Remediation of Buried Waste at the Idaho National Laboratory Site

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ABSTRACT

The remediation of buried waste at the Idaho National Laboratory Site (INL Site) has been a technical, regulatory and legal issue for the Department of Energy, the State of Idaho and the Environmental Protection Agency. Significant technical evaluations, risk development, and three-party negotiations have resulted in a legal agreement to resolve a long-standing lawsuit on transuranic waste [1] and a signed Record of Decision [2] for the remediation of buried waste.

The cleanup of the Subsurface Disposal Area (SDA) within the Radioactive Waste Management Complex (RWMC) involved two different and concurrent legal processes: (1) removal of transuranic waste under the 1995 Settlement Agreement between the Department and the State of Idaho, and (2) overall Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) among the U.S. Environmental Protection Agency, State of Idaho Department of Environmental Quality and the U.S. Department of Energy.

Remediation of the SDA will occur over approximately 20 years in three overlapping construction and operational phases followed by a final phase utilizing long-term institutional control. Phase 1 includes the continued execution of ongoing activities such as vadose zone vapor vacuum extraction, monitoring and institutional controls as well as targeted waste retrievals from selected pit areas and the removal of nontarget high-concentration organic solvent waste. Phase 2 provides for the in situ grouting of buried waste containing releasable Tc-99 and collocated I-129 to reduce the mobility of those contaminants. Phase 3 involves preparing the site, constructing an evapotranspiration surface barrier over the SDA and transferring the site to long-term institutional control. This paper focuses on the Phase 1 remediation activity of retrieval, packaging and shipment of buried targeted waste.

INTRODUCTION

The Radioactive Waste Management Complex was created in 1952 for the disposal of radioactive waste. Currently, the complex consists of three major areas: the Subsurface Disposal Area (SDA), the Transuranic Storage Area, and the Administrative and Operations Area. Remediation analyses and decision-making was focused on the SDA because the buried waste is the primary source of contamination at the RWMC and the required remedial actions to mitigate the hazards must occur there. The RWMC is designated as Waste Area Group 7 (WAG 7) under CERCLA cleanup at the INL Site. Separate cleanup actions within the WAG 7 are designated as Operable Units (OU) with a numeric identifier for each cleanup action. The comprehensive investigation and remediation action for the SDA is identified as OU 7-13/14.

The SDA encompasses 39 ha (97 acres) and the waste is buried in approximately 14 of the 39 ha (35 of the 97 acres). Within the SDA, waste was disposed of in 21 unlined pits, 58 trenches, 21 soil vaults, and on Pad A, an above grade disposal area. Disposal of waste met the laws and practices at the time of disposal. However, those laws and requirements have changed over time. Initial disposal operations were done as shallow, landfill disposal of waste generated at the INL Site with procedures that reflected a concern about worker safety. Recognition and evaluation of the long-term environmental damage was not significantly considered and classifications for types of radioactive waste (e.g. low-level, transuranic, and mixed waste) did not yet exist at the time of these disposal operations. Most of the waste that was disposed of in the pits and trenches was industrial trash contaminated with radioactivity generated by INL Site reactor research. Some waste contained hazardous chemicals in addition to radioactivity.

Numerous disagreements occurred throughout the years on how much waste and what types of waste could be brought to the INL Site and disposed of as well as how long waste could be kept on the Site. The DOE and the regulatory agencies (Agencies) were interested in resolving outstanding litigation on the issue of buried waste and at the same time meet CERCLA cleanup agreements.

BACKGROUND

Beginning in 1954, the Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the RWMC for disposal. A variety of radioactive waste streams were disposed of, including process waste (e.g. sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production. Much of the Rocky Flats Plant waste was contaminated with transuranic isotopes and solvents (e.g. carbon tetrachloride).

In 1970, burial of transuranic waste was prohibited. Transuranic waste was defined as waste contaminated with transuranic radionuclides in concentrations greater than 10 nCi/g. Transuranic waste was placed in segregated, retrievable storage in the Transuranic Storage Area and no longer accepted for landfill disposal in the SDA. In 1982, transuranic waste was redefined as waste material containing an alpha-emitting radionuclide with an atomic number greater than 92, a half-life longer than 20 years, and a concentration greater than 100 nCi/g at the time of assay.

SITE CHARACTERISTICS

The INL Site is located in southeastern Idaho and occupies approximately 890 mi^2 in the northeastern region of the Snake River Plain. The INL Site region is classified as arid to semiarid because of its low average rainfall of 22 cm (8.7 in.)/year. The Big Lost River, which flows intermittently depending on weather and the amount of water diverted for irrigation, traverses the western part of the INL Site. RWMC has no permanent surface water features, and local surface water conditions are not influenced by the Big Lost River.

The relatively dry region between the surface and the aquifer, referred to as the vadose zone, is a thick sequence of basalt flows and layers of sentiment called interbeds. The vadose zone and its interbeds are important features because they tend to filter contaminants and inhibit transport to the underlying aquifer. Beneath the vadose zone at the RWMC, at approximately 177 m (580 ft.) below ground surface, the Snake River Plain Aquifer flows generally from northeast to southwest. Like the vadose zone, the aquifer also consists of a series of basalt layers and sediment.

LAND AND GROUNDWATER USE

DOE administers land within the INL Site, and the Bureau of Land Management (U.S. Department of Interior) administers livestock grazing leases within the undeveloped portion of the INL Site. The Bureau of Land Management classified acreage within the INL Site as industrial and mixed use. The current primary use of the INL Site is to support facility and program operations. Large tracts of land are reserved as buffer and safety zones along the boundary of the INL Site. Portions within the central area are reserved for Idaho Cleanup Project and INL operations. Remaining land within the core, which is largely undeveloped, is used for environmental research, ecological preservation, and sociocultural preservation. Future INL Site land use most likely will remain essentially the same as the current use: a research facility within the INL Site boundaries and agriculture and open land surrounding the INL Site. DOE addressed sitewide potential future land use based on long-term future scenarios. Because future land-use scenarios are uncertain, assumptions were made for defining factors such as development pressure, advances in research and technology, and ownership patterns.

The Snake River Plain Aquifer is the source of all water used at the INL Site. RWMC withdraws water from a production well located in the Administration and Operations Area for industrial uses such as process water and fire water. Water from this same well is treated to provide potable water for workers. Residential groundwater use is not allowed on the INL Site, cannot occur before 2095, and is only a remote possibility after that time. For purposes of designing the OU 7-13/14 Selected Remedy, it was assumed that hypothetical future residents could live immediately outside the RWMC land-use control boundary and use the aquifer as a source of drinking water and water for other household uses. However, residential development near RWMC in the future is not expected, and it is reasonable to assume that the federal government will maintain control and restrict access in the future.

SITE INVESTIGATIONS AND CLEANUP ACTIONS

The SDA has been the subject of many investigations and cleanup actions. Site investigations include literature searches, laboratory analysis, bench-scale and field-scale studies to assess geology and hydrology, field surveys, waste zone probing, environmental monitoring, reconstructing disposal history, technology demonstrations, and much more. This extensive body of information is summarized and referenced in the Remedial Investigation / Baseline Risk Assessment [3] and the Feasibility Study [4].

Previous and on-going remedial actions for Waste Area Group 7 include the following:

1. Non-Time-Critical Removal Actions
    a. In situ grouting of buried beryllium blocks to reduce migration of C-14
    b. Ongoing buried waste retrievals for Accelerated Retrieval projects I, II and III

2. Existing Records of Decisions for Operable Units within WAG 7
   a. OU 7-08 Organic Contamination in the Vadose Zone (OCVZ)
   b. OU 7-10 Pit 9 Process Demonstration Interim Action
   c. OU 7-12 Pad A Remedial Investigation and Feasibility Study

3. Nine other operable units were investigated and the Agencies concluded that seven of those operable units should be evaluated in a remedial investigation/feasibility study and were part of the cumulative OU 7-13/14 analysis.

Investigations evaluated the nature and extent of contamination associated with waste buried in the SDA. Industrial solvents, particularly carbon tetrachloride, are the only widespread contaminants from the RWMC in the environment.

SITE ENVIRONMENTAL RISKS

The baseline risk assessment [3] evaluated risk to human health and the environment if no remedial action was taken to reduce exposures. The determination was made that remedial action was necessary to protect the public and the environment from releases of hazardous substances. To provide a protective basis for decision-making, the conservative assumption was adopted that a hypothetical future resident could be located immediately adjacent to the current facility fence line 100 years in the future.

Three values were used to define levels of contamination that warrant risk management are carcinogenic (i.e., cancer) risk, toxic effects, and concentrations in the aquifer. Risk thresholds used to define contaminants of concern based on these values are as follows:
• Probability ranging from 10-6 to 10-4 (i.e., E-06 to E-04) of developing an excess cancer
• Hazard index greater than or equal to 1
• Simulated aquifer concentrations that exceed Maximum Contaminant Levels (MCL).

Computer models that were used to predict future concentrations of contaminants that could affect soil, air, and groundwater indicate that risk from OU 7-13/14 could exceed threshold values. Estimated cumulative risk at the end of the hypothetical 100-year institutional control period for the future residential scenario (i.e., when a resident could live adjacent to the SDA) for surface exposure pathways is 7E-03 (70 in 10,000); estimated groundwater ingestion risk is 9E-04 (9 in 10,000). Residential exposure pathways that pose human health risks greater than threshold values are external exposure to radiation, soil ingestion, crop ingestion, inhalation of dust, inhalation of volatiles, dermal exposure, and groundwater ingestion. In addition to the future residential scenario, the baseline risk assessment evaluated occupational scenarios, risk to a potential inadvertent intruder (i.e., an agricultural well-driller), and ecological risk. Risk exceeds threshold values for these scenarios; however, human health risk estimates are higher for potential future residents than for workers and well-drillers. Risk for all human health scenarios and environmental risks will be mitigated by a surface barrier designed to deter intruders in combination with institutional controls to limit unauthorized access. Primary contaminants of concern include radionuclides and chemicals that could migrate to the surface or to the aquifer in concentrations that exceed risk thresholds within 1,000 years in accordance with guidance for cumulative risk assessment at the INL Site.

Two general categories of waste are associated with risk: waste received from Rocky Flats Plant weapons production and waste received from INL Site reactor research and operations. Primary contaminants of concern for surface exposure to radioactivity are mostly from Rocky Flats Plant waste, while radiological groundwater contaminants of concern (i.e., iodine-129 and technetium-99) are from waste generated at the INL Site. Almost all chemical contaminants of concern came from the Rocky Flats Plant. Secondary contaminants of concern, all of which are radioactive, also came mostly from the Rocky Flats Plant. In general, contaminants of concern from INL Site reactor operations are located in trenches and soil vaults, while most contaminants of concern from the Rocky Flats Plant were disposed of in pits.

REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

Remedial action objectives describe what site cleanup must accomplish. The generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}. The Agencies agree that the cumulative risk threshold for OU 7-13/14 is at the upper end of this range (10^{-4}) based on (1) conservative approaches in risk assessment that tend to overestimate risk, (2) use of 10^{-4} in many other risk-management decisions across the INL Site, (3) remote location of the INL Site, and (4) land-use restrictions and institutional controls specified in this ROD. Remedial action objectives for the SDA are listed below:

1. Limit cumulative human health cancer risk for all exposure pathways to 10^{-4}
2. Limit noncancer risk for all exposure pathways to a cumulative hazard index of less than 1 for current and future workers and future residents
3. Inhibit migration of contaminants of concern into the vadose zone and the underlying aquifer
4. Prevent unacceptable exposure to biota from soil
5. Inhibit transport of contaminants of concern to the surface by plants and animals.

REMEDIAL ACTION ALTERNATIVES CONSIDERED

Six assembled alternatives were developed to assess remedial actions for the SDA. The Feasibility Study [4] developed five assembled alternatives. The Proposed Plan [5] presented a sixth option, the Agencies' Preferred Alternative, which was an optimized combination of elements from alternatives evaluated in the Feasibility Study. Alternatives were developed, evaluated against seven of the nine CERCLA criteria, and compared in accordance with guidance. The last two CERCLA criteria, State and Community acceptance were evaluated in the ROD. Technologies that potentially could meet remedial action objectives were identified and screened with respect to their potential effectiveness and technical feasibility. Representative technologies were selected from those retained after screening, and the retained technologies were combined into assembled alternatives, ranging from No Action to Full Retrieval of all waste from the SDA.

The Feasibility Study [4] focused on remedial alternatives that reduce transport of contaminants from the landfill into the environment. The Agencies concluded early in the study of the SDA that an engineered surface barrier would be a component of every alternative evaluated in the Feasibility Study. Therefore, each alternative developed for the SDA, except No Action, includes a surface barrier. Several additional common elements are necessary to ensure that the selected remedial action protects human health and the environment. Elements common to all action alternatives, including the Preferred Alternative presented in the Proposed Plan and the Selected Remedy in the ROD are:

• ***Engineered surface barrier*—**Each alternative includes a surface barrier to inhibit contaminant transport to the surface by plants and animals and to inhibit infiltration and subsequent transport of contaminants to the vadose zone. Overall thickness of the barrier, coupled with long-term management and control would preclude inadvertent human intrusion.
• ***Vapor vacuum extraction and treatment*—**Continued operation of the OCVZ system established under OU 7-08 is a primary component in each action alternative. The OCVZ system extracts and treats solvent vapors from the vadose zone. Operation and maintenance of the OCVZ system would continue through construction of the surface barrier and beyond until discontinued based on monitoring.
• ***Long-term institutional control*—**Analysis for OU 7-13/14 includes 100 years of post-remediation long-term institutional control and other long-term management and control activities as a basis for modeling and cost estimating. However, these activities would not be limited to 100 years. Long-term institutional control would continue indefinitely (i.e., until eliminated through the 5-year review process in accordance with CERCLA). Other long-term management and control activities include surveillance, maintenance, and monitoring after construction of the surface barrier is complete and the remedy is declared operational and functional.

PUBLIC PARTICIPATION

The State of Idaho has been involved in development and review of all of the required CERCLA documents. In addition, the State participated in all public meetings, reviewed public comments, and offered responses. The State did not concur with the Proposed Plan presented by DOE as to concerns about the acreage subject to retrieval and volume of transuranic waste retrieved. Subsequently, the State of Idaho and DOE entered into an *Agreement to Implement U.S. District Court Order dated May 25, 2006*, effective July 3, 2008.[1]. The Agreement to Implement established detailed performance obligations regarding retrieval and shipment of buried transuranic waste out of Idaho from the Subsurface Disposal Area (SDA) at the Idaho National Laboratory (INL) Site. The Agreement to Implement [1] identifies a range from 5.69 acres to 7.14 acres for retrieval, packaging and shipment of no less than 7,485 cubic meters of “targeted wastes” most likely to be contaminated with transuranic elements (such as plutonium), as well as uranium, and volatile organic compounds. Targeted waste retrieval activities conducted as one of the remedies in the ROD are anticipated to meet the terms of the Agreement to Implement, resolving the State’s concerns. The State concurred with the selected remedial alternative and is a signatory to the ROD with DOE and EPA.

Community participation in the remedy selection process on Proposed Plan review included public meetings held November 13, 14, and 15, 2007. The 30-day public comment period was extended an additional 30 days, from October 22 to December 21, 2007 due to a request from the public. Public comments ranged from opinions that the Preferred Alternative required far more than was needed to requesting removal of all buried waste. More than 200 comments were received. More than half of the commenters expressed acceptance of either the Preferred Alternative or less remediation than included in the Preferred Alternative. Many commented that the Agencies should increase the area subjected to targeted waste retrieval to ensure protectiveness and that the Selected Remedy should be consistent with the Settlement Agreement.

SELECTED REMEDY

The Selected Remedy for OU 7-13/14 is nearly the same as the Preferred Alternative in the Proposed Plan. [5] A larger area (i.e., 5.69 acres) was identified for targeted waste retrieval, and an additional waste form, Series 742 sludge, was identified as targeted waste. Except for continued operation of the vapor vacuum extraction system, initiated under a previous CERCLA decision for OU 7-08 to collect and treat solvent vapors from the subsurface, the scope of this action focuses on source control.

The Selected Remedy controls the source by combining targeted waste retrieval and removal of high-concentration organic solvent waste with in situ grouting, continued vadose zone vapor vacuum extraction and treatment, an evapotranspiration surface barrier, and long-term management and control. The estimated cost is $1.3 billion current value ($912.6 million net present value) for direct work and will take about 20 years to complete. The combination of elements in the Selected Remedy provided the best balance of trade-offs among all the alternatives, striking a balance between waste retrieval, expediting installation of a surface barrier, worker safety, and cost. The underlying logic for the major components of the Selected Remedy is as follows:

Targeted Waste Retrieval—Retrieving targeted waste and high-concentration organic solvent waste from a minimum of 5.69 acres of pit areas will reduce inventories of organic solvent waste to address the current threat to the aquifer, transuranic radionuclides to address stakeholder concerns, and uranium radionuclides to address uncertainty. Targeted waste retrieval activities conducted under this ROD are anticipated to meet the terms of the Agreement to Implement. [1] Removing targeted waste also would reduce risk at the surface if the barrier or institutional controls fail.
In Situ Grouting—In situ grouting of soil vaults and trench areas totaling 0.2 acres will reduce mobility of technetium-99 and iodine-129 to address future threats to the aquifer. The grouting component provides relatively near-term isolation of the waste pending completion of targeted waste retrievals and installation of the surface barrier over the SDA. Grouting and targeted waste retrievals will be implemented concurrently in advance of surface barrier installation.
Vadose Zone Vapor Vacuum Extraction and Treatment—Operating the existing OCVZ vapor vacuum extraction and treatment system will continue to remove and treat solvents from the vadose zone. Extraction and treatment will continue in parallel with retrievals except when temporary shutdowns are required to maintain or modify the system. The OCVZ system, coupled with targeted waste retrieval, addresses the greatest and most imminent threat to groundwater quality. Vapor extraction from the vadose zone will continue until cleanup levels in the vadose zone are achieved.
Evapotranspiration Surface Barrier—Constructing an infiltration-reducing evapotranspiration surface barrier over the entire SDA will provide effective source control. To provide a stable

foundation for the evapotranspiration surface barrier, potential subsidence of pits, trenches, and Pad A will be addressed before constructing the surface barrier using methods to be determined during remedial design. The surface barrier will inhibit transport of contaminants of concern. Inhibiting transport to the surface by plants and animals addresses future threats to plants, animals, and nearby residents; inhibiting migration into the subsurface addresses future threats to the aquifer. To inhibit migration of contaminants from buried waste a surface barrier will be constructed to reduce infiltrating moisture that would move through the SDA and downward toward the Snake River Plain Aquifer. The selected evapotranspiration surface barrier will direct moisture away from the buried waste and store excess moisture until it evaporates or is absorbed by plants and transpired to the atmosphere.
Long-Term Institutional Controls—Establishing and maintaining long-term surveillance, maintenance, monitoring, and institutional controls will preserve integrity of the surface barrier, limit access, and enforce land-use restrictions to ensure continued effectiveness of the remedy.

RETRIEVAL OF BURIED WASTE

The focused objective of targeted waste retrieval is to remove specific waste forms that are highly contaminated with solvents, transuranics and uranium. The DOE will retrieve targeted waste and high-concentration solvent waste from a minimum of 5.69 acres of pit area within the SDA. Ten discrete portions of the SDA are primary targeted waste retrieval areas. The defined pit areas will be fully excavated. Targeted waste is defined as Series 741 sludge, Series 742 sludge, Series 743 sludge, graphite, filters, roaster oxides and other waste streams mutually agreed upon by the Agencies, as a result of operational experience or process knowledge, to be routinely transuranic waste. If a waste stream is not identified as targeted, it is nontargeted waste by definition.

The retrieval process is described below in general terms as it is currently being conducted in Accelerated Retrieval Projects:

Buried waste is exhumed inside retrieval enclosures using diesel-powered excavators and telescopic forklifts. Each defined pit area is sectioned into grids for tracking purposes. Equipment operators and retrieval specialists uncover waste and determine that it is either targeted or nontargeted based on visual observation. The excavator is used to exhume waste, vent drums, open drums, and remove waste form the pit. Telescopic forklifts move trays of waste to drum packaging stations. Targeted waste is placed in trays and processed through a drum packaging station which container a number of glove boxes, where it is examined to remove any WIPP-prohibited items, then transferred to a container (e.g., drum) for characterization to meet treatment and disposal requirements. Field screening instrumentation also may be employed in the drum packaging station to assist in identifying targeted waste. If the waste is determined to be targeted waste, technicians assign the applicable acceptable knowledge and waste stream identified codes, collect physical samples as necessary to meet shipping requirements, and remove items prohibited by Waste Isolation Pilot Plant waste acceptance criteria for transuranic waste. Nontargeted waste, including remnants of original drum carcasses, is returned to the pit. Waste identified as having high concentrations of organic solvents will not be classified as targeted waste if it does not meet targeted waste visual identification criteria.

Any transuranic waste retrieved from the SDA prior to 12/31/17 will be shipped out of the State of Idaho by 12/31/18. Any transuranic waste retrieved from the SDA after 12/31/17 will be shipped out of the State of Idaho within 365 days from retrieval.

The Agencies conduct regular site visits to observe retrieval and packaging operations and to review retrieval data to ensure compliance to legal agreements. Additionally, monthly reports describing progress including analysis of "expected" waste vs. "retrieved" waste and sampling results are transmitted to the Agencies.

PROGRESS TO DATE

Through the end of calendar year 2009, the DOE and the contractor CH2M WG Idaho (CWI) has accomplished the following:

Accelerated Retrieval Project I (Pit 4):
- Started 1/05
- Completed 4/08
- Exhumed 0.50 acres
- Retrieved and packaged 3,870 drums (805 m3)

Accelerated Retrieval Project II (Pit 4/6)
- Started 7/07
- Completed 3/09
- Exhumed 0.34 acres
- Retrieved and packaged 10,015 drums (2,083 m3)

Accelerated Retrieval Project III (Pit 6)
- Started 10/08
- Completed 10/09
- Exhumed 0.38 acres
- Retrieved and packaged 2,593 drums (539 m3)

Accelerated Retrieval Project IV (Pit 5)
- Started 1/10

Cumulative acres exhumed: 1.24 acres out of 5.69 total planned
Cumulative targeted waste exhumed and packaged: 3,546 m3
Cumulative targeted waste shipped out of the State of Idaho: 2,235 m3 out of 7,485 m3 required

SUMMARY

The challenge to integrate the remediation of buried waste at the INL Site between the resolution of litigation and compliance with CERCLA standards was well understood by all of the Agencies involved. Technical analysis provided the basis to enter into discussion on remediation actions to protect human health and the environment. A joint desire by all of the Agencies to do the right thing led to the implementation of the Preferred Alternative with adjustments in the size of the acres within the SDA to be exhumed and the addition of another waste stream.

REFERENCES

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