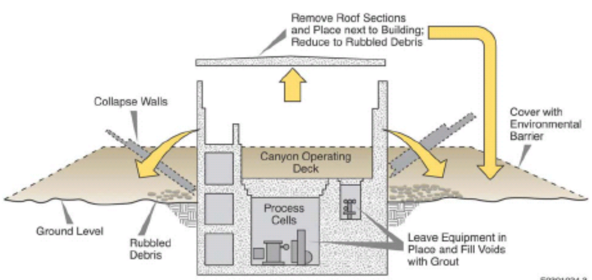
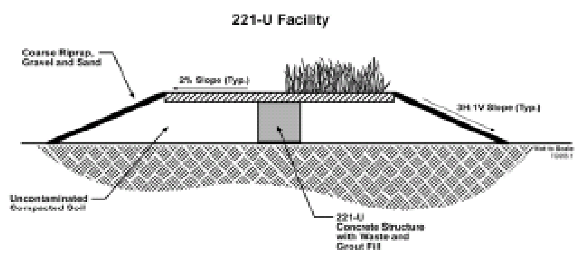
DOE EM Strategy and Experience
for
In Situ Decommissioning





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Acknowledgements

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Acronyms

ACM	asbestos containing material
AHERA	Asbestos Hazard Emergency Response Act of 1986
AOC	area of contamination
ALARA	as low as reasonably achievable
ARARs	applicable or relevant and appropriate requirements
ARRA	American Recovery and Reinvestment Act of 2009
CA	Composite Analysis
CDI	Canyon Disposition Initiative
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminants of concern
CPP	Chemical Processing Plant (facility prefix used at INL)
D&D	Deactivation and Decommissioning
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
EAROD	Early Action Record of Decision
EE/CA	Engineering Evaluation/Cost Analysis
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETR	Engineering Test Reactor
FFA	Federal Facility Agreement
FIMS	Facilities Information Management System
FS	Feasibility Study
GSF	gross square feet
HLW	high level waste
HM	Hot Makeup area
HWMA	Hazardous Waste Management Act
ICDF	Idaho CERCLA Disposal Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
ISD	in situ decommissioning
LEED	Leadership in Energy and Environmental Design
LLW	low-level waste
LOFT	Loss-of-Fluid Test Facility (also called the LOFT Reactor)
LM	Legacy Management
MCL	maximum contaminant level
MFC	Materials & Fuels Complex (at INL)
MHC	Mechanical handling cave
MLLW	Mixed low level waste
MTR	Materials Test Reactor
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDAA	National Defense Authorization Act (See Ref. N-1 for complete title)
NEPA	National Environmental Policy Act
OU	operable unit
PA	performance assessment
PAOU	P Area Operable Unit
PBF	Power Burst Facility

PCB	polychlorinated biphenyls
PEW	process equipment waste
PM	Process Makeup area
PSA	potential source area
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SNM	special nuclear material
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
TAN	Test Area North
TBC	To Be Considered
TRA	Test Reactor Area (at INL)
TRU	Transuranic
TSCA	Toxic Substances Control Act
WAC	Waste Acceptance Criteria
WCF	Waste Calcining Facility

1. Introduction

1.1 The ISD Concept

In situ decommissioning (ISD) is the permanent entombment[1] of a contaminated facility. Within this report "in situ decommissioning" and "ISD" are used for convenience in communicating the general concept of permanent entombment as the decommissioning end-state of a facility within the DOE Complex. At present, ISD is not recognized or addressed in the Department of Energy (DOE) and Office of Environmental Management (EM) lexicon[2]; however, ISD is not a revolutionary concept. Since the 1970s, the U.S. Nuclear Regulatory Commission (NRC) has recognized the option of entombing a facility as a decommissioning option.[3] Permanent entombment of a radioactively contaminated facility as a decommissioning option has been completed for one facility at the Idaho National Laboratory and is currently planned for implementation at a limited number of selected DOE facilities.

A general description of an ISD project encompasses an entombed facility; in some cases limited to the below-grade portion of a facility. The envelope of the project may extend beyond the outer walls. The entombed portions of the facility are of robust construction, generally of reinforced concrete exterior that provides a migration barrier between internal contamination and the environment; with significant internal void spaces backfilled or grouted. The scope of entombment may include ancillary equipment and structures and may contain radioactive and hazardous materials and contamination within the facility and waste imported from outside the facility.

ISD is a permanent decommissioning end-state. The defined completion (the end-state) of the decommissioned facility is project-specific and in conformance with environmental approval processes. The final condition is passive, meaning there are no requirements for ongoing operational systems or equipment within the decommissioned facility. ISD projects are presumed to be under indefinite institutional control of the U.S. Government. Following site closure, the Office of Legacy Management (LM) will assume responsibilities for management and control.

The regulatory framework is currently in place to provide assurance that the risk posed by an ISD facility is within regulatory acceptance criteria. Special emphasis is placed on the fact that an entombed facility is not considered a waste disposal facility; rather it is a decommissioning end-state option.

ISD does not eliminate proper management of contaminated materials and structures, nor does it serve to abandon contaminated buildings in place. Further, ISD is feasible and cost-effective for a very limited number of facilities across the Complex; as analyzed in this report, this number is in the range of 100–200 structures. As such, the overall combined result of ISD projects will not be a multitude of small buildings littering the landscape at any site or across the country.

1.2 Purpose

The need for this strategy and guidance report stems primarily from EM's objective to document ISD project progress, technical experience, and regulatory approaches; and to report results of work to identify opportunities for technological development. The report serves as a means for EM to formally endorse ISD and to initiate its recognition as a concept within DOE's lexicon.

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[1] In "entombment," radioactive contaminants are permanently encased on site in a structurally sound material, such as concrete, and appropriately maintained and monitored until the radioactivity decays to a level permitting restricted release of the property.

[2] See Appendix C regarding the observation that there is no language in key DOE documents that addresses, or even mentions, the practice of in situ decommissioning.

[3] One reason entombment is not practiced in the commercial nuclear industry is because of the limited availability of suitable locations for siting new power plants. It is also noted that NRC rulemaking on this subject is not currently active.

Although the ISD concept is not new, the regulatory framework is in place, it is being successfully planned at three sites, and while implementation methods appear to be within the state-of-the-art, project experience is minimal. Benchmark information and reliable data do not exist; and technology and other project aspects have not been optimized.

The results of situation-specific analyses at a variety of Field offices and the output of workshops sponsored by the Office of Engineering and Technology (EM-20), with participation by the Office of Compliance, the Field, and DOE Office of Health, Safety and Security have determined that ISD is an acceptable practice for a potential facility end-state. These findings support the conclusion that ISD is proceeding in a reasonable manner, consistent with site planning. It is recognized, however, that the application of ISD is in an early stage of maturity and requires further recognition and integration between Field implementation and EM Headquarters processes.

Thus, the overall purpose of this document is to present a common understanding of ISD as practiced within the DOE by assembling current site experience, along with several specific objectives that include:

- Putting forth an EM Strategy –
  - Articulating EM's position on ISD;
  - Raising recognition of ISD within the DOE and industry with a formal policy statement;
- Identifying other policy needs, if any, and providing recommendations as to how they should be addressed;
- Providing clarification and recommendations to make the process for DOE's regulatory approval of ISD projects clearly understood and efficiently conducted;
- Recommending a DOE-EM Headquarters communications plan for promulgating ISD as a proven safe, cost-effective, and viable end-state;
- Providing guidance based on experience to date –
  - For selecting facilities for ISD;
  - Technical approaches among the projects;
- Identifying and outlining technology development needs and opportunities for ISD.

ISD is being planned as part of the current baseline for a number of major facilities that include reactors at the Savannah River Site (SRS), canyons at Hanford, and reactor and spent fuel processing facilities at Idaho National Laboratory (INL). Importantly, the scope, schedule, and cost projected for several EM Project Baseline Summaries depend on successful implementation of ISD for these facilities, and failure would result in the additional need for hundreds of millions of new EM funding. For this reason, EM-20 has initiated studies to determine the status, maturity, technical and regulatory perspectives associated with ISD, and whether policy, regulatory, or technical development is necessary. This report brings together these subjects in one place.

1.3 Audience

This report is intended as a resource for DOE management, decommissioning project managers, and others interested in ISD as a significant approach to solving the problem of decommissioning certain contaminated facilities. It seeks to assist decision-makers by providing evidence in support of the ISD option and to project planners and implementers by distilling and providing experience to date in a number of areas. This document is not, however, intended as a primer on decommissioning and assumes some familiarity with the subjects of DOE cleanup and disposal of radioactive and hazardous wastes.

1.4 Content

The sections of this report are organized as follows:

- Sections 2 through 5 are focused on the overall management aspects of ISD and only relate to Field projects as background.
- Section 6 paints the overall regulatory picture for ISD, and Section 7 addresses the specific aspects of using an ISD project facility for the permanent placement of waste, specifically with regard to the applicability of DOE Order 435.1, *Radioactive Waste Management* (Ref. O-3).
- Sections 8 through 12 relate experience from past and current projects. This experience is useful as a form of guidance for project managers and project planners.
- Section 13 reports the results of a workshop sponsored by EM-20 to identify technology opportunities specifically for ISD.
- Appendices A through G provide information that either supports or elaborates upon the topics in the body of this report.

A companion report (Ref. S-1), "Applicability of Performance Assessment Methodologies to In Situ Decommissioning," has been developed by Savannah River National Laboratory. The regulatory sections and appendices herein have borrowed heavily from that report. In addition, the SRNL report addresses the technical and analytical aspects of risk assessment, which have not been incorporated in this report.

2. Executive Summary

2.1 DOE-EM Endorsement of ISD Approach

This report serves as EM's management endorsement of ISD as an advantageous Deactivation and Decommissioning (D&D) method for selected projects. Formal endorsement is recommended in Section 3.2.

This endorsement supports site managers' decisions to evaluate and propose ISD as the end-state option for excess facilities at suitable locations with appropriate physical attributes, and for which the personnel safety and environmental impact of the decommissioning action are within regulatory standards. The acceptance of ISD for a project/facility assumes that the appropriate regulatory process has been conducted and approvals have been received. The discussions contained herein address the benefits and merits of ISD with regard to worker safety, long-term risk, waste management, and savings to the taxpayer.

2.2 Rationale for ISD

EM faces the challenge of decommissioning thousands of excess nuclear facilities. Each project will involve the complete deactivation, decommissioning, demolition and transport of the resultant debris of a sturdy, hardened facility and its enclosed contaminated equipment and process systems, including miles of pipelines and tons of volumetrically contaminated structures. In many cases, ISD offers the safest, timeliest, and most cost-effective solution. Consideration of ISD as an acceptable end-state to decommissioning is underscored by the following questions:

- Does it make sense to demolish some of DOE's sturdy, hardened facilities, only to transport the remains to a waste disposal site, which may be only a few miles away in some cases, and a few thousand miles away in others (for which the cost would be prohibitively high)? The worker safety and environmental consequences of ISD are comparable or less than the alternative of complete removal.
- Is the ALARA (As Low As Reasonably Achievable) radiation exposure principle being practiced in which "Reasonably Achievable" refers to the cost element in the ALARA principle? Exposures to workers are typically lower for a less costly entombment option than for more expensive cleanout, demolition, and complete removal.
- Why not turn the liability of these facilities into an asset and use them for permanent placement of selected wastes? Long-term protection of the public and environment from the entombed radiation sources can be consistent with that of traditional waste disposal sites.
- Is costly complete demolition the best use of limited resources? From a purely budgetary perspective, resources saved by ISD can be used to achieve further risk reduction.

These questions are addressed on a project-by-project basis through the regulatory approval process to determine the decommissioning end-state of a facility. The ISD option is feasible for a limited number of DOE contaminated facilities for which there are substantial incremental environmental, safety, and cost benefits versus alternate actions to demolish and excavate the entire facility and transport the rubble to a radioactive waste landfill.

The bases for selection of facilities as candidates for ISD are institutional, technical, and safety.

- Institutional feasibility relates to locations at U.S. Government sites where controls will be maintained for the foreseeable future, and ultimately by the Office of Legacy Management. In many cases, such sites already contain low-level waste disposal facilities that have degrees of long-term risk similar to an entombed ISD facility. Institutional feasibility will also tend to rule out urban and suburban locations, as well as other DOE sites where the nuclear mission is clearly not indefinite.

- Technical feasibility relates to candidate facilities of robust construction, primarily some form of masonry, and sufficiently large so that there is a clear advantage to partially demolish and entomb in place compared with complete removal. It is noted that the ISD projects completed and planned to date have a significant fraction of their volume below grade, a factor that contributes significantly to technical feasibility.
- While all EM work is approached with procedures and controls to ensure the safety of its workers and the public, ISD usually offers the safest decommissioning alternative. Entombment limits the radiation exposure to demolition teams because it drastically reduces the handling and movement of the material. Encapsulation in grout prevents migration of contaminants and radiation emission, thereby ensuring the safety of on-site personnel and the public.

The long-term risk to personnel and the environment associated with ISD must be shown to be within acceptance criteria applied to other permanent sources located at the same government site. Overall site composite risk analyses include low-level waste disposal facilities and entombed waste tanks, which are comparable examples to an ISD end-state for a contaminated facility.

2.3 Current Status

ISD has been successfully accomplished at INL and is currently in diverse stages of planning and implementation at Hanford, INL, and Savannah River. Three large and several smaller DOE facilities have been through the CERCLA Record of Decision approval process:

- The U-Canyon is one of five very large, reinforced concrete structures at Hanford and was chosen as the initial facility for the Canyon Disposition Initiative (CDI), which began in 1995. A ROD for the cleanup of the 221-U Facility was issued in October 2005.
- Several facilities at INL have been or are in the process of ISD closure under CERCLA with an approach that removes all significant radioactive contamination. With regard to remaining contamination within a facility, the most significant ISD project to date at INL is the CPP-601/640 fuel reprocessing facility[4];an Action Memorandum was issued in August 2008 for its closure.
- At SRS, the P-Reactor Building Complex (part of the P-Area Operable Unit) has received an Early Action Record of Decision (EAROD) for the ISD concept. This agreement among DOE, U.S. EPA, and the South Carolina Department of Health and Environmental Control allows early remedial actions to occur in conjunction with long-term action to ensure the site is cleaned up as quickly and effectively as possible. The EAROD was completed in compliance with CERCLA and other applicable environmental requirements. This EAROD achieves agreement on the final end-state for the P-Reactor Building and will allow subsequent engineering efforts and regulatory decisions to focus only on closure alternatives that are appropriate for that end-state. The EAROD also allows for consideration of placing remediation waste inside the P-Reactor Building.

The projects at these three sites are addressed more fully in Sections 8 through 11.

These projects represent functionally permanent closure although they might not be referred to as “in situ decommissioning” in the associated documentation. There are implementation differences among these sites; these differences result from the physical attributes of facilities and their contents, the types and distribution of radiation, environmental conditions, and local regulatory agreements and preferences. Regardless, they all meet the long-term performance objectives as enforced by the EPA under CERCLA, and by the DOE under the Atomic Energy Act. At all three, the site land use where the ISD facility is to

[4] The Old Waste Calcination Facility (CPP 633) at INL can also be considered an in situ closure, although it was conducted using RCRA processes; this was accomplished in 1999. WCF was closed as a RCRA landfill because of extensive contamination.

be located is one of assumed Federal institutional control, i.e., maintaining control until the facility can meet the requirements for unrestricted release specified in DOE O 5400.5, *Radiation Protection of the Public and the Environment*. In effect, this means Federal control for the foreseeable future.

2.4 Potential Complex-Wide Scope for ISD

The most likely facilities for an ISD end-state are the production reactor facilities and the canyon process buildings. Other facilities that have similar methods of construction and contamination are also considered appropriate for the ISD end-state. As part of the analyses conducted during the preparation of this report and using the Facilities Information Management System (FIMS), 84 facilities representing a footprint of about 1.8 million square feet were identified as potential ISD candidates. These were culled by physical attributes and, with few exceptions, are not included in any current plans as ISD projects. Section 5 presents a summary of the estimated number of facilities and approximate square footage at eight sites. A detailed listing with facility attributes is presented in Appendix B.

Utilizing FIMS information as a starting point, understanding that there are candidates that cannot be readily distilled from FIMS, and considering known DOE facilities not yet placed in operation and, therefore, not in the database, it is estimated that implementation of ISD could be applicable and beneficial to a limited but significant number of facilities numbering from 100 to 125 across the DOE Complex. Small-sized facilities (of a magnitude of a few thousand GSF) in this number may not be stand-alone projects; i.e., associated with a larger ISD project. Also, ISD may not be effective for other small facilities identified by the culling attributes.

A conservative upper bound of 200 facilities accounts for factors that cannot be predicted. This estimated range provides a good perspective on the potential scope of facilities with an ISD end-state. Importantly, it provides the perspective that ISD implementation will not leave hundreds of small entombed buildings scattered about at DOE sites.

Applying documented cost estimates in various RODs to the range of potential total number of ISD facilities derived above, it is roughly estimated that ISD can result in overall, cumulative avoided costs to DOE in the range of $1.5 billion to $3 billion. This is a combination of direct cost avoidance for the ISD approach and the reduced need for waste cells, not only from the reduced demolition waste, but also from the potential of disposing of radioactive waste currently within ISD facilities. In fact, this estimate is likely to be low because many of the cost estimates upon which it was based are dated and the integrated cost of avoided waste cells has not been estimated. Also, many of the facilities to be addressed in the future would have much more severe challenges for complete removal than those that have received RODs to date, thus implying higher unit costs.

2.5 Regulatory Framework

The regulatory framework for ISD is well-defined regardless of the fact that "in situ decommissioning" is a term not specifically included in regulations. The most significant regulatory recommendations, selection, and approval of a facility for ISD are clearly local responsibilities and are to be conducted under the site-specific established regulatory authority (e.g., Federal Facility Agreements with the State and agreements with local stakeholder groups), DOE Orders, CERCLA, RCRA or NEPA per established agreements with EPA and the States. Section 6 lists those regulations related to contaminated facilities; Section 7 specifically addresses DOE Order 435.1, in the context of using an ISD facility for the permanent placement of waste.

CERCLA remedial and removal actions are being used for the three major projects at Hanford, INL, and SRS, with variations as follows:

- The Hanford U-Canyon is a CERCLA remedial action.
- The INL Fuel Reprocessing Facilities (CPP 601 and 640) are a CERCLA non-time-critical removal action.

- The SRS P-Reactor Area has received an EAROD approving the ISD concept using the CERCLA remedial process. A future CERCLA ROD will finalize the details of the ISD alternative.

2.6 Opportunity for Technology Development

Consistent with the overarching DOE goals for increased personnel and environmental safety, reduced technical uncertainties and risks, and overall gains in efficiencies and effectiveness, EM-20 has initiated efforts to identify the technical barriers and gaps and concomitant technology development needs for the optimal implementation of ISD. An ISD Technology Workshop was conducted in December 2008 to define the ISD technical challenges and explore potential investments in technical breakthroughs. These technologies are expected to improve characterization of existing conditions within ISD candidate facilities; shorten time, lower costs and reduce risks in the execution of ISD work activities; and add confidence to the long term durability of the resultant end-state.

Technology needs identified during the workshop were organized into six basic groups: characterization, materials behavior and degradation, design and closure, monitoring, knowledge management, and policy change. EM-20 will use the portfolio of technical needs from this effort to develop prioritized investment goals that will achieve clear improvements in ISD costs, schedules and safety across DOE's D&D program. The needs statements and their topics were developed as presented in Section 13 and Appendix F.

3. Issues and Recommendations

There are several topics addressed in this report and in the related SRNL report (Ref. S-1) that suggest a need for action on the part of EM Headquarters to demonstrate endorsement for ISD as feasible, and based on facility characteristics, site-specific conditions, and regulatory concurrence, at times the preferred decommissioning end state option; and share the accumulated Complex-wide experience for potential ISD projects in the future. The successful regulatory and implementation efforts to date and technical endorsement by project planners support the ISD approach to D&D. The conclusion of this report, however, is that while there is no need to develop a formal departmental directive addressing ISD, there is a clear need for a limited policy statement (memorandum) to assist in moving ISD projects forward.

This proposed policy memorandum would serve to accomplish three objectives: 1) officially define and introduce "in situ decommissioning" into the DOE vernacular; 2) state endorsement by EM management of ISD; and 3) update prior policy to address coordination of DOE O 435.1 with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) regarding use of an ISD facility for waste placement.

3.1 Definition of ISD

"In situ decommissioning" is not officially defined within DOE's hierarchy of directives (e.g., policies, orders, notices, guides, technical standards); nor is ISD otherwise defined, recognized, endorsed or discussed. Because it is an important concept that could/should be in play for many years in the future, the following definition is proposed for incorporation within DOE documents:

> "In situ decommissioning is the permanent entombment of a facility that contains radiological contamination, with or without chemical contamination. Achievement of the entombed end-state is a result of established regulatory review and approval processes for decommissioning of DOE facilities."

Other references to ISD have described the concept as applicable to the decommissioning of offshore oil platforms and large diameter pipelines, for which the regulatory system is completely different; these sources do not address radioactive contamination that is not naturally occurring. Because in situ decommissioning has been used in other industries, it is important that the reference to the DOE be kept in the above proposed definition.

<u>Recommendation – Promulgate a formal Definition of ISD</u>

Gain concurrence, with revisions as appropriate, to the definition of in situ decommissioning and formally promulgate the definition for use within DOE via a policy memorandum.

3.2 EM Endorsement of In Situ Decommissioning

It is clear that there is substantial merit to the ISD approach with regard to worker safety, waste management, and savings to the taxpayer, while being achievable within established regulatory processes.

<u>Recommendation - Promulgate EM's endorsement of ISD</u>

ISD should be endorsed by EM as a viable option for decommissioning excess contaminated facilities at suitable locations and with appropriate physical attributes, and for which the personnel safety and environmental impact of the decommissioning action conform to accepted standards and practices.

The proposed policy memorandum will be the chief vehicle for promulgating the endorsement of EM management to field managers and project managers at DOE sites. EM's Office of Engineering and Technology (EM-20) will develop and conduct a high-level management briefing to facilitate this endorsement. This office should engage the Offices of the Departmental Representative to the DNFSB and Intergovernmental and Legislative Affairs to determine if the Defense Board and Congressional staffs have interest in hearing about ISD as a decommissioning alternative. See Section 4 for elaboration.

3.3 DOE O 435.1 and the Use of ISD Facilities for the Limited Placement of Waste

ISD projects will differ among the DOE sites as a result of factors such as geology, hydrology, facility physical features, type, extent and form of contamination, and local regulators' and stakeholders' perspectives. The current body of agreements, orders, regulations, and general standards are, for the most part, sufficient for planning, engineering, and safely implementing an ISD project at a site level. Therefore, ISD projects must be managed at the site level, and there is no need for a defined Headquarters program specific to ISD. However, there is one subject that warrants focused Headquarters attention and revision of current policy: the potential use of ISD facilities for permanent placement of wastes.

Of the few ISD projects completed or in progress to date, none of the corresponding ISD Records of Decision (ROD) have included this approach to waste disposal in any selected alternative; however, doing such is technically feasible and cost effective. Additionally, the DOE Inspector General proposed that the Department consider this disposal opportunity in its 2005 review of the Hanford Canyon Disposition Initiative. Because of the significant potential for efficiency and cost savings, it is envisioned that a waste entombment option will be addressed for future ISD candidate projects.

This policy issue can be addressed by clarifying applicability of DOE O 435.1 to CERCLA actions involving ISD projects. The need for clarification principally results from the past practice of utilizing available space within hardened facilities to temporarily house both contaminated and non-contaminated waste materials and equipment. Whether the decision to contain these items as part of an ISD project constitutes "disposal" raises two questions: a) whether a crosswalk with DOE O 435.1 requirements should be conducted to demonstrate that its requirements have been satisfied by CERCLA response actions; and b) how to efficiently use the crosswalk for such a determination. The crosswalk referred to addresses how CERCLA implementation fulfills the requirements of DOE O 435.1 when it is applicable to a project. The crosswalk is addressed in Section 7 and Appendix D.

<u>Recommendation – Update DOE O 435.1 and CERCLA Implementation Policy</u>

Update previous policy (Ref. P-2) to address application of DOE O 435.1 when waste has been or is to be placed within an ISD facility.

The following draft statement is provided as a starting point for initiating a policy memorandum for the use of ISD facilities for the permanent placement of wastes. In effect, such a memorandum would be a revision to an April 22, 1993 memorandum on the subject of "Compliance with DOE Orders as part of Environmental Restoration Projects Conducted under CERCLA." That memorandum is reproduced as Appendix G.

Draft Policy Statement

Generally, a CERCLA – DOE O 435.1 crosswalk for an ISD project is required only when CERCLA response actions include the importation of wastes from outside the CERCLA Area of Contamination (AOC) that were unrelated to the facility's mission. This action is judged to be subject to the requirements of DOE O 435.1. An exception to this requirement is when regulators agree on a case-by-case basis that two CERCLA units containing waste can be consolidated as the remedial action. This would not be subject to DOE O 435.1 requirements because it is judged to be a one time decision to consolidate a) materials and equipment that would otherwise become waste if removed and/or b) waste associated with the facilities.

The CERCLA AOC constitutes the scope and boundaries as negotiated with regulatory authorities that provide the bases for the ISD project's Record of Decision.

When an ISD facility's former mission included waste processing from external sources:

- Remaining processing residues and contamination shall not be considered imported waste because they are a result of conducting the facility's mission.
- The products of processing external waste shall be considered as imported waste unless removed from the facility for disposal elsewhere.

Using a facility with a planned or (based on criteria) potential ISD end-state for miscellaneous storage is not prohibited by this policy. However, it needs to be understood that stored materials may be considered as imported waste and may impact future end-state decisions and decommissioning approaches used at the facility.

3.4 Guidance for DOE O 435.1

The potential use of an ISD facility for disposal of low level waste is an important subject. While recognizing that cost and disposal efficiency can be realized, utilizing a facility for the placement of wastes as part of the ISD end-state can complicate risk performance assessment and add complexity to the regulatory framework for approval. To fulfill DOE's responsibilities under the Atomic Energy Act of 1954, as amended, the Department must demonstrate compliance with the substantive requirements of DOE M 435.1-1 for facilities managed under CERCLA. The method by which regulatory compliance is determined is via a "crosswalk." A crosswalk between the CERCLA and the DOE M 435.1-1 requirements needs to be prepared and reviewed as described below. The crosswalk identifies those elements considered substantive for ISD, and demonstrates how compliance with DOE O 435.1 will generally be achieved for an ISD project/facility through the CERCLA process.

If a facility is to be used for the placement of hazardous waste, substantive compliance with RCRA landfill requirements also needs to be addressed. Landfill requirements are locally mandated and variable across the country and therefore are not addressed in this report.

Recommendation – Incorporate an ISD Crosswalk into DOE O 435.1 Support Documentation

Incorporate the CERCLA-435.1 Crosswalk from the SRNL report (Ref. S-1 and Appendix E) into DOE O 435.1 support documentation to be revised as a tool that could be generically applied with site-specific tailoring to ISD projects, thereby minimizing the amount of individual site interpretation required.

The SRNL report also recommends that a simpler crosswalk may be sufficient for ISD facilities and should be so addressed in future revisions to DOE 435.1 guidance documents.

3.5 Other Recommendations

In the course of developing this document, it became evident that if ISD were to become widely embraced as a safe and less costly alternative to traditional D&D, there are other opportunities and considerations that might be pursued. These are summarized below and are explored further in this report.

Recommendation – Share information

Post this report on the EM website. Provide links to key documents, such as the RODs for selected facilities, or the documents themselves for download.

Recommendation – Performance Assessment Guidelines

Develop guidelines for project managers to consider how more detailed Performance Assessment models can be used to take credit for additional features of ISD and reduce conservatism that is typically present in CERCLA modeling efforts. The guidance would build on the information in Section 3.2.1 of Reference S-1. It would help to improve awareness of available modeling approaches. It is recommended to prepare a relatively short guide that focuses on identifying what can be done and provides references for further information. The guide would not be intended as a tutorial on how to conduct the modeling.

Recommendation – Economics of Importing Waste to ISD Facilities

Perform a detailed cost study, considering likely waste types at the Hanford, INL, and SRS, which takes into consideration the costs of documenting and obtaining authorization, the disposal cost for candidate waste types, the cost of expanding existing or constructing new disposal facilities, and the long term monitoring costs. This would serve to refine the feasibility of recommendations in DOE/IG-0672 (Ref. I-1) and help close a recommendation remaining open since its publication in 2005.

Recommendations – Keep Informed on NRC Positions on Concentration Averaging

Assumptions regarding concentration averaging are typically important for decisions regarding waste classification and for intrusion scenarios, if they are required for a specific situation. Concentration averaging assumptions should be placed in the context of the exposure scenario(s) considered in the performance or risk assessment. It is important for DOE's project managers and risk assessors to keep informed on revisions to the Nuclear Regulatory Commission's Branch Technical Position (Ref. N-2) on concentration averaging and encapsulation with regard to assumptions related to activated hardware and other concentrated sources of radioactivity.

4. Communications

4.1 Overview for Headquarters Level Communications

In developing a Complex-wide strategy for ISD, the Department has sponsored workshops and technical meetings during which the following key points emerged to provide the bases for a communications plan:

- There is no need for major policy changes as appropriate ISD regulatory processes currently exist.
- Because of a variety of different conditions and situations among the DOE sites, public participation efforts, media relations, and other communications, initiatives should be conducted at local levels rather than launching a national campaign from DOE Headquarters.

The Message

With regard to the first point above, the primary message to be communicated is that the selection of ISD as the preferred decommissioning end-state for specific facilities with regard to effectiveness, implementability, and cost is in accordance with the established regulatory framework. It will be important to emphasize that ISD offers a safe and environmentally favorable alternative to otherwise completely demolishing a facility and transporting its debris elsewhere for disposal (i.e., the decision to employ ISD is not solely cost driven, although cost avoidance eventually accrues to taxpayers).

Although until recently ISD has not been widely addressed as a decommissioning end-state alternative, it is in various stages of implementation at Hanford Site, Idaho National Laboratory, and Savannah River Site. Implementation at these sites has been in full coordination with site-specific Federal Facility Agreements, regional and State regulatory agencies, and local stakeholders. This document is the first attempt to both communicate EM's endorsement of ISD and to provide the current state of affairs, identify the potential universe of applicable facilities, and capture lessons learned to date.

Communication Roles

With regard to the second point above, most appropriate and value added, the communications role for DOE Headquarters should be limited to informing Federal level stakeholders about ISD as the occasion warrants. The goal is to provide information that allows for understanding ISD as a viable decommissioning end-state alternative for specifically selected DOE facilities. ISD information should be provided as needed to communicate the concept initially within DOE and externally to Congressional staff, and other Federal regulatory agencies at a high level.

Responsibility for ISD planning and execution is with the various DOE Field sites. Communication efforts will be directed by the responsible Field office through the Federal Project Directors, site managers, and field office public affairs organizations that have a long history and experience in communicating with their regulators, resident neighbors and local stakeholders. Site project and public affairs offices have an understanding of the character and general concerns of these parties, and therefore, are best suited to develop and execute their own targeted and graded campaigns. Some of the groups they might be communicating to include: county residents, native Tribes, citizen advisory boards, state and municipal government agencies and officials, business owners, schools, and local media along with other interested individuals. Staffing, management, timeline, and communication or marketing budgets are established by each individual site. Cost, mix, and exposure are determined by the sites as appropriate for their projects.

The EM Office of Engineering and Technology, working with the Department's Office of Public Affairs, should provide assistance to the Field with corporate messaging, but the methods and channels of communication should be developed and managed by the sites.

4.2 Target Audience

The target audience at the local level will be identified by the individual sites working with their Site-Specific Advisory Boards. The audiences for Headquarters are:

- Departmental management within the Offices of Environmental Management, Legacy Management, Health, Safety and Security and other program Secretarial Offices up to the Office of the Under Secretary, as well as Federal Project Directors;
- Federal stakeholders who may influence DOE activities or have regulatory oversight, including Members of Congress, the Office of Management and Budget, the Defense Nuclear Facilities Safety Board (DNFSB), and the U.S. EPA;
- Other agencies and organizations that may express interest in ISD information, such as the U.S. Department of Transportation, the U.S. Army Corps of Engineers, the National Governors' Association, the Energy Facility Contractors Group and the Interstate Technology and Regulatory Council, among others.

4.3 Communication Methods and Channels

Informing Federal level managers and stakeholders about ISD methodologies and its benefits as a decommissioning alternative can be accomplished primarily through the use of a fact sheet and a briefing package.

ISD Fact Sheet

EM-20 has developed a fact sheet for distribution to a general audience that practically describes ISD and defines DOE's strategy for ISD (See Figures 1 and 2). Although non-technical in design, the fact sheet provides a concise explanation of how the DOE intends to approach the challenge of decommissioning a small set of "hardened" excess contaminated facilities and ensuring a safe methodology for permanent entombment of these structures. It contains renderings of example ISD methodologies to enable the lay reader to visualize the end-state of facilities.

This user-friendly fact sheet is intended to be shared with all interested parties from DOE program personnel to external stakeholders.

ISD Briefing Package

The Office of D&D and Facility Engineering (EM-23) will develop a high-level brief for DOE and EM management. Initial review should be provided by the Office of Regulatory Compliance (EM-11) and the Office of Public and Intergovernmental Accountability (EM-13).

The content of the brief will include and describe:

- EM's explicit recognition of ISD as a decommissioning end-state alternative;
- An explanation of the regulatory framework under which ISD projects are reviewed and approved;
- A discussion of the criteria that can be used by sites to decide on ISD for individual facilities;
- Technical methods for entombing facilities; and
- Differences among sites with regard to these criteria, Federal Facility Agreements with the State, and other subjects.

Field offices should be given an opportunity to review the brief. It will subsequently be made available to the field offices for their use as desired.

IN-SITU DECOMMISSIONING
A Strategy for Environmental Management

U.S. Department of Energy | Office of Environmental Management | Office of Engineering and Technology

What is In-Situ Decommissioning?

ISD: Permanent entombment of a facility that contains radiological and/or chemical contamination.

Overall Avoided Costs Through ISD

ISD offers considerable cost avoidance over demolition and complete removal of the structure and its contents, including the cost of transport and disposal. The range of avoided cost varies considerably because there is a wide variation in the facilities that may be decommissioned via ISD.

Avoided cost is judged to range from $5 million each for a large number of small facilities to as much as $300 million for a few large facilities. The combined total is potentially as much as $2 billion. Additional substantial costs may be avoided in waste cell savings.

~125 Potential ISD Candidate Facilities
Total avoided cost for ISD = ROM >$2 Billion

Values are Conceptual Rough Order of Magnitude

REDUCING THE FOOTPRINT OF THE COLD WAR

For over a decade, the Department of Energy has focused on reducing the footprint of 60 years of nuclear research and weapons testing and production. While these facilities are no longer needed, they exist with varying degrees of radiation contamination from years of operation.

Deactivation & Decommissioning (D&D) is the process of closing down a nuclear facility and placing it in a state that reduces or eliminates risk to the public and the environment. This generally includes demolition and transport of the debris to a disposal facility. Another alternative is to dispose of the facility in place (i.e., in-situ).

The concept of In-Situ Decommissioning (ISD) is not new. ISD is the practice of permanent entombment of a facility where it stands. ISD may involve various accepted methodologies. In some cases a building may be collapsed into its subsurface structure (basement), its remaining spaces filled with grout, and then capped with an earthen or concrete cover. In others, the building may be completely covered to create a large mound. In any ISD technology, radioactive contaminants and chemical residuals are entombed to minimize release and migration consistent with the regulatory requirements and demonstrated by risk-based performance analysis. The potential for accessing and spreading contaminants is essentially eliminated, ensuring long-term effectiveness.

ISD STRATEGY AND EXPERIENCE

The Office of Engineering and Technology is completing an ISD strategy and experience document for use within DOE.

REGULATING ISD

The regulatory approval to decommission a facility through ISD is authorized primarily by the Environmental Protection Agency under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In addition, sites have Federal Facility Agreements and local stakeholder agreements that influence ISD approval and oversight.

POST-DECOMMISSIONING MANAGEMENT

Long-term management considerations for ISD facilities include monitoring of physical closure; ground water monitoring; permanent markers and/or intruder deterrents. Investigations have been initiated to determine technologies for these purposes.

ISD at Idaho

ISD is currently being implemented at the Idaho National Laboratory – shown conceptually here for a former fuels processing facility. Portions of the superstructure will be removed prior to entombment.

Figure 1 – ISD Fact Sheet, Page 1

What Facilities Meet the Criteria for ISD?

Not all contaminated structures can be decommissioned via ISD. Selection criteria for ISD candidates include:

- Facility Hazard Category
- Physical size and suitability for permanent entombment (robust concrete structures)
- Contamination types and levels
- Estimated cost savings
- Non-urban location

Typical facilities that could be considered as ideal for ISD are:

- Process canyons
- Large reactors
- Small reactors below grade
- Other robust concrete facilities

80–90 DOE facilities have been identified as strong candidates for ISD through the Facilities Information Management System database.

100–125 DOE facilities Complex-wide are judged to be possible ISD candidates.

ISD May Be the Best Alternative for a Significant Number of DOE Facilities

- ISD is an effective decommissioning practice offering a safe and environmentally favorable alternative to completely demolishing a contaminated facility and transporting its debris elsewhere for disposal.
- ISD is generally less complex to implement than typical D&D and results in better utilization of resources.
- ISD limits radiation exposure and industrial hazards to workers more so than for larger scale deactivation and demolition.
- ISD has been successfully accomplished at INL.
- The regulatory framework for ISD is already in place and other projects are in the process of CERCLA approval.

ISD Projects

Savannah River P-Area Production Reactor

At Savannah River Site, the P-Reactor Area Closure Project has received an Early Action Record of Decision (EAROD) for the concept. P-Reactor is one of five reactors at the site. The EAROD achieves agreement on the final end state for reactor facilities; this will allow subsequent engineering efforts and regulatory decisions to focus only on closure alternatives that are appropriate for that end state and allow for consolidation of remediation waste inside the P-Reactor Building.

Hanford U-Plant Canyon

The U-Canyon at the Hanford Site is a very large, reinforced concrete structure that will be partially cleaned out and decontaminated. U-Plant was selected as the pilot for the DOE Canyon Disposition Initiative in 1996.

The top portion of the canyon will be partially demolished and collapsed in, the lower spaces and basement filled with grout, and the remainder of the structure covered with a soil mound and/or engineered barrier cap (Figure 1).

The ROD for Hanford U-Plant D&D was finalized in 2005. There are a number of engineering and operation decisions needed to implement ISD.

Idaho National Lab

ISD methodologies have already been successfully employed at Idaho. There remain a number of INL facilities that may be candidates for ISD. Post-closure monitoring and maintenance is conducted under a HWMA/RCRA[1] post-closure permit issued by the Idaho Department of Environment Quality.

[1] Idaho Hazardous Waste Management Act

SRS P-Reactor Area Closure Project

Hanford U-Canyon

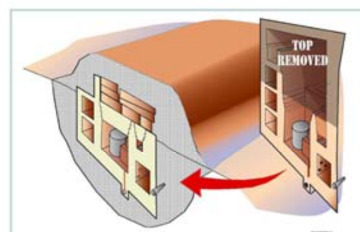

Figure 1

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Office of Engineering and Technology
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Figure 2 – ISD Fact Sheet, Page 2

5. Potential Facilities for ISD

The DOE facilities reported in this section were screened to provide a perspective on the number of facilities Complex-wide that might be appropriate for ISD. From a strategic viewpoint, it would be useful to know if the potential facilities number in the tens or in the hundreds. An idea of the associated land area represented by these facilities would also be of interest.

To arrive at this information, DOE's Facilities Information Management System (FIMS)[5] database was screened to identify facilities that are potential candidates for ISD.

It is important to emphasize that this report and the results of the screening:

- Do ***not*** select facilities for ISD
- Do ***not*** recommend facilities for ISD

The recommendation, selection, and approval of a facility for ISD are clearly local responsibilities and are to be conducted under the site-specific established regulatory authority (i.e., CERCLA, RCRA, or NEPA per established agreements with U.S. EPA and the States). The decision process will require a tailored approach to address specific concerns at individual sites, not the least of which is value for future use of the property, an attribute that is not in the FIMS database.

Each site will need to evaluate individual facilities on a case-by-case basis to assess such issues as contamination types and levels, and additional potential buildings that have a non-robust structure above-grade with a reinforced concrete structure below-grade (which FIMS does not distinguish).

5.1 Summary of Screening

Types and Numbers of Candidate Facilities

The FIMS screening, which is described later in this section, produced a set of 84 facilities representing a total footprint of about 1.8 million square feet. These were culled by physical attributes, and with few exceptions are not included in any current plans for ISD projects. Table 1 presents a summary at 8 sites which translate to 7 site locations; Hanford and River Protection are considered as one site location. A detailed listing with facility attributes is presented in Appendix B.

The most likely facilities for an ISD end-state are the production reactor facilities and the canyon process buildings. Other facilities (i.e., diversion boxes, exhaust filter houses, and other process facilities) that have similar methods of construction and extensive levels of contamination are also considered for the ISD end-state.

The screening process (described in Section 5.2) was applied to the FIMS database and provided 158 "hits" for possible candidates based on structural attributes. A detailed review of this list eliminated 94 facilities for one or more of the following reasons:

- Small Size (< 1,000 sq ft);
- Removal of contamination sources (e.g., laboratory hoods and sinks, drains, and ventilation systems) will render building non-radioactive and/or make demolition or reuse attractive;
- Located on small or urban sites where reuse of the property clearly has considerable worth;
- Construction style

[5] FIMS is a tool to assist in managing DOE's physical assets. FIMS is the Department's corporate real property database as required by DOE Order 430.1B Real Property Asset Management (Ref. O-2). The database provides the Department with an inventory and management tool that assists with planning and managing all real property assets. Real property includes land and anything permanently affixed to it, such as buildings, fences, and building fixtures (lights, plumbing, heating and air conditioning, etc).

- Where prior use is different than inferred by the name in FIMS and not contaminated.

This step resulted in 64 screened facilities from FIMS potentially appropriate for ISD. However, many candidate facilities were not captured by this process because facilities that are robust concrete below-grade but another form of structure (e.g., steel framed) above-grade cannot be discerned from FIMS. To compensate for this inability, using input from individual sites and information obtained during facility walk-downs in support of other efforts, 20 distinct facilities were added to the list bringing the total to 84 facilities.

To account for facilities that are not yet constructed or operational, such as the Waste Treatment Plant at Hanford or the Salt Waste Processing Facility at SRS, and the various anomalies within FIMS, it is conceivable that an additional 20 to 40 facilities may be considered as candidates in the future, resulting in an estimate of between 100 and 125 facilities based on known or high confidence factors.
A conservative upper bound of 200 accounts for factors that cannot be predicted.

Perspective on the Range of Facility Sizes

Figure 3 presents the distribution of ISD candidate facilities by area footprint of the facility. This figure was created to provide some perspective on the size of facilities in the population of ISD candidates derived from FIMS. The majority of the candidate facilities (61) fall within the 2,000 to 50,000 sq. ft. footprint range.

The footprints of the production reactors and canyon facilities at Hanford and SRS fall into the 10,000 to 50,000 sq. ft. and 50,000 to 100,000 sq. ft. range. By comparison with their footprints, the gross square footage (GSF) of these facilities can be much larger because of the number of floors. The Hanford and SRS reactors are respectively on the order of 59,000 GSF and 385,000 GSF. The Hanford and SRS canyons are respectively about 160,000 GSF and 240,000 GSF.

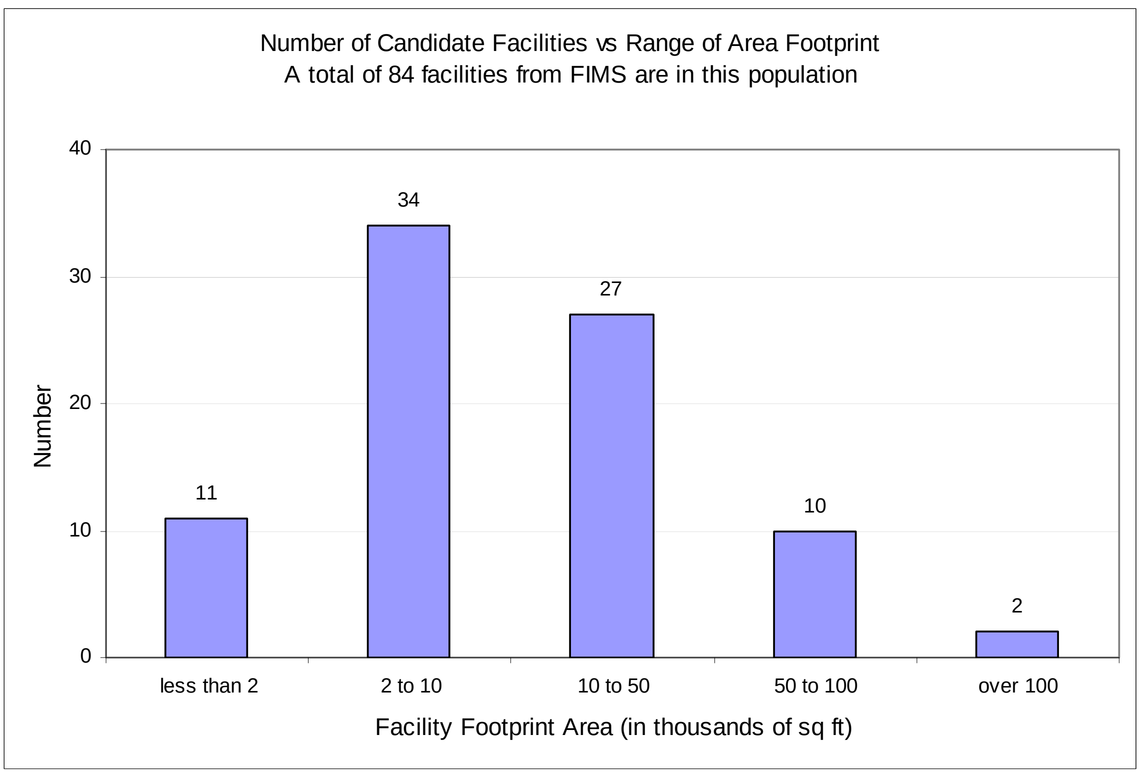


Figure 3 – Size Distribution of Candidate Facilities from FIMS

It is noted that some of the smaller facilities in this population (e.g., diversion boxes and pump pit associated with H Canyon at SRS) may be associated with larger projects and thus are not "stand-alone" projects. In other cases, these smaller facilities may not be selected for ISD because of their size although they met the FIMS sorting criteria; other factors, such as site-specific economics, may exclude them from consideration.

5.2 Criteria and Bases for Screening FIMS

A detailed review of the FIMS database was conducted to provide an understanding of the magnitude of the number of buildings/structures throughout the DOE Complex that could be considered for ISD. Facilities considered for the ISD end-state ideally are robust hardened structures physically suitable (or can be made suitable) for permanence. They are typically constructed of steel-reinforced concrete walls, floors and roof.

The screening process employed for this project is depicted in Figure 4. The database was reviewed and arranged into the following broad categories:

- Infrastructure Elements
- Utility Services
- Land Areas
- Tanks
- Waste Storage Vaults
- Other Structures
- Buildings

Tanks and waste storage vaults were automatically excluded from consideration since their closure is being addressed by other programs. The next step of the screening process was to eliminate categories based on "obvious" criteria (e.g., roadways, sidewalks, parking areas, storage yards, pads, and utility services). Mobile offices, trailers, and any records with "office building" designation were also deleted since they typically are not structures that would satisfy the robust structure criteria.

The remaining database population was electronically sorted according to the following criteria:

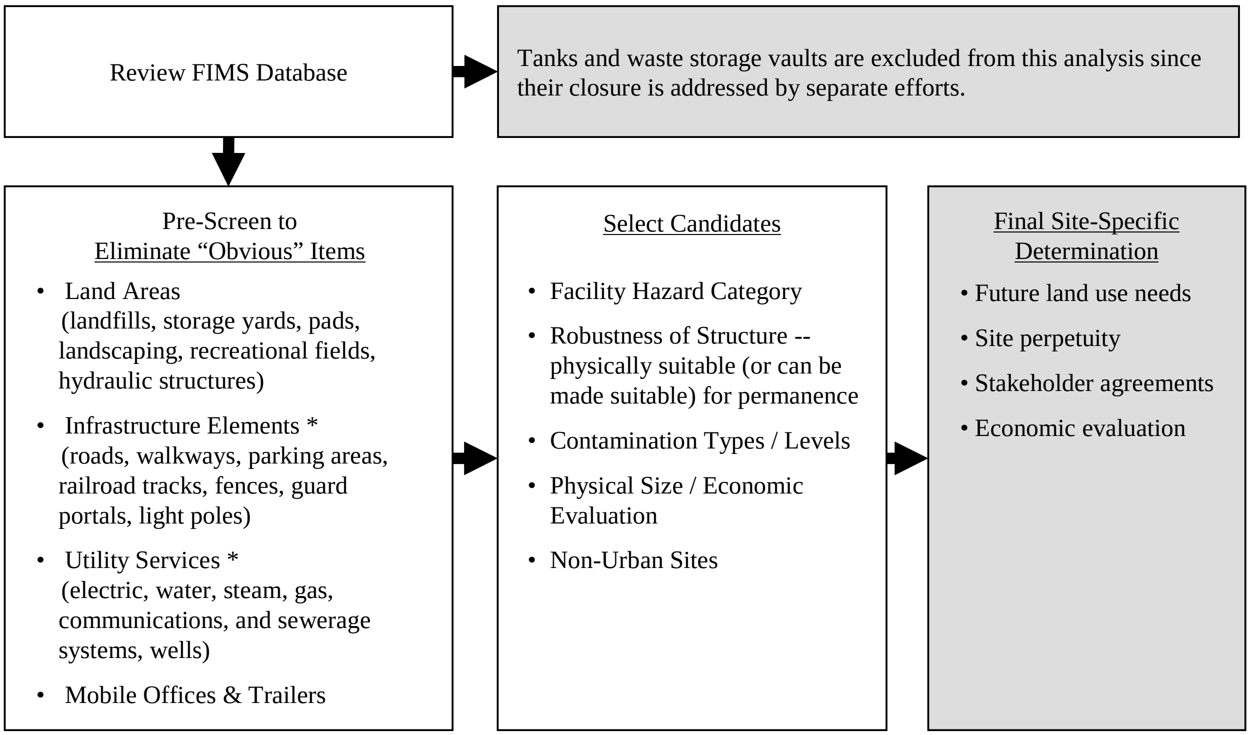
- Eliminate all records with Hazard Category field = "Not Applicable".
- Eliminate all records with Hazard Category field = Blank.
- Model Bldg field:

	=	MB08 Concrete Moment Frame
or	=	MB09 Concrete Shear Walls
or	=	MB12 Pre-cast Concrete Frames w/ Concrete Shear Wall

Table 1 – Potential ISD Facilities Culled from FIMS

Site	# of Buildings & Structures			Total Footprint (ft^2)		
	From FIMS	Additional	Total	From FIMS	Additional	Total
Idaho National Laboratory	4	4	**8**	21,149	45,036	**66,185**
Lawrence Livermore Lab Site 300	12	1	**13**	53,057	30,680	**83,737**
Los Alamos National Laboratory	5		**5**	278,396		**278,396**
Nevada Test Site	5		**5**	87,723		**87,723**
Oak Ridge National Laboratory	none	2	**2**		39,543	**39,543**
Office of River Protection	4		**4**	22,540		**22,540**
Richland Operations Office	15		**15**	433,325		**433,325**
Savannah River Site	19	13	**32**	662,538	85,718	**748,256**
TOTAL	64	20	**84**	1,558,727	200,977	**1,759,704**

Notes:
a) This list is unofficial. The only site interaction to date on this list is with Savannah River.
b) Inclusion on this list does not represent specific site plans.
c) LLNL Site 300 facilities are listed as candidates due to remoteness of site, but stakeholder concerns may exclude them from consideration.



* Infrastructure elements and utility services may be abandoned in place at some sites, but by definition this is not considered ISD.

Figure 4 – Screening Steps to Identify Potential ISD Facilities

An additional attribute, "footprint," was added by taking the gross square footage (GSF) and dividing it by the number of floors. Footprint is a better indication of the relative size of the structure with respect to demolition economics. Experience at the Savannah River Site suggests that it is more cost-effective to demolish smaller robust structures than to pursue the ISD end-state.

Manual additions were made to the database sort to account for idiosyncrasies in the FIMS database (such as missing records, inconsistent attribute assignment, data entry errors, etc.). Engineering judgment was applied to manually delete unlikely facilities such as:

- Single-story (above-grade) laboratory structures where readily removable fixtures, such as glove box units, lab hoods, and/or various equipment, will reduce the contamination to the extent that demolition (or reuse) becomes attractive or the facility will be rendered non-radioactive, thereby putting it outside of the scope of this strategy from a cost-benefit perspective;
- Structures located at small sites where the value of real estate dictates that building sites be reused to support new and/or ongoing mission needs; or
- Storage or other miscellaneous structures that would be unlikely candidates for ISD because of construction style;
- Where it is known that actual prior use is different than inferred by the name in FIMS and not contaminated.

The *Other Facilities and Structures* portion of the FIMS database does not contain the same level of completeness as the building database with respect to some of the facility attributes. To account for this lack of data, key word searches were performed to ensure complete capture of potential ISD facilities.

The following key words were utilized:

- diversion box
- HDB or FDB[6]
- gang valve house
- sand filter
- exhaust filter
- pump pit
- lift station
- delaying basin
- pumping basin

The resulting database sort was then arranged from highest to lowest footprint; those records with a footprint <1,000 square feet were eliminated (based on cost reasons cited above).

[6] These are diversion boxes specific to the F Area and H Area at SRS.

6. Regulations Affecting ISD Facility Closure and Related Waste Disposal

The purpose of this section is to provide an overview of the range of key regulations that potentially apply to an ISD project.

The primary statute for review and approval of decommissioning a DOE facility is the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In 1995, DOE and U.S. EPA agreed that decommissioning of DOE facilities can be, but does not have to be, performed as CERCLA non-time critical removal actions (Ref. P-2)[7] with DOE having delegated authority for implementation. Removal actions are generally short-term response actions under CERCLA. Because of the size, cost, and complexity of ISD projects, the CERCLA remedial process is generally more appropriate for ISD than the removal action process. ISD could also be achieved through coordination of Resource Conservation and Recovery Act (RCRA) standards with CERCLA, where appropriate. Variations on how CERCLA has been applied to current projects are described in Section 8.

The regulations that potentially apply to an ISD project are determined by the types of stabilized contamination that would be left in place. Table 2 summarizes significant regulations and requirements that affect a CERCLA ISD decision at DOE facilities. These may specify facility closure and/or disposal requirements and identify waste characterization requirements.

DOE Order 435.1, Radioactive Waste Management, is the most significant DOE directive impacting ISD decisions, and is discussed further in Section 7. Appendix C lists other regulations that apply to ISD projects.

Regulations and guidance other than those listed in Table 2 also may be Applicable or Relevant and Appropriate Requirements (ARARs) and/or To Be Considered (TBC) in the CERCLA evaluation process[8]. In addition, State and local regulations and agreements can affect an ISD decision. More restrictive State regulations or requirements, Consent Orders, Agreements (Federal Facility Agreements and Federal Facility Compliance Act agreements), and Memoranda of Understanding result in varied regulatory processes for each project and/or site. These variations must be incorporated within the planning, communication, and implementation stages of an ISD project.

[7] CERCLA and the National Contingency Plan authorize two types of responses to hazardous substance releases to the environment: remedial action and removal action. Remedial actions are longer in duration and involve the study, design and construction of long-term actions with the goal of permanent remediation of the problem. Removal actions are short-term actions taken immediately or at most within months, to “abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release.”

[8] ARARs are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. TBC consists of guidance, advisories, or criteria that are not promulgated (and therefore cannot be considered ARARs), but that may be used to establish protective Superfund remedies.

Table 2 – Significant Regulations and Requirements Impacting ISD Decisions

(Derivative documents that have regulatory status, such as DOE Manuals, should be understood to also apply)

Regulation	Title	Relevance to D&D
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Implementing regulations for CERCLA)	Executive Order 12580 delegates CERCLA authority to DOE. DOE and U.S. EPA policy authorize decommissioning of DOE facilities under CERCLA. DOE facilities on the EPA National Priorities List are subject to CERCLA and have existing Interagency Agreements. Most ISD decisions will be made under CERCLA and must be consistent with the NCP.
40 CFR 260-282	Hazardous Waste Management System (implementing regulations for RCRA)	Decommissioning of DOE facilities can be coordinated with Treatment, Storage and Disposal (TSD) facility closures under RCRA where appropriate. Some DOE facilities may be permitted and subject to RCRA. RCRA TSD standards do not require risk assessments, ARAR compliance, TBC consideration, or the level of public involvement that CERCLA mandates.
40 CFR 700-799	Toxic Substance Control Act (TSCA)	Many older DOE facilities have equipment and material containing asbestos, lead and PCBs. TSCA has specific health and safety mandates and cleanup and disposal criteria that will be ARARs under CERCLA. Old electrical equipment may be found to contain liquid PCBs which could impact leaving the equipment in place or require the draining of PCB containing fluids.
DOE Order 435.1	Radioactive Waste Management	Provides requirements for management of radioactive waste at DOE facilities. Imposes additional requirements for LLW disposed of after September 26, 1988. Imposes requirements for waste characterization, storage, disposal, and creation of new waste disposal facilities. Requires Order and CERCLA crosswalks to be applied according to DOE contracts. This order may also be considered a TBC under CERCLA by some EPA regions and State regulators. This order also identifies a process for characterization of "waste incidental to reprocessing" and recategorizing TRU waste.
DOE Order 5400.5	Radiation Protection of the Public and the Environment	Establishes standards and requirements for protection of the public from residual radioactivity. Could be a TBC under CERCLA.
EPA 40 CFR 191	Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High Level and TRU Wastes	Regulation for management of spent nuclear fuel, HLW and TRU waste at commercial facilities. Health and safety requirements may be cited as an ARAR for ISD facilities under CERCLA.
DOE O 451.1B	National Environmental Policy Act Compliance Program	Establishes requirement for assessment of potential impacts of the ISD on selected components of the 'human environment.' ISD decisions must be analyzed under CERCLA or NEPA to ensure protection of human health and the environment. SRS and Hanford incorporate NEPA values into the CERCLA process.

7. Use of an ISD Facility for Placement of Waste

The use of a large ISD facility (such as a processing canyon or reactor) for the permanent placement of waste is an attractive proposition. Physical and project attributes that favor this concept include substantial volumes of empty space that will be backfilled, robust construction, physical stabilization that minimizes migration of radionuclides, a highly secure end-state, and the ability to specify a priori the types and volumes of waste to be placed. Benefits can be realized in disposal efficiency and budget allocations that can then be used for other D&D projects. Impacts include a more complex regulatory framework for approval and a more comprehensive risk analysis (performance assessment) to demonstrate that future radiation exposure criteria will be met. The risk performance (that is, health and environmental consequences) can potentially be comparable to waste cells that are often nearby and/or on the same Federal site; the risk can be evaluated with detailed modeling and simulation analyses.

Section Summary

The primary purpose of an ISD project is to safely complete the decommissioning of a facility with a defined end state consisting of entombment. A potential additional benefit could be to use the entombed facility for permanent placement of low level waste (LLW). A clear distinction is intended and must be understood between using an ISD structure for placing radioactive waste versus designating it as a waste disposal facility. The potential placement of waste in a facility to be entombed (ISD) is derived from decisions made and documented as an integral part of a decommissioning decision and within the appropriate regulatory framework (CERCLA, RCRA, etc). Siting a waste disposal facility requires a much different regulatory framework and technical approach.

The purpose of this section is to address such use and the resultant applicability of DOE Order 435.1, Radioactive Waste Management (Ref. O-3).

An ISD project becomes subject to the requirements of DOE O 435.1 in cases where the decommissioned facility is specifically used for the placement of waste imported from outside the CERCLA Area of Contamination (AOC). Placement of LLW in an ISD facility is technically feasible; however, there are several actions that must be conducted as described in this section. These include:

- Conducting a DOE 435.1-CERCLA crosswalk to demonstrate compliance with all substantive requirements of DOE O 435.1 that are met through the CERCLA process and to identify additional requirements for which compliance with the former is necessary, if any.
- Conducting a Composite Analysis (CA) that includes the ISD Facility AOC with other site sources that contribute to the same risk receptors. CERCLA requires only a risk assessment for the specific facility/AOC being addressed. (In general, it is expected that the CA would be performed during the final closure of the AOC and not through the CERCLA decommissioning analyses.)
- Conducting a Performance Assessment sufficient in analytical detail to show conformance to the risk acceptance criteria of DOE O 435.1.
- Developing Waste Acceptance Criteria (WAC) specific to the facility under consideration for ISD in projects for which the candidate waste is not explicitly identified in the selected alternative.

The following two scenarios provide an overview of the conditions under which a crosswalk is or is not required to determine if the substantive requirements of DOE O 435.1 apply to an ISD project for the placement of low level wastes. Examples for each of these scenarios are presented later in this section to guide FPD decision making. Such decisions should be based on technical feasibility, deliberate consideration of candidate waste types, and in coordination with appropriate organizations such as the DOE Low-Level Waste Disposal Facility Federal Review Group (LFRG) and the Office of Compliance (EM-11) in a timely manner.

Scenario A – A Crosswalk is required when:

- Material and/or waste with radioactive contamination are imported from outside the ISD project's CERCLA AOC into the AOC during conduct of the ISD. The imported materials/wastes are specifically defined and accounted for as sources in the ISD baseline risk assessment, which provides a basis for the ROD.
- An ISD facility or structure receives LLW and material from CERCLA actions within and outside the AOC on a continuing basis prior to and during conduct of the ISD project. The ROD does not pre-identify the exact waste or from where it will come. The ISD baseline risk assessment establishes bounds on the sources to be placed; the ROD commits to establishing waste acceptance criteria (WAC) and a total allowable inventory. Materials and/or wastes from other removal actions/RODs that meet the WAC are placed in the ISD facility. The ISD facility can continue to receive waste until it is full or meets the inventory limits.

Scenario B – A Crosswalk is not required when:

- Existing waste, material and equipment are left within the ISD facility or structure.
- Waste, materials and equipment from within the AOC is relocated or consolidated in a facility to be entombed within the same AOC.
- Waste from one CERCLA AOC is imported into another CERCLA AOC in which one of the facilities is undergoing ISD. All the wastes are included as sources in the Performance Assessments during the analyses of alternatives during the CERCLA process. (See further explanation in Section 7.3, Scenario B.3)

To date, no sites or projects have included placement of imported LLW as part of an ISD project.

Importation of HLW or TRU waste is only addressed in this document in the context of an action that would not be normally considered. Importation of mixed low level waste is anticipated to be by exceptions to the more general consideration of LLW and is not discussed further.

Importation of hazardous waste is not subject to DOE O 435.1. It is briefly addressed in this report with regard to State and Federal hazardous waste regulations and permitting requirements (e.g., RCRA). Justification will be required to demonstrate that the configuration of an ISD facility can provide protection equivalent to features such as leak detection, liners, and leachate collection systems required by local implementation of RCRA since incorporating these features is generally not practical for existing facilities.

7.1 Background

Considerations to Date

ISD projects planned or implemented within the DOE complex have yet to propose placement of contaminated materials or equipment within the facility. Projects at Idaho National Laboratory have not addressed waste placement and the P-Area project at Savannah River Site is limited to emplacing material that exists within the project's CERCLA AOC. The U-Canyon project at Hanford, however, addressed this subject more broadly.

As part of the mid-1990s Canyon Disposition Initiative at Hanford, DOE tasked the contractor with evaluating the feasibility and cost of using the canyons for waste disposal. Preliminary estimates conducted at that time indicated that the Department could recognize a cost savings from $17 million to as much as $500 million if the canyons could be used for disposal of on-site LLW and MLLW. Using the facilities for waste disposal could also reduce the need for additional disposal facility capacity at Hanford thereby providing additional cost avoidance; however, these costs were not estimated.

When the U-Canyon Feasibility Study was issued in 2005, the evaluation did not include importing other Hanford waste for placement within the canyon. It was further assumed that debris from the demolition of U-Canyon ancillary facilities would be sent to the Environmental Restoration Disposal Facility (ERDF), which is Hanford's licensed CERCLA landfill. Although the ROD (October 2005, Ref R-1) did not document the selection of a waste importation alternative, it did state that "use of inert rubble from other nearby CERCLA demolition activities, such as the ancillary facilities, suitable for fill material in the engineered barrier, would be considered during remedial design."

Physical decommissioning of U-Canyon has not progressed substantially since 2005 because of budget allocations for higher priority projects at Hanford. A ROD amendment has been discussed that includes placement of imported waste. However, funds from the American Recovery and Reinvestment Act of 2009 (ARRA) have been allocated to the acceleration of the U-Canyon project. To meet the accelerated schedule, DOE has decided not to pursue such a ROD amendment.

Inspector General Critique

In February 2005, the DOE Office of the Inspector General issued an Audit report *Department of Energy Efforts to Dispose of Hanford's Chemical Separation Facilities* (Ref. I-1) which concluded:

> *"The Department did not thoroughly evaluate the feasibility and potential cost savings associated with using the U-Plant to dispose of mixed and low-activity waste from other Hanford sites…the Bechtel Hanford study did not identify and quantify other waste streams that could be disposed of at the facility, nor did it adequately analyze the economic benefits of using the facility as a disposal site…."*

The report also noted that the contractor did not consider the avoided cost of building new or expanding existing land disposal facilities as part of its economic analysis.

The Inspector General's report recommended that the DOE take action to address these issues. In responding to the draft report, the Acting Assistant Secretary for Environmental Management stated that, in general, the Department agreed with the report's recommendations, and EM recognized that there were weaknesses in the early cost estimates. EM committed to identify waste disposal possibilities to ensure that the future use of the canyons would be maximized and to modify the approved Record of Decision as appropriate. However, as noted above, DOE decided not to pursue a ROD amendment for waste placement in U-Canyon.

7.2 Regulatory Framework for use of ISD for Radioactive Waste Placement

In their 1995 Policy Memorandum of Understanding, DOE and EPA agreed that decommissioning DOE facilities can be preferentially conducted as a non time-critical removal action as part of the EPA's regulatory authority under CERCLA (Ref. P-2). DOE Orders are not promulgated by law and, therefore, are not automatically applied to CERCLA decommissioning actions as an ARAR[9].

DOE O 435.1 ensures that HLW, TRU, and LLW for which the DOE is responsible, is managed in accordance with its stated objective:

> *"The objective of this Order is to ensure that all Department of Energy radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment."*

The DOE has issued both a manual (Ref. M-1), and a guide (Ref. G-1) to ensure consistent implementation of requirements.

[9] DOE Orders are contractually mandated at DOE sites; however, their applicability to decommissioning must be decided on a project-by-project basis. Also some EPA regions and state regulators may also identify certain DOE Orders or parts of DOE Orders as "To Be Considered" (TBC) for CERCLA actions. Once a TBC is identified in a ROD it becomes enforceable.

DOE distinguishes between disposal of LLW at a LLW disposal facility and radioactive materials being left after closure activities have been completed. DOE G 435.1-1[10] states:

> *"Low-level waste disposal is not the only DOE activity that will leave residual radioactive material on the DOE site when operations at the site have ceased. Environmental restoration activities will be conducted to mitigate releases from former operations such as disposal of liquid radioactive waste to soil columns, but will not generally result in the removal of all of the radioactive material. Facilities currently operating that involve use of or handling of radioactive material will eventually be decommissioned. However, decommissioning will not necessarily result in the removal of all of the radioactive material[11]."*

The authority for the potential application of DOE O 435.1 is addressed in the accompanying Manual[12]:

> *"Environmental restoration activities using the CERCLA process (in accordance with Executive Order 12580) may demonstrate compliance with the substantive requirements of DOE O 435.1, Radioactive Waste Management, and this manual (DOE M 435.1-1) (including the Performance Assessment and performance objectives, as well as the Composite Analysis) through the CERCLA process. However, compliance with all substantive requirements of DOE O 435.1 not met through the CERCLA process must be demonstrated."*

Based on the above citations from the Manual and the Guide, it is concluded that an ISD project only becomes subject to the requirements of DOE O 435.1 in cases where the decommissioned (entombed) facility is specifically used for the placement of waste, contaminated materials, and/or contaminated equipment from outside of its AOC (i.e., "importation"). One exception that would allow importation from outside the CERCLA AOC without DOE 435.1 applicability is when the CERCLA action consolidates materials, equipment, and/or waste from two separate CERCLA actions into one unit. This would not be creating a new "waste disposal facility," but is a one-time consolidation of waste. See Scenario B.3 in Section 7.3 for further description of this case.

Contaminated structures, materials, and equipment within the CERCLA AOC that are part of the decommissioning scope and the CERCLA decision by themselves would not result in DOE O 435.1 applicability.

Stated another way, in interpreting the applicability of the Order, it is important to differentiate between: a) radioactive contamination associated with the decommissioned facility, and b) the deliberate importation of radioactive materials, equipment or waste originating from outside the project's AOC.

DOE O 435.1 does not regulate contamination within a facility, per se. Contamination is properly addressed by the performance assessment (PA) to evaluate the risks associated with the CERCLA action. This distinction is particularly important when dealing with facilities that may contain TRU contamination[13, 14]. The acceptability, or not, of leaving TRU contamination should be based on the

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[10] Chapter IV, page 200

[11] And in fact, as presented and discussed in this document, wastes can be left behind and even emplaced as part of the CERCLA decommissioning decisions.

[12] Chapter 1, Section 2. F (5)

[13] It should be noted that this distinction between waste and contamination may not be consistently interpreted by varying organizations (i.e., DOE, state regulators); early involvement with the local DOE LLW Disposal Facility Federal Review Group (LFRG) member is prudent when such situations arise.

[14] That is, if TRU concentrations at specific locations within a facility exceed 100 nCi/g, which is a limit applicable to waste to be received at LLW disposal sites, it does not necessarily mean the TRU must be removed from the ISD facility. To do so may not, in some cases, meet "As Low As Reasonably Achievable" objectives.

results of the PA modeling that considers factors such as location and concentrations along with pathways for various scenarios.

7.3 Importation of Radioactive Waste from Outside the CERCLA AOC

Based on the above discussion, when all the contents of an ISD facility are from within its CERCLA AOC, demonstrated compliance with DOE O 435.1 is not required. However, if material is imported from outside the AOC, then waste importation (akin to disposal) occurs and compliance with DOE O 435.1 is required (See Scenario B.3 below for the exception discussed above).

Making such determinations rely heavily on whether contaminated equipment or material is "imported." Two scenarios are described below. Scenario A illustrates importation of waste while Scenario B does not. Examples are presented for each scenario. In the importation scenarios (Case A), it would be necessary to develop a crosswalk to demonstrate that the substantive requirements of DOE O 435.1 are met by the CERCLA action.

The DOE O 435.1-CERCLA Crosswalk is addressed in Subsection 7.4 of this document.

These scenarios are hypothetical but are based on realistic situations. They represent general principles; future actual situations will need case-by-case evaluation. Such evaluations should consider where the material originated; timing of placement (i.e., effective date of DOE O 5820.2A[15]; Ref O-5; subsequently replaced by DOE O 435.1); the type of material or equipment that will become the waste (e.g., resins previously determined to be waste; equipment, contaminated soils, etc.), and whether or not a hazardous waste component is included.

<u>Scenario A – A Crosswalk is Required</u>

Scenario A.1: LLW is imported to the ISD facility from outside a CERCLA AOC into the AOC.

Scenario A.1 Examples:

- Radioactively contaminated tools were found in drums outside the AOC during the remedial investigation. As part of the CERCLA action, the drums will be characterized, brought into the facility, and entombed within the building as part of the ISD alternative selected in the ROD.
- Well characterized radioactively contaminated materials and size-reduced equipment have been generated at operating facilities in areas outside the CERCLA AOC for an ISD project. The alternative selected in the ROD includes importing these items to within the ISD facility for permanent disposal.

Scenario A.2: An existing facility or structure to be entombed will receive LLW and material from CERCLA actions within and outside the AOC on a continuing basis prior to and during conduct of the ISD project. This is not a one-time movement of waste to or within a CERCLA AOC, but is use of an ISD facility to accept CERCLA materials and/or waste from multiple removal or remedial actions. This action requires development of waste acceptance criteria to identify the types of waste and inventories that would be acceptable for disposal in the facility to be entombed (ISD), consistent with the assumptions made in the Baseline Risk Assessment and modeling process to ensure protection of human health and the environment.

The ISD project ROD does not pre-identify the exact waste or from where it will come. The ROD commits to establishing waste acceptance criteria (WAC) and a total allowable inventory. Materials and/or wastes from other removal actions/RODs that meet the WAC are placed in the ISD facility. The ISD facility can continue to receive waste until it is full or the inventory limits are met.

[15] If it can be established that material and equipment was imported prior to the effective date of DOE O 5820.2A (September 26, 1988) this requirement would not apply.

Scenario A.2 Example:

- An existing empty river water containment basin is an ISD project under CERCLA. The basin is a small area within a larger operable unit area. The alternative selected in the CERCLA ROD for the project allows the basin to be used for LLW generated from removal and remedial activities throughout the operable unit area. After the basin has been filled, among the features of the selected alternative is the installation of a protective cover meeting the substantive requirements of a RCRA hazardous waste landfill cover system. Waste acceptance criteria are subsequently established to conform to the Performance Assessment and monitoring is specified to satisfy RCRA requirements.

Scenario B – A Crosswalk is Not Required

Scenario B.1: An ISD project selected alternative under CERCLA identifies existing waste, material and equipment to be left in the entombed facility or structure.

Scenario B.1 Examples:

- The ROD for a radiologically contaminated test facility has selected ISD. Equipment and construction material that can be easily removed from the above-grade level will be placed into the basement. The remaining above-grade structure will be demolished and the debris placed within the basement prior to entombing the test facility.
- A facility processed materials and items from other locations for the purpose of creating stable waste forms or other packaged "products" that were subsequently removed from the facility. Equipment, spaces, and systems within the facility are contaminated as a result of processing. The ROD selected ISD as the appropriate remedial action for the facility. The contamination inside the building is not considered to be imported waste and will remain with in the entombed matrix.
- Within the AOC are below-grade vaults that contain filter media that supported a facility's operations. These vaults are to be entombed with grout as part of the ISD action and are within the CERCLA scope that includes the main facility. The media will remain within the below-grade vaults and not be placed within the facility.

Scenario B.2: An ISD project selected alternative under CERCLA relocates or consolidates materials and waste from within an AOC to a facility within the same AOC for ISD.

Scenario B.2 Examples:

- Prior to the CERCLA process and ISD action, contaminated materials and equipment from elsewhere on site were brought into a facility and/or stored outside the facility as a convenience for future reuse. The materials and equipment had no use within the facility and were not used to accomplish its mission. The facility and area surrounding the facility are now designated as an operable unit under CERCLA. The remedy selected in the ROD for this facility is ISD. The contaminated parts and equipment both within the building and outside were identified in the CERCLA documents and will be consolidated within the facility prior to ISD.
- Multiple areas of soil contamination are present within a fenced area surrounding a reactor complex. ISD has been selected as the CERCLA remedy for the reactor building. The ROD requires excavation of all the contaminated soil and placement within the reactor structure, along with the debris from the demolition of the ancillary reactor support buildings. The final configuration of the area will be the entombed reactor building surrounded by a large grassed buffer area and perimeter fence.

Scenario B.3: An ISD project selected alternative under CERCLA imports CERCLA waste from one AOC into the ISD CERCLA AOC. Under DOE Guide 435.1-1 (Ref. G-1, Section I-62) a crosswalk is not required because a new radioactive waste disposal facility is not being developed.

Scenario B.3 Example:

- Two areas of contamination, Operable Units X and Y (OUs-X and -Y), are separated by more than 3 miles at a large site on the EPA National Priorities List and are undergoing remediation under CERCLA. OU-X is and ISD project; it has a large, lined, earthen basin that will require fill prior to closure. The ROD for OU-X also identifies the receipt of OU-Y soil and allows both contaminated soil and personal protective equipment from the OU-X cleanup to be placed in the lined basin. The ROD for OU-Y selects excavation of low-level contaminated soil and transfer to the basin in OU-X as the remedy. After receipt of the specified material from OU-Y and as well as that in OU-X, the basin will be capped as specified in the CERCLA ROD.

7.4 DOE O 435.1-CERCLA Crosswalk

Many CERCLA requirements are similar to DOE O 435.1. Therefore, when DOE O 435.1 applies to an ISD project, compliance with much of the Order's requirements can be accomplished with equivalent CERCLA requirements. A comparison is conducted between the requirements via a "DOE O 435.1-CERCLA crosswalk." The crosswalk identifies those requirements considered substantive for ISD, and addresses them in two ways; it: a) justifies how compliance with DOE 435.1 can generally be achieved for an ISD project/facility with comparable CERCLA requirements[16], and b) identifies the requirements that are not satisfied by the CERCLA action.

Appendix E contains a crosswalk that identifies the sections of DOE M 435.1 (Ref. M-1) that may be considered substantive for an ISD project and demonstrates how compliance will generally be achieved through the CERCLA process. The crosswalk can be utilized regardless of whether compliance is required or sections identified are enforceable TBCs under CERCLA. Crosswalk results could point to the need to directly address a DOE O 435.1 requirement, such as a Performance Assessment (PA) and/or Composite Analysis (CA), discussed further below.

The crosswalk in Appendix E shows that, for the most part, compliance with CERCLA for an ISD project satisfies the requirements of DOE 435.1. However, two major stipulations in DOE O 435.1 and DOE M 435.1 may not be substantively met by the CERCLA process. These relate to Composite Analyses and TRU waste. The Appendix E crosswalk does not consider material that has been characterized as HLW. If HLW is present, it should be evaluated on a case-by-case basis.

Composite Analysis Requirement

A Composite Analysis (CA) is an assessment of the cumulative dose associated with a combination of sources of radioactivity in a given area[17, 18]. CERCLA evaluates the radiological risk (as well as the chemical risk) for the individual facility, while the DOE M 435.1 CA requirement is concerned with radiological risks from all potential contributing sources.

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[16] Similarly, if a facility is to be used for placement of waste that is hazardous, substantive compliance with RCRA landfill requirements also needs to be addressed. Landfill requirements are locally mandated and vary across the country.

[17] The objective of a CA is to confirm that the potential dose to the public from the cumulative residual radioactive material that is likely to remain on a DOE site is reasonably expected to not exceed the dose limits for protection of the public in accordance with DOE O 5400.5, "Radiation Protection of the Public and the Environment" (Ref O-4).

[18] Of related interest is that the requirement for a CA in DOE G 435.1-1, Chapter IV further supports the differentiation between disposal facilities and facility decommissioning activities. The CA must account for all residual radioactive materials that are left behind after closure and that may contribute to the dose projected to a hypothetical member of the public from a LLW disposal facility (DOE M 435.1-1, Chapter IV P (3)). This CA requirement recognizes that radioactive materials will be left behind in locations separate from LLW disposal facilities by requiring that such material be accounted for in the LLW disposal facility CAs.

Confirmation that the relevant CA has addressed any additional radioactivity to be left behind in an ISD is an important step in demonstrating compliance with DOE O 435.1 requirements. The need for a CA will have to be evaluated on a case-by-case basis when an ISD action is proposed and DOE O 435.1 compliance is triggered. Additional characterization efforts may be necessary to identify all radiological sources prior to initiating a CA. It should be noted that under CERCLA, all existing contamination in soils, surface- and groundwater within the boundaries of the AOC are evaluated; but the CERCLA risk assessment would not consider potential future sources of contamination from operating facilities.

Some examples of CERCLA satisfying the objective of the CA requirement for ISD are:

- The CERCLA risk assessment includes all contamination within an area for an ISD project that is the same boundaries as the area of a specified CA.
- The CERCLA risk assessment includes groundwater modeling that encompasses all the sources in the CA scope.
- A CA has been performed for an existing disposal facility that included the projected inventory of the candidate ISD facility (with or without imported waste).

If a CA is required but had not been completed and approved, DOE Headquarters approval of the results of the CA must be obtained before the ROD can be signed. The CERCLA project schedule may be impacted if CA approval is delayed.

<u>TRU Waste Requirement</u>

Where TRU waste may be present in the building or facility, or in the unlikely scenario in which TRU waste is proposed to be imported, the approval to leave such waste must be made a) based on a 40 CFR Part 191 performance assessment, or b) excluded from this requirement by DOE Headquarters with concurrence by the EPA Administrator. This decision must be reached prior to selection of the remedy under CERCLA (signing the ROD). Schedule milestones regarding the ISD project must consider the time necessary to obtain mandatory approvals for TRU waste.

As discussed earlier, this situation should not be confused with one in which an ISD facility contains transuranic contamination that is not waste, per se, in which case the PA performed to demonstrate CERCLA acceptance presumably will be used to assess the impacts. *However, this presumption has not been put to the test and will likely not be the case until a processing facility, such as one of the Hanford or Savannah River Site canyons with substantial TRU contamination, pursues ISD as a CERCLA action.*

<u>Recommendation for an ISD Specific crosswalk</u>

The Appendix E crosswalk is extracted from an SRNL report (Ref. S-1); therefore the discussions in Appendix E reflect SRS practices. Demonstration of substantive compliance for some of the crosswalk elements could be achieved in a different manner at another DOE site. Other DOE sites may have to modify the list based on site-specific practices and agreements, but it is expected that the crosswalks would be fairly consistent throughout the DOE Complex.

It is recommended that when DOE O 435.1 is updated, an ISD-specific crosswalk be incorporated into the requirements and guidance by adapting Appendix E to a Complex-wide scope.

7.5 Other Important Activities when Waste is Imported

In addition to the crosswalk conclusions above, importation of waste will create the need for a comprehensive characterization and for the development of Waste Acceptance Criteria (WAC).

Characterization

All ISD activities will involve extensive characterization, not only for remaining materials, but also for those to be placed within the facility and/or the AOC. ISD alternatives that include waste importation will need to identify acceptable waste forms, quantities, containers or other requirements that will impact long-term, post-closure performance.

And, regardless of the applicability of DOE O 435.1, waste and other contaminated materials and equipment left in a facility must be characterized by their quantities and reasonable estimates of radionuclide and chemical contents. This information will provide the data needed for an accurate risks and hazards assessment. A comprehensive description and inventory of the equipment, materials, and wastes will support informed decision making by Federal and State regulators.

Waste Acceptance Criteria

When the ROD selected alternative includes the placement of imported waste, WAC will need to ensure that the imported waste does not exceed the ROD assumptions and limitations. A decision between two cases will be required for determining the type and extent of waste to be imported:

- For the case in which waste is selected or specified a priori, the WAC can be narrowly specified for the waste that is subject to the ROD.
- In the case where wastes or waste streams are only generally identified, the WAC will need to be developed from risk-based objectives; these will need to address radionuclide concentrations and potentially will need to also address the waste form (e.g., activated metals) and/or container requirements.

In both cases, the WAC will operationally constrain individual waste items, as well as the total inventory that can be placed in the ISD facility.

7.6 Hazardous Materials that Remain

There are special considerations regarding hazardous materials that would remain within the facility when the CERCLA ROD includes ARARs related to RCRA landfill requirements.

For example, as part of the U-Canyon alternatives analysis, compliance with ARARs became problematic when using external materials for fill within the canyon buildings. Alternatives utilizing internal or external disposal would meet all ARARs except the RCRA landfill minimum requirements for leak detection, which requires new landfills to have two or more liners and a leachate collection and removal system. However, the Washington State Code allows for an alternative design to be used if the criteria are met such that:

- The proposed alternative design and operation together with location characteristics will prevent the migration of any dangerous constituents into the groundwater or surface water at least as effectively as the liners and leachate collection and removal system.
- The alternative design will provide for effective detection of leaks of dangerous constituents through the top liner.

The in-place disposal of waste envisioned under any U-Canyon alternative did not include liners or a leachate collection and removal system. The liner requirement could conceivably be satisfied by grout encapsulation of the waste within the canyon and the engineered barrier to provide containment.

In general, ISD projects for which RCRA landfill permitting requirements apply will require protective systems including leak detection, a liner and a leachate collection system. It is suggested that these requirements can be addressed as follows:

- Because it is technically impracticable to construct a leak detection system beneath the building, justification for waiving the leak detection requirement would be needed. The risk assessment results combined with site groundwater monitoring and/or additional preventive actions (such as increasing the engineered barrier thickness) may be a way to provide such justification.

  Alternatives to leak detection systems such as embedded sensors (in the entombed material) are being investigated and may become reasonable and equivalent detection systems (Ref S-2).

- With regard to a liner and a leachate collection system, stabilization within the facility and an engineered cap (when part of the design) can be suitable substitutes. Technical assurance must be provided that macro-encapsulation (e.g., by grouting of the hazardous materials) and containment within the facility are sufficient risk mitigation for the materials in question.

8. ISD Projects Regulatory Process Variations under CERCLA

This section provides the basis for a lesson learned, which is that there is no “cookie cutter” approach to obtaining a record of decision for an ISD project. The following discussion describes three variations for projects currently underway at Hanford, Idaho National Laboratory, and the Savannah River Site. In each case, the regulatory process has been influenced by interactions with the States’ environmental agencies and the EPA district office, overall site strategy for the long term, and facility-specific factors. Regardless, in all cases, the steps and activities leading to the application and approval of the ISD action has required functionally similar activities. For example, alternatives must be defined and evaluated, including an alternative for complete removal and another for “no action.” The basis for selecting an alternative involves assessment against CERCLA criteria that are similar to non-ISD CERCLA actions.

8.1 Background on the CERCLA Process

CERCLA and the National Contingency Plan (NCP) authorize two types of responses to hazardous substances released to the environment: remedial and removal[19] action. Non-time-critical removal actions have been typical for D&D of DOE facilities since most projects involve demolition of the building and removal of the resulting waste. Non-time-critical removal actions require development of an Engineering Evaluation/Cost Analysis (EE/CA). The EE/CA identifies the objectives of the removal action and analyzes removal action alternatives against criteria for cost, effectiveness and implementability. The EE/CA is then made available to the public for a 30-day review and comment period. DOE responds to significant comments and documents the removal decision by issuing an Action Memorandum.

Remedial actions take much longer to achieve a decision and gain regulatory approval. The remedial process involves the study, design and construction of long-term actions with the goal of permanent remediation of the problem; a Remedial Investigation/Feasibility Study (RI/FS) is the functional equivalent of an EE/CA that documents the results of sampling and project design.

Both remedial and removal actions have been used for three major ISD projects at Hanford, INL, and SRS. Section 9 addresses how CERCLA criteria have been used to evaluate ISD projects; Section 10 provides project descriptions of each of these cases; and Section 11 discusses technical approaches among the three.

The timeline for the three projects is shown in Table 3. Application of CERCLA among the three has varied in the following ways:

- The Hanford U-Canyon is a CERCLA remedial action.
- The INL Fuel Reprocessing Facilities project at INL is a CERCLA non-time-critical removal action.
- The SRS P-Reactor Area has received an Early Action Record of Decision (EAROD) approving the ISD concept using the CERCLA (remedial) process. A future ROD will address the selected ISD alternative.

[19] Three types of removal actions exist: 1) emergency - initiated within hours or days, 2) time-critical – releases requiring on-site action within six months, and 3) non-time-critical – a planning period of at least six months is available before on-site activities must begin and the need is less immediate. Non-time-critical removal actions include four major components: 1) site evaluation, 2) Engineering Evaluation/Cost Analysis (EE/CA), 3) removal action, and 4) closeout. For emergency and time-critical removals, an EE/CA is not required.

This section outlines the steps and timing for obtaining regulatory approval for these three projects.

Table 3 – CERCLA Timeline for Three Major Projects

Event	Timing		
	Hanford U-Canyon	**INL 601/640**	**SRS P Area**
Decision to pursue ISD	1996	Circa 2000	2007
RI/FS or EE/CA	Nov 2004	Feb 2008	June 2008
ROD/EAROD for SRS	Oct 2005	May 2008	Dec 2008

8.2 Remedial Action at Hanford

The Canyon Disposition Initiative grew out of a challenge to solve remediation hurdles presented by five enormous concrete facilities on the Hanford reservation. The CDI postulated that considerable cost and risk avoidance could be achieved by utilizing the facilities for the permanent disposal of certain waste types rather than demolishing, sizing, packing and shipping the building debris off-site for disposal. While the exact cost for this process had not been established, ‘several billions of dollars’ was the working cost estimate for the decontamination, demolition and disposal of all facilities encompassed in the CDI. Not included in the estimate was the cost to expand the ERDF to handle the volume of waste that would be produced from demolishing the five canyon sites. (Section 7.5 addresses the concept of using ISD facilities for the placement of waste, which to date has not been part of a selected ISD alternative.)

The U Plant (221-U Facility) was chosen as the pilot canyon building to be addressed primarily because it exhibited a much lower radioactivity signature than the other canyon buildings (B Plant, T Plant, REDOX and PUREX). While U Plant is structurally and size-wise representative of the other facilities, the varying amounts, types and locations of radiological contamination within each of the canyons will potentially yield varying remedial alternatives resulting in variations in costs and complexity to achieve their end-states.

The steps and timeline for obtaining regulatory approval for U-Canyon included:

- In 1995, a CDI Task Team was commissioned to develop a long-term disposition plan for the canyon buildings. The team was composed of personnel from DOE, U.S. EPA, and various DOE contractors at the Hanford Site. Their effort produced alternative scenarios from “No Action” to “Entombment with internal/external waste disposed of around the structure.” The team also determined that the CERCLA process would be the appropriate decision-making pathway for the project.
- In 1996, an Agreement in Principle was reached among the Tri-Parties of DOE, U.S. EPA and Washington State Department of Ecology establishing the CERCLA RI/FS process that would be followed to evaluate potential remedies and to develop a long-term disposition plan for the five canyon buildings on the reservation. The site’s intent is to begin the process for the next canyon, yet to be identified, in the 2009-2010 time period[20].
- The CDI team worked with regulators and stakeholders, and in February 1997 completed Phase I Feasibility Study (FS) for the CDI (221-U Facility). Utilizing stakeholder input they screened the initial alternatives, and eliminated two of the seven as not viable under CERCLA.
- The Phase I FS was issued in September 2001. This FS was performed for five alternatives put forward as potentially viable end-states (Alternatives 0, 1, 3, 4, and 6). The study applied U Plant

[20] Verbal communication with the site contractor

structural engineering and radiological and chemical characterization data to further evaluate the final disposition of U Plant. Based on the CERCLA evaluation criteria (See Section 9), the FS provided the technical basis for the selection of Alternative 6: "Close in Place – Collapsed Structure" as best satisfying the statutory requirements, and recommended this alternative for the final disposition of U Plant.

- In 2001, the DOE completed the second portion of the feasibility study of the U-Plant (Ref. F-1). This final FS addressed the five alternatives for remedial action that were recommended for further study by the original FS. The study concluded that Alternative 6 was the preferred remedial action protective of human health and the environment at the 221-U Facility. Under this scenario, equipment on the canyon deck is to be consolidated into the process cells and the hot pipe trench; equipment, process cells, and other open areas (void spaces) are to be filled with grout; and the structure is to be partially demolished and the remaining structure buried under an engineered barrier.

A ROD for the cleanup of the 221-U Facility was issued in October 2005, based on the recommendations in the final FS.

8.3 Removal Actions at Idaho National Laboratory

To date, INL has successfully utilized non-time-critical removal actions to remediate several facilities within operable units (OU) for which a ROD exists, prior to the final closeout of the OU. These include the Power Burst Facility, Engineering Test Reactor, and the Loss-of-Fluid Test Reactor (see Section 10). The Test Area North (TAN) Hot Shop has also been closed through the ISD approach. For each project, INL conducted an EE/CA to evaluate multiple alternative final end-states for the facility. Note, however, these projects were closely akin to removal projects because the facilities were razed to grade, below-grade contaminated equipment was removed, and decontamination was conducted to reduce the contamination to minimal levels.

The Old Waste Calcination Facility (WCF, CPP 633) at INL can also be considered an in situ closure, although it was conducted using RCRA processes; this was accomplished in 1999. WCF was closed as a RCRA landfill because of extensive contamination.

The DOE Idaho Operations Office (DOE-ID) also proposed to decommission the Fuel Reprocessing Facilities Chemical Processing Plant (CPP-601 and -640) under a CERCLA non-time-critical removal action, even though in contrast with the prior projects, a substantial portion of the facility will not be removed. Under the DOE and U.S. EPA Policy (Ref P-2) a non-time-critical removal action may be taken at the discretion of the Department.

The steps and timeline for obtaining regulatory approval for CPP-601/640 included:

- DOE-ID prepared an EE/CA (Ref. E-2) that documented and evaluated three alternatives ranging from "No Action" to "Demolition to Grade." For all three alternatives, radiologically contaminated waste will be disposed in the Idaho CERCLA Disposal Facility (ICDF) subject to meeting the ICDF Waste Acceptance Criteria (WAC). Waste that is non-hazardous and is not radiologically contaminated will be disposed at the Central Facilities Area Landfill or at the Idaho Nuclear Technology and Engineering Center (INTEC) CERCLA Demolition Waste Landfill, subject to meeting the applicable WAC. If waste does not meet the applicable WAC, a suitable off-site disposal location will be determined.

- The EE/CA evaluation proposed Alternative 2 – "Demolition to Process Makeup/Hot Makeup Decks" as the preferred alternative end-state for the facility. This alternative removes three process cells, including building and components, and the mechanical handling cave to 11 ft above grade. Large void spaces may be filled with grout or other inert material. The remaining void spaces within the building will be filled with flowable grout leaving a concrete monolith approximately 11 ft above grade. Upon completion of DOE's current operational activities at INTEC, an earthen cover will be placed over the concrete monolith.

- In August 2008, following a public comment period on the EE/CA, DOE-ID published an Action Memorandum for Decommissioning CPP-601/640 Fuel Reprocessing Facilities (Ref. I-3). The memorandum presented the selected alternative (Alternative 2 with minor revisions based on public comment) for decommissioning the CPP-601/640 under the Idaho Cleanup Project. The Action Memo noted that if any newly identified releases were discovered during implementation of the non-time critical removal action, DOE-ID will consult with the Idaho Department of Environmental Quality and U.S. EPA regarding remediation.

These activities are expected to take several years to complete and will be accomplished in three phases:

- Phase 1 places the facility in a demolition ready state (completed by 2012).
- Phase 2 completes the actual demolition and completes the concrete monolith (completed by 2013).
- Phase 3 includes the design and future installation of the earthen cover over the remaining concrete monolith to be coordinated with the closure of the remaining facilities at INTEC that includes adjoining facilities and tanks.

8.4 Early Action ROD at SRS

P-Reactor building was the second of five reactors constructed at the Savannah River Site. The reactor went critical on February 1954, and operated continually until 1988. In 1991 it was put in 'cold standby,' followed by 'cold shutdown with no capability of restart' in 1993. Currently, the P-Reactor building, together with facilities within the P Area boundaries, is undergoing deactivation in preparation for decommissioning.

The P Area Operable Unit (PAOU) is listed as a RCRA 3004(u) Solid Waste Management Unit/ CERCLA unit in Appendix C of the Federal Facilities Agreement (FFA)[21]. SRS is currently utilizing an 'area-completion' approach to accelerate cleanup by integrating assessment and remediation, under CERCLA, for subunits and D&D facilities within large industrial zones. To determine the actual or potential impact to human health and the environment through releases of contaminants to the environment, the PAOU was evaluated through an integrated RCRA (corrective action) and a CERCLA (remedial action) process.

The steps and timeline for obtaining regulatory approval for P Area included:

- In June 2005, the FFA parties agreed, in concept, that in situ decommissioning (ISD) of the Reactor Building was an acceptable end-state compared with demolition and disposal.
- ISD was officially proposed (Alternative R-2) as a potential decommissioning end-state of the reactor facility in the Early Action Proposed Plan for the PAOU (Ref. W-1). It was evaluated against two other proposed alternatives ranging from "No Action" to "Complete removal of all above- and below-grade structure," and was further evaluated against the nine CERCLA criteria. Based on these evaluations, ISD was selected as the preferred alternative for the reactor building.
- Following a period of public comment on the PP/SB for P-Area, U.S. EPA approved an EAROD (Ref. W-2) for the P Area Operable Unit in December 2008 accepting ISD as the final end-state decision for the P-Reactor building. The EAROD also details early remedial action, at subunits within the PAOU that are to occur in conjunction with long-term actions to ensure the site is remediated as quickly and effectively as possible.

[21] The FFA is a legally binding agreement among the U.S. EPA, the South Carolina Department of Health and Environmental Control and the DOE that establishes the responsibilities and schedules for remediation for the Savannah River Site.

This selection allows for the Final PAOU ROD to focus on evaluation of remedial alternatives that are consistent with an ISD end-state. The EAROD and the selection of ISD allow for the consolidation of remedial waste generated from various subunits in the PAOU into the P-Reactor building, prior to the final closure of the building. It does not require those wastes to be consolidated if more cost-effective means of disposal are available. Further, the EAROD addresses the area around the reactor facility with performance of early actions to eliminate two sources of volatile organic contamination of groundwater at Potential Source Area (PSA)-3A and PSA-3B; an early action to eliminate radiologically contaminated soils at the P02 Outfalls; and an early action to remediate a localized high contamination area of radioactively contaminated railroad bed material and soil along the P-Reactor cask car railroad tracks.

The EAROD decisions for the final end-state of P-Reactor building and the PAOU early action subunits are based on a future industrial worker scenario, in accordance with the current ‘industrial’ use of the site. Although ISD is the preferred end-state, details of the specific nature, extent and costs associated with the final in situ end-state have not yet been fully developed and will be detailed in the Final ROD for the PAOU anticipated in FY 2009.

9. ISD Comparison of Alternatives for CERCLA Criteria

When comparing alternatives for any CERCLA action, ISD or otherwise, the criteria against which they are compared include effectiveness, implementability, and cost, with sub-criteria as discussed below. For purposes of this strategy, ISD is theoretically compared to the complete removal (demolition) alternative for a facility. A qualitative discussion of effectiveness and implementability and their sub-criteria are presented below, followed by a semi-quantitative cost comparison.

The discussions in this section are a combination of criteria presented in EE/CAs and RI/FS documents for ISD projects at Hanford and Idaho. These documents each offer two or more ISD alternatives. They also include a no action alternative for reference; however, this is never the recommended alternative. As a lesson learned, these comparisons can be of use for starting similar comparisons for future projects by noting those aspects specific to ISD projects. Of course, each project must address its specific circumstances.

9.1 Effectiveness

The five CERCLA effectiveness criterion address: a) protection of workers, b) environmental safety, c) compliance with ARARS, d) long-term effectiveness and permanence, and e) the ability to achieve removal objectives.

Sub-Criterion: Worker Safety

The ISD end-state provides a variety of worker safety benefits over conventional demolition. Demolition of robust structures typically requires aggressive techniques to raze them. Significant risks to the safety of demolition personnel exist while working in close proximity to heavy equipment (e.g., excavators with specialized attachments); from the heavy and complex lifts required to disassemble the structure; and exposure to dust (containing silica, various contaminants, etc.) from crushing and rubblization of reinforced concrete structures. Although some demolition is required with the ISD alternative—usually to remove structure appurtenances and/or non-robust portions of the structure—the intensity and complexity is much less, therefore reducing the safety risks to personnel.

In addition to the industrial safety benefits, reducing radiation exposure to workers is a more significant benefit of the ISD end-state. Removal, size reduction, and packaging of contaminated process equipment and legacy items contained in the structures under consideration for ISD can be a person-rem intensive operation. Expensive, remote technologies may be required for some removal and size reduction operations. Under the ISD end-state scenario, much of this equipment and material will be left within the structure and grouted in place, thereby requiring minimal handling and subsequent exposure to personnel.

It is estimated that the ISD option for U-Canyon, where all the equipment and legacy items will be left in the process cells, will provide approximately 300 person-rem savings in personnel radiation exposure. It is noted that U-Canyon was never used as a major processing facility and thus is not as contaminated as other canyons at Hanford and SRS. It can be expected that the avoided personnel exposure in these other cases would be much greater.

Sub-Criterion: Environmental Safety

ISD concepts generally use grout or clean materials (e.g., soil, rubble, sand) to fill the void space remaining within the facility. Stabilizing remaining contamination by encapsulation in grout within the building as part of a concrete monolith is a typical approach. Accessibility and the potential for contacting and spreading contaminants are essentially eliminated, and migration is significantly impeded. Where included in the design, engineered surface barriers (cover systems) will contribute to minimizing water infiltration.

Sub-Criterion: Compliance with ARARS

In general, ISD alternatives can attain all potential ARARs. When waste importation is included in an alternative, ARARS related to requirements for liners and leachate collection/removal systems typical of landfills (which are not part of an ISD configuration) may not be directly satisfied. However, an approach on a case-by-case basis would be to show that equivalence can be provided by the ISD designs and location characteristics that can effectively mitigate the migration of dangerous constituents into groundwater and surface water. Similarly, encapsulation with grout can also be proposed as a design feature for this purpose.

Sub-Criterion: Long-term Effectiveness and Permanence

As stated above, grouting of void spaces combined with cover systems and the robust nature of reinforced concrete structures characteristic of ISD candidate facilities can provide for long-term effectiveness and permanence.

Sub-Criterion: Achieving Removal Objectives

Short-term impacts to vegetation, wildlife, and cultural resources are not considered significant because, in all cases, the site and adjacent land areas will have previously been disturbed by the construction and operation of the facility.

Other considerations for this criterion include reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, and ability to achieve non-time-critical removal action objectives. Grout placement and cover systems serve to achieve the objectives. Grouting is also a primary treatment method. It is expected that highly reactive materials will have been removed or neutralized prior to grouting.

9.2 Implementability

The CERCLA criterion of implementability addresses: a) technical feasibility and b) availability of resources to conduct the alternative. In addition, although it is not a specified CERCLA criterion, "administrative feasibility" used in at least one EE/CA has been included here.

Sub-Criterion: Technical Feasibility

Technical feasibility considers subjects such as construction and operation, demonstrated performance/useful life, adaptability to environmental conditions, and the ability to be quickly implemented. In comparison with demolition, especially in the case of large, contaminated systems, the technical feasibility of leaving all or part of the contaminated process systems/equipment and the reinforced concrete portion of such structures is more feasible than complete removal. Potential technical challenges for ISD projects include characterization of significant contamination in high radiation areas, grout placement, and placement of relatively high cover systems. Characterization is well within today's state-of-the-art for robotic and remote detection devices. Grout placement to ensure effective filling of large, oddly configured void spaces is achievable; a recommendation in this report suggests a technology development opportunity for assurance of such placement. When a cover system is part of the design, placement at grade is not an issue. For higher structures, placement of a cover system weighs in favor of alternatives that result in a lowering the skyline of the remaining structure and using less cover material.

Sub-Criterion: Availability of Resources

In general, availability of equipment, personnel, services, laboratory testing, treatment and disposal, and post-removal site control will not impose limitations on ISD.

The use of grout and cover systems for ISD is greater than would be the case for the complete demolition alternative. An order-of-magnitude volume was calculated for the total cover system volume if all of the five canyons and seven reactors at Hanford were to require such. The result was an estimated 6.65 million cubic meters of soil, which is within the availability of material at the site. Considering there are a limited number of ISD projects, estimated to be in the range of 100 to 125 and judged to possibly be as many as 200 facilities, and they are likely to be spread over several years, the Complex-wide impact on available resources appears to be manageable.

Sub-Criterion: Administrative Feasibility

One of the EE/CAs reviewed addresses administrative feasibility in the context of easements, rights-of-way, impacts on adjoining property, new permits, and exemptions from statutory limitations. At any DOE site, there may be some effort related to local permits and regulations. Impacts on adjoining property and/or the value of the ISD facility property would weigh against ISD at urban and suburban sites.

9.3 Cost

The ISD end-state offers the potential for considerable cost avoidance over demolition and complete removal of the structure and its contents.

Planning data for selected ISD projects at these sites suggest that the potential rough order of magnitude cost avoidance for individual facilities when compared to removal to greenfield or brownfield end-states ranges between $4 million and $200 million per facility (See Appendix A). The estimates have been derived based on a variety of documents and anecdotal information. Cost information for ISD projects is currently limited to a few facilities at Hanford, Idaho, and Savannah River Site.

10. In Situ Decommissioning Project Descriptions

10.1 Hanford

In 1996, the DOE initiated the Canyon Disposition Initiative (CDI) to develop a disposition path for Hanford's five canyons. The U-Canyon (Figure 5) was selected as the pilot for this initiative. The project involved significant multi-year efforts including the implementation of a Large Scale Demonstration Project. The CERCLA Final Record of Decision was issued in October 2005 (Ref R-1).

Figure 5 – U-Canyon

The U-Canyon is a very large, reinforced concrete structure that will be partially cleaned out and decontaminated. The selected remedy consolidates equipment into below-grade cells, partially demolishes the above-grade structure, and emplaces an engineered cover system over the entire structure (See Figure 6).

Facility Description

Located within the 200 West Area at the Hanford Site in Washington State, the 221-U Process Canyon Building is one of three nearly identical Hanford Site chemical separations plants constructed from 1944 through 1945 to support World War II plutonium production. U Plant is a reinforced concrete structure 810 feet long, 66 feet wide and 77 feet high, with 51 ft visible above ground level (180,000 GSF, see cutaway in Figure 7). The operating deck is approximately 25 ft above the original grade. The concrete walls and floor range from 3 ft to 9 ft thick. One large room extends the entire length with galleries on the other side of a dividing wall from this room. Covered processing cells reside below the deck in a large room. Because the building has this long, expansive room, it often is referred to as a "canyon building."

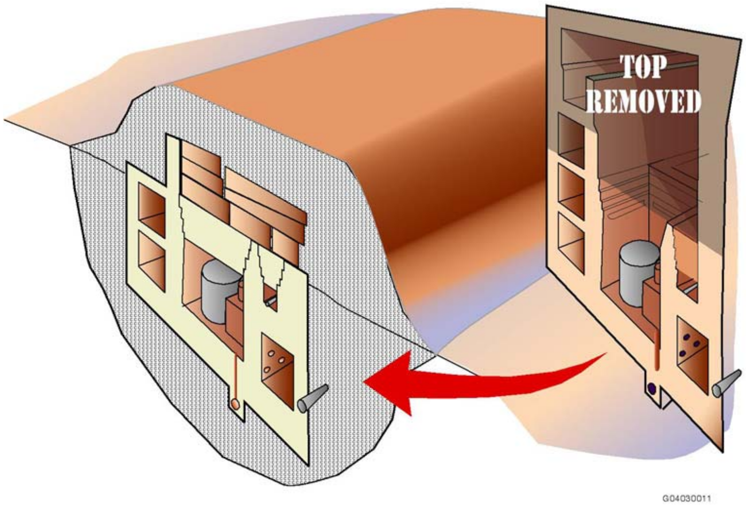

Figure 6 – U-Canyon Closure Concept

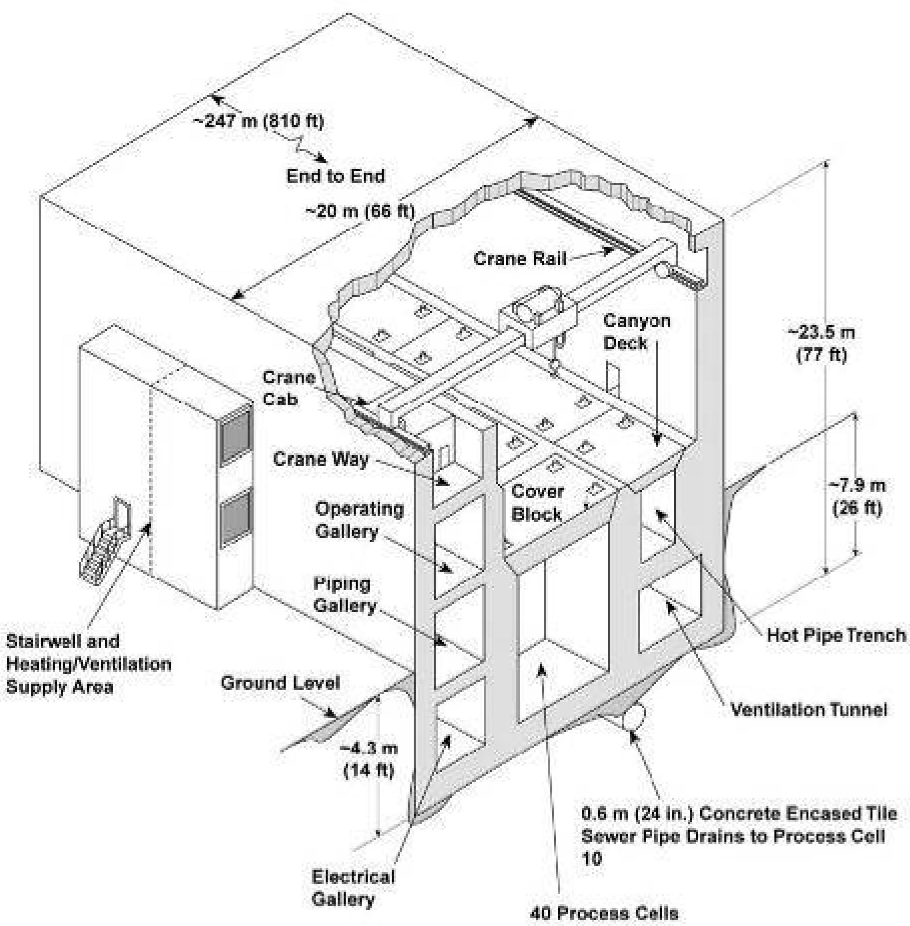

Figure 7 – Cross-section of the U-221 Canyon Facility

Located on the northwest end of the 221-U Facility, a rail line enters the facility through a tunnel that is approximately 150 ft long. The tunnel is of reinforced concrete and pumice block construction and has been used to house office space, storage, training facilities, and other activities in support of U-221 Facility. Minimal contamination exists in various parts of the building.

The 271-U Support Services Building is adjacent to the 221-U Process Canyon Building and shares its northern wall. It is a three-story structure made of reinforced concrete and pumice block and has been used to house office space, craft shops, storage, and training facilities in support of 221-U. It is 160 ft long by 48 ft wide by 65 ft high. Minimal contamination exists in various parts of the building.

The 296-U-10 Stack is an exhaust stack that sits atop the 271-U Building and is considered a part of this facility. This is approximately a 66-ft-long, 42-ft-wide, and 8-ft-high, above-grade reinforced concrete basin that extends 5 ft below grade. It is attached to the south end of the 221-U Process Canyon Building. The basin contains three tanks, as well as concrete pads from three other tanks that have already been removed.

Envisioned ISD End-State

Planning for U-Canyon in situ decommissioning began with the CDI, resulting from the 1996 Agreement in Principle among DOE, U.S. EPA and Washington State Department of Ecology. The purpose of the CDI is to investigate the potential for in situ decommissioning of the canyon buildings, rather than demolishing the structures and transferring the resulting waste to another disposal facility.

The *Phase I Feasibility Study for the Canyon Disposition Initiative* screened a set of conceptual alternatives with specific application to the 221-U Facility, but deferred identification and selection of specific waste types to later in the evaluation process. The Phase I Feasibility Study (FS) concluded with a set of five potential remediation alternatives. These alternatives included the following:

- Alternative 0: No action
- Alternative 1: Full Removal and Disposal
- Alternative 3: Entombment with Internal Waste Disposal
- Alternative 4: Entombment with Internal/External Waste Disposal
- Alternative 6: Close in Place — Partially Demolished Structure

The Phase I FS identified two additional alternatives that were not recommended for further study, which were:

- Alternative 2: Decontaminate and Leave in Place (determined to be not protective)
- Alternative 5: Close in Place — Standing Structure (determined to be not viable)

Based on the collective experience gained from previous studies and the 1997 Phase I FS, the Department released the *Final Feasibility Study for the Canyon Disposition Initiative (221-U Facility)* (Ref F-1) in November 2004. The Final FS was prepared in accordance with the CERCLA and the Hanford Tri-Party Agreement, as the final phase in the CERCLA RI/FS process. The Final FS report further developed the Phase I FS alternatives and evaluated them in detail.

The 221-U Facility Record of Decision, issued in October 2005, documented Alternative 6, “Close in Place—Partially Demolished Structure” as the selected remedy for disposition of the facility.

The four alternatives share “common elements” including institutional control; and for Alternatives 3, 4 and 6, an engineered barrier (to cover the building structure to reduce water infiltration and the risk of human and biotic intrusion), and post-closure barrier performance monitoring. In addition, Alternatives 3, 4, and 6 include post-remediation monitoring of groundwater.

The footprint of the engineered barrier could be adjusted slightly for Alternatives 3, 4, or 6 to accommodate requirements for the remediation of nearby facilities, waste sites, and pipelines, as necessary. For example, coverage by the 221-U Facility engineered barrier also could be the preferred remedy for some facilities, waste sites or pipelines as part of other ongoing CERCLA actions in the U Plant Area (See Figure 8). The specific engineered barrier design and layout would be developed during remedial design. Because of the technical difficulties that may result in the design and construction of the engineered barrier, Alternatives 3 and 4 are considered slightly less implementable than Alternatives 1 and 6.

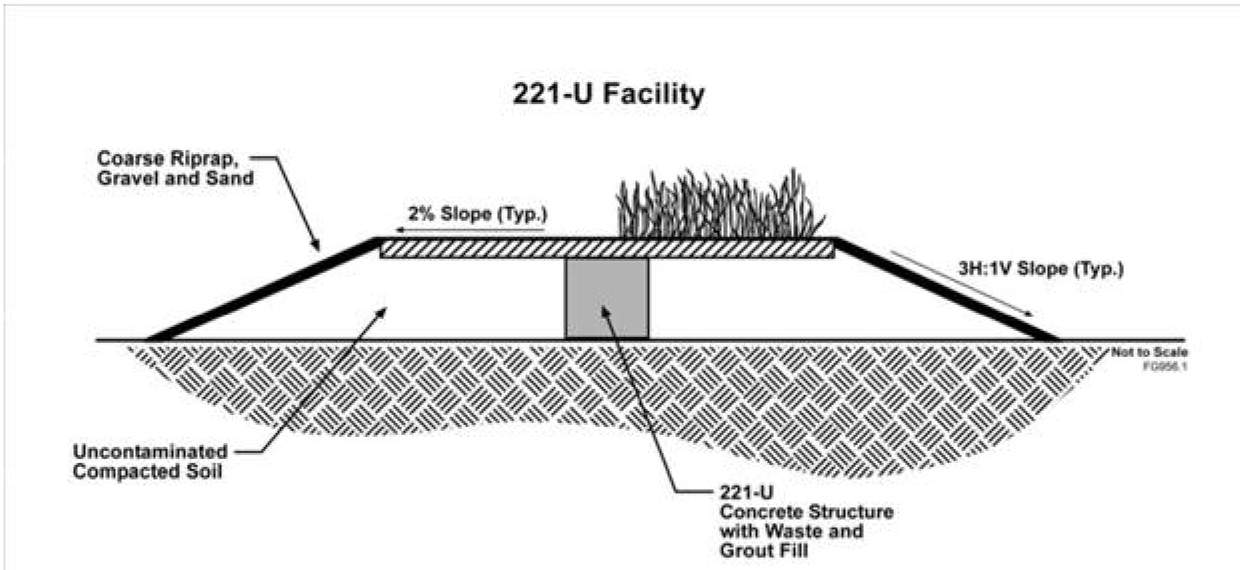

Figure 8 – U Canyon Engineered Barrier Components

The selected alternative (alternative 6, Close in place—partially demolished structure) establishes that approximately 4,400 cubic yards of existing contaminated equipment from the canyon deck be size-reduced, placed into the process cells, and grouted. Cementitious grout would be pumped into the process cells and tanks containing residual materials, the cell drain header, and the galleries to minimize the potential for void spaces and to reduce the mobility, solubility, and/or toxicity of the grouted waste. The upper part of the 221-U Facility would then be demolished to approximately the level of the canyon deck, and the remnants of the facility would be covered by an engineered barrier.

The reasonably anticipated future land use for the 200 Area is industrial, and the 221-U Facility remedy will result in protection of human health and the environment based on the exposure assumptions contained in the 200 Area industrial use scenario.

Use of Canyon for Waste Disposal

For Alternatives 1, 3, 4, and 6, transuranic wastes (such as liquid and sludge identified in a tank in process cell 30) would be removed and dispositioned prior to stabilization in accordance with an approved remedial design/remedial action workplan.

At the time the final 221-U Facility Feasibility Study was issued, low-level waste streams with quantifiable volumes and waste characteristics had not been identified or evaluated for disposal in 221-U Facility Canyon. Therefore, full evaluation of the waste importation alternative was not possible. As a result, the 221-U Facility ROD could not select a waste importation alternative[22]; the currently selected

[22] Project Experience Report, Canyon Disposition Initiative (221-U Facility), D&D-35827, Revision 0, U.S. Department of Energy (Ref. D-3)

alternative does not include disposal of imported Hanford Site remediation wastes inside or around the outside of the 221-U Facility. In this scenario an estimated 12,500 cubic yards of debris from demolition of impacted ancillary facilities would be disposed at ERDF in the 200 West Area at Hanford. These wastes would be sent to ERDF rather than disposed in the canyon. The use of inert rubble from other nearby CERCLA demolition activities, such as the ancillary facilities, suitable for fill material in the engineered barrier, would be considered during remedial design.

However, if viable waste streams from other Hanford cleanup projects are identified for disposal in the U Plant canyon and technologies become available to ensure safe disposal, the U Plant Canyon Disposition Initiative Record of Decision could be amended at some point in the future to allow the use of the U Plant canyon for disposal of these waste streams, as originally envisioned in the CDI (See Section 7.5). Final decisions reached in 2009, influenced by the project priorities identified for the ARRA, have decided against this path as the U Canyon is available for immediate use of these funds.

Description of the Project

The selected remedy for the 221-U Facility includes four primary components: demolition and barrier construction (the "construction component"), post-remediation care and environmental monitoring, institutional controls, and 5-year review. The construction component of the remedy is further divided into a predemolition phase, a demolition phase, and a barrier construction phase. Key activities associated with each phase are as follows[23]:

- Address hazards:
  - Identify and control health, safety, and environmental hazards throughout the duration of the remedial action;
- Predemolition phase:
  - Reactivate and/or upgrade as necessary the 221-U Building cranes, electrical system/lighting, ventilation system, and railroad tunnel;
  - Removal of waste from vessels and equipment in the facility that, if stabilized in place, would contain levels of transuranic isotopes greater than 100 nCi/g, in accordance with an approved Remedial Design/Remedial Action (RD/RA) work plan, and eventual disposal of that waste at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico;
  - Remove liquid from a tank in cell 30 that, if stabilized in place, would contain levels of transuranic isotopes greater than 100 nCi/g, and treat as necessary to meet receiving facility waste acceptance criteria;
  - Remove other liquids as practical, if found, from the facility or treat as necessary to meet waste acceptance criteria at an acceptable disposal facility;
  - Size reduce (as necessary) and consolidate contaminated equipment located on the canyon deck into below-deck locations (e.g., into the process cells). Partially remove contaminated equipment and piping from the gallery side of the facility, as needed to facilitate demolition activities.
- Demolition phase:
  - Grout, to the maximum extent practical, internal vessel spaces, as well as cell, gallery, pipe trench, drain header, and other spaces within the facility as well as demolition rubble, as necessary;

[23] Remedial Design/Remedial Action Work Plan for the 221-U Facility, DOE/RL-2006-21, Draft A (2006) (Ref. D-4)

  - Demolish the 271-U, 276-U, 291-U, and 292-U structures and the 291-U-1 and 296-U-10 stacks, and dispose of the resulting waste at the ERDF or other approved disposal facilities (or use the waste as barrier fill material if it is minimally contaminated and does not contain hazardous waste);
  - Demolish the railroad tunnel buttresses to the degree necessary;
  - Stabilize and/or fill depressions at the former locations of these structures to support construction of the engineered barrier;
  - Demolish the roof and wall sections of the 221-U Facility down to approximately the deck level and use the resulting rubble as fill material for the engineered barrier.
- Barrier construction phase
  - Construct an engineered barrier over the building and demolition debris in accordance with an approved remedial design;
  - Seed/plant the engineered barrier surface with native grasses and shrubs to stabilize barrier materials and improve evapotranspiration rates;
  - Seed the disturbed areas in the immediate vicinity of the 221-U Facility with native grasses and shrubs for surface reclamation purposes consistent with the expected future industrial land use.

The remedial action approach to completing each of the construction component activities, to conducting post-remediation care and environmental monitoring, and to implementing institutional controls is described in the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* (Ref. D-4).

Challenges

The path forward for this project will require many engineering and operational decisions to implement. Several studies have been conducted by Richland to support the work plan, including:

- *221-U Facility Reactivation Engineering Study*— examines alternatives for reactivating selected facility systems (e.g., ventilation, crane, electrical power) to support demolition preparation;
- *U Canyon Railroad Tunnel Reactivation* Study—addresses activities needed to reactivate the railroad tunnel to support waste removal and equipment consolidation activities;
- *Disposition of Waste from Process Vessel in Cell 30 of 221-U*— addresses activities necessary to remove liquid from Cell 30 D-10 vessel and disposition it to CWC and WIPP;
- *221-U Facility Canyon Equipment Size Reduction Engineering Study*—evaluates volumes of legacy items on canyon deck against below-deck space to assess equipment size reduction needs, assess size reduction and consolidation methodologies, and recommend specific item disposition locations;
- *Canyon Waste Acceptance Study*— identifies the bounding case wastes that could be safely and economically disposed of in the canyon for 1,000 years;
- *U Plant Void Fill Analysis and Installation Plan*— evaluates methods and sequence for grouting the lower portion of canyon structure; and
- *221-U Facility Demolition Study*—evaluates structure configurations and techniques for demolition of the upper portion of the canyon.

Future of CDI at Hanford

The Multi-Canyon Project Management Plan was developed and issued in September 2007, to map a regulatory strategy and path for key regulatory documents including RODs for disposition of the remaining canyons on the Hanford Site. The plan originally put several D&D projects on hold. The American Recovery and Reinvestment Act of 2009, however, will accelerate multiple D&D projects on Hanford Central Plateau, including a milestone to complete 25 percent of the U Plant Zone Canyon and structures D&D by the end of fiscal year 2011.

10.2 Idaho National Laboratory

Substantial progress has been made at INL for entombment of facilities. This section describes several projects that are completed or in progress.

10.2.1 CPP-633 Old Waste Calcining Facility

In situ RCRA closure of the Old Waste Calcining Facility (WCF, CPP-633) at INL was completed in 1999, making it the first completed ISD project within the DOE Complex. The WCF is located near the center of the INTEC with an original footprint of 70 by 108 feet. Its construction was a reinforced concrete structure that included concrete block construction above grade. Overall there were approximately 17,250 GSF within a ground floor and two levels below grade.

During its operation, the WCF was connected to other facilities through underground pipes. It received liquid waste feed through lines from the Process Equipment Waste facility and the Tank Farm, treated it by a high temperature drying process called calcining, and sent dry waste (calcine) to the bin sets that made up the Calcined Solids Storage Facility. The calciner processed high-level radioactive waste from 1963 through 1981, followed by evaporator operations from 1983 through 1987.

ISD Project Features

The hazardous waste units within the WCF were closed to meet the requirements applicable to the closure of landfills, or disposal units, under the Idaho Hazardous Waste Management Act (HWMA). As described in the Closure Plan (Ref. I-2), disposal unit closure was selected because it was determined that removal of remaining waste residues and contamination would not be consistent with as low as reasonably achievable (ALARA) worker radiation exposure and health and safety goals. The HWMA/RCRA Closure Plan was approved in August 1997, and closure was completed in 1999.

On-site staff completed the project design, deactivation and RCRA closure of the WCF including several distinct project activities:

- Isolating of the WCF facility from ongoing high level waste operations,
- Filling the highly radioactive WCF process piping, vessels, pumps, instrumentation, and associated components with grout,
- Filling the underground operating corridors and heavily shielded cells housing the process systems with grout,
- Demolishing of the above ground concrete block structure with the demolition debris piled on top of the subsurface structure,
- Grout solidification of the debris pile atop the grout filled structure, followed by
- Building a concrete RCRA cap over the encapsulated facility.

Figure 9 – Old Calcining Facility Before and After Decommissioning

With the debris pile encapsulated atop the grout filled structure (right side of Figure 9), the concrete RCRA cap was installed over the entire site. This approach provides several significant advantages:

- Reduced personnel exposure to 4% of the estimated 90 person-rem,
- Reduced cost: down to $11.3 million from the estimated $150 million for conventional demolition and waste disposal,
- Reduced waste generation: down to about 750 cubic feet versus more than 14,000 cubic feet requiring extensive pretreatment prior to its disposal.

Closure Plan

Elaborating on the above project features, key elements of the closure plan were:

- Preparation of the WCF for closure included rerouting connected utilities, capping and plugging utility and non-waste piping to prevent water from entering the WCF, and dismantling and size reducing chemical make-up room equipment (to be later grouted in place with the superstructure) to provide access for vessel grouting.
- Plugging of waste pipes that penetrate exterior walls of the WCF by grouting the annulus between each waste pipe and its outer or secondary pipe/casing, flushing the inside of each waste pipe with grout, pushing the grout into the connected WCF vessel or cell, and capping each waste pipe by filling with grout.
- Grouting of cells and vessels including sampling liquid in Tank WC-119, emptying to the extent possible, adding desiccant to absorb remaining liquid, and grouting the remaining empty volume; grouting other major vessels/tanks as full as practical using existing piping or, if necessary, by boring a hole into the vessel; and grouting cells and operation corridors in lifts, through existing piping and floor plugs, or drilling holes until grout was visible in the uppermost hole used for filling.
- Superstructure removal and placement included dismantling and size reducing the above ground superstructure, placing the resulting debris over the grouted and cured below-grade structure; and applying grout to fill empty spaces and voids in the rubble.
- Construction of a concrete cap included covering the WCF with a low-permeability, reinforced concrete cap that is a minimum of 1-foot thick with at least a 1% slope from the center to the edges, extending the cap approximately 5 feet beyond the ground level footprint, installing waterstops in the joints of the cap, and providing surface grading to promote drainage away from the cap.

Closure Certification

An independent Professional Engineering firm was contracted to observe and review the project. A Closure Certification Report (Ref J-1) indicated the closure was conducted with few deviations in accordance with the closure plan. Deviations and adaptations were necessary to accommodate unexpected conditions; for example, a plugged pipe that could not be flushed with grout; filter vessels thought to be present that had already been disposed as waste; and a higher final configuration than planned was needed to grout the debris volume. Resolution was achieved by alternate approaches that provided the same or better degree of protection in the final configuration.

Aspects of Grouting

Major implementation aspects of the CPP-633 project, as well as ISD projects to follow across the Complex, relate to grouting. The following summarizes results as documented in the Closure Certification (Ref. J-1)

- Type of Grout Used – Several grout formulations were utilized at WCF; all were Portland cement-based recipes that were developed by grout experts at SRS. Three main types included: Hill Displacement (which had a 6 to 8 inch slump) used for general area void filling; controlled low-strength material (CLSM) also used for general area void filling; and pipe fill grout (which is made up of Portland cement, fly ash and water; no aggregate). All formulations contained plasticizers to provide the desired degree of flowability.

  The grout that was used to fill pipe lines, tanks, and process vessels was designed to "scour" residual contaminants since WCF was not stabilized after shutdown and therefore had a lot of hold-up in these components.

- Grout Placement Methods – Grout was supplied from standard cement trucks to a hopper that fed a truck-mounted concrete pumping system with a standard 8 inch flexible feed hose. Long-handle tools were utilized in some instances to assist with placement of grout fill nozzles. Grout was supplied at 1 cubic yard per minute with this system. Smaller pump skids fed by portable cement mixers were used for forcing grout into pipe lines. The delivery system fed grout to the target system through a 1 to 1 ½ inch hose.

  Grout placement in large areas was typically done from above, either through existing penetrations or through newly cut access holes. When grout was introduced into areas with vessels, the grout was poured in lifts, alternating between the vessel interior and the surrounding cubical area to avoid floating the vessel.

  Grout was introduced into the Hot Sump Tank through a floor drain in measured quantities. Grout was introduced into pipe lines through valve boxes typically at the high point of the system to take advantage of gravity.

  Grouting of pipe lines was more of a challenge; attention had to be maintained to prevent excessive back pressure from developing and forcing the water out of the grout mixture rendering it ineffective. The project team determined that when grouting pipe lines, they had to "engineer" the pour to fill the entire line as one pour. Once the pour was started, it could not stop because too much back pressure would develop as the grout started to cure.

- Methods Used to Ensure Complete Filling of Void Space – The project team designed each pour using engineering calculations that determined the expected amount of grout needed to fill a particular area or component. Grout was delivered in metered quantities using the calculations as a benchmark with fill verification by visual observation. Video cameras were used to provide visual monitoring in inaccessible areas (i.e., high radiation areas). Filling of tanks and process vessels was verified through observation of rotometer air probes (installed at the top and bottom of the vessels prior to grouting). The ball in the bottom probe would fluctuate and drop to zero at the start of pumping indicating that grout had entered the vessel. The probe at the top of the vessel would drop to zero when the vessel was full of grout.

Post Closure

Post-closure monitoring and care is conducted under a HWMA/RCRA post-closure permit issued by Idaho Department of Environmental Quality. A 30-year period was specified with the ability to lengthen or shorten it based on sufficiency for protecting human health and the environment. The 500 page post-closure permit addresses a myriad of administrative and other requirements. With regard to field activities, the post closure permit requires ground water monitoring, inspections, restrictions on property use of the facility, and maintenance. In brief, post closure maintenance activities include:

- Maintaining the integrity and effectiveness of the cap including making repairs to the cap as necessary to correct the effects of subsidence, erosion, or other events; and the ground water monitoring system and equipment
- Maintaining the security of the facility
- Maintaining and monitoring the ground water monitoring system
- Preventing run-on and run-off from eroding or otherwise damaging the cap
- Protecting and maintaining surveyed benchmarks

10.2.2 CPP-601/640 Spent Fuel Processing Facilities

The CPP-601/640 facilities, shown below, are located at the center of the INL site. Their missions related to processing of spent fuel, as described below.

CPP-601

Built in 1953, the CPP-601 facility's process cells were used for reprocessing spent nuclear fuel at the Idaho Nuclear Technology and Engineering Center (INTEC). Work included the dissolution of spent fuel with subsequent solvent extraction processes to separate the recoverable uranium from the other highly radioactive waste materials. The uranium reprocessing mission for CPP-601 was terminated in 1992, and no more uranium was introduced into the reprocessing system after that time.

The CPP-601 is an 83,600 GSF facility containing chemical processing equipment that was used to recover uranium from various types of nuclear fuel. Flushing of the process vessels and piping has been completed to remove uranium from the facility to the maximum extent practical. The facility is essentially rectangular (244 ft by 102 ft) and consists of six levels (mostly below-grade).

The processing area of the building was designed to provide radiation shielding through the use of ordinary concrete that varied in thickness, with areas up to 5 ft thick, depending on the expected activity in each specific process cell as planned at the time of design. The process cell shielding was designed to reduce radiation levels to no more than 1 mR/h in the operating areas.

The lower levels contain 25 process cells (most of which are about 20 ft by 20 ft by 28 ft high) as well as numerous corridors and auxiliary cells that house equipment and controls. The largest is Cell N which is approximately 60 ft by 20 ft by 40 ft high. The floor and part of the walls of each cell are lined with stainless steel and most of the equipment is stainless steel. The majority of the processing equipment in the building is located in the heavily shielded cells and was designed for remote operation and hands-on maintenance. The in-cell equipment controls were installed in an operating corridor that runs the length of the building between cells. A service (piping) corridor is located below the operating corridor and a cell access corridor is located below the service corridor. Sampling and cell ventilation corridors are located outside the rows of cells.

Liquid wastes such as decontamination solutions generated to allow hands-on maintenance of equipment were collected in four 5,000 gallon tanks, located in two tank vaults approximately 57 ft below grade in CPP-601, for later treatment in the Process Equipment Waste (PEW) Evaporator located in CPP-604. These tanks were also used to collect waste from nearby facilities including CPP-602, CPP-666, and CPP-684. These four tanks, along with ancillary lines, will be closed under a HWMA/RCRA closure plan proposed as a non-time-critical removal action outside the scope of CPP-601/640 decommissioning.

The process makeup (PM) area, at 10 feet above grade, is the uppermost level of CPP-601. The PM area is not partitioned and was used to transfer fuel elements to the process equipment. It contained chemical makeup and storage systems that included tanks, pumps, filters, agitators, related instrumentation, and miscellaneous support equipment. The PM area was used for equipment access through the top of cells, either directly or indirectly through another cell. Concrete shielding was typically not required in the PM area, except for floors that were the ceiling of the process cells, and the P, Q, and R Cell extensions, which extended approximately 8 ft above the floor of the PM area. The PM walls and roof consist of structural steel framework covered with insulated Transite, which contains asbestos.

Figure 10 – Aerial View of CPP 601/640 at Idaho National Laboratory

CPP-640

The adjacent CPP-640 facility was originally built as a pilot plant for dissolving spent nuclear fuel, but the process was so successful that fuel dissolution activities were continued until operations ceased in 1984. The resulting uranium solutions were transferred to the adjoining CPP-601 building as additional feed to the uranium separation processes. Following the final process operations in each of these buildings, process vessels and process lines were rigorously flushed numerous times with acid and water to reduce radiological contamination and to support the accounting of special nuclear material.

CPP-640 is a five-level 17,600 GSF (66 ft × 89 ft) structure that is located west of and adjacent to CPP-601. CPP-640, formerly designated the Hot Pilot Plant, contains five heavily shielded cells and a mechanical handling cave (MHC) for headend processes to recover uranium from spent reactor fuel.

The CPP-640 facility included the Space Nuclear Propulsion Program (Rover) fuel dissolution process and the electrolytic dissolution process. The Rover facility provided a headend system for reclaiming uranium from both unirradiated and irradiated Rover fuels. The electrolytic dissolution process was specifically used for the recovery of uranium from fuels with stainless steel cladding. The aqueous product solution from these processes was then sent to CPP-601 to extract the uranium. The processing of fuel in CPP-640 ended in June 1984.

The hot makeup (HM) area of CPP-640 was formerly used for mixing process chemicals, decontamination solutions, or other chemical solutions used in the CPP-640 process cells. The HM roof consists of a structural steel framework covered with insulated Transite that contains asbestos. Most of the HM area process chemical makeup vessels and piping have been removed.

The MHC is located on the HM level of CPP-640 and has reinforced concrete walls and ceiling. The MHC housed the charging chute for the graphite fuel rods that were handled remotely and dropped into a fluidized bed burner to release the uranium from the graphite matrix of the Rover fuel. The MHC is located above portions of Cells 2 and 3 and has walls that are 3.5 ft thick and a ceiling that is 1 ft thick.

The five process cells in CPP-640 are located in the center of the CPP-640 building below the HM level. Mechanical equipment, ventilation, sampling, off-gas, and other operational support functions were provided on the three levels surrounding this central processing area. Cells 1, 2, 3, and 4 were primarily used to support dissolution of the Rover fuel. Cell 5 contains equipment for the former electrolytic dissolution process. Cell walls are typically 3.5 ft thick. The cell floors are lined with stainless steel that extends up the walls to a height of 4.5 ft.

The waste tank control room and waste tank vaults (containing three 500 gal tanks) are located on the two lowest levels of the CPP-640 building. The tank vaults are approximately 34 ft below grade. Decontamination-type wastes were accumulated here for later processing in the PEW Evaporator located in CPP-604. These tanks and ancillary piping are being closed under a HWMA/RCRA closure plan outside the scope of this proposed non-time-critical removal action.

Envisioned ISD End-State

The *Engineering Evaluation/Cost Analysis for Decommissioning of the CPP-601/640 Fuel Reprocessing Facilities* (Ref. E-2) identified three alternatives for the D&D of CPP-601 and CPP-640. The selected alternative removes 3 of 30 process cells, including building and components, and the mechanical handling cave to 11 ft above grade leaving most of the processing cells intact. The remaining 27 cells are below the elevation of these 3 cells. However, these intact cells, process vessels, and lines will be decontaminated and the radiological and hazardous source terms reduced as necessary to meet removal action objectives. Large void spaces without significant piping or vessels may be filled with grout or other inert material. The remaining void spaces within the building will be filled with flowable grout to minimize void spaces, leaving a grouted monolith approximately 11 ft above grade similar to the Waste Calcining Facility. The top surface of the monolith will be sloped to facilitate integration of precipitation control with the OU 3-14 remedial action to the extent practical wherein the collected precipitation will be directed toward lined ditches which will divert the water to evaporation ponds.

The selected alternative substantially eliminates infrastructure and overhead costs. Minor surveillance activities will be required to guarantee the integrity of the remaining monolith in order to ensure acceptable risk levels for future workers. The duration of these controls is commensurate with similar activities required for the OU 3-14 soils and other INTEC area facilities.

The industrial use of the INTEC facility, and specifically the OU 3-14 designated industrial-use area, is expected to continue for the foreseeable future. Upon completion of DOE's current operational activities at INTEC, an earthen cover will be placed over the concrete monolith. A comprehensive evaluation will be conducted to determine the extent of the earthen cover that will address the CPP-601/640 monolith in conjunction with the final end-state for the facilities at INTEC. These facilities include the Tank Farm

Facility, Calcine Bin Sets, New Waste Calcining Facility, Process Equipment Waste Evaporator, Integrated Waste Treatment Unit, and other miscellaneous facilities. It is assumed that DOE's administrative controls will cease in 2095, and there are no ongoing surveillance, monitoring, or maintenance activities.

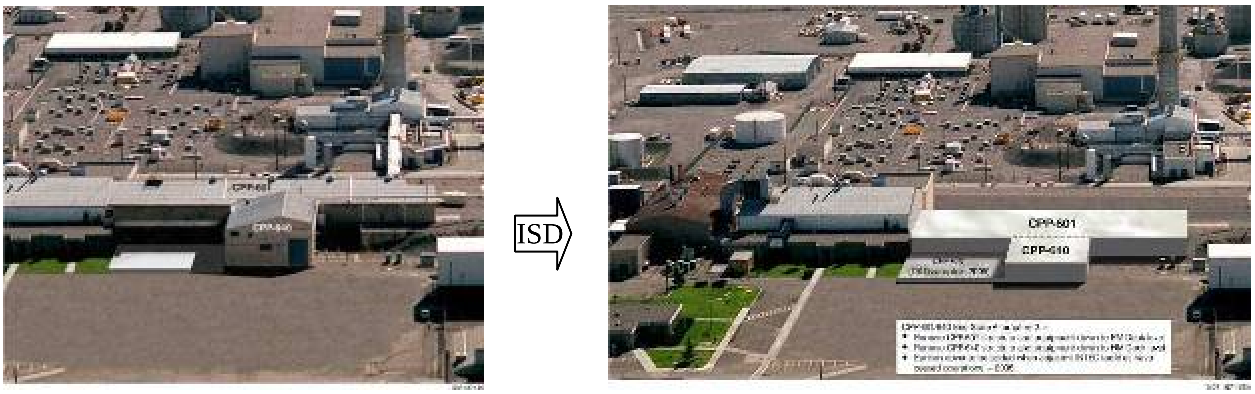

Figure 11 – Proposed End-State of CPP 601/640 (Alternative 2)

Status

Initial efforts have begun at CPP-601/640 as decommissioning preparatory actions in accordance with Action Memorandum for General Decommissioning Activities under the Idaho Cleanup Project (DOE-ID 2006a). The actions include asbestos abatement, utility isolation, decontamination, removal of the PM Deck components, and removal of accessible HWMA/RCRA and Toxic Substances Control Act (TSCA; Ref. T-1) regulated materials. Removal of HWMA/RCRA and TSCA-regulated materials includes, but is not limited to, lead, circuit boards, mercury switches, ballasts, and fluorescent tubes. These materials are being characterized and dispositioned per appropriate regulatory requirements as they are removed.

Under the American Recovery and Reinvestment Act of 2009, funding has been designated for INL to accelerate D&D of several of its nuclear and radiological facilities and supporting facilities that no longer have a mission. The initial work will focus on the upfront work planning, facility characterization, formulation and approval of regulatory documents for the facilities at the Chemical Processing Plant (CPP), Materials and Fuels Complex (MFC), Advanced Test Reactor Complex (previously known as the Test Reactor Area, (TRA)), and the Power Burst Facility (PBF) area. The work scope will complete D&D on CPP-601/640 Fuel Reprocessing Complex, the Material Test Reactor Facility, and Hot Cells Facility among others.

Other Alternatives Considered

The other significant alternative considered was demolition to grade. This alternative proposed removal of portions of 23 of the 30 process cells including removing buildings and components to grade. It included removal or displacement of some of the vessels, piping, and associated shielding located within the cells. The remaining process vessels, lines, and cells would have been decontaminated and radiological and hazardous source terms removed as necessary to meet Removal Action Objectives. Large void spaces without significant piping or vessels would be filled with grout or other inert material. The remaining void spaces within the building would have been filled with flowable grout to minimize them, leaving a grouted monolith essentially at grade. The top surface of the monolith would have been sloped as in the selected alternative with the same monitoring and controls applied.

Alternative Evaluation

Both alternatives 2 and 3 are implementable in terms of technical feasibility; availability (equipment, personnel and services); and administrative feasibility (permits, easements, ability to impose institutional controls, etc.). The major differences between the two alternatives are as follows:

Table 4 – CPP 601/640 Overview of Major Alternatives

Attribute	Selected Alternative #2	Non-Selected Alternative #3
Physical Removal	Removal of structures only above PM/HM deck	More intensive demolition to remove structures/components of 23 process cells to grade, including 14 more heavily contaminated cells
Worker Safety	Reduces short-term dose risk to worker by maintaining building structure as shielding	Work required to remove or relocate process vessels and piping would subject workers to increased dose and increased industrial hazard risk
Estimated Project Duration	4 years	6 years
Estimated Cost	$81.3 million	$116.3 million

10.2.3 Other Completed/In-Progress ISD Projects at INL

In addition to those described above, the following facilities also have been successfully deactivated, decontaminated and demolished in situ:

- Loss of Fluid Test Facility;
- Power Burst Facility; and
- Engineering Test Reactor.

A fourth facility, the Materials Test Reactor (MTR), is in process for ISD.

Of interest is the difference between the ISD methods for these facilities in comparison with Buildings 601/640. In this case, the significant radioactive items are removed for burial; the below-grade portion is partially cleaned out and decontaminated (to ensure consistency with assumptions used for the PA source term); the superstructure (generally non-masonry, steel framed structures) is demolished to grade; the remaining basement is filled with grout and/or clean backfill material; and the remaining structure is entombed at grade or below with an earthen cover. In these cases, the reactor vessels and selected other radioactive components are removed and disposed at the local CERCLA disposal facility. It is noted that these reactor vessels are considerably smaller than those at Hanford and Savannah River.

Loss of Fluid Test Facility (LOFT)

INL's Test Area North-630 (TAN-630), the Loss-of-Fluid Test (LOFT) Control and Equipment Building, and TAN-650, the Containment Service Building, were constructed in 1959, as an integral part of the Flight Engine Test facility to prove the feasibility of nuclear powered flight. The TAN-630 structure was constructed to house remote control, measuring, and data analysis equipment associated with the nuclear airplane. The project was cancelled in 1961 before the airplane was built, and TAN-630 was never used for its originally intended purpose. Several other activities and experiments were conducted at TAN-630 between 1961 until 1986.

ISD removed above ground components and structures, collapsed and removed floors and concrete walls to 3 feet below grade for TAN-630 and TAN-650 miscellaneous, filled TAN-630 and TAN-650 to grade with solid inert material (an undefined mixture of sand, gravel and uncontaminated demolition rubble). The contaminated sumps, which are in the TAN-650 containment area of LOFT, are filled with a solid inert material and the piping is capped. These sumps and embedded pipes are encased in high density, reinforced concrete as far as 30 feet below grade (Ref. F-2).

The LOFT containment building was constructed of high density concrete reinforced with #8 and #11 rebar with sumps and embedded pipes running throughout the structure. The upper containment floor, which has sumps and embedded lines, is constructed of 4 feet 9 inches of high density, reinforced concrete. The floor and embedded sumps and piping precluded removing the first 3 feet of upper containment floor. Therefore, a long-term viable cover (e.g., native soils) encompasses the footprint of the containment dome and the previously filled filter housing room to the east. The annulus voids under this area are filled with grout providing a stable long-term foundation for the cover. The adjacent areas of TAN-630 and TAN-650 that are demolished to 3 feet below grade are backfilled with site soils and compacted by processor head and track walking by equipment as feasible. These areas are not under the "long term viable cover" but are compacted with proper moisture addition to minimize subsidence and safely support equipment and vehicle traffic for the demolition of the containment dome. Figure 12 illustrates these processes during demolition.

Figure 12 – Processing LOFT to 3 ft below Grade and the Lower Containment Vessel after Grouting

The cover was constructed over the TAN-650 containment building existing grade level floor slab after above-ground equipment (including overhead crane), components (including borated water storage tank), ducting, walls and piping to grade were removed. The long-term viable cover is overlain with rock armor to prevent inadvertent intrusion on the cover during the DOE institutional control period, and to provide erosion control during heavy runoff events.

Demolition of the TAN-650 facility's dome 62 feet above grade presented significant worker safety hazards and prohibited traditional demolition techniques. The LOFT D&D team used horizontal stitch cutting to weaken the dome. Simultaneous explosive charges inside of the remaining material near the top felled and severed the dome. See Figure 13.

Figure 13 – Loss of Fluid Test Facility During Demolition

Power Burst Facility (PBF)

Built in the 1970s, the PBF (Figure 14) supported studies of reactor fuel during extreme operating conditions. The unique three-story (19,000 GSF) test reactor facility was designed to subject fuel samples to extraordinary power surges in milliseconds, causing the fuel to fail in an isolated, contained system. Knowledge gained from PBF tests has helped determine safe operating limits for the commercial nuclear industry. The facility was shut down in 1998.

Figure 14 – Power Burst Facility before Demolition in 2008

ISD removed the PBF vessel and other radioactive sources per the assumptions in the performance assessment. The reactor building was demolished to below ground level. Void spaces were backfilled as practicable, including the void left by removal of the PBF vessel. Backfill consists of grout, as necessary, and/or inert demolition waste from the above ground level structures and clean backfill materials. As shown in the conceptual end-state (Figure 15), less than 0.2 Ci of total activity, including Cs-137, would remain from 0 ft to 10 ft below ground level. Approximately 4.7 Ci of total activity would remain below the 10 ft interval.

Residual radioactive materials remaining at PBF after decommissioning activities are completed would stay in place and would be managed under the Site-wide Institutional Control Program. Reactor building void spaces would be backfilled as practicable. Backfill would consist of grout, as necessary; inert demolition waste from the above ground level structures; and clean backfill materials.

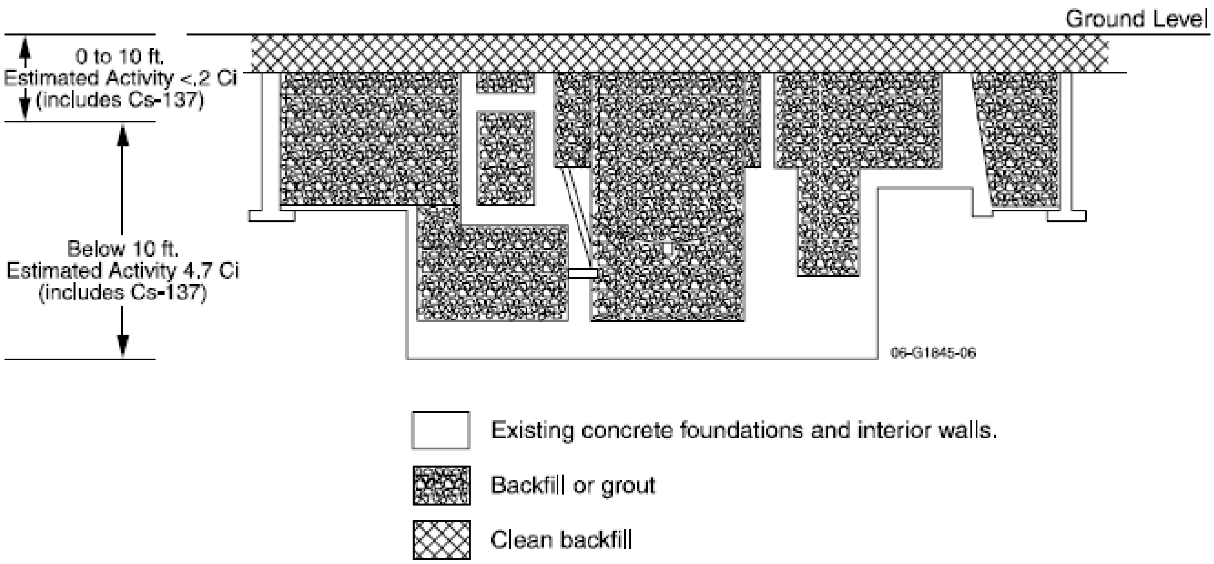

Figure 15 – PBF End-State

In July 2008, D&D crews demolished the last structure at the PBF complex – the reactor building. The most significant D&D challenge at PBF was removal of the 61-ton reactor vessel. The reactor lift required two cranes – one to pull the vessel out of the basement of the reactor building, and the other to swing the vessel into a horizontal position for placement onto a trailer for transport. The reactor vessel was disposed at the Idaho CERCLA Disposal Facility (ICDF).

Engineering Test Reactor (ETR)

When the ETR became operational in 1957, it was the largest, most advanced nuclear fuels and materials test reactor in the United States. In 1973, the ETR mission shifted to support the DOE's breeder reactor safety program.

Deactivation of the ETR Complex (reactor building is 56,000 GSF) was initiated in December 1981. The neutron startup source was removed. Radioactive water was drained from the ETR vessel, primary coolant system, water loop experiment piping and vessels, both canal sections, degassing tank and associated piping, and resin tanks. Other water systems were drained, including the secondary coolant water (including heat exchangers), utility water, the two demineralized water systems (low and high pressure), and water in heating and cooling units. The fuel in the ETR, as well as irradiated fuel in the ETR storage canal, was removed and shipped to INTEC for storage. The ETR reactor vessel was installed in a single piece.

ISD of the ETR included removal and disposal of the ETR vessel (Figure 16) with vessel internal components intact at an on-site disposal facility (Ref. E-7). The reactor building was demolished to ground surface; structures and systems below ground surface consisting of inert materials, such as piping, tanks, structural metal, and utility systems, would be abandoned in place. Residual radioactive materials in the ETR Complex remaining after D&D activities are completed will be managed under the Site-wide

Institutional Control Program. Void spaces are backfilled as practicable, including the void left by removal of the ETR vessel. Backfill consists of grout, as necessary, and/or inert demolition waste from the above grade structures and clean backfill materials.

Figure 16 – ETR Vessel installed in 1956, and during removal for disposal in 2007

Materials Test Reactor (MTR)

Built in 1952, the MTR operated as a high-flux nuclear test facility to allow testing of materials in high-intensity radiation fields. More than 15,000 different irradiation experiments were performed in MTR, which (like ETR) provided findings that were critical in developing safe reactor operations and for testing components of future reactors.

The MTR facility (45,000 GSF) is a steel-framed facility with a main floor, a basement, and two above-grade floors. The facility measures 130 ft by 131 ft and extends 58 ft above grade and 38 ft below grade. The reactor facility houses the multi-tank reactor vessel, along with the canal, subpile room, and the VH3 experiment cubicle in the basement. The reactor vessel is comprised of five integral reactor tanks and one tank extension.

Figure 17 – The Materials Test Reactor in 2005, and Conceptual View of Post-ISD

Unlike the other reactor vessels, which were cast out of single chunks of steel, the MTR was built as a series of connected tanks and had to be removed in pieces—making it the most complex and difficult of the reactor demolition projects. By the end of 2008, D&D crews had removed the concrete monolith surrounding the above-grade portion of the reactor. Demolition of the MTR facility is scheduled for late 2010. Figure 17 depicts the MTR before and after ISD.

ISD removes the MTR vessel and demolishes the facility to below ground level (Ref M-2). The MTR vessel will be disposed of at ICDF. Radiologically contaminated debris that meets the removal action objectives may be left in the sub-grade portions of the MTR facility. Upon completion of demolition, the remaining void will be backfilled with solid inert material and graded to meet the natural contour of the area.

10.3 Savannah River Site P Area

The P-Reactor is one of five reactors at the Savannah River Site and the second to operate. Reactor operations were suspended in 1988, and the facility was placed in cold shutdown in 1991. It has been defueled and is currently undergoing hazard removal and final deactivation. The reactor is being addressed as a sub-unit of the P-Area Operable Unit (PAOU).

The PAOU project, which includes the P-Reactor, is at an early stage and the final entombment details have not been decided; however, the funding provided under ARRA will accelerate completion of both P-Reactor and R-Reactor. By the end of fiscal year 2011, the project expects to reduce the Savannah River Site (SRS) operational footprint by 25 percent (approximately 78 square miles).

Facility Description

The PAOU is located in the south-central portion of Savannah River Site (SRS), encompassing approximately 126 acres. During operations, PAOU included the P-Reactor building and support facilities, administration and maintenance facilities, a cooling water and treatment system, a coal-burning power plant, waste disposal facilities, five miles of sewer lines, and effluent discharges. The P-Reactor began operations in 1954. Similar to the other SRS reactors, P-Reactor produced special nuclear materials (mainly plutonium and tritium) for defense purposes. P Area is shown in figure 18.

The P-Reactor complex as a whole is comprised of three principal components that were integral to reactor operations. These include the reactor, the disassembly basin, and the P-Reactor building structure and ancillary equipment. The reactor building is a massive reinforced concrete structure, with multiple levels over 130 ft above and 40 ft below grade. It consists of four main operating sections: the assembly area, the process room, the purification wing, and the disassembly basin. (See Figure 19 for a cross-section view of 105-P Reactor facility.)

The emergency diesel engine houses together with the standby pump house are integral with the P-Reactor building. The engine houses are concrete structures located below-grade and connected to the P-Reactor building at the minus 20 ft level (see Figure 20). Each consists of a large concrete room that houses diesel engines, electrical motors, switchgear, and day tanks for fuel and oil, and air compressors for the P-Reactor building. The primary reactor cooling circuit, which includes the heat exchangers, is located at the minus 20 ft level. The cooling water pumps, storage tanks, collection sumps and reactor instrument rooms are located at the minus 40 ft level. The minus 49.5 ft level is the lowest point in the P-Reactor building and is the bottom of two sumps. The reactor control and safety rod latches with the drive mechanisms are located in the actuator tower above the process room.

Figure 18 – Aerial View of P Area at Savannah River Site

During operations, the fuel and targets were irradiated in the reactor and then transferred to the disassembly basin where they were stored for 6 months to allow cooling and decay of radioactivity. They were then transported to F and H Areas for chemical processing. All irradiated fuel assemblies, target material and moderator have been removed from the facility and all fluids have been drained from the process systems to the extent possible.

Envisioned ISD End-State

An Early Action Record of Decision Remedial has been approved documenting ISD as an acceptable end-state for P-Reactor (Rev W-2). The current land use for the PAOU is industrial and the decisions for the final end-state of P-Reactor building and PAOU early action subunits are based on the future industrial worker scenario. Radiological and hazardous substances left in place could pose a potential future risk; therefore, PAOU will require land use controls for an indefinite period of time. The engineering details of the final actions with regard to closure for the building will be selected in the final Record of Decision for the PAOU (expected to be released in 2010). Other than the “no action” alternative, two end-states were developed for P-Reactor based on effectiveness, implementability, and cost.

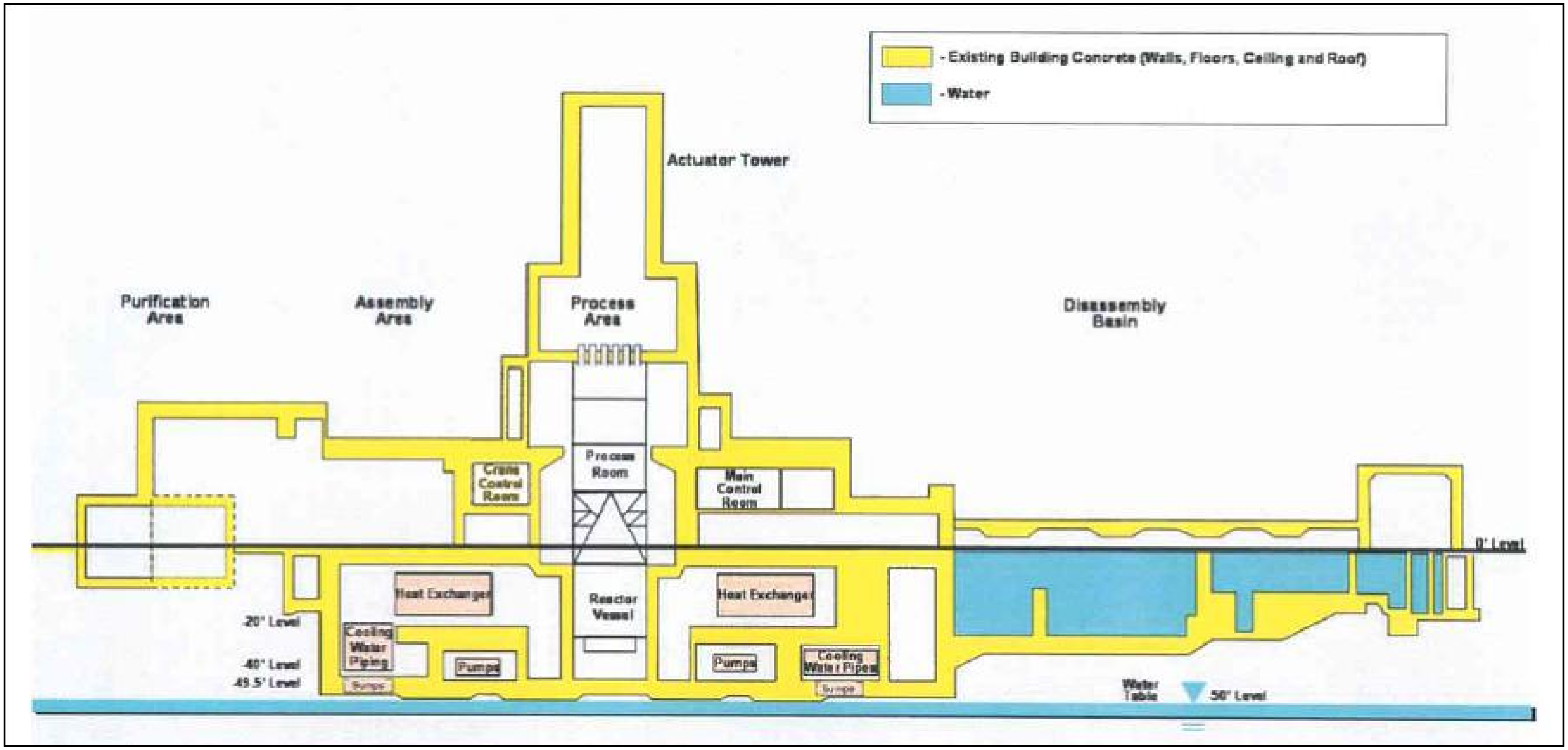

Figure 19 – Pre-Decommissioning Configuration of P-Reactor Facility

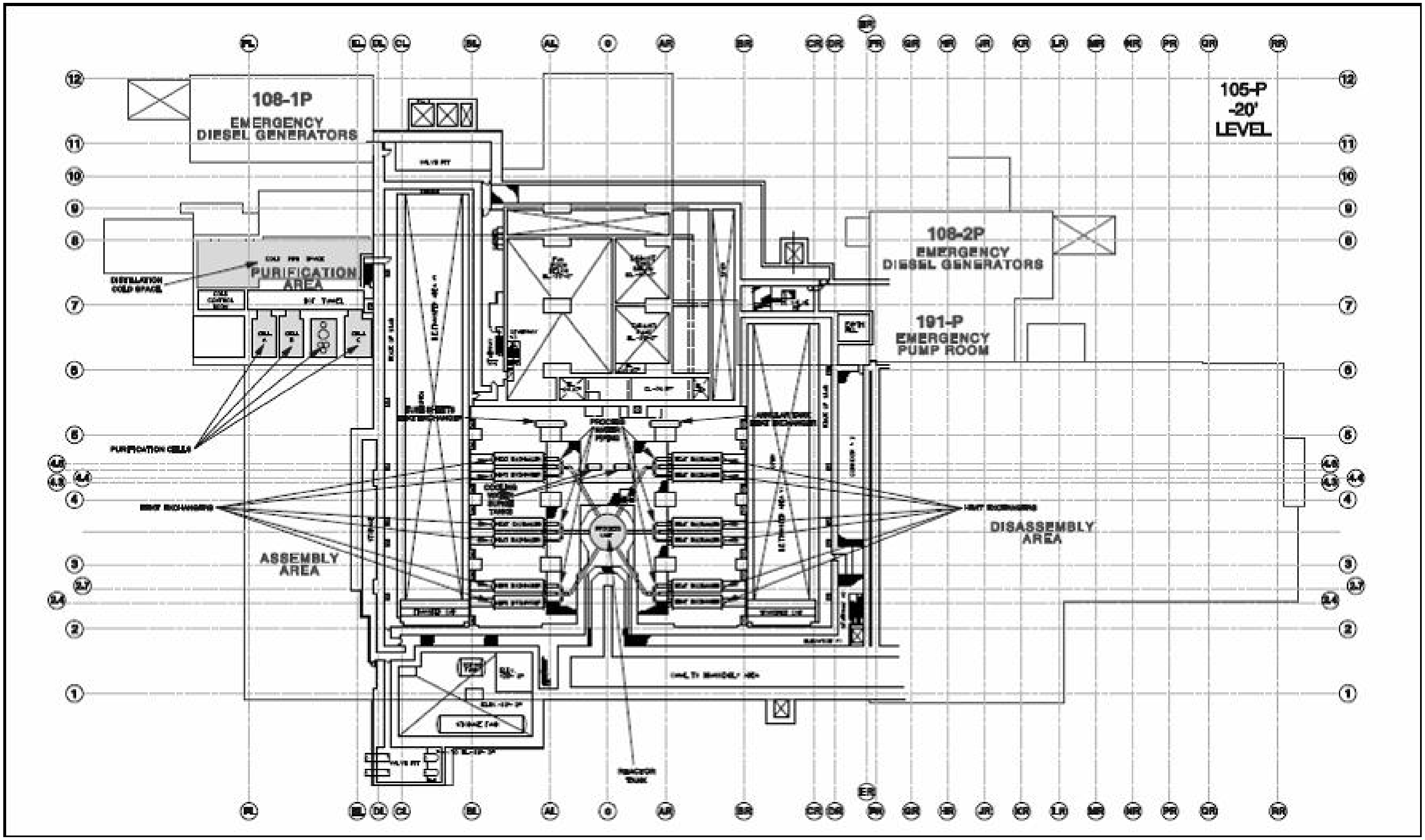

Figure 20 – 105-P Reactor Building at the minus 20 Foot Level

In Situ Decommissioning Alternative (#2)

ISD is the selected alternative (Alternative #1 is No Action). ISD can represent a range of remedial actions that include leaving the P-Reactor building structure and contaminated materials and equipment in place. The design details of the remedial action are still being evaluated. Final details will be subject to regulatory negotiation and approval. The following features of ISD are planned and are being included in the final action CERCLA documentation which is in preparation:

- Alternative R-2A is used here as the reference. Major features include:
  - The Process, Purification, and Assembly areas of the Reactor Building would be left in place, while the above-grade structure of the disassembly area would be demolished to grade-level.
  - Contaminated equipment from the above-grade structure would be relocated, probably into the basement of the building, where they would be grouted in place.
  - The reactor vessel would be grouted in place (encased) with a concrete cover placed above the vessel at grade-level. The process room would remain as-is.
  - The disassembly basin along with its contents would be grouted, including the sludge, activated metal, the contaminated concrete structure, and a small portion of the remaining basin water.
  - An environmental cover would be placed over the disassembly basin.
  - Strategically placed cut outs would be placed in the walls of the remaining structure to avoid accumulation of water; placement would be designed to not create paths for intruder access.
- Alternative R-2B is similar to Alternative R-2A with the difference being that an environmental cover would be placed over the entire P-reactor footprint in lieu of the disassembly basin.
- Alternative R-2C is similar to Alternative R-2A, with the difference being that the reactor tank and the activated portions of the biological shield would be removed prior to grouting the below-grade spaces within the building. A new partial roof would be constructed over the shield door slot to prevent rainwater ingress.
- Alternative R-2D is similar to Alternative R-2B, with the difference being that the reactor tank and the activated portions of the biological shield would be removed prior to grouting the below-grade spaces.

Regardless of the alternatives evaluated, all above- and below-ground penetrations would be sealed to prevent intrusion. Certain above-grade contaminated process equipment with associated wiring and piping would be removed and/or relocated below-grade within the building and encased in grout.

The evaluations conclude that overall protection of human health and environment is high since short-term risk is minimized to remedial workers from exposure to contaminated equipment and facilities, especially for the alternative that leaves the reactor vessel in place.

Alternative 2 includes an ongoing inspection and monitoring program that would be continued indefinitely. The details of the specific nature, extent, and costs associated with the final in situ end-state will be recorded in the final ROD for the PAOU.

Activities to Achieve Alternative #2 End-State

The major activities (cost elements) to achieve the ISD end-state include the following, the degree depending on the final details of the selected ISD scenario (to be determined):

- Dismantle and remove some contaminated equipment
- Abandon-in-place contaminated equipment (defueled reactor and associated components) for the minimum removal scenario
- Remove shield door gantries and construct a new roof
- Remove the stack above the 55 ft roof elevation
- Decontaminate or fix-in-place the radionuclide contamination on exposed surfaces within the building structure that poses a health and safety risk to workers while preparing the facility for its ISD configuration.
- Perform characterization and surveys
- Fill lower spaces with grout to grade level
- Demolish and remove above-ground structures to achieve size reduction and transport material to a waste repository
- Remove the reactor vessel (only for some scenarios)
- Grade and cover 12 acres of land with a cover design consisting of backfill, geo-synthetic material, clay, drainage, topsoil and vegetation layers
- Dispose of removed equipment and structure

Complete Removal Alternative (#3)

This alternative, which was not selected, includes dismantlement of all above- and below-ground structures. The reactor tank and internals would be dismantled, removed and relocated elsewhere, together with all equipment and waste.

The complete removal alternative provides long-term protection for human and ecological receptors and meets the remedial action objectives. This alternative requires no surveillance and maintenance costs, but would be difficult to implement as compared to the selected alternative, which leaves the reactor vessel and other selected contaminated items (and contamination) in place. However, removal and disposal of the building to another location with no reduction of exposure results in the problem simply being transferred elsewhere. In addition, removal activities would either potentially expose workers to direct contamination or require work to be conducted remotely. Likewise, the segregation and reduction of resulting waste into manageable sizes for packaging and transport would also require remote operations or result in worker exposure. Finally, selection of an appropriate waste repository for disposition of contaminated building and reactor components is limited; complete removal is the most expensive alternative.

Alternative Evaluation

Each of the remedial alternatives was assessed against EPA feasibility evaluation criteria (Ref E-8) to provide the basis for selecting a remedy. The nine criteria are divided into three categories: threshold, primary balancing, and modifying criteria.

Threshold criteria are requirements that each alternative must achieve to be eligible for selection as a permanent remedy under CERCLA. These threshold criteria are:

- Overall protection of human health and the environment; and
- Compliance with ARARs.

The ISD and complete demolition alternatives ensure a high level of overall protection of human health and the environment. In addition to managing radioactively contaminated equipment and materials, South Carolina State regulations (Ref. S-3, R.61–79) apply to both alternatives with regard to management of hazardous waste/materials. If the final alternative includes placement of imported waste, the design, construction, operation, decontamination, disposal and closure activities associated with these alternatives would need to comply with DOE Order 435.1, *Radioactive Waste Management* (see Section 7). State regulations and standards will be followed for protection of groundwater and surface water. Both alternatives require erosion and runoff controls to prevent sediment and contaminant runoff to surface water and wetlands down gradient of the remedial area.

Primary balancing criteria are factors that identify key trade-offs among alternatives. The primary balancing criteria are:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

Both the ISD and complete removal approaches are long-term in nature.

Through ISD, the mobility of contaminants would be greatly reduced as demonstrated by the PA analysis. The complete removal alternative permanently removes contaminants, thus reducing the toxicity, mobility, and volume of contaminants.

In both scenarios, engineering controls and health/safety procedures would be implemented to protect workers, the community and the environment. The selected alternative has a high short-term effectiveness and requires the temporary disturbance of contaminated media during construction activities. The non-selected alternative has a low short-term effectiveness because of the greater estimated worker radiation dose compared with ISD.

Both alternatives can be implemented using construction equipment, materials and methods that are readily available. The complete removal alternative requires no surveillance and monitoring cost, but would be difficult to implement as compared to ISD, based on decontamination, complete demolition, and waste segregation/packaging/transportation and disposal requirements.

The total present-worth cost of the alternatives range from $52.5M to $236.3M for ISD and an estimated $366.5M for the complete removal alternative.

Modifying criteria are also considered during remedy selection. These criteria were formally assessed after the public review and comment period on the Early Action Proposed Plan. The modifying criteria are State acceptance and community acceptance.

Table 5 summarizes the alternative.

Table 5 – P-Reactor Overview of Major Alternatives

Attribute	Selected Alternative #2, ISD w/Minimum Removal	Selected Alternative #2, ISD w/Additional Removal	Non-selected Alternative #3
Physical Removal	Minimal removal/ISD: Structure remains; stack removed to plus-55 ft elevation; all below-ground equipment including vessel remains and grouted in place. Disassembly Basin, Engine houses/Standby pump house demolished above grade, contents in below grade locations grouted in place and covered.	Various degrees of removal, including complete removal of reactor vessel	Complete removal: Dismantlement of all above- and below-grade structures. Reactor vessel and internals dismantled, removed and relocated elsewhere, together with all equipment and waste.
Surveillance and Maintenance	Requires ongoing inspection and monitoring program to be continued indefinitely.	Requires ongoing inspection and monitoring program to be continued indefinitely.	No incremental overall site surveillance and monitoring over current program.
Worker Safety	Short-term risk to workers.	Varying degrees of worker exposure that are greater than minimal removal scenarios	Increases worker exposure during removal, packaging and transportation
Waste Disposal Considerations	Waste disposal not a significant issue	Waste repository for disposition of contaminated building and reactor components is limited.	Waste repository for disposition of contaminated building and reactor components is limited.
Estimated Cost	$53 million	to $236 million	$367 million

11. Experience for Common Technical Elements

Several decommissioning-related activities have been identified as key factors in achieving the overall end-state configuration for ISD projects. These actions include to a varying degree: partial cleanout of contaminated equipment or material from the facility; removal of above-grade structures; filling the void spaces below-grade; filling or removing internal components having gaps and open spaces, such as piping and tanks; addressing hazardous materials such as asbestos, mercury, and PCBs; and the installation of a cover system. These activities also affect the assumptions and modeling approach for the Performance Assessment. This section describes aspects of each of these activities using examples from ISD projects at Hanford U-Canyon, SRS P-Area Reactor, and INL Buildings 601/640. The technical approaches described herein, and their project-specific variations, serve as a compendium of experience and lessons learned for ISD projects going forward.

11.1 Facility Cleanout

Prior to decommissioning, a facility must be deactivated to comply with applicable environmental requirements. The primary focus of deactivation for an ISD facility is to downgrade existing hazards through de-inventory of nuclear and/or chemical materials and make the facility consistent with the commitments in the Record of Decision and modeling assumptions. This is typically accomplished by abatement activities (See Section 11.5) and by cleanout and removal of selected attached equipment and unattached items and miscellaneous materials that are located in the facility.

At the Hanford U-Plant, contaminated legacy equipment that is currently stored on the canyon deck of U-Plant will be reduced in size and volume and relocated into the process cells. This material must be removed from the canyon deck since the ISD end-state will include demolition of the structure down to the canyon deck. Contaminated equipment that is already in the cells[24] would be size reduced to the extent possible and returned to the cells. Size reduction is necessary to optimize space utilization and accommodate the material currently sitting on the canyon deck. It is not planned to remove existing piping from the hot pipe trench or any other equipment from the facility. Materials with a TRU concentration greater than 100 nCi/g (such as the liquid/sludge heel in the tank in Process Cell #30 discussed in Section 11.4) will be removed and prepared for offsite disposal. Other canyon facilities are suspected to have TRU contamination with concentrations greater than 100 nCi/g; complicating and adding difficulty to cleanout. If the Performance Assessment shows the impact is within acceptance criteria, leaving it in place, perhaps with stabilization, may be justified.

In all of the alternatives under consideration for the P-Area Reactor at SRS, the majority of contaminated equipment in the above-grade portions of the structure are relocated to the basement areas and grouted in place. The equipment in this scope includes the seal-head tank and associated piping; Makeup Room equipment; and Blanket Gas Room equipment. Two of the proposed alternatives include complete demolition of the above-grade structure; in these scenarios the charge and discharge machines and other Process Room equipment will be removed (the Process Room for the most part is left intact in the other two alternatives). Two of the proposed alternatives include removal of the reactor tank and the activated portions of the biological shield with off-site disposal prior to grouting the below-grade spaces within the building. Approximately 88 percent of the remaining radioactivity in the reactor building is contained within the reactor vessel (the vessel is grouted in place in the other two alternatives).

INL's CPP-601/640 was prepared for ISD by flushing the process vessels, typically with two or three flush evolutions, to remove uranium holdup from the facility to meet the end points for allowable residual contamination levels negotiated with the regulators. Prior to the grout fill, process chemical systems that contained various acids and solvents and certain identified radiological "hot spots" are being removed from the facility. The majority of the chemical support equipment, which is located on the Process Makeup (PM) Area Deck, is also being removed. The PM Deck will be demolished after the lower levels

[24] Equipment was placed in cells because dose rates exceed 100 mRem/hr.

are filled with grout. The equipment removed from the facility is being disposed in the on-site LLW disposal cell. Equipment within the remaining process cells will be left in place.

11.2 Removal of Above-Grade Structure

For the most part these activities are similar to other demolitions conducted at DOE sites, but for ISD there may be additional controls needed to avoid damage to parts of the facility structure that will form the boundaries of the entombment. In some cases it may be desirable to remove all external metal components from the above-grade portion of the structure leaving only the robust reinforced concrete structure. As discussed in the following paragraphs, all ISD projects to date have involved or proposed some degree of above-grade superstructure removal.

For U-Canyon the selected approach includes demolition of the railroad tunnel, ancillary structures, and stacks, with disposal of the resulting waste at the ERDF, and removal of roof and upper wall sections of the 221-U Facility down to the canyon deck level with placement of the debris on or near the deck. Removal of the upper section of the canyon facility will reduce the height of the resulting structure for entombment from approximately 77 ft to 34 ft. This reduction will greatly reduce the dimensions of the engineered barrier cover system and require 67 percent less fill material to construct.

Building 601/640 at INTEC consists of five levels with four below grade. The uppermost level, the Process Makeup area (PM area) is constructed of structural steel with transite panels. Equipment and the structure will be removed/demolished to the PM deck. The four below-grade levels, constructed of robust reinforced concrete, will be left in place and filled with grout. The tops of P, Q, and R cells in CPP-601 will be left intact, approximately 8 ft above the PM deck, to reduce worker risk (i.e., personnel exposure and safety issues pertaining to cutting equipment in cramped quarters) in removing vessels and piping. Similarly, the above-grade portions of Process Cells 1 through 5 and the Material Handling Cave in CPP-640 will be left intact so as not to require relocation of grouted electrolytic dissolution process vessels. A concrete cap will be placed over the remaining below-grade structure.

At SRS, the above-grade portions of the Process, Purification, and Assembly areas of the reactor building would be left in place, while the above-grade structure of the Disassembly area would be demolished to grade-level. All of the below-grade structure would be left intact and grouted in place and a cover would be put in place over the remainder of the Disassembly basin. Strategically placed cut-outs would be placed in the walls of the remaining structure to avoid accumulation of water. Most of the details of ISD for the reactor building are still to be negotiated with the regulatory community before a final configuration is established.

11.3 Void Space Fill

Filling of structural void spaces for ISD serves the dual purpose of stabilizing the structure to prevent subsidence and immobilizing remaining contaminants. The introduction of fill materials also impedes infiltration of water and limits access to intruders.

Several materials can be utilized for bulk fill including grout, controlled low-density fill, soil, sand, or gravel. “Controlled density fill,” also called “flowable fill,” refers to self-compacting, cementitious material used primarily as a backfill in lieu of compacted backfill.

Placement of grout into subgrade and selected above-grade spaces requires planning with regard to the grout properties and formulation, and the ability to efficiently emplace it considering flowability, curing time for each lift (i.e., batch placement), cutting holes in floors and walls to ensure sufficient fill and proper ventilation. For the U-Canyon and P-Reactor the specific design has not been finalized; plans are to pump cementitious grout formulated to provide maximum flowability into the void spaces. This subject is addressed in the discussion of technology application; see Section 13 and Appendix F.

In addition to bulk fill, contaminated material and equipment from inside the facility or the associated CERCLA Area of Contamination may be placed prior to use of bulk fill materials. For example, plans for U-Canyon include size-reducing and consolidating approximately 4,400 cubic yards of contaminated equipment (currently stored on the canyon deck) into the below-grade process cells. Cementitious grout is to be placed around the equipment to completely fill the void space in the process cells. The internal vessel spaces, as well as the pipe and electrical galleries, hot pipe trench, ventilation tunnel, cell drain header, and other spaces within the facility will be filled with grout. This approach minimizes the potential for void spaces and reduces the mobility, solubility, and associated hazard of remaining contaminants, thereby ensuring the Performance Assessment conditions are maintained.

When placement of LLW in ISD facilities is included in the ISD design, the waste will also serve as void fill; see Section 7.6.

The Functions of Grout for ISD

Void Fill – Grout is used for filling void spaces and because of its flowable nature, can be introduced into the "nooks and crannies" of most structures easier than other fill materials. The grout formulation can be adjusted to provide structural stability to prevent subsidence of the structure over time. Filling decommissioned structures with grout also provides an aesthetic image of end-state permanence.

Stabilization – Grout is used to impede the migration of contaminates out of the confines of the structure. Various sequestering agents can be added to the grout formulation to enhance the immobilization of selected contaminants. However, note that in the case of CPP-601/640 at INL, the PA did not take credit for the grout; instead it was conservatively assumed that only the structure walls provided the integrity.

Shielding – Grout is used to provide shielding for workers by filling areas and/or components (e.g., fuel basins, process tanks, sumps, demineralizer cubicles.) that contain high radiological source terms. The density of cement-based grout can provide significant dose reduction to gamma radiation fields, allowing workers to perform other tasks in the vicinity while maintaining exposures within ALARA guidelines.

11.4 Internal Tanks and Piping

Two issues with regard to tanks, vessels, and large diameter piping systems within an ISD facility are a) addressing radioactively or chemically contaminated fluids, and b) ensuring that void space is sufficiently filled.

U-Canyon was never used for its design purpose of chemically extracting plutonium from fuel rods. Instead, the facility was used to train operators until it was adapted to include a uranium recovery process for waste from the other Hanford canyon buildings. Much of the original canyon equipment was removed from the process cells and used as spares for other facilities. Some process equipment from other Hanford facilities was brought to U-Plant where it was placed on the canyon deck or in the process cells. A vessel from the REDOX plant was placed in Process Cell #30. This vessel contains approximately a 3-inch heel of nitric acid solution with a high concentration of fission products and a TRU concentration greater than 100 nCi/g. As such, the project will remove the contents of the vessel with a custom designed, remotely operated system utilizing jet pumps. The vessel, once emptied, will be filled with grout along with the entire process cell.

Most of the HLW process equipment and piping in CPP-601 were flushed extensively to remove significant contamination at the time of shutdown such that the amount of contamination left in the systems at the start of D&D was minimal. Additional flushing and sampling is now underway in order to complete decontamination efforts in accordance with HWMA/RCRA closure plans. Upon completion of those decontamination efforts, these vessels and lines are expected to be left in the building and encapsulated as the building spaces are filled with grout or other inert material. The larger vessels and piping are expected to be filled with grout, thereby incorporated into the remaining monolith.

The entombment of CPP-601/640 will include grout filling of all levels below the PM Deck (essentially the four lower levels). The target for the grout fill is no more than 5 percent void. The current plan is to either directly fill or open and allow grout to enter all piping 4 inches in diameter and greater and all vessels greater than 50 gallons. General areas will be filled in lifts, alternating between filling the vessel and the area around it; this is to prevent floating of vessels or creating a structural imbalance for the floors and surrounding walls. The grout serves no structural purpose; it is only intended to fill void space. The robust concrete walls of the structure provide the integrity. The project is also petitioning the State of Idaho to allow use of inert fill material (in areas where practical) in place of flowable grout.

In contrast, the P-Reactor project plans to use grout to fill only the reactor vessel and the void space between the reactor vessel and the biological shield. Grout will also be used to fill the void space in the below-grade rooms around the various equipment and piping, but no grout will be directly introduced into these components. Encapsulating the equipment into the below-grade portion of the reactor building with grout will prevent release of any radiological contamination into the environment by limiting mobility. The radioactivity will have decayed to much lower levels before structural subsidence is a concern.

11.5 Abatement

Conventional demolition projects remove asbestos containing materials (ACM) and RCRA hazards such as mercury switches, PCB oils and light ballasts, and lead shielding components prior to demolition of the structure. A similar approach is being considered for the ISD projects at Hanford, SRS and INL.

However, in some instances because of location or placement of materials within an ISD facility, removal may be impossible or extremely difficult where remaining portions of a facility are not accessible. One such example is preparation for closure of the CPP-601/640 facility at INL. The facility is being stripped of all RCRA hazards (i.e., ACM, lead, mercury, and process chemical – acids and solvents –systems) and certain identified radiological “hot spots” prior to the grout fill. While all accessible lead (approximately 353 tons of bulk lead solids, primarily used for shielding) will be removed, removal of lead shielding from sampling blisters located in the Service Corridor Shielded Waste Trench and the West Vent Tunnel has proven to be problematic from schedule and personnel exposure standpoints. As such, the project will request a waiver to allow leaving in place the lead associated with these sample blisters. These devices contain large quantities of lead, but they are in inaccessible areas and the benefit of removing them is outweighed by the impacts on worker safety and personnel exposure. This waiver will necessitate closure of the facility as a RCRA landfill (because of the residual lead). In addition, some lead, such as the lead anchors embedded within load-bearing walls, and painted surfaces of the buildings that have had lead-containing paint applied at various times over the 50-year lifetime of the facility, would also remain in place.

11.6 Cover Systems

Utilization of a cover system or final closure cap is driven primarily by local climate conditions and to some extent by stakeholder interests. The configuration of a cover system should address local environmental, technical, and statutory requirements and serve to maintain the assumptions and results of the Performance Assessment. The ultimate design of a cover system is driven by site-specific climate conditions and the physical configuration of the item to be covered.

Final closure of the entombed U-Canyon will include construction of an engineered barrier over the remnants of the canyon building (with the possible inclusion of inert rubble from the demolition of ancillary facilities as fill material – see Figure 8). The barrier will consist of uncontaminated compacted soil fill around the structure with an outer layer of coarse riprap, gravel and sand on the sides with a 3:1 slope. The top of the barrier will be designed to limit water infiltration; the specific design has not been finalized but may consist of one layer, or alternatively, multiple layers incorporating a capillary break feature. The final cover will include planting semiarid-adapted vegetation on the barrier to enhance the evapotranspirative design of the barrier. The cover system enhances the containment of the contaminants and provides added assurance that migration of contaminants to the water table will not occur. The selection of the mounded cap configuration was in response to stakeholder concerns for long-term aesthetics of the Central Plateau.

Final closure of CPP-601/640 will occur upon cessation of operations at INTEC in approximately 2035. The ISD scope will leave the above-grade portion of the building demolished, the below-grade void spaces filled with grout, and a concrete cap placed over the remaining structure. An earthen cover will be installed over the remaining structure as part of the RCRA landfill closure of entire CPP-601/640 area. (Closure of the area as a RCRA landfill is driven primarily by the underground waste tanks adjacent to CPP-601/640). The cover will be integrated with covers for the surrounding facilities such as the Tank Farm and the associated evaporator/waste processing facility. The decision to incorporate the final closure with the closure of the entire area was a driver in the selection of the ISD approach and configuration.

12. Integration with Other Closures at a Site

The bases and criteria for ISD decisions are well defined via the CERCLA process, and as a result, facility ISD decisions are made case-by-case because individual projects are managed, for the most part, at the site level. However, at each site there is a need to understand what effect any single ISD project will have on other permanent closures on site. Integration is important with regard to the combined impacts, such as future land use, infrastructure needs, waste disposal site capacity, environmental impacts, and long-term exposure risk. The responsibility for such integration is primarily with DOE's Field office management with the recognition that there are other types of projects, such as those involving waste tank closures that are managed programmatically and require more Headquarters involvement.

From a management perspective, the decision to entomb a facility not only depends on typical project planning evaluations, but also on the programmatic and technical relationship to other site closure actions, such as tank closure, grouting of contaminated pipelines, and waste disposal burial sites. In pursuing a decision to decommission a contaminated facility in situ, it is important to be consistent in approach among the various actions, and where differences exist, to have a clear understanding of the bases for differences. Some of the decision factors addressed in this report are briefly discussed below.

Long-term Institutional Controls

ISD projects are generally feasible at large sites that include similar features of in situ permanent disposition, that is, sites with waste cells and other closure projects (e.g., underground storage tanks) for which Federal management is likely for the indefinite future. Proposing ISD of a contaminated building would be inconsistent at urban or suburban sites where other significant contamination sources are being removed.

As a result, the estimate in this report of the number likely ISD facilities has assumed ISD would not be feasible at sites such as Brookhaven National Laboratory on Long Island or at the Argonne National Laboratory outside Chicago.

Below-grade Contaminants and Barriers to Migration

Risk and performance analyses evaluate not only the future consequences of potential pathways for migration of radiological chemical contaminants leading to personnel exposures and environmental impacts, but also the acceptability of the contaminants that remain. Risk mitigation for each project is driven by site-specific ecological, geological, hydrological, and meteorological conditions for the site and the physical configuration of the facility's end-state.

A key method that integrates the impacts of facility ISD decisions with other remaining subsurface contamination is the Composite Analysis (CA) required by DOE O 435.1. The CA analyzes the combined risk from all sources that contribute to receptor exposures.

Generalizations regarding risk assessment of any one project depend on sources to be left in place.
An ISD project that properly stabilizes and entombs the sources within a reactor building or canyon, even with imported waste, would be expected to be a less significant contributor than an older, unlined burial ground. As a result, ISD can be considered for facilities where significant sources are removed or stabilized with barriers with an initial assumption that the contribution to risk may be small compared with that from other sources elsewhere on site considered in a CA. A performance or risk assessment is needed to verify such assumptions.

Final Physical Conditions

Above-grade physical configuration, cover systems, the entombed structure itself, and other external engineered barriers provide physical stabilization of the closed site; they can minimize infiltration of surface water so as to minimize the migration of contaminants to underlying aquifers; and can serve as a deterrent after active institutional controls have ended to prevent a person who might inadvertently enter the area from being able to contact buried contamination.

Several concepts for ISD final configurations are under consideration. These range from a minimal approach of first removing all superstructure and below-grade significant sources and then grouting the below-grade concrete structure, to a cover system comprised of a thick engineered barrier cap placed over a canyon structure, with structural fill soil mounded around the structure to support the cap.

Tank closures generally include filling with grout and an engineered closure cap consisting of several layers of various materials. In at least one case where an ISD facility is adjacent to a tank farm, a common cap is planned for the combined area.

Final closure configuration is driven by site-specific conditions and stakeholder interactions. The former is a result of the risk analyses, slope stability, and other technical factors, while the latter can influence configurations for reasons such as visual esthetics.

Use for Waste Disposal

A potential use for large ISD facilities is the placement of low level waste from elsewhere on the site. There is potentially significant cost avoidance by reducing future burial ground volume at the site. The Inspector General (Section 7.51) commented on this omission from the U-Canyon alternatives in its report on the U-Canyon Disposition Initiative Record of Decision.

Such actions would add to the ISD project burden of regulatory submittal and approval. However, by judiciously planning the type of waste to be placed, the overall environmental impact at the site should not increase and, in fact, may be less than if the waste were placed in a CERCLA burial cell.

Planning for LLW disposal should be addressed early in the evaluation document (e.g., an EE/CA) that will support the decision on which alternative to select. Consideration may be given to importing equipment (e.g., gloveboxes and process tanks) or packaged waste (e.g., drums and boxes), or the use of contaminated soil or demolition rubble as void fill material. The source term from the imported material must be factored into the performance assessment, and eventually, waste acceptance criteria will need to be consistent with the selected ISD alternative.

13. ISD Technology Needs

Consistent with the overarching Departmental goals for increased personnel and environmental safety, reduced technical uncertainties and risks, and overall gains in efficiencies and effectiveness, EM's Office of Engineering and Technology (EM-20) and Office of Deactivation and Decommissioning and Facility Engineering (EM-23), have initiated efforts to identify the technical barriers and gaps and concomitant technology development needs for optimal ISD implementation. This section summarizes an ISD Technology Workshop conducted during December 2008.

The objective of the workshop was to define the ISD technical challenges and explore potential investments in technical breakthroughs that will:

- Improve characterization of existing conditions within ISD candidate facilities;
- Shorten time, lower costs, and reduce risks in the execution of ISD work activities; and
- Add confidence to the long-term durability of the end-state disposition result.

EM-20 will use the portfolio of technical needs from this joint effort to develop prioritized investment goals that will achieve clear improvements in ISD costs, schedules and/or safety across the DOE D&D program.

ISD Technical Challenges

To help ensure success of the ISD strategy, workshop organizers sought joint input that would achieve the above objectives. This included participation from DOE and contractor representatives from key sites that possess the majority of the candidate ISD facilities, such as SRS, Idaho and Hanford. Experienced decommissioning operations personnel from the three sites discussed the engineering and technical problems that they face with ISD at their facilities. Scientists and engineers knowledgeable in specific and crosscutting technologies were assembled to identify potential incremental and 'game changing' solutions to those problems and jointly develop project summaries that will lead to successful resolution of the challenges.

Workshop participants and others contacted by phone at the three sites identified the general list of challenges listed in Table 6.

Needs Identification

Needs identified during the workshop were organized into six basic groups:

- Characterization
- Materials Behavior and Degradation
- Design and Closure
- Monitoring
- Knowledge Management
- Policy Change

The needs statements and their topics were developed as presented in Table 7. Appendix F provides an elaboration of each of the needs statements.

Table 6 – ISD Technical Challenges

Category	Challenge
Characterization	How do you obtain samples from/perform characterization of inaccessible areas?
	How do you obtain representative samples for analysis of long-lived radionuclides in the reactor vessel material to establish an accurate source term?
	Are modeling assumptions too conservative for the actual physical conditions of the ISD end-state (i.e., soil used for radionuclide transport performance when voids are filled with grout; and assumptions regarding long-term stability of concrete)?
	What types of sensors are needed for long-term monitoring of ISD structures?
	What type of monitoring can accomplish detection of precursors that indicate the potential for a release?
Stabilization	What is the proper formulation for grout to provide the necessary degree of flowability to sufficiently fill voids yet maintain desired strength (long-term stability) to minimize contaminant mobility?
	What is the proper grout formulation to minimize phase separation of water (bleeding) from the grout during curing?
	What method(s) do you use for grout placement to sufficiently fill large voids, vessels, and inaccessible areas/complex geometries within ALARA constraints?
	How do you accomplish isolation/sealing of structure penetrations and gaps to prevent access for water, vermin, vegetation growth, and others?
Disposal	How much transuranic residuals can be left in the structure?
	Can clean fill material (i.e., gravel, soil, demo debris) be used in place of grout to fill voids; if so, what method(s) do you use to introduce and compact it into the ISD facility?
	Can contaminated soil be used as fill material; if so, what method(s) do you use for contamination control during handling and placement, and what method(s) do you use to introduce and compact it into the ISD facility?
Miscellaneous	How do you drill through thick concrete and/or steel (possibly from long distances) to provide access into cubicles and/or puncture equipment?
	What alternatives do you consider for lifting heavy items, like cell cover blocks or equipment, when facility cranes are out of service and retrofitting is not possible?
	How do you remove the contents of process vessels within ALARA constraints?
	How do you deploy bulk adsorbents to sequester process vessel heels?
	What techniques do you use to demolish structure appurtenances that consist of thick concrete (> 4 ft) and/or high structures (i.e., 200 ft+ tall stacks) without damaging the main structure thereby compromising the integrity of the entombment barrier?

Table 7 – ISD Needs Statements Summary

	Needs Statement	Purpose
Characterization	In-Tank Characterization with Isotopic Discrimination	Develop ability to perform in-tank characterization with isotopic discrimination that would provide timely data for project planning and decision making.
	Field-Deployment Systems for difficult COCs (can also fit in Knowledge Management category below)	Field instruments that require introduction of a sample are available for most Contaminants of Concern (COC). The real interest is in remote sensing to find and quantify amounts of COCs.
Materials Behavior and Degradation	Degradation rates and local chemistry	Obtain realistic and technically justifiable estimates of: 1) Degradation/corrosion rates for the various engineered materials associated with ISD facilities, and 2) Sorption coefficients, solubilities, etc. for long-lived radionuclides in various structural materials and possible fill materials to reduce the uncertainties in the contaminant transport models
	Long-term Materials Performance Studies	Provide well defined long-term (greater than 500 years) performance data for Portland cement-based materials.
	Release of activation products from corroded stainless steel	Define the release mechanism and release rates for activation products from corroded carbon steel and stainless steel components.
Design and Closure	Design flow path or decision guide for sealing/filling ISD facilities	Develop guidance for the identification of strategies, functional requirements and designs for fill and seal of ISD facilities.
	Seal/fill material "Toolbox"	Develop material properties and performance characteristics reference guide for fill materials and sealants pertinent to ISD requirements.
	Energy and Environmentally Responsive Fill Material Designs	Research and identify fill material with environmentally sustainable contributions and accounting for LEED criteria, i.e. carbon dioxide capture material.
Monitoring	Design monitoring into ISD facility	Develop a monitoring system that would demonstrate whether the ISD performance meets program goals and conforms to project planning predictions.
Knowledge Management	Measures to Improve Communication of Risk Assessment Modeling Approaches, Data, and Lessons Learned	Develop a means to upload, organize, and disseminate information that would be useful for conducting risk assessments to support ISD.
	Technical Resources	Develop technical reference documents for vetted data from past ISD related work. Potential Topics: Design Concepts, fill materials, other barriers, vetted physical/chemical properties
	Significant sample analysis is required to establish ratios for many contaminants of concern (COCs).	Compile data available from existing sample analyses to establish baseline uncertainty ratios for low-energy, longer-lived radionuclides.
Policy	DOE Order 470.4-6, Nuclear Material Control and Accountability	Revise DOE Manual DOE M 470.4-6, Nuclear Material Control and Accountability, to be more in line with current D&D practices.

14. References

D-1 DOE/EM-0383, January 2000 Decommissioning Handbook: Procedures and Practices for Decommissioning

D-2 DOE-STD-1120-05, Integration of Environment, Safety and Health into Facility Disposition Activities, Vol. 1 & 2, 2005

D-3 D&D-35827, Project Experience Report, Canyon Disposition Initiative (221-U Facility), Revision 0, January 2008

D-4 DOE/RL-2006-21, Remedial Design/Remedial Action Work Plan for the 221-U Facility, Draft A (2006)

E-1 DOE/ID-11253, Engineering/Cost Analysis for Decommissioning of TAN-630 and TAN-650 at the Loss-of-Fluid Test (LOFT) Area, January 2006

E-2 DOE/ID-11346, Engineering/Cost Analysis for Decommissioning of the CPP-601/640 Fuel Reprocessing Facilities, January 2008

E-3 DOE/ID-11302, Engineering/Cost Analysis for Decommissioning of TAN-607 Hot Shop Area, January 2007

E-4 DOE/ID-11328, Engineering/Cost Analysis for the Materials Test Reactor Facility End-State and Vessel Disposal, July 2007

E-5 DOE/ID-11309, Engineering/Cost Analysis for Power Burst Facility (PER-620) Final End-State and PBF Vessel Disposal, May 2007

E-6 DOE/ID-1172, Engineering/Cost Analysis for Decommissioning of the Engineering Test Reactor Complex, October 2006

E-7 DOE/ID-11303, Revision 0, Action Memorandum for Decommissioning the Engineering Test Reactor Complex under the Idaho Cleanup Project, January 2007

E-8 40 CFR 300.430, Remedial Investigation/Feasibility Study and Selection of Remedy

F-1 Final Feasibility Study for the Canyon Disposition Initiative (221-U Facility), DOE/RL-2001-11, 2004

F-2 DOE/ID-11321, Final Removal Action Report for the LOFT Facility, January 2008

G-1 DOE G 435.1-1, Implementation Guide for Use with DOE M 435.1-1, July 9, 1999

G-2 DOE G 430.1-4, Decommissioning Implementation Guide, September 2, 1999

G-3 DOE G 430.1-2, Implementation Guide for Surveillance and Maintenance During Facility Transition and Disposition

G-4 DOE G 430.1-3, Deactivation Implementation Guide

G-5 DOE G 430.1-5, Transition Implementation Guide

I-1 DOE/IG-0672, Audit Report, Department of Energy Efforts to Dispose of Hanford's Chemical Separation Facilities, February 2005

I-2 INEEL-96/0189 Rev 2, HWMA Closure Plan for the Waste Calcining Facility at the Idaho National Engineering and Environmental Laboratory, June 1997

I-3 DOE/ID-11360, Action Memorandum for Decommissioning CPP-601/640 Fuel Reprocessing Facilities, August 2008

J-1 Jason Associates Corporation, Supporting Documentation for HWMA/RCRA Closure Certification of the Waste Calcining Facility, June 1999

M-1 DOE M 435.1-1, Radioactive Waste Management Manual, July 9, 1999

M-2 DOE/ID-11340, Revision 0, Action Memorandum for the Materials Test Reactor Facility End-State and Vessel Disposal, August 2007

N-1 Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA)

N-2 BTP Nuclear Regulatory Commission's Branch Technical Position on Concentration Averaging, January 17, 1995

N-3 DOE O 451.1B, National Environmental Policy Act Compliance Program, October 2000

O-1 DOE O 413.3A, Program and Project Management for the Acquisition of Capital Assets, July 2006

O-2 DOE O 430.1B, Real Property Asset Management, September 2003

O-3 DOE O 435.1, Radioactive Waste Management, January 2007

O-4 DOE O 5400.5 Change 2, Radiation Protection of the Public and the Environment, January 1993

O-5 DOE O 5820.2A, Radioactive Waste Management, September 1988

P-1 DOE P 450.4, Safety Management System Policy

P-2 U.S. Department of Energy and the U.S. Environmental Protection Agency, Policy on Decommissioning of Department of Energy Facilities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 1995

R-1 Record of Decision, 221-U Facility (Canyon Disposition Initiative), Hanford Site, Washington

S-1 P. L, Lee, et al, Applicability of Performance Assessment Methodologies to In Situ Decommissioning, SRNS-STI-2008-SRNL-RP-2009-00329, March 9, 2009.

S-2 P. L. Lee, J. B. Gladden, C. S. Urland, E. Reynolds, Technical Requirements for In Situ Decommissioning Workshop, SRNL-RP-2009-00269, June 2009.

S-3 SCHWMR R.61-79, South Carolina Hazardous Waste Management Regulations (implements RCRA)

T-1 15 USC (C. 53) 2601-2692, Toxic Substances Control Act, 1976

W-1 WSRC-RP-2007-4064, Revision 1, Early Action Proposed Plan for the P Area Operable Unit (U), May, 2008

W-2 WSRC-RP-2008-4037, Rev 1.1, Early Action Record of Decision Remedial Alternative Selection for the P Area Operable Unit, U.S. DOE/Savannah River Site, CERCLIS Number 94, December 2008.

Appendix A – ISD Potential Avoided Cost

The ISD end-state offers the potential for considerable cost avoidance over demolition and complete removal of the structure and its contents. From a strategic viewpoint, the objective here is to broadly estimate a Complex-wide range of cost avoidance by implementing ISD.

The estimates presented below have been derived based on a variety of documents and anecdotal information. Cost information for ISD projects is currently limited to a few facilities at Hanford, Idaho, and Savannah River Site.

Planning data for selected ISD projects at these sites suggests that the potential rough order of magnitude cost avoidance for individual facilities when compared to removal to greenfield or brownfield end-states ranges between $4 million and $210 million per facility (See Table 8). The low end cost avoidance being associated with less complex facilities such as the Loss of Fluid Test (LOFT) facilities at INL; the high end is associated with large, heavily contaminated, complex structures such as the process canyons and the SRS P-Area, including the reactor building.

To fully understand the magnitude of the potential cost avoidance for the entire Complex, the ISD candidate list presented in Section 5 was arranged into categories of a) canyons, b) canyon-like facilities, c) reactors, and d) miscellaneous. The current breakout of potential ISD facilities by category in Section 5 is 8 canyons and canyon-like[25], 12 production reactors, and 64 miscellaneous facilities. To provide a range for the avoided cost that includes facilities not extractable from FIMS (such as the anomalies discussed in Section 5) and future facilities (See footnote), it was assumed by the authors that the number of potential ISD facilities may be as high as 125. The breakout by facility category was further assumed to be 16 canyons and canyon-like facilities, 12 production reactors (remains unchanged since no new reactors are expected), and 97 miscellaneous facilities.

Using this approach, it is very roughly estimated that the potential cost avoidance for ISD Facility projects across the nation is between $2.1 billion and $2.6 billion (Table 9).

Waste Cell Avoided Cost

A February 2005 Inspector General Audit Report (Ref. I-1) stated:

> "Preliminary estimates indicated that the use of the five canyon facilities for disposal of on-site mixed and low activity waste could save the Department as much as $17 million to $500 million in waste disposal costs at Hanford and could reduce the need for additional disposal facility capacity."

The bases for this range of estimate were studies conducted in the mid 1990s for the Canyon Disposition Initiative at Hanford.

Overall Avoided Cost

Combining the overall potential avoided cost for facilities with the upper Inspector General report, it can be concluded that a total avoided cost value for ISD is in the range of $2.6 billion to $3 billion. These savings could be increased to $4 billion if the avoided cost for the six contaminated canyon facilities were to average $300 million each instead of the $100 million assumed for the above estimated range. The avoided cost for contaminated canyons could be much greater. In the 1990s, the cost for complete removal and disposal of PUREX was judged to be about $1 billion.

[25] "Canyon-like" means similar in construction and operations with less mass/bulk. The Defense Waste Processing Facility (DWPF) at the SRS is an example of what is meant by canyon-like. The future Salt Waste Processing Facility (SWPF) at SRS and Waste Treatment Plant (WTP) at Hanford are also examples.

Table 8 – Project Information for ISD Cost Avoidance

Site	Facility	Complete Removal Alternative Description	ROM Cost ($M)	ISD Alternative Description	ROM Cost ($M)	ROM Avoided Cost ($M)	Notes
Hanford	U-Canyon (221-U)	Complete disassembly /demolition of the 221-U Facility and disposal of the resulting debris in the ERDF.	$84.4	Demolish the building to the canyon deck level, dispose of legacy waste & debris in the process cells, filling the remaining void spaces w/ grout, and covering the partially demolished structure with a surface barrier.	$66.3	$18	From the U-Canyon EE/CA
Hanford	Production Reactors (B, C, D, DR, F, H, KW, KE, N)	Structure and graphite core completely dismantled and demolished; waste disposed at the ERDF; site backfilled & graded.	$48.7	Partial demolition of superstructure down to the reactor block, contaminated surfaces coated w/ fixative; voids filled w/ grout; cover with a protective barrier.	$38.1	$10.6	From a study conducted in 2005
INL	Loss of Fluid Test Area (TAN-630 & TAN-650)	Complete removal (demolition) and disposal of entire superstructure. Note that the reactor was removed earlier.	$25.7	Removal of all above-grade components & structures, collapse & removal of floors & concrete wall to 3 ft below grade; remaining below-grade shell filled to grade w/ solid inert material. No decontamination.	$21.7	$4	Complete removal estimate based on work in 2003. Alternative from the EE/CA
INL	CPP-601/640 Fuel Reprocessing Facilities	Complete demolition; removal of building and components; disposal of debris on site.	$126.3	Demolition to the Process Makeup/Hot Makeup Decks (approx 11 ft above grade); decontaminate remaining process equipment and fill voids with grout; cover with monolith cap.	$81.3	$45	Added $10M to the EE/CA value of $116.3 to account for removal of sub-grade structure
SRS	P-Area Reactor	Complete disassembly /demolition of the reactor facility and off-site disposal of the resulting debris.	$367	Significant footprint reduction via partial demolition of structure; reactor vessel NOT removed, but grouted in place.	$53	$214	Based on estimates to support the EAROD

Table 9 – Avoided Cost Based on the Number of Potential ISD Candidates

Type of Facility	Representative Facility Avoided Cost (ROM; $M)	Lower Range No. Facilities	Lower Projected Avoided Cost (ROM; $M)	Upper Range No. Facilities	Upper Projected Avoided Cost (ROM; $M)	Notes
U-Canyon	$18	1	$18	1	$18	U-Canyon is not representative in that it never processed highly radioactive fuel.
Other Canyons	$100	6	$600	6	$600	Used the same representative cost as for the SRS reactors because they are much more contaminated than U-Canyon
DWPF (canyon like)	$45	1	$45	9	$405	Used CPP-601/640 delta of $45M
SRS Reactors	$214	5	$51,070	5	$1,070	Based on estimates to support the EAROD
Hanford Reactors	$10.6	7	$74	7	$74	See Text
Misc. Others	$4	64	$256	97	$388	See Text
Total		84	$2,063	125	$2,555	

Appendix B – Potential ISD Facilities Culled from FIMS

Site	Facility	ID	Hazard Category	Building Function
INL INL	Fuel Process Building Headend Process Plant	CPP-601 CPP-640	Nuclear Facility Cat 2	Process/Production Process/Production
INL	Unirrad. Fuel Storage Facility	CPP-651	Nuclear Facility Cat 2	Storage
INL	Experimental Breeder Reactor	EBR-II-725	Nuclear Facility Cat 1	Reactors
INL	ZPPR Vault-Workroom Eq Rm	MFC-775	Nuclear Facility Cat 2	Laboratory/Research
INL	ZPPR Reactor Cell	MFC-776	Nuclear Facility Cat 2	Reactors
INL	Material Test Reactor Bldg.	TRA-603	Radiological Facility	Reactors
INL	Warm Waste Treatment Facility	TRA-605	Radiological Facility	Process/Production
LANL	CMR Laboratory	03-0029	Nuclear Facility Cat 2	Laboratory/Research
LANL	Weapons Component Test Facility	16-0207	Radiological Facility	Laboratory/Research
LANL	Critical Assembly Bldg	18-0032	Nuclear Facility Cat 2	Laboratory/Research
LANL	Critical Assembly Bldg Kiva 3	18-0116	Nuclear Facility Cat 2	Laboratory/Research
LANL	Plutonium Bldg	55-0004	Nuclear Facility Cat 2	Process/Production
LLNL Site 300[26]	Firing Facility(FXR)	801A	Radiological Facility	Laboratory/Research
LLNL Site 300	Dynamic Test Facility	836D	Radiological Facility	Laboratory/Research
LLNL Site 300	Inert Machng/Explvs Wst Packng	805	Radiological Facility	Process/Production
LLNL Site 300	He Machining	806A	Radiological Facility	Process/Production
LLNL Site 300	He Machining	806B	Radiological Facility	Process/Production
LLNL Site 300	He Machining	807	Radiological Facility	Process/Production
LLNL Site 300	He Pressing	809A	Radiological Facility	Process/Production
LLNL Site 300	He Assembly	810A	Radiological Facility	Process/Production
LLNL Site 300	Firing Facility	812A	Radiological Facility	Laboratory/Research
LLNL Site 300	Dynamic Test Facility	836C	Radiological Facility	Laboratory/Research
LLNL Site 300	Firing Facility	850	Radiological Facility	Laboratory/Research
LLNL Site 300	Firing Facility	851A	Radiological Facility	Laboratory/Research
LLNL Site 300	Advanced Test Accelerator Facility	865		Accelerator
NTS	27-5180	202278	Radiological Facility	Laboratory/Research
NTS	27-5321	202284	Radiological Facility	Laboratory/Research
NTS	06-DAF	202650	Nuclear Facility Cat 2	Laboratory/Research

[26] LLNL Site 300 facilities are listed as candidates due to remoteness of site, but stakeholder concerns may exclude them from consideration.

Site	Facility	ID	Hazard Category	Building Function
NTS	27-5310	995662	Radiological Facility	Laboratory/Research
NTS	27-5400	998081	Radiological Facility	Laboratory/Research
ORNL	Oak Ridge Electron Accelerator - ORELA	6010	Radiological Facility	Accelerator
ORNL	EGCR Containment Building	7600	Radiological Facility	Laboratory/Research
ORP	Waste Unloading Facility	204AR	Nuclear Facility Cat 2	Process/Production
ORP	Evaporator Building	242A	Nuclear Facility Cat 2	Process/Production
ORP	Evaporator Facility	242S	Nuclear Facility Cat 2	Process/Production
ORP	Sludge Vault Storage & Processing	244AR	Nuclear Facility Cat 2	Process/Production
RL	B Plant Canyon		Nuclear Facility Cat 2	Process/Production
RL	Reactor Building	105C	Radiological Facility	Reactors
RL	Reactor Facility	105DR	Radiological Facility	Reactors
RL	Reactor Facility - Abandoned	105H	Radiological Facility	Process/Production
RL	Reactor Facility	105KE	Radiological Facility	Reactors
RL	Reactor Facility	105KW	Radiological Facility	Reactors
RL	Reactor Facility	105N	Radiological Facility	Reactors
RL	Recirculation Cooling Building	107N	Radiological Facility	Industrial/Manufacturing
RL	PUREX Canyon & Service Facility	202A	Not Applicable	Process/Production
RL	REDOX Canyon & Service Facility	202S	Nuclear Facility Cat 3	Laboratory/Research
RL	Process Canyon/Office	221T	Nuclear Facility Cat 2	Process/Production
RL	U Plant Canyon & Service Bldg	221U	Nuclear Facility Cat 3	Process/Production
RL	Transuranic Storage & Assay Facility	224T	Nuclear Facility Cat 2	Storage
RL	Waste Encapsulation & Storage Bldg	225B	Nuclear Facility Cat 3	Storage
RL	Radioactive Particle Research Lab	242B	Radiological Facility	Laboratory/Research
SRS	Reactor Bldg	105000	Nuclear Facility Cat 2	Process/Production
SRS	Reactor Bldg	105000	Radiological Facility	Process/Production
SRS	Reactor Bldg	105000	Nuclear Facility Cat 2	Storage
SRS	Reactor Bldg	105000	Nuclear Facility Cat 2	Storage
SRS	Reactor Bldg	105000	Radiological Facility	Process/Production
SRS	Vitrification Building	221000	Nuclear Facility Cat 2	Process/Production
SRS	Canyon Building	221000	Nuclear Facility Cat 2	Process/Production
SRS	Canyon Bldg	221000	Nuclear Facility Cat 2	Process/Production
SRS	A-Line	221001	Nuclear Facility Cat 3	Process/Production
SRS	Manufacturing Bldg.	232000	Nuclear Facility Cat 2	Process/Production
SRS	New Manufacturing Building	233000	Nuclear Facility Cat 2	Process/Production

Site	Facility	ID	Hazard Category	Building Function
SRS	Metallurgical Bldg	235000	Nuclear Facility Cat 2	Industrial/Manufacturing
SRS	Gang Valve House	241011	Nuclear Facility Cat 2	Other Misc Structures
SRS	FDB-5 Diversion Box	241033	Nuclear Facility Cat 2	Other Misc Structures
SRS	HDB-2 And Pump Pits 1-4	241035	Nuclear Facility Cat 2	Other Misc Structures
SRS	Diversion Box DB#5	241052	Nuclear Facility Cat 2	Other Misc Structures
SRS	HDB-6	241056	Nuclear Facility Cat 2	Other Misc Structures
SRS	Proc Pump Pit New Wst Hdr	241070	Nuclear Facility Cat 2	Other Misc Structures
SRS	Return Water Pumping Basin	281002	Nuclear Facility Cat 3	Other Misc Structures
SRS	Canyon Exhaust Fan Hse	292000	Radiological Facility	Industrial/Manufacturing
SRS	Vitrification Building Fan House	292000	Nuclear Facility Cat 2	Industrial/Manufacturing
SRS	Canyon Exhaust Fan House	292000	Radiological Facility	Industrial/Manufacturing
SRS	Sand Filter Fan House	292002	Nuclear Facility Cat 3	Industrial/Manufacturing
SRS	Canyon Exhaust Filters	294000	Nuclear Facility Cat 2	Process/Production
SRS	Additional Canyon Sand Filter	294001	Nuclear Facility Cat 2	Process/Production
SRS	Sand Filter	294002	Nuclear Facility Cat 2	Process/Production
SRS	Lift Station	607020	Radiological Facility	Other Misc Structures
SRS	Lift Station	607024	Radiological Facility	Other Misc Structures
SRS	Inter Transfer Lines Diver Box/Pump Pit	641000	Nuclear Facility Cat 2	Other Misc Structures
SRS	Ilt Vault	662000	Nuclear Facility Cat 3	Storage
SRS	Ilnt Vault	663000	Nuclear Facility Cat 3	Storage
SRS	Control Laboratory	772000	Nuclear Facility Cat 2	Laboratory/Research

Appendix C – Review of Orders, Manuals, and Guides for Reference to ISD

A limited review was conducted to determine if there was language contained in any DOE policies, orders, notices, guides, or standards that could be interpreted as contrary to the concept of ISD. The primary documents reviewed were:

- DOE/EM-0383, January 2000 Decommissioning Handbook Procedures and Practices for Decommissioning
- DOE G 430.1-4, Decommissioning Implementation Guide September 2, 1999
- DOE M 435.1-1, Radioactive Waste Management Manual July 9, 1999
- DOE-STD-1120-05, Integration of Environment, Safety and Health into Facility Disposition Activities
- DOE O 5400.5, Radiation Protection of the Public and the Environment, January 7, 1993

In addition, the above four documents referenced the following five:

- DOE G 430.1-2, Implementation Guide for Surveillance and Maintenance During Facility Transition and Disposition
- DOE G 430.1-3, Deactivation Implementation Guide
- DOE G 430.1-5, Transition Implementation Guide
- DOE P 450.4, Safety Management System Policy
- 1995 Decommissioning Policy (Policy on Decommissioning of DOE Facilities Under CERCLA)

The review was conducted by searching for “in situ” as a phrase coupled with decommissioning. The review of these ten documents did not reveal any instance or addressing of ISD. It is therefore also concluded these documents are contradictory to the practice of in situ decommissioning.

Appendix D – Regulations and Requirements Impacting ISD Decisions

D.1 Significant Regulations

CERCLA (40 CFR 300)

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), a.k.a. Superfund, enacted by Congress on December 11, 1980, established prohibitions and requirements concerning closed and abandoned hazardous waste sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified. CERCLA established the National Contingency Plan (40 CFR 300), which contains the governing regulations for identification and response to releases of hazardous substances. In accordance with the terms of Section 120 of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986, the Department of Energy was required to enter into an interagency agreement at each site with the Environmental Protection Agency for each site listed on the NPL. In addition, Hanford has a separate agreement with the Tribes.

In 1995 U.S. EPA and DOE established the approach agreed upon by DOE and U.S. EPA for the conduct of decommissioning projects consistent with CERCLA requirements. This Policy provides guidance to U.S. EPA Regions and DOE Operations Offices on the use of CERCLA response authority to decommission such facilities and ensures that decommissioning activities are protective of worker and public health and the environment, consistent with CERCLA and, where applicable, RCRA, ensure stakeholder involvement, and achieve risk reduction without unnecessary delay. The policy states that generally, decommissioning activities are conducted as non-time critical removal actions.

CERCLA §121(d) specifies that on-site Superfund remedial actions must attain Federal standards, requirements, criteria, limitations, or more stringent State standards determined to be legally applicable or relevant and appropriate (ARAR) to the circumstances at a given site. To be applicable, a State or Federal requirement must directly and fully address the hazardous substance, the action being taken, or other circumstance at a site. A requirement which is not applicable may be relevant and appropriate if it addresses problems or pertains to circumstances similar to those encountered at a Superfund site. For on-site response activities, CERCLA requires compliance with only the substantive requirements of other laws, such as chemical concentration limits, monitoring requirements, or construction standards. Administrative requirements, such as permits, reports, and records, along with substantive requirements, apply only to hazardous substances sent off site for management. To–Be-Considered (TBCs) guidelines are guidance documents, proposed concentration-based action or cleanup levels or other non-promulgated standards. DOE Orders are not promulgated and therefore are not identified as ARARs. Some U.S. EPA regions may consider DOE Orders as TBC standards. However, DOE and their contractors, in accordance with their contractual requirements, must comply with the DOE Orders, independent of CERCLA.

CERCLA requires that on-site remedies achieve compliance with ARARs unless an ARAR waiver under 40 CFR §300.430(f) (1) (ii) (C) is invoked in the Record of Decision.

Each U.S. EPA region or State may differ on how they apply regulations to an ISD facility. Early discussion with the appropriate Federal and State regulatory agencies will help ensure that ARARs are identified in a timely manner and minimize impacts and delays caused by identification of additional requirements late in the project.

RCRA (40 CFR 260-282)

The Resource Conservation and Recovery Act (RCRA) of 1976, as amended, gave U.S. EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. The 1984 Federal Hazardous and Solid Waste Amendments (HSWA) to RCRA required phasing out land disposal of hazardous waste and instituted requirements for investigation and remediation of all solid waste management units that present a threat to human health or the environment. Some of the other mandates of this law include increased enforcement authority for U.S. EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program.

RCRA establishes minimal national standards for management of hazardous waste. It applies to all owners and operators of facilities that treat, store and dispose of hazardous waste as well as waste generators and transporters. It regulates intentional land disposal of hazardous wastes. Hazardous waste is a subset of solid waste; therefore, to be a hazardous waste, waste must first satisfy the definition of a solid waste. Based on *40 CFR 261,* the definition of a *solid waste* is any material that is discarded or disposed of, that is not excluded by the regulations; a solid waste is not necessarily solid; it may be semi-solid, liquid, or even a contained gaseous material.

RCRA regulations established requirements for waste analysis, personnel training, emergency planning, labeling and storage of hazardous waste containers, manifesting, and transportation. The RCRA regulations specify treatment standards and treatment requirements prior to land disposal for certain listed wastes and debris and media containing hazardous wastes.

The definition of a mixed waste is waste that contains both a RCRA hazardous waste and a radioactive component in one waste matrix. Mixed waste is regulated jointly by the U.S. EPA, which regulates the hazardous components and the DOE or the NRC, which regulates the radioactive component.

Importation of hazardous waste into an ISD facility from outside the AOC may trigger RCRA permitting requirements and design standards. Depending on State regulations and interpretation, importation of hazardous waste may be considered creation of a new hazardous waste disposal facility and require compliance with minimum technology requirements, location standards and permitting.

Depending on the specifics detailed in the Interagency Agreements signed by each DOE facility on the NPL or other site-specific permits, decommissioning activities can also be regulated under RCRA and not CERCLA, or an integration of both RCRA and CERCLA. If ISD is undertaken solely under RCRA, then the ISD action would have to comply with both the administrative and substantive portions of all applicable laws. Under these circumstances it is also highly recommended that the remedial alternative study do a CERCLA type ARARs/TBC review and evaluate whether additional requirements need to be implemented to meet DOE Orders and be protective of both human health and the environment.

Toxic Substances Control Act (TSCA)

This law was passed initially in 1976. Until 1976, mixtures developed and manufactured that were potentially dangerous to health or environment were not regulated. Under TSCA the U.S. EPA regulates PCBs (Polychlorinated Biphenyls), lead and asbestos. Title III Amendments to TSCA are known as the Asbestos Hazard Emergency Response Act (AHERA) of 1986, and requires schools to identify and remediate asbestos.

Polychlorinated biphenyls are a family of synthetic chlorinated aromatic hydrocarbon compounds. The most common commercial mixtures manufactured in the United States are referred to as Aroclors. PCBs possess excellent dielectric properties, which along with their chemical stability and fire resistance properties, led to their widespread use in transformers, capacitors and other electrical equipment. Other common uses included hydraulic fluids, heat transfer fluids, special purpose paints and coatings, carbonless copy paper, and plasticizers that were used in a wide variety of applications. PCBs are classified as a carcinogen. TSCA banned the manufacture of PCBs in 1979 following a highly publicized incident of rice oil poisoning in Japan.

PCBs may be found in transformers and large capacitors, and small capacitors used in equipment manufactured prior to July 1, 1979. Fluorescent light ballasts containing PCBs in their (small) capacitors and in the adhesive "potting material" may also be found in facilities selected for ISD. In addition, PCB contamination has been found in various environmental waste sites that are undergoing remediation.

Asbestos, also a TSCA regulated material, can be found in older buildings and equipment. Asbestos was commonly used as an acoustic insulator, in thermal insulation and fire proofing, in certain types of cement pipe, roof coatings and shingles, and in automobile clutch facings, brake pads and brake linings.

Since Congress passed AHERA, which requires asbestos removal from schools, many organizations, the government included, are using AHERA for guidance in general asbestos removal. U.S. EPA regulations govern risk assessment, abatement and removal of lead-based paint in housing. Inspectors and abatement contractors must be trained and certified. Most older DOE facilities have lead-based paint.

PCBs, lead and asbestos have stringent removal and disposal requirements under TSCA. Early discussion with local regulators is recommended to identify appropriate response actions to support ISD activities.

DOE O 5400.5

DOE O 5400.5, Radiation Protection of the Public and the Environment, establishes standards and requirements for operations of DOE and their contractors with respect to protection of members of the public and the environment against undue risk from radiation.

DOE O 5400.5 addresses unrestricted release of property (currently suspended) containing residual radioactive material generated during decommissioning activities.

- The release of real property (land and structures) from DOE-owned facilities and private properties shall be in accordance with the guidelines in Section IV of DOE 5400.5. Properties being sold to the public are subject to CERCLA requirements and any other applicable Federal, State, and local requirements.
- Personal property may be released for unrestricted use if results of an appropriate survey indicate that the contamination does not exceed limits in Figure IV-1 of DOE 5400.5.

These requirements are applicable to unrestricted and restricted release of materials and equipment. Release requires the consideration of removable and surface contamination (including contamination present under any coating), process knowledge (potential for contamination), survey techniques and release criteria, area accessibility, and volume contamination.

The ISD action must achieve the protective standards established under DOE 5400.5.

D.2 Other Potentially Significant Requirements

Section 3116 of the Ronald Reagan Act

> *"Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA) provides that certain waste from reprocessing spent nuclear fuel is not considered high-level radioactive waste (HLW) if the Secretary of Energy, in consultation with the Nuclear Regulatory Commission (NRC), determines that the waste meets the statutory criteria set forth in Section 3116(a)."*

Section 3116 of the NDAA would only apply to ISD performed at DOE facilities in South Carolina and Idaho that would potentially contain material or waste meeting the definition of HLW, which is a highly unlikely situation. Section 3116 (a) excludes from the definition of HLW, certain waste that would normally fall within the definition of HLW based on three criteria: The waste must have had highly radioactive radionuclides removed to the maximum extent practical, not require isolation in a deep geologic repository, and disposal and approval requirements must be based on comparison of the waste concentration to the Class C concentration limits in 10 CFR 61.55.

EPA 40 CFR 191

EPA 40 CFR 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Wastes, establishes requirements for the management and disposal of spent nuclear fuel, HLW, and TRU waste. It establishes radiation dose limits for protection of the public as a result of management and disposal of spent nuclear fuel, high level and TRU wastes. This regulation could be cited as relevant and appropriate under CERCLA for ISD actions dependent on site-specific conditions. 40 CFR 191 may apply to an ISD facility *if* it is ruled that the entombment of the facility creates a waste disposal facility, where TRU waste is planned to be disposed. On the surface this would apply if the facility contains transuranics that *could potentially exceed* the 100 nCi/g and the activity in the facility was placed there beyond the date 40 CFR 191 was initiated. *However, it is important to distinguish between the definitions of waste versus contamination when making such interpretations.*

40 CFR Part 191, §191.1, identifies the applicability of Part 191 to include:

> *"(b) Radiation doses received by members of the public as a result of the management and storage of spent nuclear fuel or high-level or TRU wastes at any disposal facility that is operated by the Department of Energy and that is not regulated by the Commission or by Agreement States."*

DOE O 451.1B

The National Environmental Policy Act Compliance Program (Ref. N-3) states that it is DOE's policy to incorporate NEPA values, to the extent practicable, in DOE documents prepared under the CERCLA. The Order establishes requirements for assessment of potential impacts of the ISD on selected components of the "human environment." ISD decisions must be analyzed under CERCLA or NEPA to ensure protection of human health and the environment.

Appendix E – Partial Crosswalk Between DOE M 435.1 and CERCLA

DOE M 435.1 General Requirements & Responsibilities		**RCRA/CERCLA**
Chapter I. l.E. (13)	Radiation Protection. Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR 835, "*Occupational Radiation Protection*," and DOE O 5400.5, *Radiation Protection of the Public and the Environment*.	SRS complies with 10 CFR 835 and the DOE Order for radiation protection of the public. 10 CFR 835 is an ARAR under CERCLA and the CERCLA risk assessment requirements address risk to human health and the environment. This requirement will be substantively met by the CERCLA process
Chapter I. l.E. (15)	Release of Waste Containing Residual Radioactive Material Processes for determining and documenting that waste is suitable to be released and managed without regard to its radioactive content shall be in accordance with the criteria and requirements in DOE 5400.5, *Radiation Protection of the Public and the Environment.*	CERCLA process will determine disposal path for waste. Any waste that is destined for off-SRS disposal must be fully characterized for both chemical and radionuclide concentration. Any waste remaining will be considered in the CERCLA Risk Assessment. This requirement will be substantively met by the CERCLA process.
Chapter III.	**Transuranic Waste Requirements**	
Chapter III.A	Definition of Transuranic (TRU) Waste. TRU waste is radioactive waste containing more than 100 nanocuries of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) High-level radioactive waste; (2) Waste that the Secretary of Energy has determined, with the concurrence of the EPA, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; (3) Waste that the Nuclear Regulatory Commission (NRC) has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.	General definition that applies to all DOE facilities and DOE radioactive waste. Waste characterization will require determination of whether radiological contaminated waste is low level or TRU. This requirement will be substantively met by the CERCLA process. If TRU contaminated areas or equipment is to be left within an entombed facility, appropriate approvals must be obtained. This could potentially delay or impact a ROD milestone as the approval would be required prior to the ROD approving the in situ alternative.
Chapter III.G	Waste Acceptance. (1) Waste acceptance requirements for all TRU waste storage, treatment, or disposal facilities, operations, and activities shall specify: (a) Allowable activities and/or concentrations of specific radionuclides; (b) Acceptable waste form and/or container requirements (c) Restrictions or prohibitions on waste, materials, or containers that may adversely affect waste handlers or compromise facility or waste container performance;	All ISD activities will involve extensive waste characterization. The CERCLA risk assessment process will evaluate current risks, and remedial goal objectives that will be protective of human health and the environment. ISD alternatives evaluated will identify acceptable waste forms, quantities, containers or other requirements that will impact long-term performance. This requirement will be substantively met by the CERCLA process. ISD facilities will not allow importation of TRU waste.

DOE M 435.1 General Requirements & Responsibilities		**RCRA/CERCLA**
Chapter III.I	Waste Characterization. TRU waste shall be characterized using direct or indirect methods, and the characterization documented. (2) Minimum Waste Characterization. Characterization data shall, at a minimum, include the following information relevant to the management of the waste: (a) Physical and chemical characteristics; (b) Volume, including the waste and any stabilization or absorbent media; (c) Weight of the container and contents; (d) Identities, activities, and concentrations of major radionuclides; (e) Characterization date; (f) Generating source; (g) Packaging date; and (h) Any other information which may be needed to prepare and maintain the disposal facility PA or demonstrate compliance with applicable performance objectives.	The CERCLA process provides a description of the waste, nature, and extent of contamination, along with the risks posed by the facility. Much of this information is needed to perform the Baseline Risk Assessment and evaluation of remedial options. This requirement will be substantively met by the CERCLA process for any TRU contaminated equipment or areas within an ISD facility.
Chapter III.J	Waste Certification. A waste certification program shall be developed, documented, and implemented. (1) Certification program shall designate the officials who have the authority to certify and release waste for shipment; and specify what documentation is required for waste generation, characterization, shipment, and certification. (2) TRU waste shall be certified as meeting waste acceptance requirements before it is transferred to the facility receiving the waste. (3) TRU waste that has been certified as meeting the waste acceptance requirements for transfer to a storage, treatment, or disposal facility shall be managed to maintain its certification status.	If TRU waste is to be transferred offsite to a storage, treatment, or disposal facility, compliance with this section is required. Any TRU waste that is stored at the CERCLA site will be managed to maintain its certification status.
Chapter III.K	Waste Transfer. (1) TRU waste shall not be transferred to a storage, treatment, or disposal facility until personnel responsible for the facility receiving the waste authorize the transfer. (2) Waste characterization data, container, generation, storage, treatment, and transportation information for TRU waste shall be transferred with or be traceable to the waste.	If TRU waste is to be transferred offsite to a storage, treatment, or disposal facility, compliance with this section is required.

DOE M 435.1 General Requirements & Responsibilities		RCRA/CERCLA
Chapter III.L	Packaging and Transportation. (1) Packaging. (a) TRU waste shall be packaged in a manner that provides containment and protection for the duration of the anticipated storage period and until disposal is achieved or until the waste is removed from the container. (b) Vents or other mechanisms to prevent pressurization of containers or generation of flammable or explosive concentrations of gases shall be installed on containers of newly-generated waste at the time the waste is packaged. Containers of currently stored waste shall meet this requirement as soon as practical unless analyses demonstrate that the waste can otherwise be managed safely. (c) When TRU waste is packaged, defense waste shall be packaged separately from non-defense waste, if feasible. (d) Containers of TRU waste shall be marked such that their contents can be identified.	If TRU waste is to be transferred offsite to a storage, treatment, or disposal facility, compliance with this section is required.
Chapter III.N	Storage. (1) Storage Prohibitions. TRU waste in storage shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water. Prior to storage, pyrophoric materials shall be treated, prepared, and packaged to be nonflammable. (2) Storage Integrity. TRU waste shall be stored in a location and manner that protects the integrity of waste for the expected time of storage and minimizes worker exposure. (3) Container Inspection. A process shall be developed and implemented for inspecting and maintaining containers of TRU waste to ensure container integrity is not compromised.	Any TRU material or waste stored at the ISD facility or project should meet this requirement.
Chapter III.O	Treatment. TRU waste shall be treated as necessary to meet the waste acceptance requirements of the facility receiving the waste for storage or disposal.	If TRU waste is to be transferred offsite to a storage or disposal facility, compliance with this section is required.
Chapter III.P	Disposal. TRU waste shall be disposed in accordance with the requirements of 40 CFR Part 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and TRU Radioactive Wastes.	If TRU waste is to be disposed of 40 CFR Part 191 is an ARAR under CERCLA. If TRU waste is to be disposed of offsite, compliance with 40 CFR 191 is required by the receiving disposal site, most likely WIPP.

DOE M 435.1 General Requirements & Responsibilities		RCRA/CERCLA
Chapter III.Q	Monitoring. (1) All Waste Facilities. Parameters that shall be sampled or monitored, at a minimum, include: temperature, pressure (for closed systems), radioactivity in ventilation exhaust and liquid effluent streams, and flammable or explosive mixtures of gases. Facility monitoring programs shall include verification that passive and active control systems have not failed. (2) Stored Wastes. All TRU wastes in storage shall be monitored, as prescribed by the appropriate facility safety analysis, to ensure the wastes are maintained in safe condition. (3) Liquid Waste Storage Facilities. For facilities storing liquid TRU waste, the following shall also be monitored: liquid level and/or waste volume, and significant waste chemistry parameters.	If an ISD project will contain TRU waste or contamination, specific requirements will have to be established by agreement with the regulators. Prior to the ISD action, any TRU waste or material inside the facility should be monitored to ensure that it is maintained in a safe condition.
Chapter IV	**Low-Level Waste (LLW) Requirements**	
Chapter IV.A.	Definition of LLW. Low-level radioactive waste is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, TRU waste, byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.	General definition that applies to all DOE facilities and DOE radioactive waste. Waste characterization will require determination of whether radiological contaminated waste is low level or TRU. This requirement will be substantively met by the CERCLA process.
Chapter IV.G	Waste Acceptance. (1) Waste acceptance requirements for all low-level waste storage, treatment, or disposal facilities, operations, and activities shall specify: (a) Allowable activities and/or concentrations of specific radionuclides; (b) Acceptable waste form and/or container requirements; (c) Restrictions or prohibitions on waste, materials, or containers that may adversely affect waste handlers or compromise facility or waste container performance; (d)… (4) LLW must not contain, or be capable of generating by radiolysis or biodegradation, quantities of toxic gases, vapors, or fumes harmful to the public or workers or disposal facility personnel, or harmful to the long-term structural stability of the disposal site. (2) Evaluation and Acceptance. The receiving facility shall evaluate waste for acceptance, including confirmation that the technical and administrative requirements have been met. A process for the disposition of non-conforming wastes shall be established.	All ISD activities will involve extensive waste characterization. The CERCLA risk assessment process will evaluate current risks, and remedial goal objectives that will be protective of human health and the environment. ISD alternatives evaluated will identify acceptable waste forms, quantities, containers or other requirements that will impact long-term performance. This requirement will be substantively met by the CERCLA process, unless LLW is brought into the ISD facility from outside the area of contamination. If LLW is imported from elsewhere on site, it would be considered creation of a new waste disposal facility and additional waste acceptance criteria may be required to meet this section.

DOE M 435.1 General Requirements & Responsibilities		**RCRA/CERCLA**
Chapter IV.I	Waste Characterization. LLW shall be characterized using direct or indirect methods. (2) Minimum Waste Characterization. Characterization data shall, at a minimum, include the following information relevant to the management of the waste: (a) Physical and chemical characteristics; (b) Volume, including the waste and any stabilization or absorbent media; (c) Weight of the container and contents; (d) Identities, activities, and concentrations of major radionuclides; (e) Characterization date; (f) Generating source; and (g) Any other information which may be needed to prepare and maintain the disposal facility PA, or demonstrate compliance with applicable performance objectives.	The CERCLA process provides a description of the waste, nature and extent of contamination, along with the risks posed by the facility. Much of this information is needed to perform the Baseline Risk Assessment and evaluation of remedial options. This requirement will be substantively met by the CERCLA process.
Chapter IV.J	Waste Certification. A waste certification program shall be developed, documented, and implemented to ensure that the waste acceptance requirements of facilities receiving LLW for storage, treatment, and disposal are met. (1) The waste certification program shall designate the officials who have the authority to certify and release waste for shipment; and specify what documentation is required for waste generation, characterization, shipment, and certification. (2) LLW shall be certified as meeting waste acceptance requirements before it is transferred to the facility receiving the waste. (3) Maintaining Certification. LLW that has been certified as meeting the waste acceptance requirements for transfer to a storage, treatment, or disposal facility shall be managed to maintain its certification status.	If LLW is to be transferred offsite to a storage, treatment, or disposal facility, compliance with this section is required, as would normally be the case for the site waste management operation. Any LLW that is certified and stored at the CERCLA site prior to transfer will be managed to maintain its certification status.
Chapter IV.K	Waste Transfer. (1) LLW shall not be transferred to a storage, treatment, or disposal facility until personnel responsible for the facility receiving the waste authorize the transfer. (2) Waste characterization data, container information, and generation, storage, treatment, and transportation information for LLW shall be transferred with or be traceable to the waste.	If LLW is to be transferred offsite to a storage, treatment, or disposal facility, compliance with this section is required, as would normally be the case for the site waste management operation.

DOE M 435.1 General Requirements & Responsibilities		RCRA/CERCLA
Chapter IV.L	Packaging and Transportation. (1) Packaging. (a) LLW shall be packaged in a manner that provides containment and protection for the duration of the anticipated storage period and until disposal is achieved or until the waste has been removed from the container. (b) When waste is packaged, vents or other measures shall be provided if the potential exists for pressurizing or generating flammable or explosive concentrations of gases within the waste container. (c) Containers of low-level waste shall be marked so that their contents can be identified.	If LLW is to be transferred offsite to a storage, treatment or disposal facility, compliance with this section is required, as would normally be the case for the site waste management operation.
Chapter IV.N	Storage and Staging. (1) LLW in storage shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water. Prior to storage, pyrophoric materials shall be treated, prepared, and packaged to be nonflammable. (3) Storage Integrity. LLW shall be stored in a location and manner that protects the integrity of waste for the expected time of storage and minimizes worker exposure. (5) Container Inspection. A process shall be developed and implemented for inspecting and maintaining containers of LLW to ensure container integrity is not compromised. (6) Storage Management. LLW storage shall be managed to identify and segregate LLW from mixed LLW. (7) Staging. Staging of LLW shall be for the purpose of the accumulation of such quantities of waste as necessary to facilitate transportation, treatment, and disposal.	Any LLW stored at a CERCLA site should meet this requirement, as would normally be the case for the site waste management operation
Chapter IV.O	LLW treatment to provide more stable waste forms and to improve the long-term performance of a LLW disposal facility shall be implemented as necessary to meet the performance objectives of the disposal facility.	The remedial alternative evaluation and selection process performed under CERCLA will meet this substantive requirement.

DOE M 435.1 General Requirements & Responsibilities		RCRA/CERCLA
Chapter IV.P	Disposal. (a) Dose to representative members of the public shall not exceed 25 mrem in a year TEDE from all exposure pathways, excluding the dose from radon and its progeny in air. (b) Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny. (c) Release of radon shall be less than an average flux of 20 pCi/m^2/s (0.74 Bq/m^2/s at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/1 (0.0185 Bq/l) of air may be applied at the boundary of the facility. (3) Composite Analysis (CA). For disposal facilities which received waste after September 26, 1988, a site-specific radiological CA shall be prepared and maintained that accounts for all sources of radioactive material that may be left at the DOE site and may interact with the low-level waste disposal facility, contributing to the dose projected to a hypothetical member of the public from the existing or future disposal facilities. Performance measures shall be consistent with DOE requirements for protection of the public and environment and evaluated for a 1,000-year period following disposal facility closure. The CA results shall be used for planning, radiation protection activities, and future use commitments to minimize the likelihood that current low-level waste disposal activities will result in the need for future corrective or remedial actions to adequately protect the public and the environment. (4) PA and CA Maintenance. Additional iterations of the PA and CA shall be conducted as necessary during the post-closure period. (6) Disposal Facility Operations. (a) Operating procedures shall be developed and implemented for LLW disposal facilities that protect the public, workers, and the environment; ensure the security of the facility; minimize subsidence during and after waste emplacement; achieve long-term stability and minimize the need for long-term active maintenance; and meet the requirements of the closure/ post-closure plan. (b) Permanent identification markers for disposal excavations and monitoring wells shall be emplaced. (c) LLW placement into disposal units shall minimize voids between waste containers. Voids within disposal units shall be filled to the extent practical. Uncontainerized bulk waste shall also be placed in a manner that minimizes voids and subsidence.	Dose to members of the public and release of radon requirements could be considered TBCs under CERCLA and cited as cleanup goals. It is anticipated that PA requirements will be met by the CERCLA risk assessment process. For example, at SRS groundwater must meet the Safe Drinking Water Act MCLs, which will generally be more restrictive than the 25 mrem TEDE. However, a comprehensive CA is not required under CERCLA and may already include all the radiological material so additional work may not be required. Confirmation that the radiological material has been adequately considered in the relevant CA is necessary for compliance with DOE O 435.1. It is possible that a review of site documents may indicate that a revised CA considering an updated source term may be required. For example, during Area Closure at SRS, information obtained under CERCLA would identify all other sources of potential cumulative radiological doses to the public and meet the intent of the CA. However, if the ISD facility is within an area that will remain active, all current and future potential sources of radiological dose to the public will require evaluation. The CA requirement may NOT be substantively met in CERCLA because CERCLA models the current condition of the facility. Addressing this requirement will require DOE Headquarters involvement that must be factored into the CERCLA documentation schedule. The CERCLA risk assessment process is risk-based and includes radiological and chemical contaminants. The CA is dose based and considers only radiological components. Converting dose to risk is not generally a straightforward accepted practice and may require additional work. CERCLA remedies must achieve a risk within the 10^{-4} to 10^{-6} risk range. Depending on the radionuclides present, some ISD remedies that meet the DOE dose requirements may not be acceptable to CERCLA.

DOE M 435.1 General Requirements & Responsibilities		RCRA/CERCLA
Chapter IV.Q	Closure. (2) Disposal Facility Closure. (a) Prior to facility closure, the final inventory of the LLW disposed in the facility shall be prepared and incorporated in the PA and CA which shall be updated to support the closure of the facility. (c) Institutional control measures shall be integrated into land use and stewardship plans and programs, and shall continue until the facility can be released pursuant to DOE 5400.5, Radiation Protection of the Public and the Environment. (d) The location and use of the facility shall be filed with the local authorities responsible for land use and zoning.	(2) (c) and (d) This requirement will be substantively met by the CERCLA process which requires 5-year reviews if waste is left in place and restricts land use. Long term institutional controls and land use restrictions will be part of the CERCLA post-closure requirements and land use control implementation plan.
Chapter IV.R	Monitoring. (1) All Waste Facilities. Parameters that shall be sampled or monitored, at a minimum, include: temperature, pressure (for closed systems), radioactivity in ventilation exhaust and liquid effluent streams, and flammable or explosive mixtures of gases. Facility monitoring programs shall include verification that passive and active control systems have not failed. (3) Disposal Facilities. (a) The site-specific PA and CA shall be used to determine the media, locations, radionuclides, and other substances to be monitored. (b) The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters which may affect long-term performance. (c) The environmental monitoring programs shall be capable of detecting changing trends in performance to allow application of any necessary corrective action prior to exceeding the performance objectives in this Chapter.	This requirement will be substantively met by the CERCLA process which requires 5-year reviews if waste is left in place and restricts land use. Monitoring to ensure the remedy is still protective after closure is required by the CERCLA post-closure operation and maintenance plans approved by EPA and SC at SRS. The continued protectiveness must be evaluated as a component of the 5 Year ROD review and the report will be available to the public and approved by both EPA and the State.

Appendix F – Needs Statements from the ISD Technology Workshop

Need 1: In-Tank Characterization with Isotopic Discrimination

Need

The ability to perform in-tank characterization with isotopic discrimination would provide timely data for project planning and decision making.

Justification

There are hundreds of tanks and sumps that require characterization prior to closure. Current protocols require mixing of tank liquids and sludge and retrieving multiple samples for laboratory analysis. The cost can be as much as $200,000 per sample. Also, turnaround time for sample analysis can be several weeks. Sampling of sumps follows a similar approach.

Technical Approach

The objective of this task is to use an integrated systems approach to develop and demonstrate field deployable in situ characterization technologies that can be deployed in tanks or sumps to determine total radiation levels and determine the specific isotopic content.

Identify and demonstrate technologies and approaches that can be used to characterize liquids and sludge remaining in tanks and sumps:

- Identify candidate tanks and/or sumps for demonstration of potential characterization technologies
- Identify and evaluate possible in situ characterization technologies that meet the specific conditions and requirements of identified tanks and/or sumps
- Evaluate readiness of technologies for site-specific field deployment
- Demonstrate selected technologies in targeted tanks/sumps
- Document cost and performance data

Task Identification

Identify Demonstration Site and Performance Criteria: Identify the tank(s) and/or sump(s) for demonstration of the selected technology (ies) and the operating and performance criteria for the technology (ies) to be demonstrated. The initial demonstration may be in a tank or sump that has been previously characterized. This would help limit the cost of site support and provide quality data for comparison of the demonstration results.

Technology Identification and Assessment: Identify the technologies suitable to meet site specified operating and performance criteria and assess the readiness of those technologies for field deployment.

Identify commercially available in situ characterization technologies, their ability to meet specified criteria, and any additional development or engineering needed.

Field Demonstration: Conduct field demonstration of selected technology in one or more tanks and/or sumps.

Report: Document cost and performance data for field demonstration. Complete draft and final report documenting the cost and performance data from the technology demonstration.

Need 2: Assessment of the State-of-the-Art for Field Deployment Systems for Difficult COCs

Need

Field instruments that require introduction of a sample are available for most Contaminants of Concern (COCs). The real interest is in remote sensing to find and quantify amounts of COCs.

Justification

Providing remote access for sensors would provide accurate contaminant classification while improving worker safety by reducing proximity risk.

Technical Approach

The objective of this task is to provide remote sensor capability for difficult COCs that are important from a risk or Performance Assessment (PA) perspective. These COCs of interest often include:

- Low-energy, longer-lived radionuclides
- Special nuclear materials (SNM) in situ (inside equipment, inside pipes embedded in walls and floors)
- SNM in high radiation environments
- RCRA metals (e.g., Be)

This technical assessment should include how DOE sites are currently handling sampling, indicator species, and isotopes ratios for quantification of these COCs.

Task Identification

Identify demonstration site and performance criteria: Identify the project sites with typical remote access needs for demonstration of the selected technology (ies) and the operating and performance criteria for the technology (ies) to be demonstrated. The initial demonstration may be at a site that has been previously characterized. This would help limit the cost of site support and provide quality data for comparison of the demonstration results.

Technology Identification and Assessment: Identify the technologies suitable to meet site specified operating and performance criteria and assess the readiness of those technologies for field deployment.

Identify commercially available in situ characterization technologies, their ability to meet specified criteria, and any additional development or engineering needed.

Field Demonstration: Conduct field demonstration of selected technology in one or more tanks and/or sumps.

Report: Document cost and performance data for field demonstration. Complete draft and final report documenting the cost and performance data from the technology demonstration.

Need 3: Degradation Rates and Sorption Behavior

Objective

The objective of this task is to obtain realistic and technically justifiable estimates of 1) degradation/ corrosion rates for the various engineered materials associated with ISD facilities, and 2) sorption coefficients, solubilities, etc. for long-lived radionuclides in various structural materials and possible fill materials. Better estimates of these parameters will greatly reduce the uncertainties in the contaminant transport models.

Background

Activated stainless steel contains much of the activation product inventory in reactor buildings and other radiological facilities; therefore a key need is to obtain a set of corrosion rates for stainless steel that is exposed to air, water, and grout environments. Additional materials for which degradation/corrosion rates are desired include:

- Carbon steel (contaminant source)
- Concrete (contaminant source)
- Oxidized grout (possible fill material)
- Reduced grout (possible fill material)

It is also desired to obtain improved sorption coefficients (K_ds), solubilities, etc. for selected radionuclides, in concrete and in materials being considered for fill. Elements which may benefit from additional study include Ag, C, Cl, I, Ni, Nb, Mo, Tc, U, and TRU

Estimated rates must be applicable to specified chemical environments.

Technical Approach

For both the degradation/corrosion issue and the contaminant chemistry problem, materials must be considered with respect to a specified surrounding chemical environment. Studies are needed for the situations listed below.

Degradation/corrosion of steel or concrete in contact with:

- aerated water
- anoxic water
- soil
- grout

Contaminant chemical behavior in:

- soil
- grout (oxidized or reduced)
- fly ash
- other possible amendments

For concrete, considerations of degradation rate should include estimates of the extent to which contaminant transport via fracture flow might be important, relative to transport by pervasive flow.

Task Identification

Identify Appropriate Experiments.

Consult with stakeholders to identify the most important needs with respect to degradation/corrosion rates and chemistry.

Identify the methods and experimental set-ups (laboratory or field) that would lead to the best estimates of the desired degradation/corrosion rates and sorption coefficients, solubilities, etc. Because of the long time frames associated with these parameters, applicable acceleration methods must be considered.

Retardation Technology Identification and Assessment: Identify the technologies that explore the extent to which the degradation/corrosion of contaminated materials could be retarded by altering their chemical environments with coatings, jackets, or surrounding them with other, non-traditional materials.

Report: Document the finding in technical reports and/or peer-reviewed journals.

Need 4: Long Term Materials Performance Studies

Need

Well defined long-term (greater than 500 years) performance data for Portland cement-based materials.

Justification

The ISD end-state is a viable option for disposition of contaminated robust concrete structures. The current practice for the preparation of these structures for ISD is to fill them with grout to immobilize remaining contaminants. The basis for this costly practice has come under question; a better understanding of the long-term performance of the concrete materials (in terms of providing both containment and stability) may enable removal of conservatisms from modeling assumptions that drive costly ISD implementation approaches.

Technical Approach

The objective of this task is to conduct long-term performance studies on Portland cement-based materials to provide a better understanding of their long-term behavior in the anticipated environment(s) for ISD projects.

The study will focus on Portland cement-based materials used in the construction of the candidate facilities, as well as the grout materials used for filling these structures. Tests will be designed to determine the performance period where these materials can safely and effectively maintain structural stability and/or containment of contaminants.

This work should be coordinated to supplement (and draw on the lessons learned from) related work being conducted by the Cementitious Barriers Partnership Project.

Close cooperation (needs, technical issues and resources and funding) among EM-23, EM-21 and EM-11 is recommended because all of these organizations have projects that involve cementitious barriers for radionuclide containment. EM-21 established the Cementitious Barriers Partnership Project, (CBP) in 2008 to address long-term performance needs of these materials. The CBP is a multi-disciplinary, multi-institution cross cutting collaborative effort supported by the US Department of Energy (DOE) to develop a reasonable and credible set of tools to improve understanding and prediction of the structural, hydraulic and chemical performance of cementitious barriers used in nuclear applications. The period of performance is >100 years for operating facilities and > 1000 years for waste management.

The CBP partners, in addition to the US DOE, are the U.S. Nuclear Regulatory Commission (NRC), the National Institute of Standards and Technology (NIST), SRNL, Vanderbilt University (VU)/Consortium for Risk Evaluation with Stakeholder Participation (CRESP), Energy Research Center of the Netherlands (ECN), and SIMCO, Technologies, Inc.

The project focus includes reducing uncertainties associated with current methodologies for assessing cementitious barrier performance and increasing the consistency and transparency of the assessment process. The results of this project will support long-term performance predictions and performance-based decision making and are applicable to several of the strategic initiatives in the DOE Environmental Management Engineering & Technology Roadmap.

Task Identification

The study should be conducted on representative material samples in simulated environments to define the performance period for the materials. Close coordination with the Cementitious Barriers Partnership Project should be employed to prevent duplication of effort and to help define the investigation approach. The major steps in the study would include:

- Identify cementitious materials (i.e., foundation, wall, slab, and above-grade reinforced concrete structure members) representative of candidate ISD structures that should be evaluated.
- Identify the characteristics of the physical environments that these materials will be exposed to during the ISD lifetime.
- Define the parameters that will be used to quantify the performance (in terms of providing contaminant containment and providing structural stability) of these materials.
- Conduct simulated "aging" tests to determine the performance characteristics of the materials in the various environments. The objective being to identify at what point(s) in time do the materials a) loose their ability to provide effective containment of contaminants, and b) loose their ability to maintain structural integrity and eventually collapse.
- Confirm the results through computer modeling. Confer with the Cementitious Barriers Partnership Project as needed.
- Document the findings in a report.

Need 5: Release of Activation Products from Corroded Stainless Steel

Need

Define the release mechanism and release rates for activation products from corroded carbon steel and stainless steel components. Provide parameters for use in performance assessments (phase changes and phase volumes, solubility, K_ds, etc.)

Justification

A better understanding of the release mechanism for activation products from corroded carbon and stainless steel is needed to quantify the source term used in release calculations for ISD projects. More accurate predictions of the amount that will be released and the time frame for the release may enable a reduction in the conservatism in modeling assumptions thus allowing implementation of more streamlined and cost-effective "engineered" measures.

Technical Approach

The objective of this task is to conduct material science studies on activated or surrogate activated carbon steel and stainless steel specimens to provide a better understanding of the manner and timing in which activation products are released from these materials.

Simulated material studies, similar to the work conducted by the U.S. NRC to support the licensing of High Integrity Containers for LLW burial, should be conducted to provide the necessary data.

Task Identification

The study should be conducted on representative material samples in simulated environments to define the release mechanisms. The major steps in the study would include:

- Identify stainless and carbon steel specimens representative of equipment typically found in candidate ISD structures that should be evaluated. If feasible, obtain actual coupon samples from existing components (i.e., reactor vessel, canyon process tank, etc.).

- Identify the characteristics of the physical environments that these materials will be exposed to during the ISD lifetime.
- Design the tests to simulate the aging process in the expected ISD environments. Parallel tests should be conducted with the specimens encased in grout to understand the affects of grout chemistry on the release mechanisms.
- Conduct the tests. The objective being to establish an activation product release profile over time.
- Document the findings in a report.

Need 6: Design Guide for Sealing/Filling ISD Facilities

Need

Develop guidance for the identification of strategies, functional requirements and designs for fill and seal of ISD facilities.

Justification

Most, if not all, ISD facilities will be sealed and filled to some degree. This is a significant and critical design issue that determines the degree of certainty by which contaminants remaining in the closed facility will remain sequestered and for how long. This decision making appears to occur on a case-by-case basis dependent on the local regulatory environment and the experience of the D&D personnel involved.

Technical Approach

Designs are needed for both sealing and filling. Generic performance and functional requirements need to be specified/identified to allow the designer to prepare material specifications and drawings. These requirements need to be aligned with generic hazards and specify a preferred sequence of hazard identification versus engineered control. A flow sheet or “design guide” would be beneficial to a designer/engineer tasked with preparing a facility for ISD.

‘Classes’ of ISD targeted facilities should be identified based on facility structural integrity, design characteristics and level/type of contamination to be left behind during ISD (e.g. short vs. long lived isotopes). Relationships among the integrity of the existing structure and the required duration of hazard isolation should be developed to identify the extent and rigor of mitigating measures to be required through seal and fill technologies. From these criteria, guidance can be developed to ensure that appropriate, but not excessive, design requirements can be identified for facilities to be decommissioned in situ.

Task Identification

- Develop criteria for identifying classes of facilities destined for ISD within the Complex.
- Based on results of ongoing surveys, classify all facilities into appropriate categories.
- Determine commonalities among hazard exposure pathways, source of contaminants, pathways of release from the facility, and timing of release.
- Identify sealant materials that ensure reliable containment against the contaminant and throughout the required containment interval.
- Identify fill materials that provide required properties of:
  - Structural fill or support

  - Hydrologic containment
  - Contaminant stabilization
- Develop guidance document and guides identification of design requirements and recommended materials for sealing and filling of ISD facilities.

Need 7: Seal/Fill Material 'Toolbox'

Need

Information on and examples of fill material (mix designs and properties) and sealing materials (products and properties) that meet typical requirements for ISD applications with supporting documentation for use by designers and systems engineers (alternatives studies) across the DOE Complex.

More specifically the need for two "Toolbox" documents which summarize the information listed below was identified in the In situ Decommissioning Technology Workshop at Savannah River National Laboratory:

Fill Material Toolbox

- Functional performance requirements for infills and backfills
- Generic or typical fill materials which meet the placement and cured requirements
- Properties of types of fill materials
- Long-term performance and property evolution of fills over long times (emphasis on Portland cement-based fills)
- Production and placement requirements of various types of fills
- Non-radioactive construction experience using various types of fills
- Pros and cons comparison of the types of fills

Sealing/Fixative Materials Toolbox

- Sealing material needs/requirements for objects and buildings, i.e., openings in the buildings themselves (doors, ventilation ducts, electrical and water lines, joints, cracks, etc.)
- Fixative material needs/requirements for activities that support ISD activities including to: facilitate particulate consolidation and removal, fix contaminants during ISF operations or address other short or long term need
- Functional performance requirements of sealants for crack repair and for fixative materials
- Typical sealants and fixative materials (specific examples of commercially available materials).
- Properties of types of sealants and fixative materials
- Performance and property evolution of sealants and fixative materials over time and under relevant expected conditions
- Production and placement requirements of various types of sealants and fixative materials
- Non-radioactive construction experience using various types of sealants and fixative materials
- Pros and cons comparison of the types of sealants and fixative materials

Opportunities for enhancing performance of the various types of fill should be addressed, as well as areas for near-term (1-3 years) and long-term (1-4 years) testing to reduce performance assumptions.

Justification

A materials tool box for ISD activities is necessary for planning, designing, and performing ISD activities.

Hundreds of thousands of cubic meters of infill and back fill materials will be used for ISD at the SRS and considerably more will be used in throughout the DOE Complex.

Fixing contaminants for removal and/or to reduce personnel exposure and spread of contamination during ISD activities is essential.

Sealing openings to buildings (doors, ventilation ducts, electrical and water lines, structural joints and cracks, as well as assessing moisture transport through intact walls is an essential part of ISD projects.

Technical Approach

The technical approach consists of:

- Identifying generic and typical ISD applications and requirements for fills, sealing materials, and fixatives based on experience and projects in the DOE Complex.
- Conducting a literature review of: fill, sealing, and fixative materials used for ISD and related activities and to compile the information in a "Toolbox" document format for use by designers and systems engineers (alternatives studies) across the DOE Complex.

Task Identification

Sealing Materials "Toolbox"

- Identify information resources: Sources of information include: publications from the DOE sites and communication with project managers and technical experts in the DOE Complex.
- Identify ISD activities and material needs and performance requirements
- Identify materials that have been or are planned to be used for ISD applications
- Compile and summarize the information
- Prepare Draft Report, Incorporate Comments, and Issue Final Report

Fill Materials "Toolbox"

- Identify information resources: Sources of information include: publications from the DOE sites and communication with project managers and technical experts in the DOE Complex.
- Identify ISD activities and material needs and performance requirements
- Identify materials that have been or are planned to be used for ISD applications
- Compile and summarize the information
- Prepare Draft Report, Incorporate Comments, and Issue Final Report

Need 8: Energy and Environmentally Responsive Fill Material Designs

Need

Leadership in Energy and Environmental Design (LEED) for high volume ISD fill materials.

Justification

The high volume of infill and back fill materials that will be used for the 100,000's of cubic material used in the DOE ISD projects warrants LEED consideration. DOE is heavily invested in LEED technology to reduce carbon emissions and the use of fossil fuels.

Technical Approach

The technical approach consists of identifying a base case(s) for fill materials that meets the requirements for bulk fill and using standard LEED practices for:

- Assessing the carbon emissions and fossil fuels consumption involved in producing these materials
- Identifying alternatives or options for reducing the fossil fuel consumption and carbon emissions involved in producing these materials.

The U.S. Green Building Council LEED practices will be applied where applicable. If they are inadequate for capturing the full carbon emissions, fossil fuel consumption, innovative approaches need to be developed and calculation expanded.

Task Identification

- Identify reference case fill materials for evaluation.
- Evaluate carbon emissions and fossil fuel use for production and placement of the reference case(s).
- Develop alternative lower carbon emissions and fossil fuel use options.
- Compile and summarize the information
- Prepare Draft Report, Incorporate Comments, and Issue Final Report
- Publicize DOE ISD LEED activities.

Need 9: Design Monitoring Into ISD Facility

Need

A monitoring system should be developed that would demonstrate whether the ISD performance meets program goals and conforms to project planning predictions.

Justification

The early design and implementation of a comprehensive monitoring scheme for an ISD structure is seen as a benefit in the near term (20 to 50 years) to demonstrate that the ISD design is functioning as planned to isolate the source term. A series of robust sensors distributed throughout the facility could provide time dependent information about performance, thus helping to validate the modeling assumptions and structural performance.

Technical Approach

The parameters in the Table 10 would need to report out to a control panel, exterior to the facility, that could be visited periodically (e.g., annually to start then growing into part of the CERCLA required 5 year inspection) and the data download. The monitors would be installed in the ISD facility as part of the project work with some duplication of function to allow the data to provide a picture of how the source term confinement is performing over time.

- The sensors would be buried/installed throughout the structure, in duplicate/triplicate in most cases.
- The design operating life of the sensor and download interface should be at least 50 years, but longer would clearly be a preference.
- Must be passive with exterior power source (energized when collecting data only is preferred).

- Numerical output/quantitative data is most useful for the monitored parameters. One time sensors can provide information when collecting quantitative data is not possible.
- Standardized interface for collected data is critical and should be able to be updated without entry to the facility or access to the sensor.

Table 10 – ISD Facility Monitoring Concepts

Parameter to be Monitored	Data use for demonstrating ISD Performance
Strain and Stress	Materials structural failure, cracking, settling
Subsidence	Indicate subsidence by placing targets on the surface of the building
Oxygen	Aid in the identification of overall corrosion potential and geochemical environment.
pH	Identify presence of water, corrosivity, metal corrosion, cementitious materials degradation and geochemical environment can aid in the overall corrosion potential/progress.
Electrical Conductivity	Identify presence of water, the amount of soluble materials, the geochemical environment, or carbonation can aid in the overall corrosion potential/progress.
Temperature	Can be an indicator of water movement
Moisture	Identify the presence of water or in leakage to the structure.
Gamma Radiation	Monitor any change (up or not down as expected based on decay) within the structure to assess movement of the source term.
Sulfate	Monitor increase in sulfates as an indicator of infiltration
Corrosion Potential	Status of steel reinforcement bars and corrosion of metal structures
Acoustic change	Provides information on cracking and water infiltration

Task Identification

Identify demonstration site and performance criteria: Identify the project site(s) for demonstration of the selected sensor technology(ies) and the operating and performance criteria for the technology(ies) to be demonstrated. The candidate sites do not need to be exclusively in situ, only appropriate for demonstrating the sensor capabilities in satisfying the monitoring program goals. Where sensor objectives are unique to in situ conditions, selected demonstration sites should reflect those conditions.

Technology Identification and Assessment: Identify the technologies suitable to meet site specified operating and performance criteria and assess the readiness of those technologies for field deployment.

Identify commercially available in situ sensor technologies, their ability to meet specified criteria, and any additional development or engineering needed.

Field Demonstration: Conduct field demonstration of selected technology in one or more locations.

Report: Document cost and performance data for field demonstration. Complete draft and final report documenting the cost and performance data from the technology demonstration.

Need 10: Measures to Improve Communication of Risk Assessment Modeling Approaches, Data and Lessons Learned

Need

The ability to have access to Complex-wide experience, data and modeling tools, and lessons learned to support risk assessments for facility closure and ISD. Note that this need discussion is focused on risk assessment aspects, but such a system could also be used to share information related to another need identified at the ISD Workshop.

Technical Justification

Senior management in DOE-EM have recognized risks associated with inconsistencies in modeling approaches and assumptions being applied at individual DOE Sites and Complex-wide. Also, as more challenging closure projects are being addressed, it is becoming necessary to use more complex models than are typically used for CERCLA risk assessments. Experience with more complex modeling approaches and data used for performance assessments for disposal facilities and tank closures can be shared with those conducting assessments for ISD. Furthermore, modeling approaches and data from ISD at one facility can be shared with those responsible for ISD of other facilities. Fostering a means to efficiently share information provides for more cost effective and robust modeling in support of ISD and will help to reduce the potential for significant inconsistencies in modeling approaches.

This activity is not unique to ISD and has also been discussed in the context of Performance Assessments being conducted for disposal facilities, tank closures and risk modeling being conducted in support of NEPA, CERCLA, RCRA, etc. In this respect, there may be opportunities for shared funding across different programs.

Technical Approach

The objective of this task is to develop a means to upload, organize, and disseminate information that would be useful for people conducting risk assessments in support of ISD. The types of information to be maintained could include: parameter values used in assessments, listing of available experimental data, modeling approaches, lessons learned, computer codes, subject matter experts, regulator preferences, analysis needs, links to key websites, etc. It has been suggested that such a system could be constructed in a manner similar to Wikipedia, where individuals would be able to load information onto the system. Pros and cons of this concept will need to be discussed. Initially, the system may simply include a number of reports that are categorized based on the information that can be obtained. In the future, the possibility of extracting information from reports and consolidating information from a variety of sources into a structured database could be considered. The need for and level of effort associated with reviews of different types of information to be included in the system would be assessed as part of the project.

Task Identification

This information system would be developed in a phased approach. There could be coordination and expansion to address similar needs for risk assessment and performance assessment across the DOE Complex (e.g., Performance Assessment Community of Practice and Performance Assessment Assistance Team concepts being discussed with EM-11 and EM-21). The major steps include:

- Basic Framework
    - Identify types and key sources of specific information that will form the initial package (e.g., information on subject matter experts, key references, example input parameters and modeling assumptions for key areas of need [e.g., cement degradation, corrosion, etc.], lessons learned).
    - Review similar web portals developed for other applications and identify beneficial features.

- Requirements Identification and System Design
  - Develop requirements for the system (e.g., capability for external users to add/access information when logged in, security requirements, types of files, database structure for subject matter expert information and lessons learned, categories and pedigrees of information to be included (i.e., data, model assumptions, lessons learned).
  - Develop initial design for the system (e.g., page layouts, reports, databases, queries, menus, links to other sites, etc.).
- Implementation
  - Consult with practitioners at DOE sites to obtain initial set of references for data, modeling assumptions, lessons learned, list of subject matter experts, etc.
  - Roll out limited version for testing with initial set of information.
  - Make modifications based on initial use of the system.
  - Conduct regular expert reviews of information included on the web site (frequency depending on funding), annual lessons learned meetings, issue quarterly newsletters highlighting important developments and new information, etc.

Need 11: Technical Resources Needed for ISD

Need

Technical Guidance/Resource documents specifically related to ISD facilities need to be developed and disseminated throughout the DOE Complex. At a minimum, the following four areas should to be addressed: Design Concepts, Fill Materials, Barriers, and Physical/Chemical Properties.

Justification

The potential synergies between waste isolation performance, materials property evolution, and costs could likely result in avoiding mistakes already experienced and lead to more effective engineering designs for ISD facilities. Without existing benchmarks and adaptive thinking, ISD (and other) projects are generally approached as a “first-of-a-kind” effort. ISD projects are too often designed by engineers without experience with performance assessment limitations and largely based on initial materials properties. Tight time schedules and shifting priorities make it difficult to engage groups of experts in individual ISD designs.

A set of guidance documents would facilitate implementation of better designs by practicing engineers who are by necessity generalists. While cost savings through an enlightened engineering design process are likely to be significant, they can only be assessed after the fact on a case by case basis. The synergies would also contribute to compliance with ALARA by improving waste isolation.

Technical Approach/Task Identification

The following technical resource documents should be developed and disseminated throughout the DOE Complex. These could be a set of four separate documents, one large document, or combinations thereof.

Design Concepts: The design concept document would combine an understanding of performance assessment, materials performance, and engineering to develop a set of engineering design concepts for ISD facilities. The focus would be on the options available for optimizing long term waste isolation performance at low cost with consideration of desirable features such as reversibility and irretrievability. The work would consider existing designs along with new concepts based upon technical analysis of long-term performance, feasibility, reliability, and cost.

Fill Materials: Many facility designs will utilize fill materials of some type. Examples are: cementitious materials, clay, sand, soil, rubble, and decommissioned equipment (and potentially a combination of these and other materials). Fill materials may function to provide long term structural reliability (avoiding subsidence); chemical conditioning to influence corrosion, solubility, and sorption; and/or permeability changes to influence water migration. The technical resource would summarize the current state of the art for these materials; explain their advantages, disadvantages, and proper use; and provide a bibliography of selected detailed references.

Other Barriers: Other barriers besides fill materials exist and should be considered in ISD. Examples are: geomembranes, asphalt layers, clay, epoxy, and metals. The technical resource would summarize the current state of the art for these materials; explain their advantages, disadvantages, and proper use; and provide a bibliography of selected detailed references.

Vetted Physical/Chemical Properties: Performance assessment modelers need to estimate a variety of model parameters. This can be a difficult and lengthy process. When individual groups do this separately there is likely to be inconsistency in assumptions between different portions of the DOE Complex and perhaps differences between these assumptions and references preferred by regulatory agencies. These differences lead to unnecessary model iterations that cause delays and accelerate costs. A carefully peer reviewed source of model parameters (e.g., K_d in concrete, corrosion rate of stainless steel) will lower DOE Complex wide costs while improving consistency.

Need 12: Problem: Significant Sample Analysis Is Required to Establish Ratios for Many COCs

Need

Data available from existing sample analyses should be compiled to establish baseline uncertainty ratios for low-energy, longer-lived radionuclides.

Justification

These ratios can be used in conjunction with a few representative samples to validate the ratios for low-energy, longer-lived radionuclides on a new project. If samples fall within the baseline the overall sample and analysis plan should be able to be reduced, particularly if results are being used to provide bounding values.

Technical Approach

The objective of this task is to provide a resource for determining ratios of certain COCs on a new project without the need for extensive sample analysis. The potential isotopes for which the ratios would be helpful in reducing a new project’s overall sample and analysis plan should be identified. For the scoped isotopes, the project parameters that define the criteria for applicable ratios need to be determined. Under these resource definitions, the results from available sampling analyses should be compiled and correlated with the project parameters to apply appropriate isotopic ratios on a new project. As additional isotopes and parameters are identified as being necessary for accurately assessing project conditions, the ratio database should be further developed accordingly.

Task Identification

Identify demonstration site and performance criteria: Criteria for evaluating candidate projects to determine whether they would make a good test case will have to be defined. Candidate projects against which the ratio database method can be tested should be identified. The candidate projects may be new or having previously undergone a traditional sample and analysis plan. The test cases will be assessed under a traditional method, as well as using the ratio database. The accuracy and completeness of the ratio database compared to extensive sampling will determine the project stages/uses for which the resource would be appropriate.

Field Demonstration: Success will be demonstrated through project test cases.

Report: Complete draft and final report documenting the baseline uncertainty ratios for low-energy, longer-lived radionuclides and providing guidance on project uses for which the ratios may be applied.

Need 13: DOE Order 470.4-6 Nuclear Material Control and Accountability

Need

Revise DOE Manual DOE M 470.4-6, Nuclear Material Control and Accountability, to be more in line with current D&D practices.

Justification

Many of the facilities that are candidates for ISD have been involved in some manner in the processing of special nuclear material (SNM). Considerable effort is expended to measure, quantify, and/or remove material hold-up during decommissioning of these facilities as dictated by the current DOE Order for Nuclear Material Control and Accountability. A change in the requirements could provide significant savings in terms of project cost and schedule and personnel exposure by eliminating the need for costly and time consuming measurement techniques and "mining" work to recover hold-up.

Technical Approach

Three specific issues are to be addressed by the revision:

- The Order should be changed to allow the end-state of the facility to drive the attractiveness level of residual holdup. An example of this would be grouting a facility which renders the SNM to attractiveness level "E," regardless of its original level.
- Currently the Order requires measurement of all SNM attractiveness level "E" to quantify holdup. The Order should be revised to allow use of process knowledge and engineering estimates in place of direct measurement to quantify the residual material.
- The Order should also be revised to allow leaving material greater than attractiveness level "E" in systems/facilities if the removal of the material exposes workers to hazardous hostile environments or has no economical value.

Task Identification

The DOE Order should be revised to adequately address the above stated issues. Some empirical justification may be required to demonstrate that these new approaches do not unduly compromise Safeguards and Security Program ideals or affect a facility's vulnerability. The revision process would include:

- Establish coordination with order owner.
- Identify the actual section(s) within DOE M 470.4-6 that need to be revised to address the above identified issues.
- Draft language to affect the requisite change(s).
- Prepare the necessary justification to support the approval process.
- Solicit field input as needed to support the revision process.
- Submit the proposed document revision(s) through the appropriate DOE review and approval chain.
- Incorporate the changes and re-issue DOE M 470.4-6.

Need 14: Developing and Testing Flowable Concrete and Grout Mixes for ISD applications

Need

Flowable Concrete and Grout Mixes are required for ISD of reactor, separation, and other DOE facilities with radioactive and hazardous contamination. Hundreds of thousands of cubic meters of fill material are required for ISD of DOE facilities. (At SRS, the estimate for R and P Reactors is over 100,000 cubic meters each.)

Justification

The above and below grade structures that make up reactor, separation, and other large contaminated DOE facilities need to be physically stabilized to prevent collapse or creation of a "bath tub" effect and chemically stabilize contaminants. Flowable fill materials are needed to reduce labor costs and to enhance ALARA. A menu of demonstrated flowable mix designs will facilitate designs of ISD activities, reduce costs and risks, and accelerate implementation.

Technical Approach

The objective of this task is to apply existing concrete technology for flowable and self consolidating concrete to designing fills with low hydration heat, zero bleed/segregation, and enhanced contaminant stabilization properties for ISD applications. The fill materials need to be tailored for underwater, pre-placed aggregate/debris, light and heavy weight, and bulk fill applications. Flows ranging from 6 to 30 meters are desirable.

The rheological properties of flowable concrete/grout fill materials will be measured using advanced concrete rheometer technology. Concrete/grout rheology is necessary for designing placement plans and sizing delivery lines and pumps. Since quantitative concrete rheology is a relatively new field, the National Institute of Standards and Testing will be contracted to support this activity.

In addition to characterizing the rheology of "fresh concrete/grout," properties of the cured flowable concretes and grouts will be measured to support long-term Performance Assessments and Risk Analyses. The properties of interest include: permeability, moisture retention, porosity, density, shrinkage, strength, and retention of contaminants of concern.

Task Identification

Identify ISD fill requirements for a typical applications and design a suite of candidate mixes: Identify performance requirements and specify fresh and cured properties. The fill materials need to be tailored for underwater, pre-placed aggregate/debris, light and heavy weight, and bulk fill applications. Flows ranging from 6 to 30 meters are desirable.

Design mixes to meet requirements: Design mixes to meet placement and cured property requirements. Collaborate with commercial suppliers of concrete chemical admixtures to identify the need for new/enhanced additives that will meet the ISD placement needs.

Measure Properties on a Series of Mixes: Collaborate with materials scientists at the National Institute of Standards and Technology to obtain quantitative measurements on concrete and grout rheology. Use the rheological data to specify pumping and placing equipment and flow rates.

Cured properties will be characterized as a function of time (up to at least 180 days and longer for durability studies). These data will be used to support long term Performance Assessments.

Design Monitoring Techniques: Monitoring techniques to support placement and performance will be developed.

Field Demonstrations of Placement Techniques: Conduct field demonstration of selected mixes and placement technologies that simulate ISD needs, e.g.:
High volume flowable concrete for underwater placement,

- Neutral pH fill for reactor vessels that contain aluminum components. (Al metal reacts with Portland cement and generates heat and hydrogen gas in addition to expansive corrosion products.)
- Low heat low permeability flowable fill.
- Dry grout placement for in situ solidification of standing water in basins.
- Pre-placed aggregate/debris solidification or grouting.

Field Demonstration of Performance: Test beds will be designed, constructed, and instrumented to monitor long term performance of the ISD materials.

Report: Document cost and performance data for field demonstration. Complete draft and final report documenting the cost and performance data from the technology demonstration.

Appendix G – April 22, 1993 DOE Memorandum

DOE F 1325.8
(8-89)
EFG (07-90)

United States Government Department of Energy

memorandum

DATE: APR 22 1993

REPLY TO ATTN OF: EM-22 (Golian:3-7791)

SUBJECT: Compliance with DOE Orders as part of Environmental Restoration Projects Conducted under CERCLA

TO: Distribution

The purpose of this memorandum is to clarify compliance requirements with DOE Orders as part of Environmental Restoration projects conducted under CERCLA authorities.

Headquarters oversight of restoration projects to date indicates not all remedial actions being considered and/or recommended at various DOE facilities reflect full compliance with existing DOE Orders. The apparent reasons for this are: 1) the perception that because DOE Orders are not promulgated, compliance with their specified requirements is not mandated as with applicable or relevant and appropriate requirements (ARARs); and 2) the recognition that the Office of Management and Budget (OMB) does not view DOE Orders as regulatory drivers necessitating funding.

DOE Orders represent internally established requirements for which full compliance is mandated by the Secretary for all affected DOE activities, including CERCLA remedial and removal actions. It is recognized, however, that interpretation often is necessary to determine which of the specific requirements within the Order apply, and where discretion in the degree/level of effort to ensure compliance exists, to select the appropriate extent of response, i.e., graded approach. Furthermore, circumstances may arise in which strict compliance with an Order or section of an Order presents significant implementation concerns or conflicts to some extent with existing statutory/regulatory requirements. As such, many DOE Orders contain provisions to waive or allow exceptions to be made for specified requirements as a means of providing field offices flexibility in the conduct of their operations and responsibilities. Although these waivers/exceptions may be analogous to the CERCLA statutory waivers for ARARS, the latter do not apply to DOE Orders.

In the event compliance issues arise and no waiver or exception is provided in an Order, field offices, the appropriate EM-40 program office, and EM-22 should coordinate with the office of primary responsibility for the Order to seek a resolution of the concern or apparent conflict. This joint coordination will minimize the potential for inconsistent interpretations of the compliance requirements among the Field Offices.

In summary, response actions conducted under CERCLA at DOE facilities are to comply with relevant DOE Order requirements unless: 1) the respective Order or section of the Order provides a waiver or exception to the requirements under similar conditions; or 2) the field office, EM-40, and EM-22 coordinate with the originating office of the Order to successfully resolve all identified issues associated with compliance.

Should you have any questions concerning compliance with DOE Orders within the context of CERCLA projects, please contact Randal S. Scott, Deputy Assistant Secretary for Oversight and Self-Assessment, on (202) 586-8754 or Michael Kleinrock, Director of Environmental Oversight, on (202) 586-0338.

Paul D. Grimm
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