HANFORD’S PROGRESS REMEDIATING HAZARDOUS, LOW-LEVEL, AND MIXED WASTE BURIAL GROUNDS

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ABSTRACT

This paper summarizes Bechtel Hanford, Inc.’s remediation experience with low-level waste burial grounds at the Hanford Site. The burial grounds were used for disposal of waste from fuel target fabrication, production reactor operations, and nuclear research laboratories. A summary is provided of the waste streams recovered from each type of burial ground as well as a discussion of the problematic waste streams that were encountered. Waste recovered in burial grounds that received fuel fabrication waste included drummed uranium turnings, drummed uranium oxides, elemental lead and lead oxides, asbestos-lined kilns, process equipment, and large process vessels. Waste streams found in the production reactor burial grounds included several different types of fuel element spacers and slugs, reactor parts, and miscellaneous small equipment. Waste recovered from a laboratory burial ground included glass bottles and vials, laboratory glassware, asbestos insulation, and miscellaneous construction debris. This paper is intended to provide an understanding of the burial ground remediation process and techniques used at the Hanford Site, describe wastes types found and challenges faced during remediation, and present important lessons learned that may be applicable to similar work elsewhere in the environmental cleanup industry.

INTRODUCTION

Bechtel Hanford, Inc. (BHI), a subsidiary of Bechtel National, Inc., has been the Environmental Restoration Contractor for the Hanford Site since 1994. Under contract to the U.S. Department of Energy, BHI has characterized, designed, and executed remediation of more than 10 burial grounds and 100 liquid waste disposal sites. The burial grounds received low-level and/or mixed wastes from fuel target fabrication, plutonium production reactor operations, and nuclear research laboratories located adjacent to the Columbia River in Hanford’s 100 and 300 Areas. The burial grounds range in size from 10 m by 30 m to greater than 100 m by 300m. This paper summarizes the types and quantities of waste found during remediation and provides a discussion of problematic wastes that were encountered through December 2004. This paper also provides a summary of the upcoming major burial grounds to be remediated.

SITE BACKGROUND

The Hanford Site encompasses 1,450 m^2 (560 mi^2) and is divided into three major areas. The 100 Areas, located at the north end of the site, contain the production reactors. The 200 Areas, located in the center of the site, contain the chemical processing facilities and the high-level waste storage tanks. The 300 Area, located at the south end of the site, contains the fuel fabrication facilities and research laboratories. The focus of this paper is on remediation of burial grounds located in the 100 and 300 Areas. Cleanup of the 200 Area waste sites is not within the scope of the BHI contract.

A brief summary of Hanford’s 100 and 300 Area operational history is provided to better understand the nature and types of burial ground waste and waste disposal operations in these areas. Hanford began production of plutonium in 1945 at the 100-B Reactor. During the next 18 years, eight additional production reactors were constructed and brought on line in the 100 Areas and ultimately were shut down between 1964 and 1986 [1]. During reactor operations, numerous waste streams were generated and disposed in 100 Area burial grounds resulting from failed reactor hardware components, contaminated equipment, and facility equipment and process modifications. The 300 Area burial grounds primarily received fuel fabrication and laboratory wastes from 300 Area facility modifications. In 1989, the mission of the Hanford Site was changed from production to environmental cleanup with the signing of a Federal Facility Agreement and Consent Order between the State of Washington, the U.S. Environmental Protection Agency, and the U.S. Department of Energy [2].

WASTE DISPOSAL AND TRANSPORTATION

In 1996, BHI opened the Environmental Restoration Disposal Facility (ERDF) located near the 200 West Area. The mission of ERDF is to receive waste generated from cleanup activities for long-term containment. The ERDF is a *Resource Conservation and Recovery Act* (RCRA) compliant, *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) authorized hazardous waste landfill consisting of six waste disposal cells. Its current design capacity is 7.2 million metric tons (8 million US tons) with room for additional expansion. In September 2004, ERDF received its 4.5 million metric ton (5 million US ton) of waste.

Contaminated soil and debris is shipped from waste sites to ERDF in reusable 18 mt (20 US ton) roll-on/roll-off containers. The containers are constructed of carbon steel and have a soft top. To minimize contamination issues, the containers are lined with a 6-mil low-density polyethylene liner. The remediation subcontractor is responsible for installing the liner in the containers, loading the containers, sealing the container liners, and securing the soft top. The loaded containers are then placed in a container transfer area located near the remediation site for pickup by the ERDF transportation subcontractor. BHI personnel manifest each shipping container and verify that its contents meet the ERDF waste acceptance criteria. At the ERDF, the full containers are unloaded and an empty containers are picked up so that the process can be repeated. For a typical burial ground remediation project at the Hanford Site, between 25 to 50 containers per day are loaded depending on its distance from ERDF. On average, ERDF receives and empties 150 containers per day.

300 AREA BURIAL GROUNDS

The 300 Area burial grounds were the first burial grounds to be remediated at the Hanford Site. These burial grounds were operated between 1945 and 1976. During this time frame, burial grounds were not lined. Typically, they were constructed by digging a trench 5 m (16 ft) deep, 30 m (100 ft) wide, and 50 to 100 m (165 to 330 ft) long. The trenches were filled with bulk waste consisting of construction debris, process equipment, industrial equipment, laboratory waste, protective equipment, and drummed wastes, and then covered with several feet of soil. Uranium is the primary radionuclide found in these burial grounds, although small quantities of laboratory waste containing fission products and plutonium may be present. An aerial view of the major burial grounds in the 300 Area burial grounds is shown in Figure 1 (note their proximity to the Columbia River on the right). Two other burial grounds associated with the 300 Area, JA Jones and 600-23, are located (2 mi and 6 mi, respectively) to the north.

Fig. 1. Aerial View of 300 Area Burial Grounds Looking North.

As of December 2004, the 618-4, 618-5, Landfills 1A and 1B, JA Jones, and 600-23 Burial Grounds have been remediated and backfilled. The 618-3 and 618-8 Burial Grounds have been totally excavated, and the waste material is in the process of being shipped. The 618-2 Burial Ground is 30% excavated and is currently on hold awaiting further characterization. The 618-1 and 618-7 Burial Grounds are scheduled to undergo remediation in early 2005. A summary of the major 300 Area burial ground remediation status is provided in Table I.

Table I. Remediation Status of 300 Area Burial Grounds

Name	Type of Waste	Date Operated	Contaminated Material (US Ton)	Remediation Date
Landfill 1A [3]	300 Area laboratory wastes with mixed construction debris	Undocumented	19,500	6/2000
Landfill 1B [4]	300 Area construction debris	Pre-1953 based on historical records.	35,600	6/2000
JA Jones Dump Site [5]	300 Area construction debris	1975 to 1976	14,000	3/2001
600-23 Dump Site [6]	100 and 300 Area construction debris	Undocumented	18,000	5/2001
618-4 Burial Ground [7]	300 Area fuel fabrication waste and process equipment	1955 to 1961	51,300	5/2003
618-5 Burial Ground [8]	300 Area fuel fabrication waste and process equipment	1945 to 1962	46,200	9/2003
618-3 Burial Ground[a]	300 Area construction debris and process equipment	1954 to 1955	21,000	10/2004
618-8 Burial Ground[a]	300 Area construction debris	1954	10,000	11/2004
618-2 Burial Ground[a]	300 Area laboratory and fuel fabrication waste	1951 to 1954	9,400	12/2004
618-1[b]	300 Area laboratory wastes with mixed construction debris	1945 to 1950	19,500	9/2005
618-7[b]	300 Area Construction Debris	Pre-1953 based on historical records.	35,600	9/2005

[a] Under remediation as of December 2004; estimated weight from design.
[b] Planned for future remediation; estimated weight from design.

Worker protection is always a primary concern during burial ground remediation. BHI has developed a safety program that mitigates identified hazards and is fully OSHA compliant. During burial ground remediation, workers involved in the initial excavation activities always work with respiratory protection (Level B) because of the possibility for unknown liquids to be uncovered. After the initial excavation has been completed, worker protection may be downgraded based on industrial hygiene and radiation monitoring. This safety approach coupled with training workers to be knowledgeable of the remediation hazards has resulted in no major accidents or worker exposures associated with handling burial ground wastes.

To date, 200,000 mt (225,000 US tons) of material has been removed from the 300 Area burial grounds and sent to ERDF. Of this material, approximately 10% required treatment. Many of the burial grounds contained asbestos-containing material (ACM) that could be shipped to ERDF after packaging in double-lined containers.

Almost all of the 300 Area burial grounds remediated to date contained large pieces of process equipment and construction debris. Typically at the time of its disposal, large equipment was sized reduced so that it could be transported to the burial grounds in dump trucks or on flatbed trailers. As a result, the majority of waste encountered during burial ground remediation did not require additional size reduction. In some instances concrete slabs or structural steel were sized reduced using hydraulic attachments (impact hammers and shears) mounted to an excavator so that they would more compactly fit in shipping containers.

A large volume of material recovered from the burial grounds required treatment before it could be sent to ERDF. A summary of this material is provided in Table II. Soil and/or debris contaminated with heavy metals (e.g., Ba, Pb, and Cd) often failed toxicity characterization leaching procedure (TCLP) levels and required encapsulation or solidification before disposal at ERDF.

ERDF waste management operations have the capability to perform bulk solidification and macro-encapsulation for material not meeting the facility's waste acceptance criteria. Bulk solidification is performed using a backhoe and a mixing tank. Material to be treated is placed in a mixing tank with a 15 m^3 (20 yd^3) capacity, and cement and water are added based on proportions determined from a treatability test. The material is mixed with the backhoe bucket and then placed wet in the ERDF disposal cell.

Macro-encapsulation is performed for radioactively contaminated lead solids and other materials that cannot be readily solidified. The current macro-encapsulation procedure followed by ERDF operations staff is to construct a concrete pad inside the waste disposal cells. Next, walls are formed and poured around the perimeter of the pad, forming a box of the required volume. Waste material is then placed in the box and then the box is flooded with a cement grout mixture.

Table II. Summary of Burial Ground Waste that Required Treatment[a]

Media	Contaminants	Quantity	Treatment Method
Soil	Barium	220 US Ton	Bulk solidification.
Soil	Lead	18,400 US Ton	Bulk solidification.
Soil	Lead and cadmium	1,100 US Ton	Bulk solidification.
Metal Solids	Lead and lead oxide	3,700 US Ton	Macro-encapsulation.
Uranium Chips	Uranium and PCB contaminated oil	520 drums	Offsite separation of oil and chips, followed by incineration of oil and solidification of chips. Solidified chips returned to site for disposal at ERDF.
Uranium Oxide	Uranium	266 drums	Macro-encapsulation.
Tar	PAH	60 drums	Sent offsite for incineration.

[a] Does not include inventory from the 618-2, 616-3, and 618-8 Burial Grounds, which are under remediation; volume estimates from design drawings.

300 AREA PROBLEMATIC WASTE

During remediation of the 618-4 Burial Ground, a large number of drums containing depleted uranium shavings and uranium oxide were encountered as shown in Figure 2. Removal and sampling of the drums was always done with respiratory protection (Level B). The uranium shavings were potentially pyrophoric and were originally packaged in oil. Both the oil and the uranium oxide contained RCRA and TSCA regulated waste. The uranium oxide drums contained elevated levels of heavy metal that presented a significant health risk if airborne. To minimize the potential for the oxide drum contents to spill, the drums were first placed in disposable lifting bags and then hoisted from the excavation. A digital scale attached to a crane hook provided drum weights, which helped with characterization. The lifting bag and drum were then placed in an overpack. Drums containing uranium shavings were over-packed and then stabilized with mineral oil. Treatment of the uranium chips and oil was performed by an offsite vendor. The uranium oxide drums were disposed at ERDF after being macro-encapsulated.

During remediation of the 618-5 Burial Ground, a 15-cm (6-in.) section of pipe was recovered that contained a precipitate-like material. During sorting operations, pressure exerted on the pipe by a front-end loader caused the precipitate material to ignite in a bright flash. The flash did not cause injury to workers or equipment, but presented a risk to workers who sorted material. Analysis of the precipitate showed high concentrations of iron and aluminum but did not indicate why the mixture was reactive. Material sorting procedures and training were changed to eliminate hand sorting of suspect material.

Two large steel mixing vessels were uncovered from the 618-4 Burial Ground, which had high levels of radioactive contamination. The vessels were approximately 3 m (10 ft) in diameter and weighed approximately 9 mt (10 US tons). Size reduction of the vessels was undesirable because they presented an exposure risk to workers. As a result, it was determined that the vessels could be shipped intact after spraying with a fixative to adhere the contamination and then double wrapping in plastic. The vessels were then lifted with a crane onto a flatbed trailer for transport. Shipping the vessels in one piece to ERDF greatly lessened exposure risks and did not significantly impact the project schedule or budget.

Large volumes of lead solids ranging from less than 5 cm (2 in.) to greater than 0.6 m (2 ft) in diameter have been found in all burial grounds. The lead solids typically have low levels of radioactivity but require separation for disposal purposes. Several methods have been used to separate lead solids including stationary and mechanical screens and manual sorting. The use of screening methods proved to be difficult because wires and scrap metal would often clog the screens. A manual sorting process using a front-end loader has proved to be the most effective. In this method, the end loader dumps a bucket of material on a stockpile and the lead solids roll to the bottom of the stockpile were they can be removed.

Fig. 2. Removal of Drum Containing Depleted Uranium from the 618-4 Burial Ground.

100 AREA BURIAL GROUNDS

Waste generated in the 100 Areas was generally disposed of in burial grounds located near the production reactors. A listing of the major burial grounds located in the 100 Areas is provided in Table III along with their remediation status. To date, 3 of the burial grounds listed in Table III are under remediation and 13 are scheduled for remediation. An aerial view of the 118-B-1 Burial Ground under remediation is shown in Figure 3. This burial ground is typical of those found in the 100 Areas and is similar in construction to those in the 300 Area.

Waste encountered in the 100-B/C Area burial grounds consists of process equipment, piping, construction debris, and fuel spacers. In addition some specialty waste forms have been encountered such as tritium target, which contain lithium and elemental mercury.

Table III. Remediation Status of the 100 Area Major Burial Grounds

Name	Type of Waste	Date Operated	Contaminated Material (US Ton)[a]	Remediation Start Date[b]
118-B-1	100 Area reactor waste and construction debris	1944 to 1973	84,400	3/2004[c]
118-B-3	100 Area reactor waste and construction debris	1956 to 1960	17,100	6/2004 [c]
118-C-1	100 Area reactor waste	1953 to 1969	33,000	6/2004 [c]
118-D-1	100 Area reactor waste	1944 to 1967	96,300	7/06 – 12/11
118-D-4	100 Area reactor waste	1953 to 1967	189,000	7/06 – 12/11
126-D-2	100 Area reactor waste	1943 to 1986	143,000	7/06 – 12/11
118-D-2	100 Area reactor waste	1949 to 1979	70,000	7/06 – 12/11
118-D-3	100 Area reactor waste	1956 to 1973	381,000	7/06 – 12/11
126-DR-1	100 Area construction waste	1975 to NA	46,300	7/06 – 12/11
118-F-1	100 Area reactor waste	1954 to 1965	399,000	7/05 – 12/08
118-F-2	100 Area reactor waste	1945 to 1965	186,000	7/05 – 12/08
118-F-5	Laboratory animal waste	1954 to 1975	62,600	7/05 – 12/08
118-F-6	Laboratory animal waste	1965 to 1973	182,000	7/05 – 12/08
118-H-1	100 Area reactor waste	1949 to 1965	144,000	7/07 – 12/10
118-H-3	100 Area reactor waste	1953 to 1957	25,200	7/07 – 12/10
118-K-1	100 Area reactor waste	1953 to 1975	30,100[d]	1/05 – 7/06 [d]

[a] Contaminated soil volumes are taken from the Remedial Design Report [9].
[b] Remediation start dates are based on Tri-Party Agreement milestones unless otherwise noted.
[c] Currently under remediation, actual remediation start date.
[d] From 118-K-1 Burial Ground Remedial Action Request for Proposal.

100 AREA PROBLEMATIC WASTE

Highly radioactive fuel elements and other irradiated reactor waste present unique remediation and waste disposal challenges. Fuel element fragments encountered in the 118-B-1 and 118-C-1 Burial Grounds are reported to have contact dose readings of 30 and 15 R/hr, respectively. The fuel elements fragments must be separated from soil and other waste going to ERDF. Procedures for safely sorting the fragments are currently being developed. The ultimate disposal of the separated fragments has not been determined at this time. An example of soil expected to contain fuel element fragments is shown in Figure 4. Also mixed with the soil are aluminum fuel spacers.

Fig. 3. 118-B-1 Burial Ground (100 B/C Area) Under Remediation, Looking South.

Fig. 4. Material Suspected of Containing Highly Radioactive Fuel Elements Fragments.

The 118-B-1 Burial Ground experienced a spontaneous ignition of some material during sorting operations that resulted in a bright flash. The cause of the flash was never identified but was believed to be similar to the event that occurred in the 300 Area burial ground. Other waste material recovered from the 100 Area burial grounds has been similar in nature to that in the 300 Area and has not presented a significant waste handling or disposal problem.

SUMMARY

To date two major burial grounds (618-1 and 618-7) remain to be remediated in the 300 Area. Remediation work on these burial grounds is scheduled to begin in early calendar year 2005. Of these burial grounds, 618-7 is expected to contain a large number of drums containing Zircaloy chips. Research and characterization sampling indicate that the Zircaloy chips may be pyrophoric and require treatment before disposal. The safe excavation, storage, and treatment of the Zircaloy drums is a primary concern.

Remediation of the 100 Area burial grounds began in March 2004. To date three burial grounds are in various stages of remediation with work expected to be completed in March 2006. A total of 13 other major burial grounds will be remediated in the time period between 2005 and 2011. Waste forms encountered thus far (excluding the two animal burial grounds) have not presented significant treatment or disposal problems with the exception of highly radioactive fuel elements. Plans are currently under way to develop a sorting method to remove fuel elements that will minimize the potential for worker exposure.

Important lessons learned from burial ground remediation include the following:

- Conduct a thorough review of historical records including radiological surveys if available to be knowledgeable of the waste forms to be encountered
- Anticipate that some recovered waste may be pyrophoric and require stabilization for interim storage
- Have the capability to solidify waste that does not meet land disposal restrictions such as lead
- Be prepared to sort and remove highly radioactive fuel element fragments from burial grounds associated with production reactors.

In conclusion, BHI has acquired much knowledge remediating low-level waste burial grounds since starting work on the 618-4 Burial Ground in 1998. Since then many improvements have been made to contract bid packages and design documents that have resulted in more competitive bids. BHI expects the trend for burial ground remediation costs to continue to decrease.

REFERENCES

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[4] "Cleanup Verification Package for Landfill 1B (WIDS Site 300-50)," CVP-2000-00021, Rev. 0, Bechtel Hanford, Inc., Richland, WA (May 2003).

[5] "Cleanup Verification Package for the JA Jones 1Site," CVP-2001-00019, Rev. 0, Bechtel Hanford, Inc., Richland, WA (November 2001).

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[8] "Cleanup Verification Package for the 618-5 Burial Ground," CVP-2003-00021, Rev. 0, Bechtel Hanford, Inc., Richland, WA (June 2004).

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