

River Corridor Closure Contract

ERDF Risk Reduction ARAR Waiver Proposal

August 2015

For Public Release

Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor



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EXECUTIVE SUMMARY

The Hanford Site Environmental Restoration Disposal Facility (ERDF) is a 4-km² (1.6-mi²) engineered mixed waste disposal landfill with associated support facilities that is regulated by the U.S. Environmental Protection Agency (EPA) through a 1995 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*¹ (CERCLA) record of decision (ROD) (with amendments) (EPA 1995, 1997, 1999, 2002, 2007, 2009²). The landfill is located in an arid environment with less than 20 cm (8 in.) of rainfall annually and consists of multiple *Resource Conservation and Recovery Act of 1976*³ (RCRA)-compliant double-lined disposal trenches with a leachate collection system. Onsite disposal of waste from the Hanford Site cleanup mission at ERDF began in 1996. Waste from any sources other than the Hanford Site is not accepted at ERDF. ERDF is a centerpiece of the Hanford Site cleanup mission with safe, compliant, and economic onsite disposal of more than 17 million tons of radioactive, hazardous, and mixed waste during its operational lifetime. Waste treatment, including macroencapsulation of hazardous debris, began in 1997 when the first ROD Amendment was issued (EPA 1997). More than 10,000 tons of hazardous debris has been macroencapsulated at ERDF instead of the waste being transported offsite for treatment.

The RCRA land disposal restriction (LDR) regulations generally prohibit placement of hazardous waste in a land disposal unit such as a landfill prior to completing treatment (see 40 CFR 268.7,

¹ *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.

² EPA, 1995, *Record of Decision for the Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington*, EPA/ROD/R10-95/100, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA, 1999, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA, 2002, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA, 2007, *U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA, 2009, *Amended Record of Decision Authorizing Supercells 9&10*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

³ *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.

“Land Disposal Restrictions”⁴). The intent of this requirement is to diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste after disposal. For hazardous waste being disposed in ERDF, however, the requirement to treat outside the disposal trench and subsequently move the treated waste into the unit for disposal results in increased risk to workers. In-trench macroencapsulation will produce equivalent or better isolation of hazardous constituents from the environment while reducing risk of physical injury or radioactive exposure to ERDF workers.

A waiver to the compliant process of treatment prior to placement of hazardous waste streams within the disposal trench is proposed for radioactively contaminated long, large, and/or heavy hazardous (LLHH) waste items. Much of the LLHH waste items consist of contaminated equipment and materials removed from the Hanford Site tank farms. “Tank waste” is the residual mix of chemicals and radionuclides left over from the processes used to dissolve irradiated reactor fuel elements and to remove and purify plutonium from the dissolved fuel. The process residues included acids, organic chemicals, and dissolved radioactive metals. Sodium hydroxide was added to all the tanks to neutralize the acids. This created a variety of salts and sludges in the tanks. Tank contents were further concentrated by removing much of the water present in the tanks. The result is a highly radioactive and concentrated mixture of sludges, salt cakes, and liquids. Every tank has a different mixture of chemicals and radionuclides. Items removed from the tanks contain tank waste residuals and are remotely handled due to their elevated contamination and/or ionizing radiation levels. More than 1,000 LLHH waste items are anticipated over the next 20 years based on current waste forecasts.

The waiver request is based on the greater risk for physical injury and exposure to radioactive contamination and ionizing radiation for ERDF workers performing treatment at the compliant out-of-trench location. Additional handling and lifts of hazardous waste items, a larger number of involved workers, and closer proximity of involved workers to the waste, in comparison to the proposed in-trench alternative, pose greater risks. This proposal does not seek a waiver from the required treatment or treatment method; hazardous waste will be treated in accordance with the method prescribed by the regulations (macroencapsulation) and managed within the double-lined trench in a manner that prevents migration of hazardous constituents. Only a change to the treatment location from out-of-trench to in-trench is proposed. The final disposal condition

⁴ 40 CFR 268, “Land Disposal Restrictions,” *Code of Federal Regulations*.

and location for the treated waste remains unchanged, and protectiveness of the remedy is unaffected. In addition to reducing the risk of injury and exposure to ERDF workers, treatment within the disposal trench can be completed at a lower cost and without adding any adverse impacts to the environment.

CERCLA Section 121(d)(4)(B) allows otherwise applicable or relevant and appropriate requirements (ARARs) to be waived in situations where compliance with the requirement poses greater risk to human health and the environment than alternative options. In promulgating the CERCLA “National Oil and Hazardous Substances Pollution Contingency Plan” (NCP) (40 CFR 300)⁵, EPA identified three factors to be considered in evaluating application of this waiver:

1. Magnitude of adverse impacts. The risk posed or the likelihood of present or future risks posed by the remedy using the waiver should be significantly less than that posed by the totally compliant remedy posing the risk.
2. Duration of adverse impacts. The more long lasting the risks from the totally compliant remedy, the more this waiver becomes appropriate.
3. Reversibility of adverse impacts. This waiver is especially appropriate if the risks posed by meeting the ARAR could cause irreparable damage (55 FR 8748, March 8, 1990; 53 FR 51439, December 21, 1988).

As EPA explained in the NCP proposed rule (and adopted in the final NCP), this “greater risk” waiver could be used in situations where compliance with a requirement resulted in greater risk to workers. “Meeting an ARAR could also pose greater risks to workers or residents. For example, excavation of a particularly toxic, volatile, or explosive waste to meet an ARAR could pose high, short-term risks. If protective measures were not practicable for such excavation, use of this waiver might be appropriate” (53 FR 51439).

The compliant process of treatment prior to placement involves multiple lifts and rotational manipulation of the LLHH waste items. An industrial accident involving a suspended waste item could result in irreparable impacts to ERDF workers including serious injuries or death. ERDF

⁵ 40 CFR 300, “National Oil and Hazardous Substances Pollution Contingency Plan,” *Code of Federal Regulations*.

workers also accumulate more exposure to radioactive materials, with attendant increase in excess cancer risk, during the compliant treatment process. A simpler and safer in-trench treatment process uses fewer workers for shorter periods and positioned at greater distances from the LLHH waste items. These factors lead to less exposure to radioactive waste (exposure increases as distance decreases and time increases). They also decrease the likelihood of industrial accident and injury. Therefore, in-trench treatment results in a reduction of the risk of irreparable impacts to workers while resulting in the same treatment endpoint (see Table ES-1).

In-trench treatment of the waste is consistent with the remedial action objectives established in the ERDF ROD to prevent unacceptable direct exposure to waste, prevent unacceptable contaminant releases to air and groundwater, and minimize ecological impacts. A proposed plan will be developed to support obtaining public input on the proposed waiver to authorize in-trench treatment.

Table ES-1. Risk Reduction Summary for In-Trench Treatment of LLHH Waste Items at ERDF. (3 Pages)

Worker Risk Considerations	In-Trench Treatment (ARAR Waiver) <i>Flood Grout</i>	Out-of-Trench Compliant Treatment <i>Polymer Coating</i>	Comments
Risk Reduction Factors <i>In-trench treatment reduces risk based on number, proximity, and time for workers involved in the treatment process.</i>			
Workers Required	4 	13 <i>(3 times more workers)</i> 	Additional workers required for out-of-trench treatment increases number of workers at risk.
Worker Proximity (closest/average)	8 ft to 12 ft 	1 ft to 5 ft <i>(2.4 to 8 times closer = 40 to 64 times more exposure)</i> 	Industrial events involving suspended items can result in serious injury/death to workers in close proximity. Workers will not need to be closer than 8 to 12 ft from suspended waste items. Workers closer to the LLHH waste items receive higher radiological exposure. Worker exposure decreases with distance (8 ft is 1/64 th the exposure of 1 ft).

Table ES-1. Risk Reduction Summary for In-Trench Treatment of LLHH Waste Items at ERDF. (3 Pages)

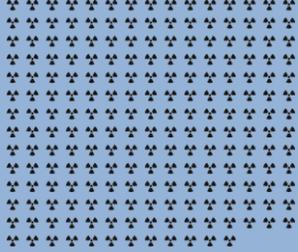
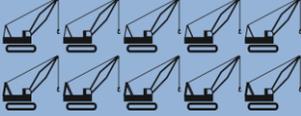
Worker Risk Considerations	In-Trench Treatment (ARAR Waiver) <i>Flood Grout</i>	Out-of-Trench Compliant Treatment <i>Polymer Coating</i>	Comments
Job Duration (hours; typical)	2.2 	9.5 <i>(~4 times longer)</i> 	Estimated time just for treatment activity and does not include LLHH waste items storage prior to treatment. Workers spending more time near the LLHH waste items receive higher radiological exposure.
Radiological Exposure to Workers and Excess Cancer Risk	1x <i>(6.0 x 10⁻⁶ risk)</i> 	200x <i>(1.2 X 10⁻³ risk)</i> <i>(200 times more risk)</i> 	Out-of-trench treatment puts workers close to LLHH waste items for extended times, increasing exposure and excess cancer risk by a factor of 200 in the course of a year. Workers receiving more radiological exposure have a greater chance of developing cancer. In-trench risk is within EPA's "acceptable" risk range (10⁻⁴ to 10⁻⁶); the out-of-trench risk exceeds the "acceptable" range. <i>Industrial risk for in-trench is 6.0 x 10⁻⁶.</i> <i>Industrial risk for out-of-trench is 1.2 x 10⁻³.</i>
Crane Lifts	1 	4-10 <i>(4 to 10 times more lifts)</i> 	Number of lifts/manipulating rotations depends on complexity of waste item. More lifts mean more chances for lift-related accidents to occur.
Industrial Hygiene/PPE	No special PPE required for use of grout 	Powered air-purifying respirator and Level C PPE required for polymer spray 	<i>PPE required to perform treatment out of trench adds physiological stress to workers (especially in warm weather).</i>

Table ES-1. Risk Reduction Summary for In-Trench Treatment of LLHH Waste Items at ERDF. (3 Pages)

Worker Risk Considerations	In-Trench Treatment (ARAR Waiver) <i>Flood Grout</i>	Out-of-Trench Compliant Treatment <i>Polymer Coating</i>	Comments
Supporting Factors <i>In addition to reduced risk to workers, in-trench treatment fully meets treatment requirements, costs less, and can be of better quality.</i>			
Durability of Treatment	Waste is not moved post-treatment 	Multiple lifts/transport prior to final placement could compromise treatment 	Grout in-trench treatment is more durable than polymer coating and is not subject to damage due to transport into the trench. One of 17 polymer coatings conducted to-date on LLHH developed a crack, requiring retreatment.
Additional Waste Generated	None 	Protective clothing, equipment, tools 	Workers will need less protective clothing, respiratory protection, supplies, and tools because they will not be in contact with, or near, radiologically contaminated waste items and will not use dangerous chemicals to apply polymers to waste items.
Capital Cost/O&M Cost per year	\$0	\$15M / \$240K	Represents cost to construct weatherproof facility to conduct treatment prior to placement to protect human health and the environment.
Relative Cost (per item)	\$5,000	\$15,000 - \$30,000	Excluding capital and operating cost for out-of-trench treatment.
Finished Product	<i>Macroencapsulated hazardous debris</i>	<i>Macroencapsulated hazardous debris</i>	All LLHH waste items are treated before burial. Difference is treatment location.
Final Disposal Location	<i>Engineered ERDF cell</i>	<i>Engineered ERDF cell</i>	No change in final disposal location or ERDF design and operating requirements.

NOTE: Data are from Appendix B of this document.

The Hanford Advisory Board, a nonpartisan group of diverse interests that are affected by Hanford Site cleanup issues, has expressed support of in-trench treatment to the U.S. Department of Energy, Richland Operations Office, the EPA, the Washington State Department of Ecology, and political leaders in a letter⁶. Additional input from the public and Tribal Nations will be solicited during a 30-day review period of the proposed plan. Following consideration of the public input, a ROD amendment to the ERDF ROD is anticipated to implement the provision of the waiver.

⁶ Letter, "In-Trench Macroencapsulation of Waste at ERDF," to D. Shoop, U.S. Department of Energy, Richland Operations Office, and D. Faulk, U.S. Environmental Protection Agency, from S. Hudson, Chair, Hanford Advisory Board, Richland, Washington.

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
HHE	human health and the environment
LDR	land disposal restriction
LLHH	long, large, and/or heavy hazardous
NCP	“National Oil and Hazardous Substances Pollution Contingency Plan” (40 CFR 300)
PCB	polychlorinated biphenyl
PPE	personal protective equipment
PVC	polyvinyl chloride
RAO	remedial action objective
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
ROD	record of decision
SNF	spent nuclear fuel
SST	single-shell tank
WAC	<i>Washington Administrative Code</i>

REVISION HISTORY

Revision	Date	Reason for revision	Revision initiator
1	08/2015	Document was reorganized at the request of ERDF's lead regulator	RWO
0	05/2015	Initial issuance	NA

1.0 SITE BACKGROUND AND CONDITIONS TO JUSTIFY A WAIVER

The fundamental objective of the Environmental Restoration Disposal Facility (ERDF) is to support the timely removal and disposal of contaminants from various locations within the Hanford Site. The locations of the Hanford Site and ERDF are shown in Figure 1-1.

1.1 SITE USE

1.1.1 Hanford Site Operations History

From the 1940s to 1989, the Hanford Site's mission encompassed defense-related nuclear research, development, and weapons production activities. This included operation of a plutonium production complex with nine nuclear reactors and associated facilities.

To produce plutonium, uranium metal (fuel rods) was irradiated in reactors near the Columbia River. The irradiated uranium metal (spent nuclear fuel [SNF]) was cooled and treated through chemical separation in reprocessing plants in the central part of the Hanford Site. At the reprocessing plants, the SNF was dissolved in acid, and the plutonium was separated from the remaining uranium and byproducts for use in nuclear weapons production.

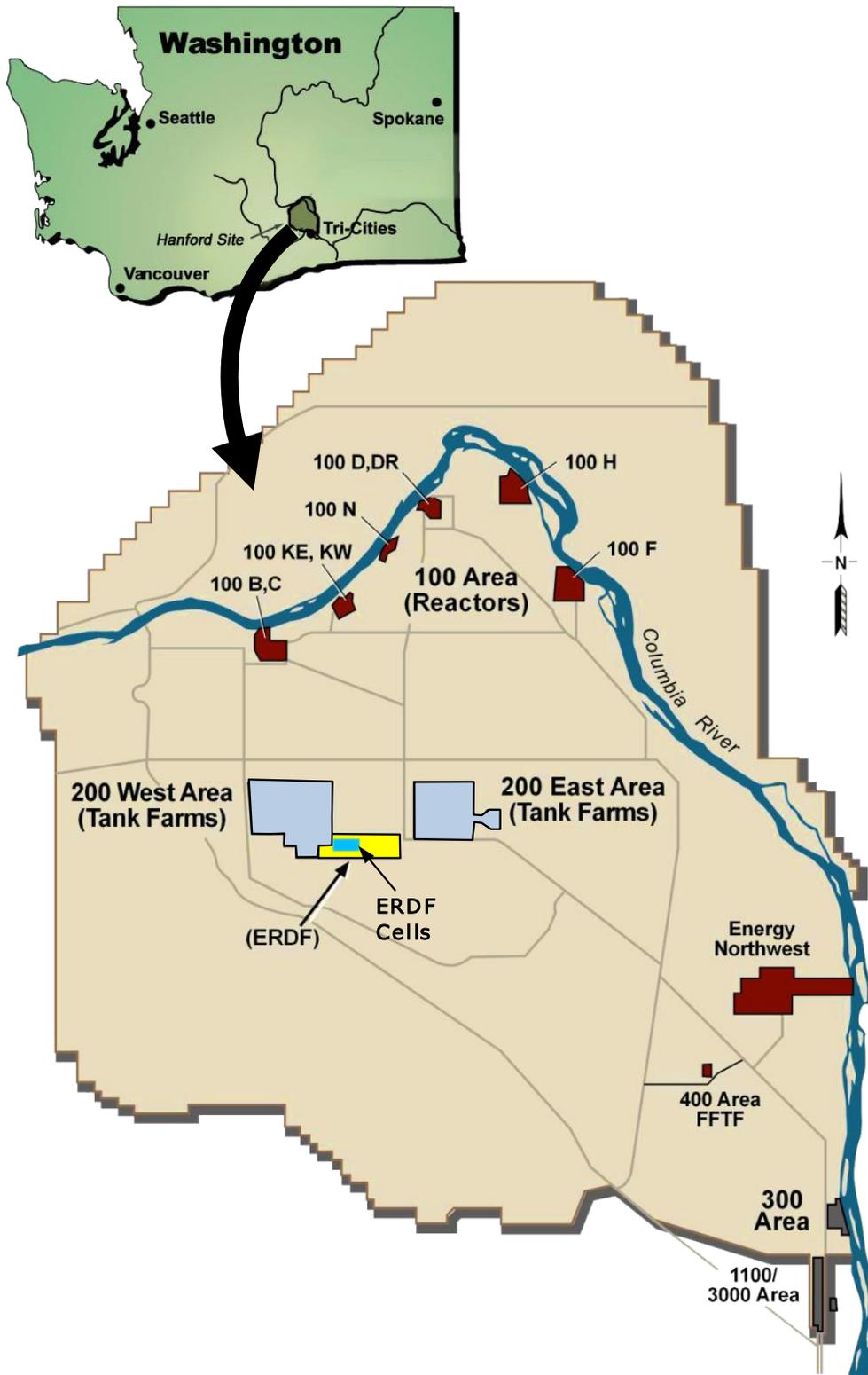
The Hanford Site's SNF reprocessing generated several hundred thousand metric tons of chemical and radioactive waste. Included were high-level radioactive waste, transuranic waste, low-level waste, mixed low-level waste, and hazardous waste. Between 1943 and 1964, the U.S. Department of Energy (DOE) commissioned 12 tank farms containing 149 single-shell tanks (SSTs) to store waste containing the radioactive and chemical constituents. To address SST leakage and provide safe storage of the waste, 28 double-shell tanks grouped in 6 additional tank farms were placed in service between 1971 and 1986. Because of the complexity of the production, processing, and waste management operations, the exact radiological and chemical characteristics of each tank are uncertain.

An indication of the amounts of radioactive and chemical constituents in the tanks and in leaks, discharges, and waste forms associated with tank operations, retrieval, and closure can be found in Appendix D of the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* (DOE/EIS-0391) environmental impact analyses.

1.1.2 ERDF's Operational History

ERDF began operations in 1996 through a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) record of decision (ROD) (as amended) (EPA 1995, 1997, 1999, 2002, 2007, 2009) to address hazardous substances and hazardous wastes from the Hanford Site that may present imminent and substantial endangerment to public health, welfare, or the environment.

Figure 1-1. ERDF Facility Location Within the Hanford Site.



The ROD addresses the disposal of radioactive, hazardous/dangerous, asbestos, polychlorinated biphenyls (PCBs), and mixed wastes resulting from Hanford Site remediation.

ERDF has proven to be a safe and compliant means to dispose of Hanford Site remediation waste. More than 17 million tons of solid waste has been disposed in ERDF, or an average 900,000 tons annually. Approximately 10,000 tons of the over 17 million tons of waste disposed has been macroencapsulated at ERDF. ERDF does not accept liquid waste for disposal.

As required by the ROD, ERDF is constructed with a *Resource Conservation and Recovery Act of 1976* (RCRA) subtitle “C” equivalent double-liner and double leachate collection system to isolate the waste from the environment. Leachate is treated at a Hanford Site treatment facility with residues being returned to ERDF for disposal. The location of ERDF places it at least 24 km (15 mi) from the Columbia River and 73 m (240 ft) above groundwater in an arid desert environment (average precipitation less than 20 cm/yr [8 in./yr]). Air and groundwater monitoring are conducted in accordance with applicable standards. Appropriate measures to protect facility workers and the public are employed during ERDF operations, including contamination and dust migration control, and protection of personnel from industrial hazards presented. The protective measures comply with the *Occupational Safety and Health Act of 1970*; the *Washington Industrial Safety and Health Act of 1973*; 40 CFR 300.150, “National Oil and Hazardous Substances Pollution Contingency Plan” (NCP), “Worker Health and Safety,” and ERDF-specific safety requirements.

A variety of waste streams are generated during Hanford Site remediation activities. These include the two following broad categories of waste:

- Solid waste contaminated with low-level radioactivity and/or chemical contaminants; building rubble and debris from the decommission and decontamination of reactors, process plants, laboratories, support and administrative buildings, and site infrastructure
- Ancillary equipment waste (e.g., pumps, probes, valve pits, and related hardware) removed from waste tanks that hold liquids and sludges from past-practice fuel processing activities.

Many of the tank waste-contacted ancillary equipment items are the long, large, and/or heavy hazardous (LLHH) waste items that are the primary focus of this document.

1.2 HANFORD WASTE RADIOLOGICAL AND CHEMICAL PROPERTIES AND RISK

At any given time, waste from multiple sources on the Hanford Site is transported to and disposed of in ERDF. The majority of the waste (i.e., bulk waste) is low-radioactivity waste dumped from trucks into the disposal trench, spread to a specific thickness, and compacted using specialized equipment and procedures. A lesser quantity of waste is transported to ERDF in individual containers that are placed in the landfill, crushed, and/or filled with grout. Compaction and grout filling prevent future differential settlement within the placed waste. All ERDF operations are designed to minimize the spread of radioactive and chemical contamination to the environment, minimize worker exposure to ionizing radiation, and minimize the risk for physical worker injuries.

Some of the waste disposed in ERDF includes hazardous land disposal restricted (LDR) debris. Much of this hazardous debris is also contaminated radioactively with low-level waste.

Radioactive hazardous debris is called mixed waste. Some of the mixed waste treated at ERDF (i.e., the LLHH waste items summarized in Table 1-1) has contacted highly radioactive tank waste with high levels of alpha, beta, and gamma contamination. ERDF also receives nonradioactive hazardous debris for treatment and disposal.

1.3 HAZARDOUS DEBRIS CHARACTERISTICS

The principal concern of this document is the LLHH waste items (e.g., equipment and debris) that require macroencapsulation treatment to achieve LDR requirements prior to disposal. These hazardous waste items include contaminated equipment and debris from the Hanford Site tank farms (e.g., tank jumpers, pumps, instrument trees, sluices, water lances) and 200/300/400 Area industrial complex items (e.g., radioactive and chemical separation process equipment, hot cells, gloveboxes). The tank farm equipment/debris listed in Table 1-1 (more complete descriptions are in Appendix A) has been in contact with the hazardous and radioactive contamination in Hanford Site tank waste and has already been through the out-of-trench polymer coating process. Data collected from processing of these items (except waste item 18) were used to calculate the exposure factors, distance, and time in Appendix B and shown in Table 3-1. The 200/300/400 Area industrial complex LLHH waste item hazardous and radioactive contamination is similar to tank farm LLHH waste items, and it requires macroencapsulation treatment for disposal at ERDF. Although these represent a small portion of total waste disposed in ERDF (estimated to be less than 0.4%), they account for a significant portion of dose received by ERDF workers for general waste disposal.

1.3.1 LLHH Waste Item Characteristics

In many instances, Hanford Site cleanup waste is considered “hazardous waste” under RCRA because it contains RCRA hazardous waste. Hazardous waste must meet specified treatment requirements known as the LDR standards before it is placed in a land disposal unit such as the ERDF trench. These hazardous waste items are often radiologically contaminated and contain hazardous substances (LDR metals such as lead and chromium), as well as listed waste (F001 through F005) with no appreciable volatile constituents.

The ERDF LDR treatment method for hazardous debris consists of macroencapsulating the waste to immobilize and prevent the migration of contaminants. Macroencapsulation is described in 40 CFR 268.45⁷, “Treatment Standards for Hazardous Debris,” as the application of surface coating materials such as polymeric organics (e.g., resins and plastics) or use of a jacket of inert inorganic materials to substantially reduce surface exposure to potential leaching media. Cementitious grout is frequently used at ERDF to macroencapsulate hazardous debris.

⁷ *Washington Administrative Code (WAC) 173-303-140, “Land Disposal Restrictions,” incorporates the federal land disposal restrictions at 40 CFR 268 by reference.*

Table 1-1. LLHH Waste Items Received at ERDF. (2 Pages)

Item	Dose (mR/hr)	Internal Contamination	Length (ft)	Diameter (in.)
241AN-1-1-01A Tank Farm Supernate Pump	80	3.01E7 dpm/100 cm ² βγ, 1.18E2 dpm/100 cm ² α	27	18
241AN-1-1-01A Tank Farm Slurry Distributor	700	4.1E8 dpm/100 cm ² βγ, 1.61E3 dpm/100 cm ² α	40	20
241-AN-101 Tank Farm Riser 009, Cone Penetrometer	100	8.57E6 dpm/100 cm ² βγ, 9.76E3 dpm/100 cm ² α	48	12
241-C-111 Tank Farm Riser 6 Sluicer #1	5	4.47E6 dpm/100 cm ² βγ, 1.63E2 dpm/100 cm ² α	26	22
241-C-111 Tank Farm Riser 3 Sluicer #2	5	4.47E6 dpm/100 cm ² βγ, 1.63E2 dpm/100 cm ² α	26	22
241-C-101 Tank Farm Dip Tube	75	3.28E8 dpm/100 cm ² βγ, 2.38E4 dpm/100 cm ² α	28	6
241-C-101 Tank Farm Thermocouple	210	8.26E7 dpm/100 cm ² βγ, 5.55E4 dpm/100 cm ² α	40	16
241-C-101 Tank Farm Thermocouple Riser #1	250	1.29E8 dpm/100 cm ² βγ, 1.30E4 dpm/100 cm ² α	40	14
241-C-101 Tank Farm Salt Well Screen	2,500	3.48E8 dpm/100 cm ² βγ, 3.64E5 dpm/100 cm ² α	39	14
241-C-102 Tank Farm Thermocouple	<200	2.56E6 dpm/100 cm ² βγ, 1.32E5 dpm/100 cm ² α	40	8
241-C-102 Tank Farm Salt Well Pump Riser 13	<200	1.21E7 dpm/100 cm ² βγ, 3.59E5 dpm/100 cm ² α	40	16
241-C-109 Tank Farm Slurry Pump	1,000	6.16E8 dpm/100 cm ² βγ, 6.51E4 dpm/100 cm ² α	35	18
241-C-104 Tank Farm Thermocouple	<200	2.04E8 dpm/100 cm ² βγ, 8.74E5 dpm/100 cm ² α	40	6
241-AN-106 Tank Farm Supernate Pump	70	3.88E7 dpm/100 cm ² βγ, 2.44E3 dpm/100 cm ² α	25	20
AN-106/06A Tank Farm Supernate Pump	300	1.20E8 dpm/100 cm ² βγ, 1.20E3 dpm/100 cm ² α	32	50

Table 1-1. LLHH Waste Items Received at ERDF. (2 Pages)

Item	Dose (mR/hr)	Internal Contamination	Length (ft)	Diameter (in.)
241-AN-106 Tank Farm Riser 10, Cone Penetrometer	1.5	8.57E6 dpm/100 cm ² βγ, 9.79E3 dpm/100 cm ² α	48	12
241-C-107 Tank Farm Slurry Pump Disposition	13	1.22E7 dpm/100 cm ² βγ, 1.33E5 dpm/100 cm ² α	45	18
241-C-05B Tank Farm Heel Pit (not treated yet)	30	<2000 dpm/100 cm ² βγ, 20 dpm/100 cm ² α	12 ^a	Not applicable

NOTE: Column headings are described in Appendix A.

^a The heel pit was 1.8 m (6 ft) wide and 2.7 m (9 ft) tall.

The LLHH waste items are mixed hazardous debris with the following characteristics:

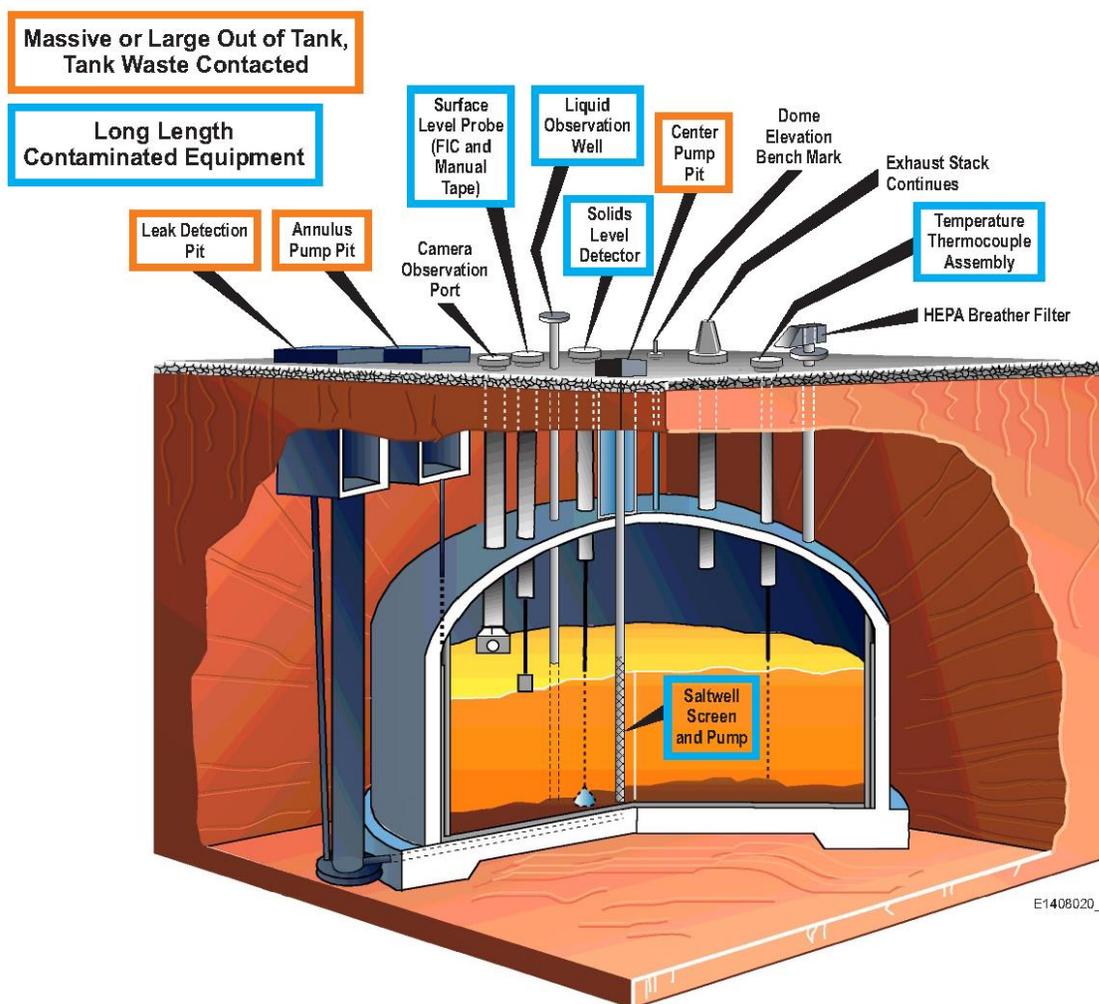
- Items that do not fit in a standard 15.3-m³ (20-yd³) ERDF container are more than 6 m (19 ft) long, more than 2 m (7 ft) wide, and/or more than 1 m (3 ft) tall.

And one or both of the following:

- Items with elevated radiological contamination (see Table 1-1 for known external dose ranges) that result in direct worker exposures during the current macroencapsulation process and could cause airborne radioactivity if an industrial accident caused the LLHH waste items packaging to breach or the tank-contacted item to break (potentially releasing internal contamination) during treatment or transport activities.
- Items with nonuniform weight distributions present issues with rigging, crane lift capabilities, multi-crane lifts, etc. These issues contribute to the potential for accidents that could result in worker physical injuries.

To date, 17 of the 18 LLHH waste items listed in Table 1-1 (see also Appendix A) have been successfully treated outside of the ERDF trench using a polymeric coating macroencapsulation technique. Approximately 1,000 similar tank farm items (Figure 1-2) are expected at ERDF for macroencapsulation treatment over the next 20 years. The physical characteristics and contaminant profiles for the waste items already received at ERDF and a partial list of items expected over the next few years have been used to develop LLHH waste item categories to evaluate and sort these waste items as they are received at ERDF.

Figure 1-2. Hanford Site Tank Typical Hazardous Debris Waste Items.



1.3.2 LLHH Waste Item Categories

Based on the information above and LLHH waste item descriptions, the following waste item categories were identified.

Category 1: Long-Length Tank-Waste-Contacted Equipment. This category includes in-tank items that, because they contacted tank waste, should not be size reduced due to the high contamination levels that would be encountered on the surfaces of the items. This category includes in-tank monitoring equipment such as thermocouples, equipment trees, corrosion probes, dip tubes, and cone penetrometers. This category also includes in-tank transfer equipment used to redistribute waste within a tank and transfer waste between tanks such as pumps, sluicers, screens, water lances, and slurry distributors. These waste items are represented by the blue boxes on the tank cutaway illustration (Figure 1-2).

Category 2: Large Tank-Waste-Contacted Debris. This category includes out-of-tank items (including tank lids) that, because they contacted tank waste, should not be size reduced.

These items include pits, jumpers, pumps, equipment skids, top hats, cover blocks, cover plates, and other out-of-tank equipment used for tank-waste distribution. These waste items are represented by the red boxes on the tank cutaway illustration (Figure 1-2).

Category 3: Large Hot Cells. This category includes hot cells (including large gloveboxes) used to isolate waste items and prevent airborne contamination. Hot cells are enclosed rooms or boxes that were used to handle radioactive items with such high dose levels, contamination levels, or both that workers had to manipulate them from outside the cell. The interiors of the cells retained the high contamination levels and cannot be safely entered for decontamination. Hazardous contents (aside from the radioactive contamination) may include lead, cadmium, asbestos, and F-listed substances. Many hot cells are too large to fit in 15.3-m³ (20-yd³) ERDF containers and should not be size reduced because the potential for compromising worker safety and creating airborne radioactivity areas would be too great.

Table 1-2 presents how the items received by ERDF plus some expected LLHH waste items from the tank farms, the 200 Area, and the 300 Area were sorted into these three waste item categories.

Table 1-2. Received and Expected LLHH Waste Items, Sorted by Waste Category for ERDF Land Disposal Restriction Treatment and Disposal. (2 Pages)

Category 1: Long-Length Tank-Waste- Contacted Equipment	Category 2: Large Tank-Waste- Contacted Debris	Category 3: Large Hot Cells (Including Large Gloveboxes)
241-C-101 Tank Farm Dip Tube	C-105 heel pit	324 Building hot cells (300 Area)
241-C-101 Tank Farm Thermocouple	Valve, jumper, and transfer pits	Plutonium Finishing Plant hot cells and gloveboxes
241-C-102 Tank Farm Thermocouple	Cover blocks/plates	
241-C-101 Tank Farm Thermocouple Riser #1	Rigid jumpers	
241-C-101 Tank Farm Salt Well Screen	Top hats	
241-C-109 Tank Farm Slurry Pump		
241-C-102 Tank Farm Salt Well Pump Riser 13		
241AN-1-1-01A Tank Farm Supernate Pump		
241AN-1-1-01A Tank Farm Slurry Distributor		
241-C-104 Tank Farm Thermocouple		
241-AN-106 Tank Farm Supernate Pump		
AN-106/06A Tank Farm Supernate Pump		

Table 1-2. Received and Expected LLHH Waste Items, Sorted by Waste Category for ERDF Land Disposal Restriction Treatment and Disposal. (2 Pages)

Category 1: Long-Length Tank-Waste-Contacted Equipment	Category 2: Large Tank-Waste-Contacted Debris	Category 3: Large Hot Cells (Including Large Gloveboxes)
241-AN-106 Tank Farm Riser 10, Cone Penetrometer		
241-AN-101 Tank Farm Riser 009, Cone Penetrometer		
241-C-107 Tank Farm Slurry Pump Disposition		
241-C-111 Tank Farm Riser 6 Sluicer #1		
241-C-111 Tank Farm Riser 3 Sluicer #2		
MARS Units		
Various In-Tank Pumps		
Slurry Distributors		
Water Lances		
Surface Level Probes		
Liquid Observation Wells		
Solids Level Detectors		
Risers for Instrumentation		
Radiation Hardened Cameras		
Instrument Trees		
Corrosion Probes		

1.3.3 Current Processes

Current LDR debris treatment at ERDF falls into the following two categories. The first category includes encapsulating waste items within cementitious grout jackets. Waste items are placed into a container equipped with offsets to ensure the grout surrounds the waste item. This treatment category is limited to smaller items that can fit within a container that can be lifted with a forklift after it has been grouted.

The second treatment category uses polymer coatings applied to LLHH waste items that are too large to be placed in a container and grouted and are too highly contaminated to safely size reduce (e.g., shearing, cutting). This encapsulation method involves at least four crane lifts to position and rotate the waste items so that they can be completely coated, increasing the risk of injury due to crane-related mishaps. The process requires a crew of 13 workers and supervisors working close (0.3 to 1.5 m [1 to 5 ft]) to the radioactive items being treated. Treatment typically requires 9.5 hours per item using this method. Some of the workers are required to wear anti-contamination suits and respirators due to the toxic nature of the chemicals used to coat the waste items. Any accident resulting in a breach in the LLHH waste item packaging could cause high levels of radioactive contamination inside the packaging to escape, contaminating the workers and the environment. Since the operation takes place

outside of the trench, the trench's liner system is not present to contain the spread of contamination that may result from an accident.

The polymer coating process is very sensitive to moisture. Mist or dew on the LLHH waste item can hinder the coating's adhesion, compromising the macroencapsulation.

Following treatment the waste item is inspected for cracks or other imperfections in the polymer coatings, loaded onto a truck, transported into the trench, and offloaded into the trench. Since the loading, transport, and unloading can potentially harm the polymer coatings, a second inspection is required before the item is buried. The repeated handling of the waste items increases the potential for damage to the macroencapsulation coatings.

This treatment method is less than optimal for worker safety. It places workers in close proximity to waste items for every phase of the treatment process increasing their risk of injury due to overhead (crane) hazards as well as increasing their exposure to ionizing radiation and the polymer coating chemicals. The multiple times the items must be hoisted and manipulated also increases the risk of physical injuries to workers.

These operations take place in a staging area adjacent to the disposal trench. Following treatment, the LLHH waste items are placed in the trench and covered with soil.

1.4 ERDF ROD SUMMARY

On January 20, 1995, the U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), and U.S. Department of Energy, Richland Operations Office (DOE-RL) (referred to as the Tri-Parties) signed the ERDF ROD to provide waste disposal capacity for cleanup of contaminated areas at the Hanford Site (EPA 1995). The ERDF ROD provides the overall plan for construction and operation of the facility and provides for disposal of CERCLA remediation waste originating only from the Hanford Site. A subsequent Explanation of Significant Difference (ESD) to the ERDF ROD was issued on July 26, 1996, to allow for the disposal of investigation-derived waste; decontamination and decommissioning waste; waste from RCRA past-practice operable units and closure waste; and nonprocess waste from inactive treatment, storage, and disposal facilities (EPA 1996). The waste is accepted for ERDF disposal (see Section 1.4.2 of WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) on a case-by-case basis, in accordance with a ROD or removal action memorandum issued under CERCLA and the NCP. The ESD also authorized the conditional use of the ERDF leachate for dust suppression and waste compaction.

Five amendments to the ERDF ROD have been issued. The first amendment, signed on September 30, 1997, authorized the first ERDF expansion for disposal cells 3 and 4 and limited treatment of waste at ERDF. The second amendment, signed on March 25, 1999, allowed leachate from ERDF to be managed as nonhazardous waste if testing shows it to be appropriate ("delisting" of the ERDF leachate). The third amendment, signed on March 11, 2002, authorized another ERDF expansion for disposal cells 5 through 8 and allowed remediation waste staging at the ERDF while awaiting treatment at the ERDF or other facilities. The fourth amendment, signed on May 24, 2007, authorized the disposal at the ERDF of specific Hanford Site wastes in storage that pose a substantial threat of release. The fifth amendment, signed on August 6, 2009, authorized construction of "super cells" 9 and 10,

including a change in design to allow a single cell with the disposal capacity of two previously constructed cells (EPA 1997, 1999, 2002, 2007, 2009).

1.4.1 ERDF ROD Remedial Action Objectives

The NCP states that remedial action objectives (RAOs) should reflect the media and contaminants of concern, the exposure pathways, and the remediation goals (40 CFR 300.430(e)(2)(i)).

Remedial action objectives for ERDF are unusual in that the scope in this instance is limited to the siting and configuration of a waste disposal facility and does not address remediation of specific contaminated sites. The decision to establish a central disposal facility stems from the concern that current conditions (i.e., numerous uncontrolled waste sites along the Columbia River) are less desirable. The primary objective of ERDF is to provide a centralized land disposal facility at the Hanford Site for consolidation of remediation wastes found suitable for land disposal. In order to support the siting design of a facility that provides safe disposal of remedial wastes, the following supporting RAOs have been selected.

- 1. Prevent unacceptable direct exposure to waste in accordance with applicable or relevant and appropriate requirements (ARARs) and health-based criteria.** Direct exposure to the types of waste received at ERDF could result in unacceptable health risks. Direct exposure of workers and biota to waste could occur during operation of ERDF (i.e., during waste handling and filling operations). Because of access control at the Hanford Site, the direct exposure pathway does not apply to the public during operations. Once ERDF is closed, direct exposure to waste is only possible if institutional controls fail and the surface cover is breached.
- 2. Prevent unacceptable contaminant releases to air in accordance with ARARs and health-based criteria.** Inhalation exposure to the types of waste received at ERDF could result in unacceptable health risks. Similar to the direct exposure pathway, inhalation of waste by workers and biota could occur during operation of ERDF (i.e., during waste transport and filling operations). Airborne transport of waste off the Hanford Site could result in exposures to the public, but these exposures would be negligible compared with worker risks. Once ERDF is closed, air releases are only possible if institutional controls fail and the surface cover is breached.
- 3. Prevent contaminant releases to groundwater above ARARs and health-based criteria.** Migration of contaminants through the vadose zone to groundwater could result in unacceptable human exposure to contaminants. This RAO has been acknowledged in the fourth amendment to the Tri-Party Agreement (Ecology et al. 1989, *Hanford Federal Facility Agreement and Consent Order*), which states: “the point of [risk] assessment will be the intersection of the groundwater and the vertical line drawn from the edge of the disposal facility.” The Tentative Agreement on Tri-Party Agreement Negotiations, which was circulated for public comment in 1993 and formed the basis for the fourth amendment to the Tri-Party Agreement, further provided the time of assessment (10,000 years) and the compliance standard (10^{-5} for the first 100 years and 10^{-4} thereafter). Since the risk assessment indicates that the risk associated with the groundwater pathway should remain below 10^{-5} for the first 100 years, the relevant compliance standard is 10^{-4} .
- 4. Minimize Ecological Impacts.** Construction of ERDF will result in harmful impacts to the ecology of the ERDF site and possibly to the borrow sites (if needed) that provide materials

for ERDF construction. Significant value is attached to the ecology at these sites. Mitigation measures to reduce ecological impacts have been incorporated into the alternatives. DOE will evaluate potential options for additional mitigation measures.

Mitigation measures required by the ROD amendments are (i) clearing of the site in preparation for construction prior to nesting season to ensure that wildlife is not destroyed, only displaced; (ii) constructing the landfill in a sequential fashion on an as-needed basis, which may minimize the ultimate habitat loss; (iii) use of the deep area fill trench configuration to minimize the amount of land disturbed at ERDF; (iv) initiating site clearing activities in the southern corner, progressing to the north, to buffer the shrub-steppe habitat immediately south of the ERDF site from ongoing construction activities; and (v) revegetation. Additional mitigation measures to be evaluated include restoration of the site, creation or enhancement of similar habitat, and actions to acquire or provide protection for similar habitat.

1.4.2 Waste Acceptance Criteria

The *Environmental Restoration Disposal Facility Waste Acceptance Criteria* (WCH-191, Rev. 4) states:

“The ERDF is authorized to accept radioactive, hazardous/dangerous, asbestos, polychlorinated biphenyls (PCBs), and mixed wastes only from cleanup of operable units within the 100, 200, 300, and 400 Area National Priorities sites of the Hanford Site in accordance with the ERDF ROD, ESD, and ROD amendments (EPA 1995, 1996, 1997, 1999, 2002, 2007, 2009). As provided in those documents inactive treatment, storage, and disposal; RCRA past-practice; and decontamination and decommissioning waste may be placed in the ERDF through a remedial action ROD or removal action memorandum issued in accordance with CERCLA and the "Oil and Hazardous Substances Pollution National Contingency Plan" (40 CFR 300). Waste that has not been subjected to the waste acceptance process defined in Section 3.0 shall not be accepted for disposal at the ERDF.”

1.4.3 ERDF ARARs

Resource Conservation and Recovery Act of 1976 – Title 42 USC 6901 et seq., Subtitle C.

RCRA regulates the generation, transportation, storage, treatment, and disposal of hazardous waste. These regulations also provide authority for the cleanup of spills and environmental releases of hazardous waste to the environment because of past practices. Hazardous waste management regulations promulgated pursuant to RCRA are codified at 40 CFR 260 through 40 CFR 268. Washington State dangerous waste regulations implement the federal waste regulations and are administered by Ecology. These state regulations are codified in WAC 173-303. Regulations established under RCRA are applicable to ERDF because the facility is expected to receive hazardous waste and operation of the facility may generate hazardous waste.

Significant ARARs include the following:

- 40 CFR 264: Construction and operation of the disposal facility receiving hazardous/dangerous waste include federal RCRA landfill requirements.
- WAC 173-303-665: Washington State dangerous waste landfill requirements.

- RCRA LDRs specified in 40 CFR 268 and WAC 173-303-140.
- 40 CFR 761, “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions”: *Toxic Substances Control Act of 1976* requirements.
- 40 CFR 268 Subpart E, “Prohibitions on Storage”; 40 CFR 264 Subpart I; and WAC 173-303-630, “Use and Management of Containers.” Storage and treatment of waste at ERDF.

1.4.4 ARAR Waiver Impacts on the ROD

Implementing the proposed treatment alternative would require a modification to the ROD that would allow treatment of LLHH waste items within the ERDF trench after establishing controls to prevent releases and ensure human health and environment (HHE) protection. The proposed alternative does not seek a waiver from the required treatment or treatment method – all hazardous waste will continue to be treated in accordance with the method prescribed by the regulations (macroencapsulation) and managed within the double-lined ERDF trenches in a manner that prevents migration of hazardous constituents. Only a change to the LLHH waste item treatment location from out-of-trench to in-trench is proposed. The final disposal location for the treated waste remains unchanged and the protectiveness of the remedy is unaffected.

A CERCLA decision document, with opportunity for public comment, will be developed to support obtaining the proposed waiver to authorize in-trench macroencapsulation. The Tri-Parties will seek input on the proposed greater-risk waiver from the Tribal Nations and other interested parties during a public review period. Following consideration of the public input, a modification to the ERDF ROD is anticipated to implement the provision of the waiver.

2.0 REGULATORY BASIS FOR RCRA LDR ARAR AND WAIVERS (CURRENT REQUIREMENTS AND WAIVER JUSTIFICATION)

The following subsections summarize the regulatory basis for LDR treatment under RCRA and the justification for the waiver treatment option.

2.1 CURRENT RCRA LDR REQUIREMENTS

In many instances, Hanford Site cleanup waste meets the criteria for “hazardous waste” under RCRA. All RCRA hazardous waste is also a CERCLA hazardous substance, and potentially subject to response under CERCLA authority (including use of CERCLA waivers). Hazardous wastes must meet specified requirements known as the “land disposal restriction” (LDR) standards before they are placed in a land disposal unit, such as a landfill. The remedy selected in the 1995 ERDF ROD identifies the RCRA LDR standards as ARARs for disposal of hazardous waste in ERDF (EPA 1995).

The EPA interprets the LDR “placement” requirements to prohibit treatment of waste within the physical confines of a land disposal unit even if the waste, following treatment within the unit, meets the applicable treatment standard. This policy reflects EPA’s concern that untreated waste could be exposed to rainfall or other sources of leachate generation within the land disposal unit, resulting in potential migration of contaminants.

One type of hazardous waste frequently encountered at ERDF consists of “hazardous debris”: solid material exceeding 60 mm particle size that is contaminated with RCRA hazardous waste. Examples of such materials include radioactively contaminated demolition debris containing concrete rubble, contaminated metal debris from building demolition, and waste equipment such as old pumps or piping contaminated with radioactive and hazardous waste constituents. The LDR treatment standard routinely used for such wastes consists of “macroencapsulation.” “Macroencapsulation” as described in 40 CFR 268.45 means application of surface coating materials such as polymeric organics or use of a jacket of inert inorganic materials (e.g., cementitious grout) to substantially reduce surface exposure to potential leaching media.

Due to the nature of debris waste encountered during Hanford Site cleanup, treatment via macroencapsulation outside of the ERDF trench exposes workers to greater risk than in-trench treatment. However, lacking a waiver from the LDR “placement” requirements, in-trench treatment of RCRA hazardous waste is prohibited.

2.2 WAIVER TREATMENT OPTION JUSTIFICATION

CERCLA Section 121(d)(4)(B) allows otherwise applicable or relevant and appropriate requirements (ARARs) to be waived in situations where compliance with the requirement poses greater risk to HHE than alternative options. In promulgating the CERCLA “National Oil and Hazardous Substances Pollution Contingency Plan” (NCP) (40 CFR 300)⁸, EPA identified three factors to be considered in evaluating application of this waiver:

⁸ 40 CFR 300, “National Oil and Hazardous Substances Pollution Contingency Plan,” *Code of Federal Regulations*.

- Magnitude of adverse impacts. The risk posed or the likelihood of present or future risks posed by the remedy using the waiver should be significantly less than that posed by the totally compliant remedy posing the risk.
- Duration of adverse impacts. The more long lasting the risks from the totally compliant remedy, the more this waiver becomes appropriate.
- Reversibility of adverse impacts. This waiver is especially appropriate if the risks posed by meeting the ARAR could cause irreparable damage. (See 55 FR 8748, March 8, 1990, and 53 FR 51439, December 21, 1988.)

As EPA explained in the NCP proposed rule (and adopted in the final NCP), this “greater risk” waiver could be used in situations where compliance with a requirement resulted in greater risk to workers. “Meeting an ARAR could also pose greater risks to workers or residents. For example, excavation of a particularly toxic, volatile, or explosive waste to meet an ARAR could pose high, short-term risks. If protective measures were not practicable for such excavation, use of this waiver might be appropriate” (53 FR 51439).

3.0 COMPLIANT TREATMENT OPTION DESCRIPTION

The remedy selected in the 1995 ERDF ROD identifies the RCRA LDR standards as ARARs for operation of ERDF, including 40 CFR 268, "Land Disposal Restrictions," which specifies that treatment standards must be met **before** these wastes can be placed (land disposed) within the ERDF trench. The 1995 ERDF ROD also identifies the Washington State dangerous waste regulations (WAC 173-303) as ARARs for ERDF. WAC 173-303-140 contains the state LDRs, which, similar to the federal regulations in 40 CFR 268, also prohibits land disposal of waste **prior** to meeting treatment standards (EPA 1995).

In 2011, the National Enforcement Investigation Center and the State of Washington observed treatment being conducted within land disposal units at a RCRA-permitted unit on the Hanford Site. A similar process was being done in the ERDF landfill and subsequently discontinued. The treatment method used since 2012 for tank farm LLHH waste items consists of encapsulating or encasing the LLHH waste item to immobilize and prevent the migration of LDR and/or radioactive contaminants. "Macroencapsulation" is the application of surface coating materials such as polymers (e.g., resins and plastics) or jackets of inert inorganic materials (e.g., cementitious grout) on waste items to substantially reduce their surface exposure to potential leaching media. However, due to the nature of LLHH waste items, which do not fit into 15.3-m³ (20-yd³) roll-on/roll-off containers and are too radiologically contaminated to safely size reduce (see Table 1-1 and Sections 3.3.1 and 3.3.2), macroencapsulation has been performed in the open air, outside the ERDF trench, using a polymer coating technology.

Currently, long-length items are delivered to a staging area outside of the trench for treatment. They are removed from their transport box and secured to stanchions or other supports. Radiological surveys are performed after this and every subsequent movement of the waste item. Workers use straps or tape to secure any loose wrappings prior to application of spray coatings. Polyurethane foam is then applied to portions of the waste item that require a firm, smooth base to support the polyurea coat that will be applied later. In order to ensure even application of the polyurethane foam the waste items are partially lifted with a crane and rotated on their stanchions by laborers working in close proximity to the waste item. This process may be repeated several times depending on the configuration of the waste item being treated. The foam is applied at a temperature of 170 degrees from a nozzle held by a specially trained person. The spraying operation places the operator very near the waste item, increasing their potential to accumulate radiation from the waste item. When sufficient foam has been applied, polyurea coatings are sprayed over the waste item in order to encapsulate it. Like the foam, the polyurea must be applied at 170 degrees by a person working very near the waste item. This usually requires multiple coats, and the waste item is manipulated (picked up and rotated) at least once during this phase of the operation. The coatings are inspected for areas of insufficient coverage and resprayed as necessary. This inspect- and respray phase usually requires further manipulation of the waste item. After a final inspection, a crane hoists the waste item onto a truck and it is transported to its final disposal location in the trench. As a crane lifts the item off the truck, it is again inspected prior to being placed in the trench. On at least one occasion, the handling associated with trucking and burial has damaged the encapsulation layer, requiring removal and recoating with polyurea.

The workers applying the polymer coatings are required to wear a powered air-purifying respirator and Level C personal protective equipment (PPE). They must work in close proximity to radioactive waste items for extended periods of time and are subjected to the hazards

associated with overhead loads due to the multiple (i.e., at least four) crane hoists required by this method. Seasonal weather-related treatment delays, primarily from precipitation that affects LLHH waste item coating adhesion and integrity, occur with this current process.

4.0 TREATMENT OPTION WITH WAIVER DESCRIPTION

Past efforts to treat tank-waste-contacted LLHH waste items involved packaging the waste for shipment to an offsite processing facility. Transportation-related problems prompted experiments with size reduction at the Hanford Site prior to shipment offsite (Blackford 2008). These efforts were problematic and were stopped when ERDF became available as a treatment and disposal solution for these waste streams. In-trench treatment at ERDF with cementitious grout was developed and used (see Figure 4-1) until 2012 when it was discontinued when the practice was called into question at another Hanford Site disposal facility.

Figure 4-1. ERDF In-Trench LLHH Waste Item Flood Grouting Example.



The differences between the compliant out-of-trench and the alternative in-trench treatment methods are depicted in Table 4-1. This table does not include operations that are common to both methods such as rigging and hoisting the item out of a transport box. Therefore, it only shows the difference between the methods, not the complete process of either alternative.

Table 4-1. Risk Reduction Summary for In-Trench Treatment of LLHH Waste Items at ERDF. (3 Pages)

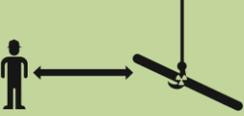
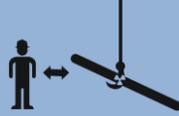
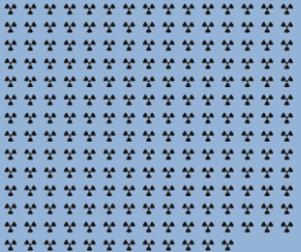
Worker Risk Considerations	In-Trench Treatment (ARAR Waiver) <i>Flood Grout</i>	Out-of-Trench Compliant Treatment <i>Polymer Coating</i>	Comments
Risk Reduction Factors <i>In-trench treatment reduces risk based on number, proximity, and time for workers involved in the treatment process.</i>			
Workers Required	4 	13 <i>(3 times more workers)</i> 	Additional workers required for out-of-trench treatment increases the number of workers at risk.
Worker Proximity (closest/average)	8 ft to 12 ft 	1 ft to 5 ft <i>(2.4 to 8 times closer = 40 to 64 times more exposure)</i> 	Industrial events involving suspended items can result in serious injury/death to workers in close proximity. Workers will not need to be closer than 8 to 12 ft from suspended waste items. Workers closer to the LLHH waste items receive higher radiological exposure. Worker exposure decreases with distance (8 ft is 1/64 th the exposure of 1 ft).
Job Duration (hours; typical)	2.2 	9.5 <i>(~4 times longer)</i> 	Estimated time just for treatment activity and does not include LLHH waste item storage prior to treatment. Workers spending more time near the LLHH waste items receive higher radiological exposure.
Radiological Exposure to Workers and Excess Cancer Risk	1x <i>(6.0 x 10⁻⁶ risk)</i> 	200x <i>(1.2 X 10⁻³ risk)</i> <i>(200 times more risk)</i> 	Out-of-trench treatment puts workers close to LLHH waste items for extended times, increasing exposure and excess cancer risk by a factor of 200 in the course of a year. Workers receiving more radiological exposure have a greater chance of developing cancer. In-trench risk is within EPA's "acceptable" risk range (10⁻⁴ to 10⁻⁶); the out-of-trench risk exceeds the "acceptable" range. <i>Industrial risk for in-trench is 6.0 x 10⁻⁶</i> <i>Industrial risk for out-of-trench is 1.2 x 10⁻³</i>

Table 4-1. Risk Reduction Summary for In-Trench Treatment of LLHH Waste Items at ERDF. (3 Pages)

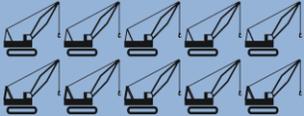
Worker Risk Considerations	In-Trench Treatment (ARAR Waiver) <i>Flood Grout</i>	Out-of-Trench Compliant Treatment <i>Polymer Coating</i>	Comments
Crane Lifts	1 	4-10 <i>(4 to 10 times more lifts)</i> 	Number of lifts/manipulating rotations depends on complexity of waste item. More lifts mean more chances for lift-related accidents to occur.
Industrial Hygiene/PPE	No special PPE required for use of grout 	Powered air-purifying respirator and Level C PPE required for polymer spray 	PPE required to perform treatment out of trench adds physiological stress to workers (especially in warm weather).
Supporting Factors <i>In addition to reduced risk to workers, in-trench treatment fully meets treatment requirements, costs less, and can be of better quality.</i>			
Durability of Treatment	Waste is not moved post-treatment 	Multiple lifts/transport prior to final placement could compromise treatment 	Grout in-trench treatment is more durable than polymer coating and is not subject to damage due to transport into the trench. One of 17 polymer coatings conducted to-date on LLHH developed a crack, requiring retreatment.
Additional Waste Generated	None 	Protective clothing, equipment, tools 	Workers will need less protective clothing, respiratory protection, supplies, and tools because they will not be in contact with, or near, radiologically contaminated waste items and will not use dangerous chemicals to apply polymers to waste items.
Capital Cost/O&M Cost per year	\$0	\$15M / \$240K	Represents cost to construct weatherproof facility to conduct treatment prior to placement to protect human health and the environment.
Relative Cost (per item)	\$5,000	\$15,000 - \$30,000	Excluding capital and operating cost for out-of-trench treatment.

Table 4-1. Risk Reduction Summary for In-Trench Treatment of LLHH Waste Items at ERDF. (3 Pages)

Worker Risk Considerations	In-Trench Treatment (ARAR Waiver) <i>Flood Grout</i>	Out-of-Trench Compliant Treatment <i>Polymer Coating</i>	Comments
Finished Product	<i>Macroencapsulated hazardous debris</i>	<i>Macroencapsulated hazardous debris</i>	All LLHH waste items are treated before burial. Difference is treatment location.
Final Disposal Location	<i>Engineered ERDF cell</i>	<i>Engineered ERDF cell</i>	No change in final disposal location or ERDF design and operating requirements.

NOTE: Data are from Appendix B of this document.

The in-trench treatment alternative discussed and compared against the current out-of-trench treatment alternative in the following sections provides evidence that supports an ARAR waiver based on “greater risk.” Because approximately 1,000 LLHH waste items are expected over the next 20 years for treatment and disposal at ERDF, an ARAR waiver is requested to improve LLHH waste item treatment and ensure continued protection of HHE. The proposed waiver is only from the LDR “placement” prohibition, not a waiver from treatment. Full macroencapsulation will be accomplished in-trench using methods that reduce risks to HHE.

5.0 TREATMENT OPTION COMPARISON

Under the waiver treatment option, LLHH waste item macroencapsulation would be performed in the ERDF trench by flood grouting. By using this approach, almost none of the LLHH waste item handling activities and specialized equipment required for the current treatment alternative would be needed. Instead, the proposed alternative would use standard ERDF equipment (blocks, cranes, forklifts, support facilities, etc.) and cementitious grout equipment to encapsulate LLHH waste items requiring LDR treatment for ERDF trench disposal. Implementing the waiver treatment option would greatly reduce worker health and safety risks associated with potential radiological exposure, chemical exposure, and physical injury due to industrial accidents during treatment activities compared to the current compliant option.

5.1 MAGNITUDE OF ADVERSE IMPACTS

(The risk posed or the likelihood of present or future risks posed by the remedy using the waiver should be significantly less than that posed by the totally compliant remedy posing the risk.)

Granting an ARAR waiver that would allow LLHH waste item treatment inside the ERDF trench would be more protective of HHE compared to outside-the-trench treatment for the following reasons:

- The in-trench treatment is a much simpler method of treatment yielding the same, or better, treatment of hazardous debris than the current out-of-trench method of treating LLHH waste item. In-trench treatment requires four operations:
 - Preparing a location (stand-off and berm) to receive the LLHH waste item
 - Transporting the items from the tank farms and/or 200/300/400 Areas directly into the ERDF trench
 - Performing one crane lift to unload and set the LLHH waste item in the prepared location
 - Pouring grout from a truck or grout pump.
- The out-of-trench method requires more operations than the in-trench alternative. These additional steps increase workers' exposure to radiological and industrial hazards:
 - Transporting the items from the tank farms and/or 200/300/400 Areas
 - Performing additional close-up radiological surveys
 - Performing 4 to 10 crane lifts of the item during the polymer application
 - Spraying four or more coatings
 - Inspection and touch-up
 - Reloading onto a truck for transport into the trench
 - Inspection and touch-up
 - Performing one last crane lift to offload the encapsulated LLHH waste item in the trench.

- A comparison of radiological exposure factors between the current method (treating outside the trench) and the proposed method (treating in the trench) demonstrates that out-of-trench treatment exposes workers to 200 times more radiological dose than the proposed in-trench alternative. The details for this conclusion are presented in Appendix B.
- The data gathered for radiological exposure can also be used to gauge workers' exposure to industrial accidents related to crane lifts of LLHH waste item undergoing treatment. As documented in Appendix B, out-of-trench treatment puts workers in closer proximity to LLHH waste items suspended from cranes for longer periods during treatment than in-trench treatment.
- The factors have not been calculated for heavy, bulky items such as the heel pit described in Appendix A (page A-21), which have not been treated yet. The physical danger related to these is much greater due to the increased mass of these objects and their irregular centers of gravity making manipulation of them for out-of-trench treatment very hazardous. The factors of time, distance, and shielding for radiological exposure are different from other LLHH waste item, but will be decreased by in-trench treatment as well.
- The potential for incomplete encapsulation and/or encapsulation damage while moving the treated LLHH waste items into the ERDF trench, resulting in poly coating rework, would be reduced to zero.
- The ability to control potential radioactive contamination released to the ground or in the air is substantially greater in the ERDF trench compared to outside the ERDF trench because:
 - The simplified in-trench treatment process greatly reduces the potential for air and ground releases.
 - The areas inside the ERDF trench are less susceptible to wind dispersion of potential air releases than outside-the-trench areas; therefore, enhanced protection against HHE risks from potential releases would occur with in-trench treatment. Outside-the-trench air releases would be closer to the ERDF boundary and more likely to escape the facility boundary than releases from in-trench treatment locations.
 - The ERDF trenches are double-lined for leachate control, so potential soil releases will be better controlled and ensure enhanced groundwater and environmental protection compared to the outside-the-trench treatment process.

An industrial accident involving a suspended waste item during the treatment process could result in serious injuries/death to ERDF workers in the vicinity. In addition, the dose from exposure to radioactive waste is a function of the distance and time spent near the item (dose increases as distance decreases and time increases). The significant risk reduction of performing treatment in-trench at ERDF supports approval of the proposed waiver when considering the magnitude of an industrial accident with potential for serious injury/death or exposure to radiation, the increased number of workers that would be in close proximity, the increased duration of the work process, and the long-lasting and irreparable impacts associated with performing the treatment out-of-trench (see Table 4-1).

As mentioned above, performing additional steps increases the risks to workers. ERDF is operated to rigorous safety standards and, as such, in 20 years of operation and 17 million tons

of waste disposed, the treatment and disposal operation has had only one lost-time accident. Even so, since 2012 the additional handling required for LLHH waste items has resulted in a number of near-miss incidents that had the potential to seriously injure workers and spread high levels of contamination to them and to the environment.

5.2 DURATION OF ADVERSE IMPACTS

(The more long lasting the risks from the totally compliant remedy, the more this waiver becomes appropriate.)

Continuing the compliant, out-of-trench macroencapsulation process and not granting the proposed waiver will increase the potential for serious worker injury over the next 20 years of ERDF operation. An industrial accident involving a waste item suspended from a crane during the treatment process could result in serious injuries to ERDF workers in the vicinity. In addition, the dose from exposure to radioactive waste is a function of the distance and time spent near the item (dose increases as distance decreases and time increases). The potential for serious physical injuries, combined with increased potential for cancer due to greater dose absorbed by workers, represents long-lasting potential impacts.

Approximately 1,000 LLHH waste items are expected for treatment over the next 20 years, and the proposed in-trench treatment alternative will greatly reduce the potential risk for adverse impacts associated with the outside-the-trench treatment process. This significant risk reduction of performing treatment in-trench at ERDF supports approval of the proposed waiver when considering the duration of an industrial accident with potential for serious injury/death or exposure to radiation, the increased number of workers that would be in close proximity, the increased duration of the work process, and the long-lasting and irreparable impacts associated with performing the treatment out of trench (see Table 4-1).

5.3 REVERSIBILITY OF ADVERSE IMPACTS

(This waiver is especially appropriate if the risks posed by meeting the ARAR could cause irreparable damage.)

To date, approximately 12 LLHH waste items have been treated outside-the-trench using the poly-coating macroencapsulation alternative. Fortunately, no long-term risks to HHE have been identified for this process. However, approximately 1,000 LLHH waste items are expected for treatment over the next 20 years, and the proposed in-trench treatment alternative will reduce the potential risk for adverse impacts associated with the outside-the-trench treatment alternative (3.0 to 6.0×10^{-6} versus 6.0 to 11.9×10^{-4} excess cancer risk for industrial workers) due to the following improved conditions during treatment:

- The reduced number of workers exposed to LLHH waste items radiation and the reduced duration of their exposure will reduce their potential risk for developing cancer, which could be an irreversible worker impact.
- The reduced number of workers required to manipulate the LLHH waste items during the proposed treatment alternative will reduce their potential risk for physical injuries during rigging, crane operation, and LLHH waste item placement. Physical injuries suffered during these tasks could result in irreversible worker impacts.

- Conducting the proposed in-trench treatment alternative will greatly reduce the potential for radioactive/chemical releases to the environment, where potentially irreversible impacts to native plants, wildlife, soils, and groundwater could occur.

5.4 OTHER ALTERNATIVES CONSIDERED

The LLHH waste item treatment alternatives presented below were evaluated against the attributes of the current compliant treatment option and the waiver treatment option.

5.4.1 Polymer Treatment Coatings Applied in an All-Weather Facility

Under this alternative, macroencapsulation would be performed in a dedicated, all-weather facility outside the ERDF trench by applying multiple polymer coatings. This alternative was not selected over the proposed waiver option because treatment outside-the-trench using this all-weather facility poses greater potential risks to workers due to direct exposure to radioactivity, exposure to potential airborne releases, and industrial physical and chemical exposure hazards (e.g., multiple crane lifts, working with polymer coating chemicals).

5.4.2 Size Reduction at an Open Air Location

Based on technology and process evaluations and an assessment of the conceptual engineering designs, LLHH waste item size reduction to fit the waste in sacrificial containers for grouting and transport to the ERDF trench for disposal was not retained for further consideration for the following reasons:

- Previous serious Hanford Site worker health and safety problems with the size-reduction process
- Complicated and largely unproved techniques would be needed to provide worker and environmental protection during size-reduction activities
- Increased potential for creating radioactive and chemical releases during the size-reduction process
- Much higher costs than the proposed waiver option.

5.4.3 Size Reduction in an All-Weather Facility

Based on technology and process evaluations and an assessment of the conceptual engineering designs, LLHH waste item size reduction to fit the waste in sacrificial containers for grouting and transport to the ERDF trench for disposal was not retained for further consideration for the following reasons:

- Previous serious Hanford Site worker health and safety problems with the size-reduction process
- Complicated and largely unproved techniques would be needed to provide worker and environmental protection during size-reduction activities

- Increased potential for creating radioactive and chemical releases during the size-reduction process
- Much higher costs than the proposed waiver option
- Increased waste generation (contaminated facility structure and equipment).

6.0 RECOMMENDED ALTERNATIVE

Based on the information available, WCH recommends implementing Alternative 2, *Flood Grouting Treatment in the ERDF Trench*. This alternative would amend the ERDF ROD to grant a CERCLA ARAR waiver allowing certain hazardous equipment and debris (LLHH waste items) subject to LDR requirements, to be treated within the ERDF trench rather than outside the trench, as would otherwise be required by 40 CFR 268 and WAC 173-303-140. As EPA explained in the NCP proposed rule (and adopted in the final NCP), this “greater risk” waiver could be used in situations where compliance with a requirement resulted in greater risk to workers. “Meeting an ARAR could also pose greater risks to workers or residents. For example, excavation of a particularly toxic, volatile, or explosive waste to meet an ARAR could pose high, short-term risks. If protective measures were not practicable for such excavation, use of this waiver might be appropriate” (53 FR 51439).

This in-trench treatment, with provisions for LLHH waste item protection prior to and during treatment, would better-achieve the ERDF objectives, reduce worker risk, achieve enhanced performance compared to the current polymer coating practice, cost less, and provide more overall protection for HHE.

7.0 REFERENCES

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APPENDIX A

**DESCRIPTIONS OF LONG, LARGE, AND/OR
HEAVY HAZARDOUS WASTE ITEMS**

APPENDIX A

DESCRIPTIONS OF LONG, LARGE, AND/OR HEAVY HAZARDOUS WASTE ITEMS

Waste Item Description Key

This key explains the data presented on the Waste Item Descriptions that summarize information for the approximately 18 waste items that have already been received and 10 waste items that are expected for treatment at the Environmental Restoration Disposal Facility (ERDF). Except for the 241-C-05B Heel Pit, 17 of the first 18 items presented have been treated via a jacket of polyurea and disposed.

- **Item:** This presents a name of the waste item, including identifiers for the waste tank with which the item is associated. In the case of long-length tank-waste-contacted equipment, waste items were located inside the tank and in contact with the tank waste. All of these items are custom made. Naming conventions have not always been consistent for these items over the course of Hanford Site history, so multiple names for similar items are possible. "Tank waste" is the residual mix of chemicals and radionuclides left over from the processes used to dissolve irradiated reactor fuel elements and to remove and purify plutonium from the dissolved fuel. The process residues included acids, organic chemicals, and dissolved radioactive metals. Sodium hydroxide was added to all the tanks to neutralize the acids. This created a variety of salts and sludges in the tanks. Tank contents were further concentrated by removing much of the water present in the tanks. The result is a highly radioactive and concentrated mixture of sludges, salt cakes, and liquids. Every tank has a different mixture of chemicals and radionuclides.

All of the 18 items have been in contact with and contaminated by tank waste from one or more of the tanks, whether by immersion into them or contact with waste outside of tanks while the waste was being transferred from one tank to another. Note: Waste Item Description #4 includes two identical items. Therefore, the 18 items are described in the first 17 Waste Item Descriptions. Additional future items that will be sent to the ERDF for treatment and disposal are also included as one-page descriptions numbers 18 through 27. There are no radiological data listed on the Item Descriptions for the additional items since radiological readings are not collected until an item is pulled from a waste tank. Because they are all tank waste contacted, it is reasonable to assume that their radiological characteristics will be similar to those of the 18 waste items.

- **Category:** For the purpose of this feasibility study, waste items are grouped into different categories.
- **Physical Characteristics:** Length, width or diameter, and weight of each item, as packaged, are listed. Some items have a size range that will allow some of them to fit into an ERDF container for treatment. Only those items that will not fit inside an ERDF container are included in the requested waiver.
- **Land Disposal Restriction (LDR) Waste Codes:** All of the tank wastes carry the F001, F002, F003, F004, and F005 LDR waste codes. Some of the items also carry characteristic codes. The listed waste codes are assigned to the waste in the tanks and, therefore, to

items contacting the waste. Since the items are all debris, they must be treated by macroencapsulation.

- **Internal Contamination Levels:** Waste items are wrapped and packaged prior to shipment to ERDF. “Interior” in this case refers to the waste item inside the protective packaging. The waste item itself has removable contamination on its exterior and, in many cases, interior surfaces due to contact with tank waste. The removable contamination will become airborne if exposed to air and present an airborne radioactivity hazard to workers and the environment. Usually, the amount of removable contamination is determined by swabbing an area of a waste item with a cloth or other media. The contamination removed is then read by a variety of dose meters and reported as disintegrations per minute (dpm) per 100 cm². In the case of highly contaminated items, such as tank-waste-contacted debris, levels of radioactivity are too high to safely swab. In this case, the alpha, beta, and gamma radiation of the object is read directly by different dose meters and a portion of the reading is assigned to removable contamination as dpm/100 cm². The proportion assignment is made according to radiation control organization protocols and procedures. In the case of the tank-contacted waste 10% of the readings are assigned to removable contamination.
- **External Dose:** This is the highest radiation field reading at any point on the outside of the waste item’s packaging. This is usually read on contact, or at 1 ft or 1 m away from the surface of the packaging.
- **Derived Air Concentration (DAC) Value:** For the radionuclides listed in 10 CFR 835 (“Occupational Radiation Protection,” Appendix A, *Code of Federal Regulations*, as amended) this is the airborne concentration that equals the Annual Limit on Intake divided by the volume of air breathed by an average worker for a working year of 2,000 hours (assuming a breathing volume of 2,400 m³ [84,756 ft³]). A DAC-hour is defined as the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide, in hours.
- **Treatment/Disposal Information:** The disposition of the waste item is described and the specific waste shipping and receiving plan (WSRP) is referenced. The WSRPs are written to provide guidance on the packaging, shipping, treatment (if required), and disposal of waste items that require special handling at ERDF. This section of the page also describes why the waste item was not treated in the more conventional manner of grouting within a container prior to disposal in the trench. The airborne radiation area referred to is a 10 CFR 835 definition of an area in which airborne radioactive materials exist in concentrations exceeding the derived air concentration limits or would result in an individual present in the area without respiratory protection exceeding the regulatory limits.

Macroencapsulated Waste Item Description 1

Item: Supernate Pump from Tank No. 241-AN-101-01A (OWTF # 200E-12-0138)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Pump installed in a tank with motor at top and impellers at bottom. The pump decants supernatant waste (liquids) in order to transfer them out of a tank.

Physical Characteristics: 27 ft long by 18 in. in diameter, 4,830 lb.

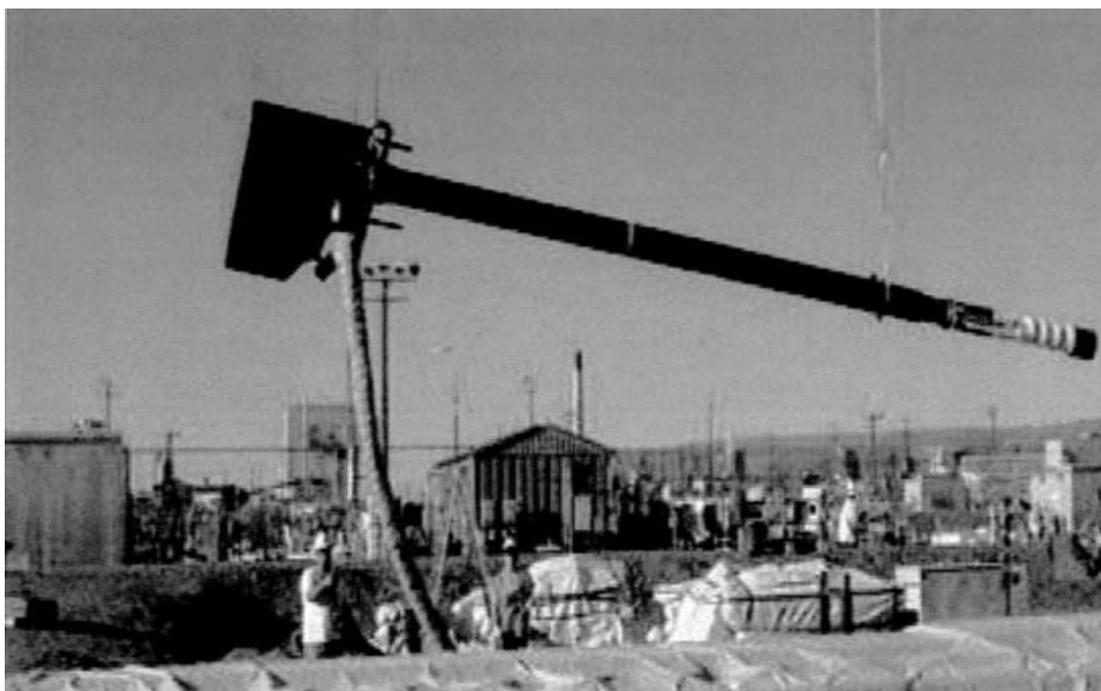
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: $3.01E7$ dpm/100 cm² βγ, $1.18E2$ dpm/100 cm² α

External Dose: 80 mR/hr

Derived Air Concentration Value: $1.92E+1$ DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0122 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in the ERDF roll-on/roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 2

Item: Tank Farm 241AN-1-1-01A Slurry Distributor (OWTF # 200E-12-0150)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: A pipe and with a nozzle at the bottom placed in a tank to distribute slurry received from a different tank.

Physical Characteristics: 40 ft long by 20 in. in diameter, 4,100 lb.

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 4.1E8 dpm/100 cm² βγ, 1.61E3 dpm/100 cm² α

External Dose: 700 mR/hr

Derived Air Concentration Value: 2.62E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0124 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 3

Item: 241-AN-101 Riser 009, Cone Penetrometer (OWTF # 200E-14-0006)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Instrument used to measure shear strength of tank solids.

Physical Characteristics: 48 ft long by 12 in. in diameter, 3,300 lb.

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 8.57E6 dpm/100 cm² βγ, 9.76E3 dpm/100 cm² α

External Dose: 100 mR/hr

Derived Air Concentration Value: 2.05E+01 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0136 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 4

Item: Tank Farm 241-C-111 Sluicers #1 and #2 (OWTF # 200E-14-0034)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Adjustable nozzle used to mobilize settled solids in a tank so that they can be pumped into another tank.

Physical Characteristics: 26 ft long by 22 in. in diameter, 3,307 lb. (each)

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 4.471E6 dpm/100 cm² βγ/1.63E2 dpm/100 cm² α

External Dose: 5 mR/hr

Derived Air Concentration Value: 3.14E+00 DAC; airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0138 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 5

Item: Tank Farm 241-C-101 Dip Tube (OWTF # 200E-12-0057)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Narrow diameter steel piping used as part of tank waste level detection system.

Physical Characteristics: 28 ft long by 6 in. in diameter, 305 lb. (Note: the figure below is typical with different dimensions than the waste item described on this page)

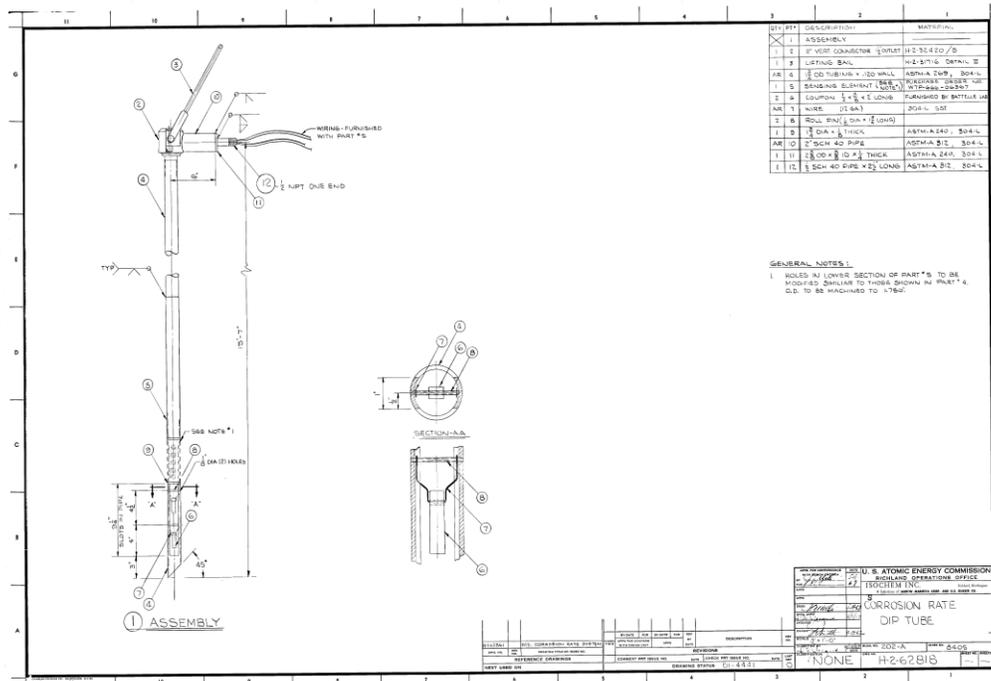
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 3.28E8 dpm/100 cm² βγ, 2.38E4 dpm/100 cm² α

External Dose: 75 mR/hr

Derived Air Concentration Value: 2.46E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0108 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 6

Item: Tank Farm 241-C-101 Thermocouple (OWTF # 200E-12-0056)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Thermocouple internal to the tank in contact with liquids and/or solids. Used to monitor temperature of the tank's contents.

Physical Characteristics: 40 ft long by 16 in. in diameter, 620 lb.

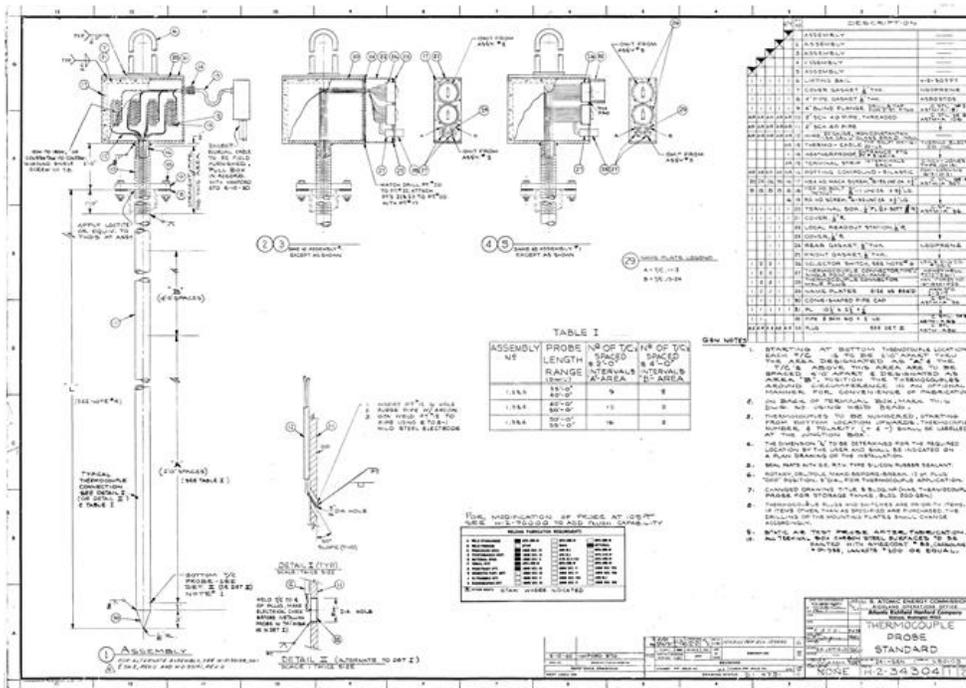
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 8.26E7 dpm/100 cm² βγ/5.55E4 dpm/100 cm² α

External Dose: 210 mR/hr

Derived Air Concentration Value: 2.08E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0109 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 7

Item: Tank Farm 241-C-101 Riser #1 Thermocouple (OWTF # 200E-12-0090)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Thermocouple internal to the tank in contact with liquids and/or solids. Used to monitor temperature of the tank's contents.

Physical Characteristics: 40 ft long by 14 in. in diameter, 1,420 lb.

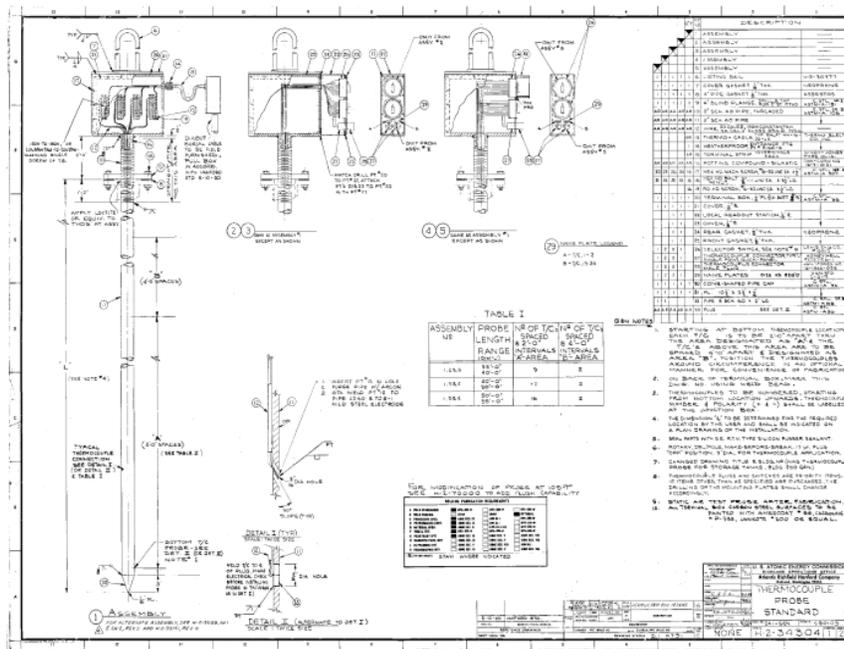
LDR Waste Codes: F001, F002, F003, F004, F005, D007

Internal Contamination Levels: 1.29E8 dpm/100 cm² βγ/1.30E4 dpm/100 cm² α

External Dose: 250 mR/hr

Derived Air Concentration Value: 1.03E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0113 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container and could not be safely size reduced due to high levels of removable contamination. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 8

Item: Tank Farm 241-C-101 Saltwell Screen (OWTF # 200E-12-0098)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Salt well screens act much like a screen in a water well, filtering fine particulates out of the liquid so that it can be pumped. The salt well screen is installed in the tank waste solids to filter out tank solids allowing tank liquids to be pumped out of the tank.

Physical Characteristics: 39 ft long by 14 in. in diameter, 2,000 lb.

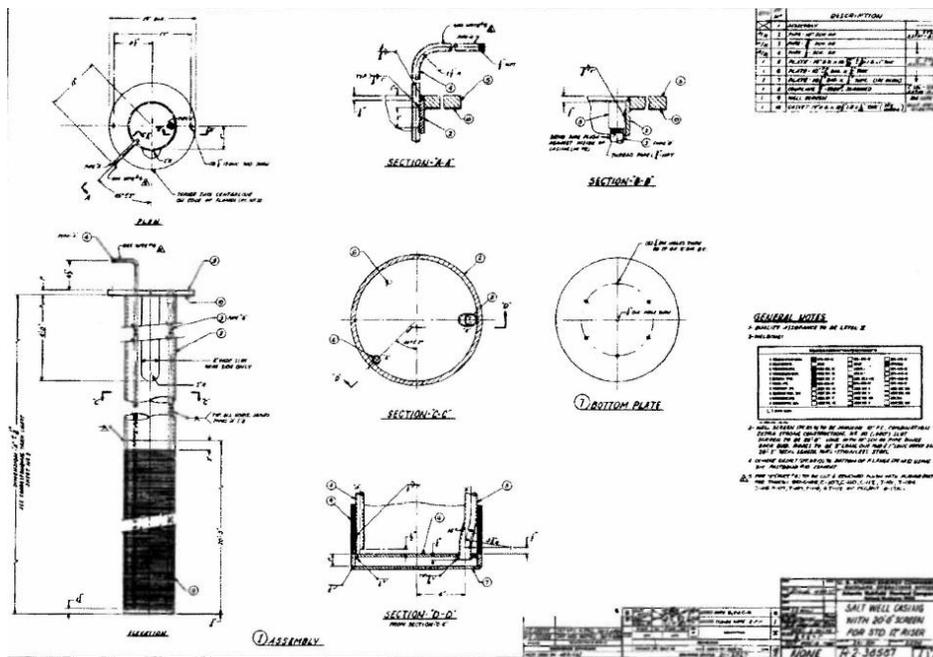
LDR Waste Codes: F001, F002, F003, F004, F005, D006, D007, D008, D010, D030, D032

Internal Contamination Levels: 3.48E8 dpm/100 cm² βγ/3.64E5 dpm/100 cm² α

External Dose: 2,500 mR/hr

Derived Air Concentration Value: 5.72E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0114 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container and could not be safely size reduced due to high levels of removable contamination. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 9

Item: Tank Farm 241-C-102 Thermocouple (OWTF # 200E-12-0084)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Thermocouple internal to the tank in contact with liquids and/or solids. Used to monitor temperature of the tank's contents.

Physical Characteristics: 40 ft long by 8 in. in diameter, 828 lb.

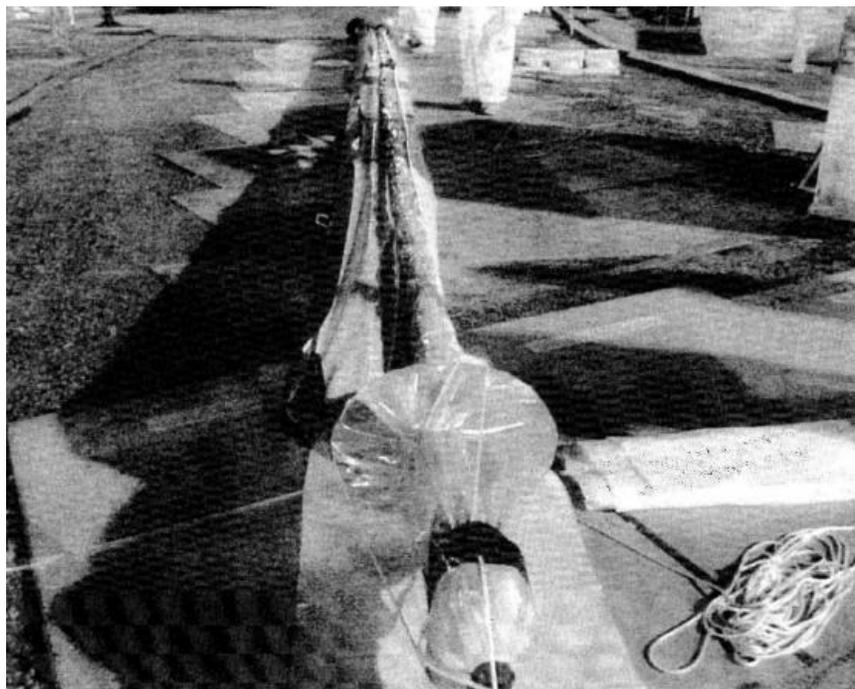
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 2.56E6 dpm/100 cm² βγ/1.32E5 dpm/100 cm² α

External Dose: Less than 200 mR/hr

Derived Air Concentration Value: 2.02E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0111 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container and could not be safely size reduced due to high levels of removable contamination. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 10

Item: Tank Farm 241-C-102 Salt well Pump, Riser 13 (OWTF # 200E-12-0118)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Pump located within a salt well screen for pumping liquids out of a tank.

Physical Characteristics: 40 ft long by 16 in. in diameter, 1,975 lb.

LDR Waste Codes: F001, F002, F003, F004, F005, D007

Internal Contamination Levels: 1.21E7 dpm/100 cm² βγ, 3.59E5 dpm/100 cm² α

External Dose: Less than 200 mR/hr

Derived Air Concentration Value: 5.48E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0118 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 11

Item: Slurry Pump from Tank No. 241-C-109 (OWTF # 200E-12-0109)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Pump inserted into a waste tank used to pump tank waste slurry out of the tank.

Physical Characteristics: 35 ft long by 18 in. in diameter, 2,880 lb.

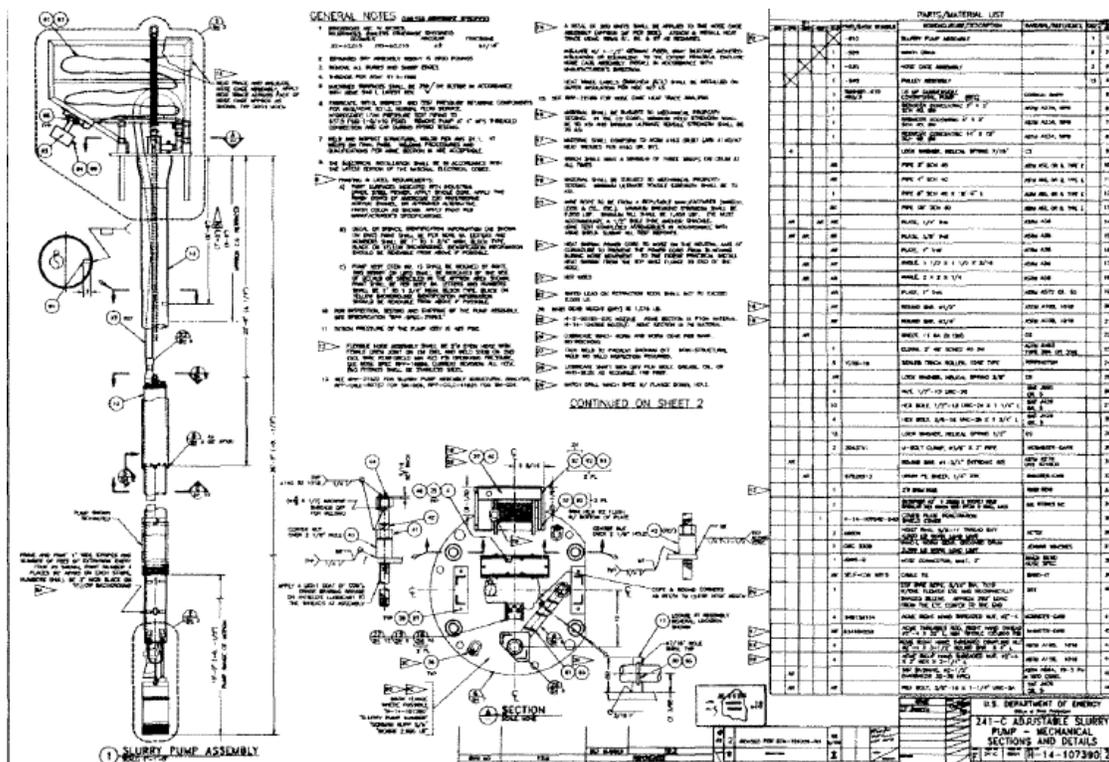
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 6.16E8 dpm/100 cm² βγ, 6.51E4 dpm/100 cm² α

External Dose: 1,000 mR/hr

Derived Air Concentration Value: 4.98E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0115 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 12

Item: Tank Farm 241-C-104 Thermocouple (OWTF # 200E-12-0039)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Measures temperatures within tank waste.

Physical Characteristics: 40 ft long by 6 in. in diameter, 369 lb. (photo of this item is not available; photo used is of a similar object [waste item description #9])

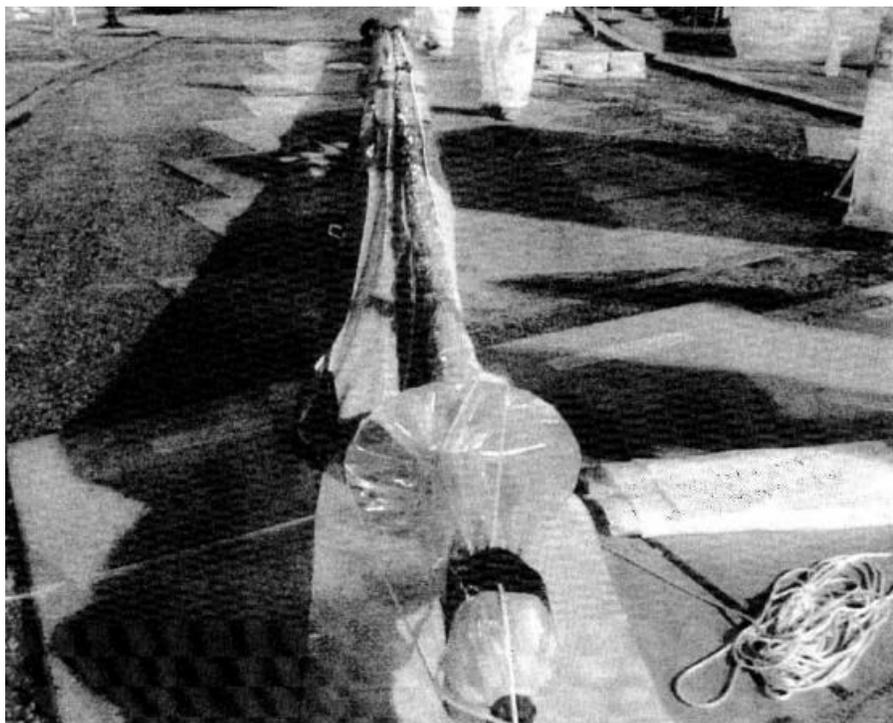
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 1.21E7 dpm/100 cm² βγ, 3.59E5 dpm/100 cm² α

External Dose: Less than 200 mR/hr

Derived Air Concentration Value: 5.48E+02 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0106 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 13

Item: Supernate Pump from Tank No. 241-AN106 (OWTF # 200E-13-0049)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Pump installed in a tank with motor at top and impellers at bottom. Decants supernatant waste (liquids) in order to transfer them out of a tank.

Physical Characteristics: 25 ft long by 20 in. in diameter, 6,247 lb.

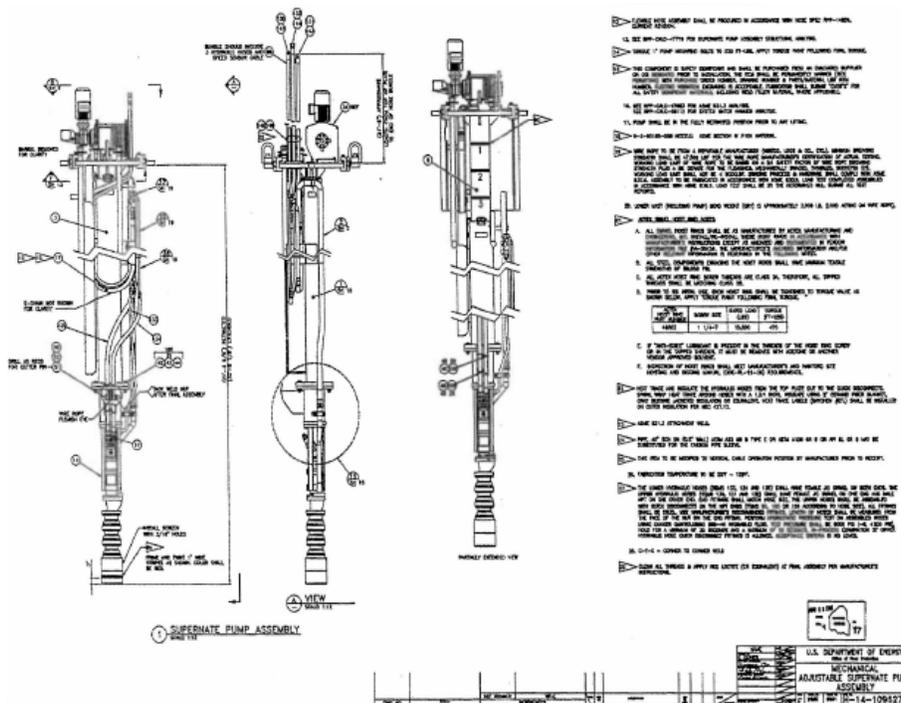
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 3.88E7 dpm/100 cm² βγ, 2.44E3 dpm/100 cm² α

External Dose: 80 mR/hr

Derived Air Concentration Value: 2.87E+01 DAC; airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0125 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 14

Item: Supernate Pump from Tank No. 241-AN106/06A (OWTF # 200E-12-0044)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Pump installed in a tank with motor at top and impellers at bottom. Decants supernatant waste (liquids) in order to transfer them out of a tank.

Physical Characteristics: 32 ft long by 50 in. in diameter, 10,000 lb.

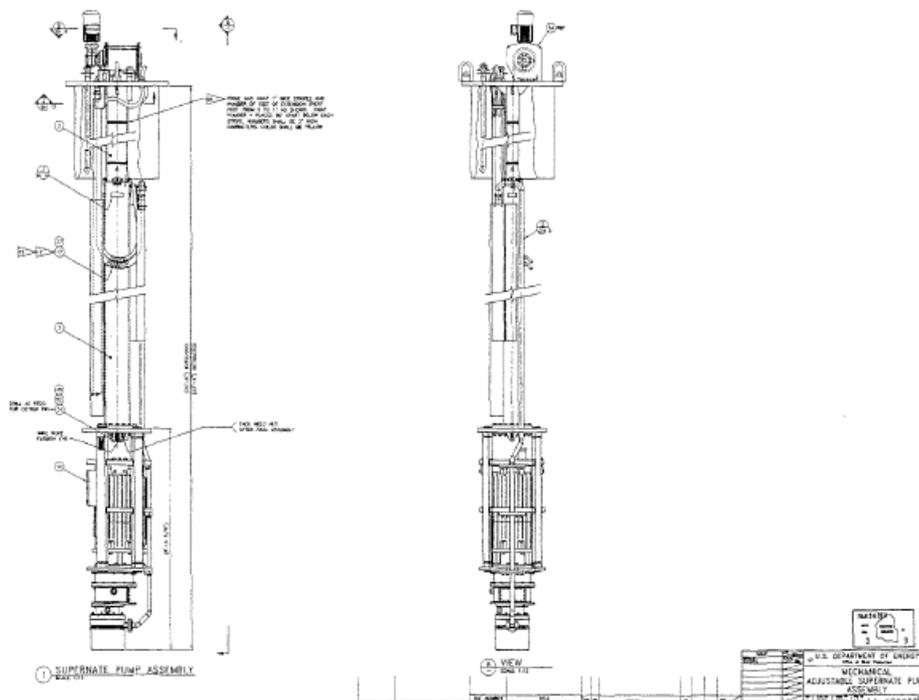
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 1.20E8 dpm/100 cm² βγ, 1.20E3 dpm/100 cm² α

External Dose: 300 mR/hr

Derived Air Concentration Value: 2.87E+01 DAC; airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0107 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 15

Item: Cone Penetrometer from Tank No. 241-AN106 Riser 10 (OWTF # 200E-14-0005)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Probe that is pushed through salt cake or sludge in order to measure the physical strength of the salt cake or sludge.

Physical Characteristics: 48 ft long by 12 in. in diameter, 3,400 lb.

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 8.57E6 dpm/100 cm² βγ, 9.79E3 dpm/100 cm² α

External Dose: 1.5 mR/hr

Derived Air Concentration Value: 7.88E+01 DAC; high airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0135 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulated Waste Item Description 16

Item: Slurry Pump from Tank No. 241-C-107 (OWTF # 200E-14-0012)

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Pump installed in a tank with motor at top and impellers at bottom to pump slurry out of the tank.

Physical Characteristics: 45 ft long by 18 in. in diameter, 4,934 lb.

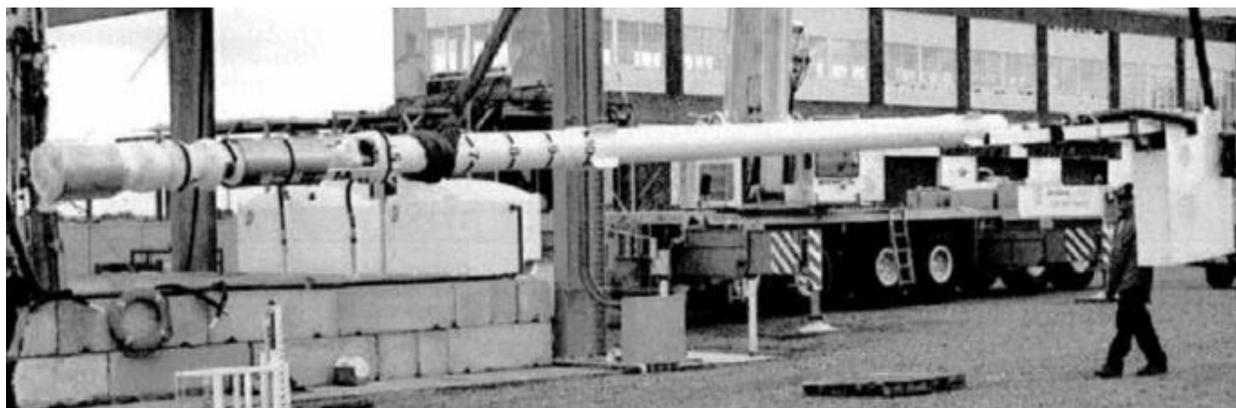
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 1.22E7 dpm/100 cm² βγ, 1.33E5 dpm/100 cm² α

External Dose: 13 mR/hr

Derived Air Concentration Value: 2.05E+01 DAC; airborne contamination potential if internal contamination is exposed to the atmosphere (e.g., item is broken open or size reduced).

Treatment/Disposal Information: WSRP # OHC-RP-W0137 treated via polyurethane/polyurea jacket. This item was too long to be macroencapsulated in an ERDF roll-off container. The multiple crane lifts and rotations required to treat with polyurethane foam and polyurea jacket increase the possibility of dropping and/or breaching the protective wrappings of this item and creating an airborne radiation area.



Macroencapsulation Waste Item Description 17

Item: 241-C-05B Heel Pit (OWTF # 200E-12-0149)

Category: Large Tank-Waste-Contacted Debris

Function: The C-5B Pit is a concrete vault that was used as a “riser interface” for access into the dome of the C-105 tank. This riser interface held a liquid transfer pump that was used to transfer waste to other tanks.

Physical Characteristics: The dimensions of the C-5B Pit are 12 ft long by 6 ft high by 9 ft wide. The mass of the C-5B Pit is estimated at 78,000 lb. Protruding from the bottom of the C-5B Pit is a riser pipe 5 ft long by 12 in. in diameter with some additional concrete firmly attached to it that measures 2 ft high by 3 ft wide by 12 ft long.

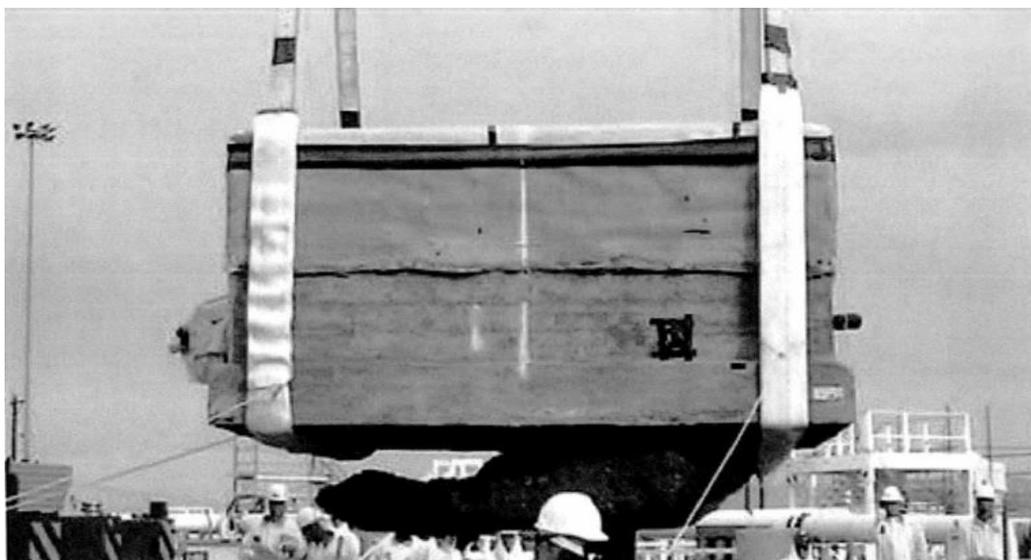
LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels: 2.33E8 dpm/100 cm² βγ, 3.04E4 dpm/100 cm² α

External Dose: 50 mR/hr on contact; 25 mR/hr at 1 ft

Derived Air Concentration Value: 2.0E+1 DAC; airborne radiation area potential because contamination fixative coatings are of a temporary nature and are degrading with time.

Treatment/Disposal Information: WSRP # OCH-RP-W0123. Not treated nor disposed at this time. This item will require multiple manipulations in order to apply a jacket of polyurea. The large size, mass, and uncertain center of gravity increase the potential for a crane drop incident. The radiological hazard stated above makes application of polyurea physically and radiologically hazardous.



Macroencapsulation Waste Item Description 18

Item: Cover Blocks and Plates

Category: Large Tank-Waste-Contacted Equipment

Function: Concrete Blocks or Steel Plates used to cover process pits such as the Heel Pit described as Macroencapsulation Waste Item Description 17.

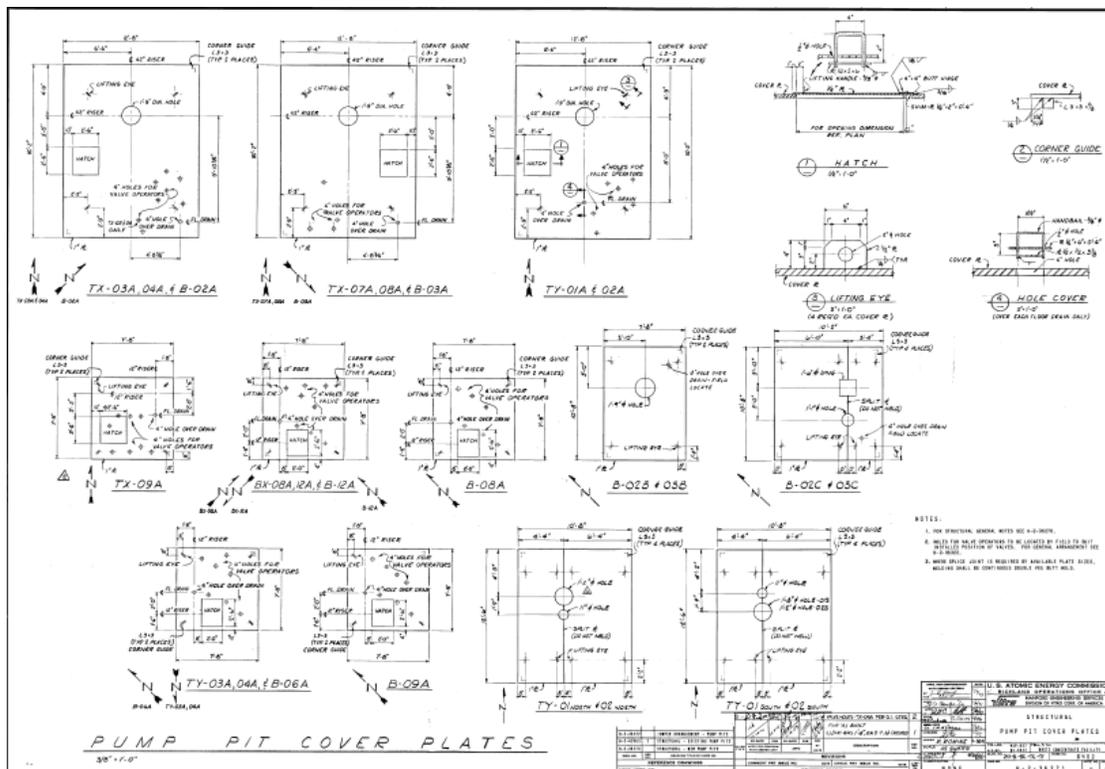
Physical Characteristics: Varies from 1 ft by 4 ft by 1 ft upwards to sizes that cannot fit inside a 15.3-m³ (20-yd³) roll-off container (those that fit in roll-off containers will be macroencapsulated outside of the trench in roll-off containers), 1,000 lb. and up

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels and External Dose: Similar to the 241-C-105B Heel Pit (Macroencapsulation Waste Item Description 17)

Derived Air Concentration Value: Unknown until it is prepared for shipment. Similar to the 241-C-105B Heel Pit (Macroencapsulation Waste Item Description 17).

Treatment/Disposal Information: These items will be macroencapsulated and disposed in ERDF.



Macroencapsulation Waste Item Description 19

Item: Rigid Jumpers

Category: Large Tank-Waste-Contacted Equipment

Function: Steel piping ranging in diameter from 1 to 4 in. Jumper may contain valves and mechanical connection devices (e.g., PUREX connectors).

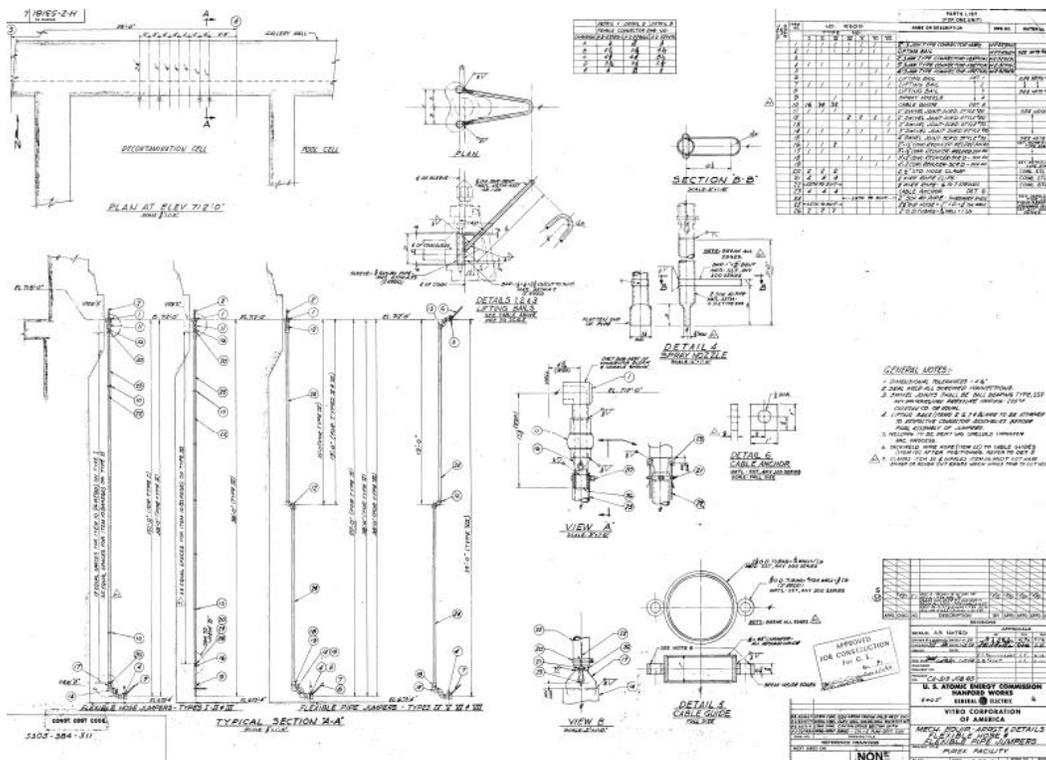
Physical Characteristics: Varies, may be up to 30 ft long (those that fit in a 15.3-m³ [20-yd³] roll-off container will be macroencapsulated outside of the trench in roll-off containers), 200 lb. and up

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels and External Dose: Similar to the 241-C-102 Salt Well Pump (Macroencapsulation Waste Item Description 10)

Derived Air Concentration Value: Unknown until it is prepared for shipment. Similar to the 241-C-102 Salt Well Pump (Macroencapsulation Waste Item Description 10).

Treatment/Disposal Information: These items will be macroencapsulated and disposed in ERDF.



Macroencapsulation Waste Item Description 20

Item: Top Hats

Category: Large Tank-Waste-Contacted Equipment

Function: Steel/PVC Pipe and Flange Assemblies, typically running from the top of a tank to structures or equipment located at ground level.

Physical Characteristics: Varies, may be up to 10 ft long (those that fit in a 15.3-m³ [20-yd³] roll-off container will be macroencapsulated outside of the trench in roll-off containers), 100 lb. and up

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels and External Dose: Similar to the 241-C-105B Heel Pit (Macroencapsulation Waste Item Description

Derived Air Concentration Value: Unknown until it is prepared for shipment. Similar to the 241-C-105B Heel Pit (Macroencapsulation Waste Item Description 17).

Treatment/Disposal Information: These items will be macroencapsulated and disposed in ERDF.

(No Illustration Available)

Macroencapsulation Waste Item Description 21

Item: Slurry Pump

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Used to pump liquids and slurry within or between tanks.

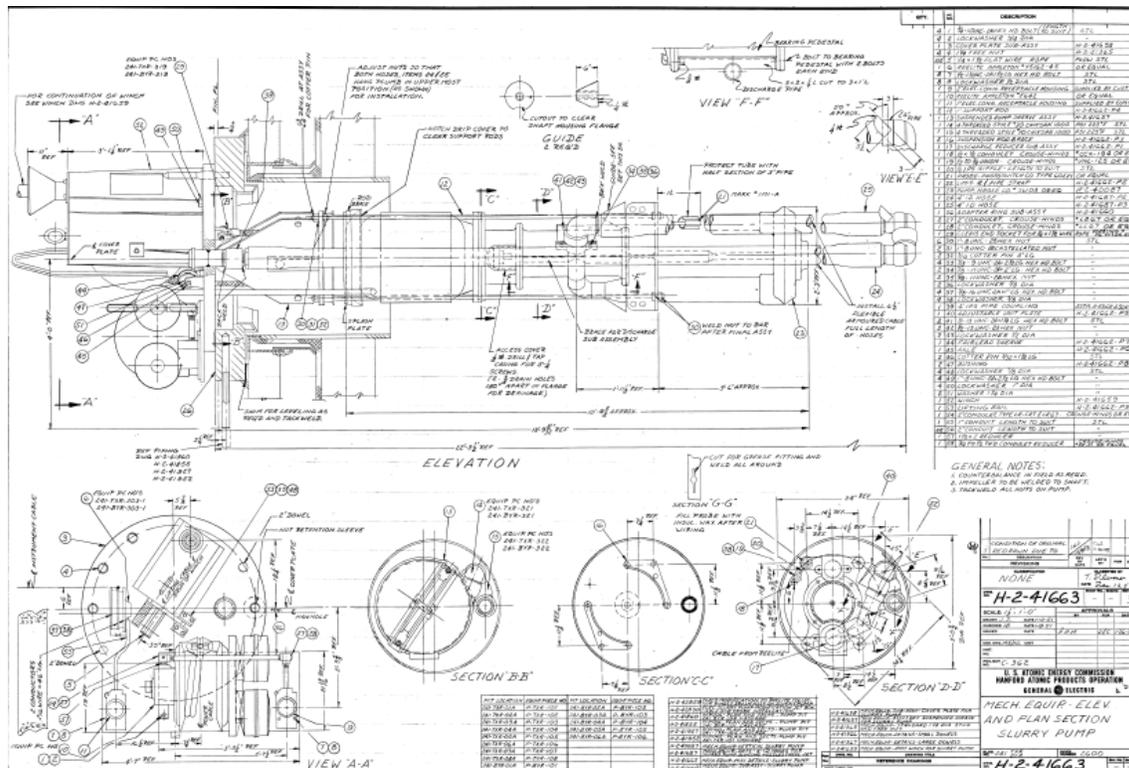
Physical Characteristics: Varies, may be up to 54 ft long and 6 ft in diameter (those that fit in a 15.3-m³ [20-yd³] roll-off container will be macroencapsulated outside of the trench in roll-off containers), 14,000 lb. and up

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels and External Dose: Similar to the 241-C-109 Slurry Pump (Macroencapsulation Waste Item Description 11)

Derived Air Concentration Value: Similar to the 241-C-109 Slurry Pump (Macroencapsulation Waste Item Description 11).

Treatment/Disposal Information: These items will be macroencapsulated and disposed in ERDF.



Macroencapsulation Waste Item Description 22

Item: MARS Units (Mobile Arm Retrieval System)

Category: Large Tank-Waste-Contacted Equipment

Function: MARS-V is a remotely operated in-tank retrieval system installed through a 47-in.diameter riser through the center of a single shell tank dome. The system is designed to accomplish both bulk waste retrieval and hard heel retrieval. The system mobilizes the tank waste and transfers the waste to the waste accumulator tank, then pumps the tank waste to a double-shell tank.

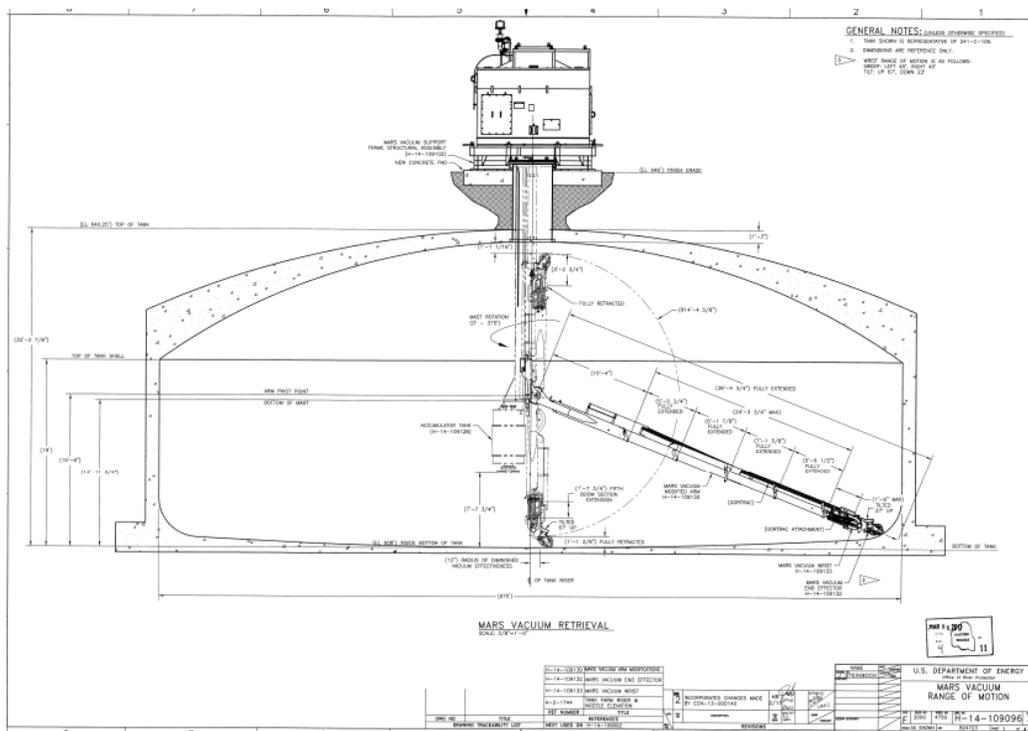
Physical Characteristics: 15 ft by 15 ft by 15 ft, 130,000 lb.

LDR Waste Codes: F001, F002, F003, F004, F005

Internal Contamination Levels and External Dose: Similar to the 241-C-109 Slurry Pump (Macroencapsulation Waste Item Description 11).

Derived Air Concentration Value: Unknown until it is prepared for shipment. Similar to the 241-C-109 Slurry Pump (Macroencapsulation Waste Item Description 11)

Treatment/Disposal Information: These items will be macroencapsulated and disposed in ERDF.



Macroencapsulation Waste Item Description 25

Item: Water Lance

Category: Long-Length Tank-Waste-Contacted Equipment

Function: Steel pipe with spray fittings at the end, which enters the tank in order to move debris/hardened tank waste for the purposes of installing other equipment.

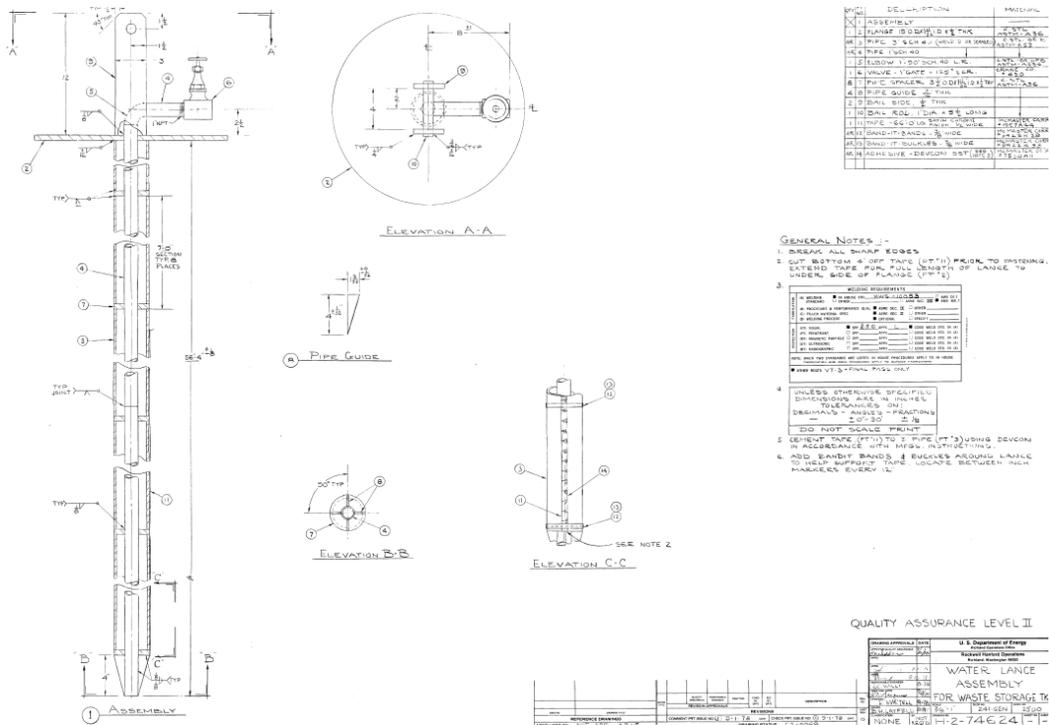
Physical Characteristics: Varies, 10 ft long by 3 ft wide to 56 ft long by 4 ft wide (those that fit in a 15.3-m³ [20-yd³] roll-off container will be macroencapsulated outside of the trench in roll-off containers)

LDR Waste Codes: F001, F002, F003, F004, F005, Possible Characteristic Codes

Internal Contamination Levels and External Dose: Similar to the 241-C-111 Sluicers (Macroencapsulation Waste Item Description 4).

Derived Air Concentration Value: Unknown until it is prepared for shipment. Similar to the 241-C-111 Sluicers (Macroencapsulation Waste Item Description 4)

Treatment/Disposal Information: These items will be macroencapsulated and disposed in ERDF.



Macroencapsulation Waste Item Description 27

Item: 324 Building Hot Cell

Category: Hot Cells (Including Glove Boxes)

Function: Enclosed room or box equipped with leaded windows, pass-through chambers, remote manipulators, cranes, etc., for manipulating radiological items or conducting process operations within the room while isolating the contents of the room from the environment outside of the box.

Physical Characteristics: Varies, these can be very large with dimensions in the tens of feet and weighing up to or over 1,000 tons

LDR Waste Codes: Characteristic Codes, possible, F001, F002, F003, F004, F005

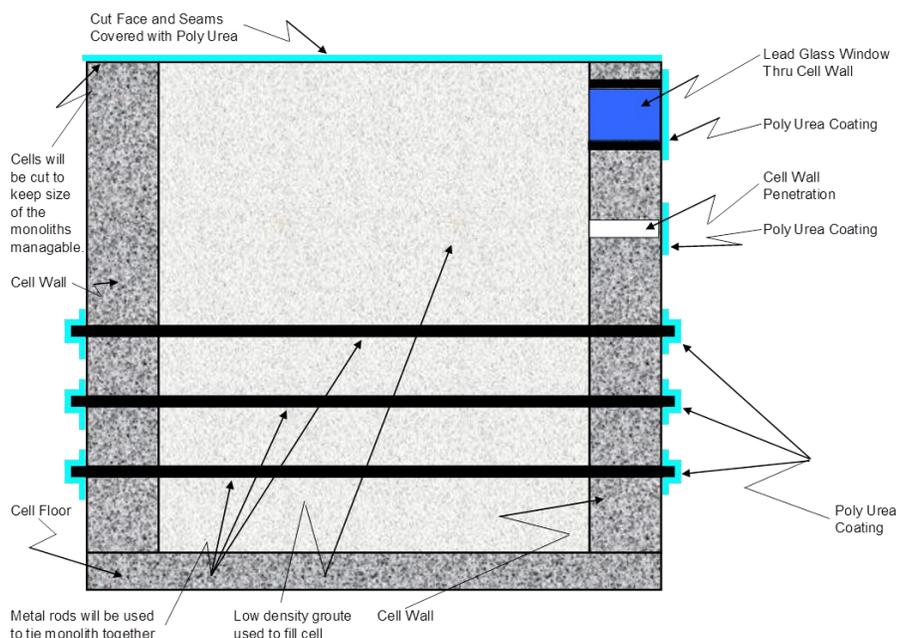
Internal Contamination Levels: Levels are high enough to be immediately dangerous to human life and health

External Dose: Generally low due to thick concrete walls

Derived Air Concentration Value: Unknown until it is prepared for shipment.

Treatment/Disposal Information: These items may be partially macroencapsulated or filled prior to shipment and disposed in ERDF. They may require specially prepared concrete pads in the ERDF Trench.

Example of 324 Bldg. Hot Cell Monolith



APPENDIX B
DOSE AND RISK COMPARISONS

APPENDIX B

DOSE AND RISK COMPARISONS

A comparison of radiation dose received and the corresponding relative cancer risks for out-of-trench versus in-trench treatment of long, large, and/or heavy hazardous (LLHH) waste items is presented in this appendix. Dose received by workers depends on the following:

- A waste item's dose rate
- The amount of time workers spend near the waste item
- The distance between the waste item and workers while they are performing various tasks
- The number of workers required to complete different tasks.

The dose rate of any given waste item would be the same for both treatment methods. Therefore, for the purposes of comparison dose rate can be ignored. This leaves duration of exposure (time), proximity to the waste item (distance), and number of required workers to accomplish treatment as the basis for comparison of dose received during out-of-trench versus in-trench treatment for any given waste item.

This comparison is based on interviews of workers, radiological control technicians (RCTs), supervisors, and senior supervisory watch personnel who participated in or closely observed out-of-trench waste treatment operations. Some of the personnel interviewed had also worked on or supervised in-trench treatment in the past. All of those interviewed had participated in multiple treatment operations. While the LLHH waste items being treated out-of-trench have been similar in terms of general configuration and nature of treatment, the number of subtasks, time required to complete the work, and time spent in close proximity to the waste item are different for each one. This is due to differences in configuration, radioactive dose, and packaging of the individual waste items.

The interviews and data gathered constitute an after-the-fact time and motion study (actual time and motion studies were not conducted during treatment). The queries were generalized due to the length of time that had elapsed since some of the items had been treated. The general nature of the questions allowed participants to consolidate their experiences in treating multiple items. Interviews were conducted with individuals or small groups depending on the availability of individuals being interviewed. The individuals/groups interviewed included the following:

- 1 Field Work Supervisor and 1 RadCon Engineer
- 1 Operations Manager (serving as senior supervisory watch)
- 1 Conops Coach (serving as senior supervisory watch)
- 1 Operations Superintendent (serving as senior supervisory watch)
- 3 RCTs
- 1 Transportation Superintendent (serving as senior supervisory watch)
- 1 Subcontract Technical Representative (serving as senior supervisory watch)
- 2 Lead Laborers
- Waste Management Officer (completed macro inspector).

Treatment of waste items was broken down into six tasks. Radiation received while performing each task is summed to provide the total radiation received by a work crew while treating a waste item. The tasks required to complete out-of-trench treatment include the following:

1. Radiation surveys (a compilation of the numerous surveys taken during each job)
2. Unloading the item from the transport box (coffin) and conveying it by crane to stanchions
3. Manipulating the item (i.e., rotating and shifting it) during treatment
4. Treating – applying polyurethane foam and polyurea liner material to the item
5. Reloading the item back onto a truck, securing it, and unloading it in the Environmental Restoration Disposal Facility (ERDF) trench
6. Final inspections: performed once before loading an item onto the truck and once as it is being unloaded from the truck.

In each interview the following questions were asked about the six subtasks:

1. How many people were involved in the subtask?
2. What was their average distance from the item during the subtask?
3. How much time did they spend at that distance from the item?

The questions were repeated in interviews with workers who had experience performing in-trench treatment. Because in-trench treatment has fewer steps, the tasks were limited to the following:

1. Radiation surveys
2. Unloading the item from the transport box and conveying it by crane to its treatment location
3. Treatment (surrounding and covering item with grout).

The most significant aspect influencing dose received by a worker is the worker's distance from the radiation source because dose received generally varies with the square of the distance from the source (i.e., working 1 ft away from a radioactive item gives a worker 4 times the dose that would be received while working 2 ft away from it). This relationship assumes a "point source" of radiation (the worker is far from the source). When workers are very close to a long or large radioactive item, the radiation received is greater than the inverse square relationship that applies to a point source. For conservatism and ease of estimation, the present comparisons assume a point source regardless of workers' proximity.

Time and distance parameters for treating LLHH waste items outside of the trench vary greatly from item to item depending on the size and physical complexity of the item, number of polymer coatings required to complete encapsulation, and ambient weather conditions encountered during treatment. In contrast, the simplicity of flood grouting for the in-trench treatment method greatly minimizes the differences in treatment parameters from item to item. As a result, estimates of time and proximity for the treatment phases made by different individuals or groups of individuals interviewed varied from one another. This was accounted for by calculating an average time for each of the activities and the average proximity of workers to the waste item for each of the subtasks. Once the average values of the individual interviews were consolidated into Tables B-1 and B-2, they were used to calculate the exposure factors for out-of-trench

versus in-trench treatment. Operations that are identical for both in-trench and out-of-trench treatment (e.g., opening the transport box, removing blocking) have been left out of the analysis. The results of the determination are presented in Tables B-1 and B-2.

Table B-1. Out-of-Trench Treatment Exposure Factor Summary.

Operation	Out-of-Trench Treatment			Factor*
	Persons	Distance (ft)	Time (hr)	
Surveys	1.1	1.4	2.1	1.2
Unload	3.0	10.6	0.6	0.02
Manipulate	3.0	3.5	0.7	0.2
Treat	1.0	2.6	4.3	0.6
Reload/Unload	4.0	8.4	1.1	0.06
Inspections	1.0	1.0	0.7	0.7
Total Factor				2.8

* Factor = $P \times 1/D^2 \times T$

Table B-2. In-Trench Treatment Exposure Factor Summary.

Operation	In-Trench Treatment			Factor*
	Persons	Distance (ft)	Time (hr)	
Surveys	1.0	8.2	0.2	0.003
Unload	2.2	12.0	0.4	0.006
Manipulate	n/a	n/a	n/a	n/a
Treat	1.0	18.0	1.6	0.005
Reload/Unload	n/a	n/a	n/a	n/a
Inspections	n/a	n/a	n/a	n/a
Total Factor				0.014

* Factor = $P \times 1/D^2 \times T$

The factor calculation for each operation is summed for both methods to yield the total for the treatment method; 2.8 for out-of-trench and 0.014 for in-trench. Dividing the total factor of the out-of-trench treatment by the total factor of the in-trench treatment yields a relative out-of-trench to in-trench dose factor of 200:1.

The actual dose absorbed by the entire crew was monitored and calculated for the first 12 items treated using polymers outside the trench. The total for the crew for all 12 items was 1,098 mrem. When divided by 12 (the number of items treated) the average estimated dose received per item is 90 mrem for the entire crew. This estimated received dose is used below to calculate the relative excess cancer risk.

Relative excess cancer risk for out-of-trench and in-trench treatment was evaluated using dose-to-risk conversion factors recommended by the EPA (EPA 540-R-012-13, *Radiation Risk Assessment At CERCLA Sites: Q & A*). This new recommendation for radiation risk assessment at CERCLA sites equates a 12 mrem/yr dose to a 3×10^{-4} cancer risk, resulting in a dose to cancer risk conversion factor for a residential scenario of 2.5×10^{-5} risk per mrem/yr. Similarly, the dose to risk conversion factor for an industrial scenario is determined by equating the identical 12 mrem/yr dose to the industrial cancer risk determined from RESidual RADioactivity (RESRAD) (ANL 2009) evaluation of soil contaminated with Hanford Site radionuclides, resulting in a 5.2×10^{-5} cancer risk. This provides an industrial scenario dose to risk conversion factor of $(5.2 \times 10^{-5} \text{ risk}) / (12 \text{ mrem/yr})$ or 4.3×10^{-6} risk per mrem/yr (residential scenarios are shown for reference only; the industrial scenario is more pertinent to ERDF treatment operations).

Residential and Industrial excess cancer risks for out-of-trench and in-trench treatments have been calculated in Tables B-3 and B-4 using the average dose per item of 90 mrem for the LLHH waste items that have been macroencapsulated and anticipating 40 items per year to be treated by 13 workers. For out-of-trench treatment of LLHH waste items the residential and industrial cancer risks are predicted to be higher than the EPA recommended risk range of 10^{-4} to 10^{-6} (EPA 540-R-012-13, *Radiation Risk Assessment At CERCLA Sites: Q & A*), as shown in Table B-3. However, residential and industrial cancer risks for in-trench treatment are predicted to be within the EPA recommended risk range, as shown in Table B-4. The RESRAD input parameters were identical for the Residential and Industrial scenarios, EXCEPT for the Indoor and Outdoor time fractions spent on site by the exposed individual. There are more than 100 input parameters required to run the RESRAD software. Of necessity, some are default parameters. However, Hanford Site-specific input parameters were used wherever Hanford Site input parameters differed from default input parameters.

Table B-3. Out-of-Trench Risk Calculations.

Scenario	Conversion Factors, Risk per mrem/yr	Number of Items	Dose per Item (mrem)	Number of Workers	Out-of-Trench Cancer Risk
Residential	2.5×10^{-5}	40	90	13	6.9×10^{-3}
Industrial	4.3×10^{-6}	40	90	13	1.2×10^{-3}

Example Calculation of Industrial Out-of-Trench Cancer Risk: 4.3×10^{-6} risk per mrem/yr x 40 items x 90 mrem/item / 13 workers = 1.2×10^{-3} cancer risk per worker

Table B-4. In-Trench Risk Calculations.

Scenario	Out-of-Trench Cancer Risk	Ratio of Out-of-Trench to In-Trench Risk	In-Trench Cancer Risk
Residential	6.9×10^{-3}	200:1	3.5×10^{-5}
Industrial	1.2×10^{-3}	200:1	6.0×10^{-6}

Example Calculation of Industrial In-Trench Cancer Risk: 1.2×10^{-3} Out-of-Trench cancer risk / 200 = 6.0×10^{-6} cancer risk per worker

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