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		Design Authority	1	1	K. L. Pearce K L Pearce 8/28/98 H7-20
		Design Agent			
1	1	Cog.Eng.T. A. Flament [signature] 9/3/98			
1	1	Cog. Mgr.W. W. Rutherford [signature] 9/2/98 H7-20			
		QA			
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K. L. Pearce K L Pearce 8/28/98 Signature of EDT Originator Date	[signature] 9/2/98 Authorized Representative for Receiving Organization Date	[signature] W. W. Rutherford 9/2/98 Design Authority/ Cognizant Manager Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

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SOLIDIFICATION PROCESS FOR SLUDGE RESIDUE

K. L. Pearce
Numatec Hanford Corporation, Richland, WA 99352
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Abstract: This report investigates the solidification process used at 100-N Basin to solidify the N Basin sediment and assesses the N Basin process for application to the K Basin sludge residue material. This report also includes a discussion of a solidification process for stabilizing filters. The solidified matrix must be compatible with the Environmental Remediation Disposal Facility acceptance criteria.

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SOLIDIFICATION PROCESS FOR SLUDGE RESIDUE

K. L. Pearce (NHC)

Numatec Hanford Corporation
Richland, Washington

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LIST OF TERMS

BHI	Bechtel Hanford Incorporated
CNS	Chem Nuclear Systems
CWC	Central Waste Complex
ERDF	Environmental Restoration Disposal Facility
KE	K East
KW	K West
NCP	North Cask Pit
OIER	Organic Ion Exchange Resin
PCB	Polychlorinated Biphenyl
RCRA	*Resource Conservation and Recovery Act*
SNF	Spent Nuclear Fuel
TSCA	*Toxic Substances Control Act*
TRU	Transuranic
USNRC	U.S. Nuclear Regulatory Commission
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to investigate the solidification process used at 100-N Basin to solidify the N Basin sediment and to assess its application to the K Basin sludge residue material. This report also includes a discussion of a solidification process for stabilizing filters. The solidified material must be compatible with the Environmental Remediation Disposal Facility (ERDF) acceptance criteria.

1.2 Background

Both the K East (KE) and K West (KW) Basins contain contaminated sludge. Sludge on the floor and in the pits of the KE Basin is a mix of fuel corrosion products (including metallic uranium, and fission and activation products), small fuel fragments, zirconium cladding, iron and aluminum oxide, concrete grit, sand, ion exchange resin and biological debris. The large quantity of fuel corrosion products in the KE Basin floor and pit sludge is a result of the open tops, and in some cases open-screened bottoms, of the fuel storage canisters. Because the Spent Nuclear Fuel (SNF) stored in the KW Basin was placed in closed containers before storage, corrosion products were retained within the canisters and the sludge buildup in the KW Basin is a much smaller volume than that in KE Basin. The small quantity of sludge on the floor of the KW Basin appears to consist primarily of dust and sediment; the floor sludge is not expected to contain significant amounts of fuel corrosion products because the KW Basin canisters have closed tops and bottoms. Only one of the pits (North Loadout Pit) in the KW Basin contains a significant amount of sludge and is likely to consist of a mix of sand and fuel corrosion products. Sludge in the KE and KW Basin fuel storage canisters consists primarily of fuel corrosion products.

The baseline path for disposal of the K Basin sludge is to chemically treat the sludge by separating the organic resin material, dissolving the fuel constituents in nitric acid, separating the insoluble material, adding neutron absorbers for criticality safety, and then reacting the solution with caustic to co-precipitate the uranium and plutonium.

There will be five distinct feed streams going to the sludge treatment process, two from KE Basin and three from KW Basin. The characteristics of these five feed streams are documented in Pearce (1998). The sludge, from one feed stream at a time, will be transported to the treatment system lag storage tank where it will be held until it can be moved on through the process. From the lag storage tank the sludge will be transferred through a screen to the dissolver feed tank. The screen will separate out the organic resin beads and direct them to a resin holding tank. The undissolved solids in the dissolver product will be separated out using a sedimentation centrifuge followed by a polishing filter (cartridge filter with polyethylene filter elements). The solids that are removed by the centrifuge will be transferred to a leaching tank where Transuranic (TRU) and fission products will be leached from the solids. The resin beads will also be transferred to the leach tank where they will be treated to remove Cs-137 and transuranics. Following leaching, the leach solution and washed resin beads/solids will be sent to the centrifuge for separation. The overflow from the centrifuge will be transferred through cartridge filters for further solids separation. The separated resin beads and undissolved solids will then be transferred to a holding tank until processed for final disposal.

The pressure drop across the filter will be monitored and the filter elements will be changed out when the pressure drop approaches the design limit or when the flow rate through the filter decreases to the point that it is slowing down sludge processing. The filters will be stored until processed for final disposal at the completion of the sludge treatment process. A complete description of the sludge treatment process, including the solids/liquid separations for the resin beads and undissolved solids, is provided in Westra (1998).

2.0 N BASIN SEDIMENT DISPOSAL

105-N Basin sediment consisted of corrosion product (e.g., reactor fuel element, structural steel, and aluminum oxide corrosion), windblown sand and dirt, biological debris, and organic flocculation material. During stabilization of the 105-N Basin, the basin sediments were collected in the North Cask Pit (NCP) of the basin complex. The consolidated sediment was subject to Toxic Substances Control Act (TSCA) regulation, but was not a Resource Conservation and Recovery Act (RCRA) waste. The mass of the settled sediments (solids plus interstitial water) in the NCP was calculated to be 13, 636 kg. The final sediment volume was 401 ft^3 (11.36 m^3) based on a wet, settled condition (corresponding density: 1.20 g/cc). The N Basin Project solidified the sediment and disposed of the waste at the ERDF in accordance with the ERDF waste acceptance criteria and applicable regulations. The project completed solidification of the N Basin sediment in July 1998.

This section provides an overview of the solidification process used at N Basin (Logan 1998).

2.1 Industry Practices

In developing plans for the disposal of the N Basin sediment, Bechtel Hanford Incorporated (BHI) evaluated industry practices for similar waste processing activities to ensure conformance:

- The U.S. Nuclear Regulatory Commission (USNRC) Branch Technical Position titled Issuance of Final Branch Technical Position on Concentration Averaging and Encapsulation, Revision in Part to Waste Classification Technical Position (January 17, 1995) states that "Classification of evaporator concentrates, filter backwashes, liquids, or ion-exchange resins solidified in a manner to achieve homogeneity or meet the stability criteria of 10 CFR 61.56 should be based on solidified nuclide activity divided by the volume or weight of the solidified mass." This text establishes the commercial nuclear precedent for averaging the activity over the volume or mass of the final waste matrix.

- Solidification is an established method of removing freestanding water and satisfying waste form and structural stability criteria. The Chem Nuclear process is approved by the USNRC, and used in commercial nuclear power plants for the disposal of various waste resins.

- Commercial nuclear processing relies on tank recirculation times and process flow rates to ensure adequate homogenization before commencing waste processing operations. A similar approach was used for the N Basin NCP contents. The USNRC position on activity averaging referenced above states that:

  " A homogeneous waste type is one in which the radionuclide concentrations are likely to approach uniformity in the context of the intruder scenarios used to establish the values included in Tables 1 and 2 of 10 CFR 61.55 (i.e., intruder interactions with the waste are assumed to take place 100 years or more after disposal site closure). Such waste types would include, for example, spent ion-exchange resins, filter media, solidified liquid, evaporator bottom concentrates, or contaminated soil."

  Therefore, with proper consideration during the design process, homogeneity may be assumed after the NCP contents are mixed. (Analytical validation of homogeneity is not required.)

- The ratio of the total volume of the N Basin waste matrix after processing to the volume of material before processing was about 6:1. This ratio is consistent with industry experience in solidifying liquid radioactive waste.

2.2 N Basin Sediment Characteristics

The physical, chemical and radiological characteristics of the consolidated N Basin sediment, on an as-settled basis, are presented in Tables 2-1 and 2-2 (partial list, only, provided [Logan 1998]).

Table 2-1. Chemical and Physical Characteristics of N Basin As-Settled Sediment.

Analyte	Concentration	Units	Physical Property	Value	Units
Aluminum	1.02E+04	µg/g	Settled Density	1.20E+00	g/mL
Calcium	5.60E+03	µg/g	Slurry Density	1.09E+00	g/mL
Iron	1.10E+05	µg/g	Percent H_2O	5.61E+01	%
Silicon	1.44E+03	µg/g	Sediment Volume	11.36	m^3
Uranium	2.24E+03	µg/g	Slurry Volume	22.91	m^3
Zirconium	1.52E+01	µg/g	Particle Size	up to 6350	µm
PCBs					
Aroclor 1254	22.5E+00	µg/g			

Table 2-2. Radionuclide Characteristics of N Basin As-Settled Sediment.

Radionuclide	Concentration	Unit	Radionuclide	Concentration	Unit
Am-241	5.23E-01	µCi/g	Pu-241	2.22E+01	µCi/g
Am-242m	1.02E-03	µCi/g	Pu-242	8.96E-05	µCi/g
Am-243	3.84E-03	µCi/g	U-234	1.52E-03	µCi/g
Cs-137	3.08E-00	µCi/g	U-235	3.55E-05	µCi/g
Co-60	1.24E-00	µCi/g	U-236	1.49E-04	µCi/g
Cm-243	5.41E-04	µCi/g	U-238	6.82E-04	µCi/g
Np-237	1.70E-03	µCi/g	Sr-90	2.53E-00	µCi/g
Pu-238	9.17E-02	µCi/g			
Pu-239	3.39E-01	µCi/g	Gross Alpha	1.01E-00	µCi/g
Pu-240	2.01E-01	µCi/g	Gross Beta	1.11E+01	µCi/g

2.3 Waste Processing

2.3.1 Homogenization

The N Basin sediment was homogenized in the NCP prior to removal of the sediment for solidification. An array of four pumps, with a combined flow rate of about 800 gpm, were each placed about two feet out from a corner of the Pit. The final contents of the NCP were mixed and allowed to settle. Following mixing and settling it was expected that the sediment in the NCP was homogeneously distributed in the horizontal plane and stratified in the vertical plane. Treating the waste in order to create separate, equivalent containers of solidified waste assumes that the waste is homogeneous when it is withdrawn from the NCP. It was estimated that the amount of water required for homogenization and removal operations (408 ft^3 [11.55 m^3]) was approximately equal to the volume of settled sediment (401 ft^3 [11.36 m^3]). The water also provides shielding for the sediment in the Pit.

2.3.2 In-Liner Processing

The N Basin slurried material was transferred to commercial L14-170 liners. The internal volume of each liner is 170 ft^3 (4.81 m^3) supplied by Chem Nuclear Systems (CNS) and processed using the CNS 4313-01354-01NP-A Mobile Cement Solidification System. This system has been approved by the USNRC for use in commercial nuclear power plants.

Three liners at a time (each placed inside a concrete shield plug) were located in the basin for processing. Each liner is equipped with an internal, full-span, mixing paddle connected to a fill head assembly by a hydraulic drive assembly/clutch. After the proper volume of sediment slurry was transferred to each of the three liners (measured by a line inside the liner), the solidification ingredients were added through a fill head to one liner at a time. The mixing paddle drive was engaged during introduction of the solidification agents. The paddle continued to turn until the cement was solidified to the point that the hydraulic drive clutch "slipped." The fill head was then removed from the liner (the mixing paddle remains) and moved to the next liner to be solidified. After all three liners were filled, they were moved outside of the basin to cure. Thermocouples were placed inside each liner. Exotherms indicated the liner was ready for transportation to the ERDF. Approximately three liners per week were solidified and sent to ERDF. It required 28 liners to solidify all of the N Basin sediment.

The only testing that was required for the N Basin sediment was to perform a bench-scale grout test using actual basin sediment. The test was conducted to verify the grout matrix would solidify and there would be no free standing water.

The grout operation went fairly smooth. The only failures were transfer seals in a couple of the pumps used to homogenize the sediment. The process produced only incidental waste (rags, protective clothing, etc.); the fill head was decontaminated and returned to CNS. Completion of the project took approximately 9 months from the time of acquiring Phase 2 characterization samples to shipment of the last liner to ERDF.

2.3.3 Final N Basin Sediment Waste Form

The following calculations provide an approximation of the mix of sediment, solidification agent and additional water in each liner:

Total amount of "as-found" waste = 401 ft^3 (wet sediment) + 408 ft^3 (NCP water for pumping/homogenization) = 809 ft^3

Slurry/liner = 809 ft^3 / 28 liners = 29 ft^3

Volume of grout = 170 ft^3 (volume of liner) - 29 ft^3 = 141 ft^3

Volume of Additional H_2O = 141 ft^3 / (27 ft^3/yd) = 5.22 yd grout
5.22 yd grout x 44 gal H_2O/yd grout = 230 gal H_2O
230 gal H_2O / 7.48 gal/ft^3 = 30.7 ft^3 = 0.870 m^3

NOTE: Common grout mixtures require at least 40 gallons of water per yard of grout. The amount of water required to grout the N Basin sediment was approximately 44 gallons of water per yard of grout.

Given that the mass of the N Basin as-settled sediment is 13,636 kg and contains 56.1 wt% water and assuming the final solidified liner density is 1762 kg/m^3, the mass of materials in each liner is calculated as:

Interstitial Water = (0.561 * 13636)/28 liners = 273 kg
Dry Sediment = (0.439 * 13636 kg)/28 liners = 214 kg
NCP Water = (11.55 m^3 * 1000 kg/m^3)/28 liners = 413 kg
Additional Water = 0.870 m^3 * 1000 kg/m^3 = 870 kg
Solidification Agent = (1762 kg/m^3 * 4.814 m^3) - 214 kg - 1556 kg = 6712 kg

Table 2.3 provides a summary of the above calculations and the wt% of the liner materials.

Table 2.3. Liner Material Masses and Weight Percent.

Material	Mass (kg)	Wt %
Dry Sediment	214	2.52
Total Water (Interstitial + NCP+ Additional)	1556	18.34
Solidification Agent	6712	79.14

3.0 K BASIN SOLIDIFICATION PROCESS

3.1 Composition of Residue and Comparison to N Basin Sediment

The physical, chemical, and radiological characteristics of the resin material and insoluble solids generated during chemical treatment are presented in Appendix A. The characteristics of the contaminated water used in the solidification process is also given in Appendix A. The characteristics of the filters are presented in Appendix A. The data were excerpted from Westra (1998). Table 3-1 provides a comparison of the major constituents in K Basin residue (from Appendix A), to the N Basin sediment constituents. The K Basin residue consists of the insoluble solids and the resins.

Table 3-1. Comparison of K Basin Residue to N Basin Sediment on Dry Solids Basis.

Analyte	K Basin Concentration (µg/g)	N Basin Concentration (µg/g)	Isotope	K Basin Concentration (µCi/g)	N Basin Concentration (µCi/g)
Aluminum	4.99E+03	2.32E+04	Am-241	2.63E-02	1.19E+00
Iron	5.43E+03	2.51E+05	Cs-137	1.25E+01	7.02E+00
Carbon	3.42E+03	not listed	Pu-238	2.12E-02	2.09E-01
Calcium	2.11E+03	1.28E+04	Pu-239	4.78E-02	7.72E-01
Silicon	3.54E+05	3.28E+03	Pu-240	4.78E-02	4.58E-01
Uranium	2.14E+02	5.10E+03	Sr-90	6.22E-01	5.76E+00
Zirconium	1.98E+04	3.46E+01			

The isotope concentrations related to TRU determination show the N Basin sediment concentrations are approximately ten times higher than those predicted for the K Basin residue. Most of the analyte concentrations for K Basin residue are also much less than the N Basin sediments' (10 times for aluminum and uranium, and 100 times for iron). The exception is zirconium (comes from zircalloy cladding pieces generated during the fuel cleaning operation) which shows the K Basin residue concentrations are significantly higher than the sediments'. Additionally, the K Basin residue will contain organic ion exchange resin (OIER) material (approximately 1.20E+05 μg/g).

3.2 Application of N Basin Solidification Process

3.2.1 Solidification of Special-Case Materials

Two materials in the K Basin sediment which were not seen in large quantities in the N Basin sediment are the organic resin beads and the zircalloy cladding (identified in the ERDF acceptance criteria as special-case waste types). ERDF requires that resins be stabilized before they are transported to prevent reaction with their surroundings and generation of excessive heat. If the material is capable of generating gas, the containers shall be vented and/or a catalyst pack may be required. Additionally, the resins may be subject to restrictions associated with organic carbonaceous compounds. If the OIER is designated a dangerous/hazardous waste, and contains greater than 10% organic/carbonaceous compounds it is restricted from disposal at the ERDF (see Appendix B), and must be incinerated. This criteria is interpreted as applying to resin beads which are dewatered then placed in a drum (i.e., no drying is required, removal of free liquids is sufficient) for disposal at the ERDF. In the sludge treatment process, the resin beads will be combined with the residue and be part of the solidified waste matrix. In this matrix, the organic carbonaceous compounds will be less than 10%. The Chem Nuclear solidification process has been used in commercial nuclear power plants for the disposal of waste resins. Other commercial companies (such as SGN) also have approved solidification systems which have been used to solidify resins (Monsch 1995).

ERDF restricts disposal of pyrophoric materials (zirconium cladding may be pyrophic under certain conditions) unless treated, prepared, and packaged to be nonflammable prior to being disposed. In a solidified waste matrix, the zirconium would be nonflammable. Because hulls and end-pieces separated from irradiated fuel have been embedded in a cement grout in the head-end process at the La Hague UP3 plant in La Hague, France, (Bernard 1994), it is concluded that the solidification process used at N Basin would be feasible for solidifying the zircalloy cladding pieces.

3.2.2 K Basin Residue

Application of the N Basin solidification process to the K Basin sludge residue requires capturing the residue from each process stream and storing the material in a holding tank until treatment of all of the K Basins sludge has been completed. Since a large portion of water will be transferred with the residue to the holding tank, a decant operation will be performed to remove excess water. The remaining volume of water will be sufficient for homogenizing the residue and for pumping the residue into the liners. Assuming each liner contains 15 wt% solids (N Basin liners have about three wt% solids), then 7 of the commercial L14-170 liners (supplied by CNS) would be required to solidify all of the K Basin residue. If three liners are solidified per week, it would take about three weeks to solidify all of the K Basin residue.

The characteristics of the solidified waste in the liners is provided in Appendix A. Applying the same methods used by the N Basin project, for calculating radionuclide and TRU concentrations in the solidified waste matrix, resulted in concentrations which are below the ERDF acceptance criteria (summary of criteria provided in Appendix B). Table 3-2 presents the results for the radionuclide and TRU concentrations in the solidified liners.

Table 3-2. Solidified Waste Concentrations vs ERDF Limits.

Constituent	Solidified Waste Concentrations (Ci/m^3)	ERDF Limits (Ci/m^3)
Americium-241	2.9E-02	5.0E-02
Cesium-137	3.8E+00	3.2E+01
Plutonium-238	7.0E-03	1.5E+00
Plutonium-239	1.4E-02	2.9E-02
Plutonium-240	1.4E-02	2.9E-02
Strontium-90	1.9E-01	7.0E+03
TRU:	31 nCi/g	< 100 nCi/g

3.2.3 Cartridge Filters

It is predicted that the pressure drop across a cartridge filter used in the solid/liquid separation step will reach the design limit when the wet solids load on a cartridge is about 30 kg. This solids loading will result in the use of about 49 cartridge filters during processing of the sludge. Three options exist for the cartridge filters used in the solid/liquid separation step based on the TRU and PCB concentrations:

- The used cartridge filters which are non TRU (~46) will be grouted, one each, in 55 gallon drums for disposal at the ERDF.

- The used cartridge filters (~ 1) which exceed the TRU limit for the ERDF but are below the Polychlorinated Biphenyl (PCB) TSCA treatment standards will be placed in 55 gallon drums and disposed of at the Waste Isolation Pilot Plant (WIPP).

- The used cartridge filters (~ 2) which exceed both the TRU limit for the ERDF, and the TSCA treatment standards for PCB regulated waste (predicted PCB concentrations in the cartridge solids are 53 ppm and 152 ppm in the solids) currently do not have a disposal path. The cartridges will be stored until a disposal path is identified. The PCB concentrations are based on the maximum values seen in the K Basin sludges (Pearce 1998). Therefore, these values may be lower in the actual process.

The characteristics of the cartridge filters before processing (i.e., solidification) and after processing are provided in Appendix A.

4.0 CONCLUSION

Applying the N Basin solidification process to the K Basin residue will produce a solidified waste that complies with the ERDF waste acceptance criteria. Additionally, the waste acceptance process defined in Section 3.0 of BHI-00139 is required before the waste will be accepted at the ERDF.

Most of the cartridge filters can be solidified into a waste matrix which complies with the ERDF waste acceptance criteria. The filters which do not meet the ERDF criteria for TRU and are below the PCB treatment standards for TSCA regulated waste can be disposed of at the WIPP. The treatment process will however, produce about two cartridges which currently have no disposal path identified. The waste acceptance process defined in Section 3.0 of BHI-00139 is also required for the cartridge filters before the solidified matrix will be accepted at the ERDF.

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APPENDIX A

K BASIN RESIDUE AND FILTER CHARACTERISTICS

COMPOSITION OF SOLID RESIDUES GROUTING STREAMS

	Total Solid Residues sent to Grouting (ST-403)	Supernate Eliminated before grouting (ST-702)	Grout Formers (ST-703)	Final Grouted Wastes sent to ERDF (ST-704)
Volume	*52.1 m3*	*33.2 m3*	*17.3 m3*	*32.0 m3*
Density	*1.097*	*1.000*	*2.400*	*2.046*
Total Mass	**57,189.3 kg**	**33,161.9 kg**	**41,406.6 kg**	**65,434.0 kg**
Liners #				**6.7**
LIQUID				
Volume	*47.4 m3*	*33.2 m3*		
Density	*1.000*	*1.000*		
Total Mass Liquid +	**47,374.2 kg**	**33,161.9 kg**		
H2O	47,328.5 kg	33,130.0 kg		
HNO3	44.6 kg	31.2 kg		
H2C2O4	0.3 kg	0.2 kg		
HF	0.7 kg	0.5 kg		
NaOH				
Al(NO3)3	0.0 kg	0.0 kg		
AlF3				
Fe(NO3)3	0.1 kg	0.1 kg		
CaO	0.0 kg	0.0 kg		
NaNO2				
NaNO3				
Miscellaneous	0.0 kg	0.0 kg		
UO2(NO3)2	0.0 kg	0.0 kg		
Pu	*0.0 Ci*	*0.0 Ci*		
Am	*0.0 Ci*	*0.0 Ci*		
Cs	*0.2 Ci*	*0.1 Ci*		
Sr	*0.1 Ci*	*0.0 Ci*		
PCB	*0.000 g*	*0.000 g*		
SOLIDS + RESINS				
Volume	*4.8 m3*		*17.3 m3*	*32.0 m3*
Density	*2.065*		*2.400*	*2.046*
Total Mass Solids +	**9,815.1 kg**		**41,406.6 kg**	**65,434.0 kg**
Wt% solids	*17.16 wt%*	*0.00 wt%*	*100.00 wt%*	*100.00 wt%*
Al(NO3)3				0.0 kg
Al(OH)3	9.7 kg			9.7 kg
Al2O3	86.2 kg			86.2 kg
Fe(NO3)3				0.0 kg
FeOOH	84.8 kg			84.8 kg
C	33.6 kg			33.6 kg
CaO	29.0 kg			29.0 kg
Na2C2O4				
CO2				
H2O				14,198.6 kg
SiO2	7,426.1 kg			7,426.1 kg
Grout			41,406.6 kg	41,406.6 kg
Miscellaneous	18.1 kg			18.2 kg
Zircaloy	194.7 kg			194.7 kg
Grafoil	52.5 kg			52.5 kg
HNO3				13.4 kg
H2C2O4				0.1 kg
Na2U2O7				
U	0.7 kg			0.7 kg
U3O7	0.5 kg			0.5 kg
UH3	0.1 kg			0.1 kg
UO2	0.9 kg			0.9 kg
UO2(NO3)2				0.0 kg
UO4-4H2O	0.0 kg			0.0 kg
Pu	*0.6 Ci*			*0.6 Ci*
Am	*0.7 Ci*			*0.7 Ci*
Cs	*47.2 Ci*			*47.3 Ci*
Sr	*6.0 Ci*			*6.0 Ci*
PCB	*1,467.552 g*			*1,467.552 g*
RESINS				
Zeolite	696.5 kg			696.5 kg
OIER	1,181.8 kg			1,181.8 kg
Pu	*0.506 Ci*			*0.506 Ci*
Am	*0.258 Ci*			*0.258 Ci*
Cs	*74.762 Ci*			*74.762 Ci*
TOTAL ACTIVITIES				
Total U	2.1 kg	0.0 kg		2.0 kg
Total Pu	1.1 Ci	0.0 Ci		1.1 Ci
Total Am	0.9 Ci	0.0 Ci		0.9 Ci
TRU	**2.0 Ci**	**0.0 Ci**		**2.0 Ci**
Total Cs	122.2 Ci	0.1 Ci		122.1 Ci
Total Sr	6.1 Ci	0.0 Ci		6.0 Ci
Beta Gamma	**128.3 Ci**	**0.2 Ci**		**128.1 Ci**
CONCENTRATION				
PCB in liquid	0.00 ppb	0.00 ppb		
PCB in solids	149.520 ppm			22.428 ppm
Solids	188.29 g/l			2045.76 g/l
U	0.000 g/cm3	0.000 g/cm3		0.000 g/cm3
Pu total	**0.021 Ci/m3**	**0.000 Ci/m3**		**0.035 Ci/m3**
238 Pu	0.004 Ci/m3	0.000 Ci/m3		0.007 Ci/m3
239 Pu	0.009 Ci/m3	0.000 Ci/m3		0.014 Ci/m3
240 Pu	0.009 Ci/m3	0.000 Ci/m3		0.014 Ci/m3
Am	0.018 Ci/m3	0.000 Ci/m3		0.029 Ci/m3
TRU	0.039 Ci/m3	0.000 Ci/m3		0.064 Ci/m3
TRU	**36 nCi/g**	**0 nCi/g**		**31 nCi/g**
Beta Gamma	**2.460 Ci/m3**	**0.005 Ci/m3**		**4.004 Ci/m3**

Sludge Treatment Summary

	KE1	KE2	KW1	KW2	KW3	Residues Grouting	TOTAL
Initial Sludges							
Volume of as-settled sludges	41.5 m3	2.4 m3	4.7 m3	0.2 m3	1.9 m3		**50.58 m3**
%	*82.0%*	*4.7%*	*9.2%*	*0.4%*	*3.7%*		
Total Solids	564 g/l	1650 g/l	382 g/l	8216 g/l	1910 g/l		
U	63 g/l	1190 g/l	19 g/l	7375 g/l	1175 g/l		
PCB in solid	191.5 ppm	0.6 ppm	0.0 ppm	0.0 ppm	4.2 ppm		
TRU	17 335 nCi/g	192 684 nCi/g	6 666 nCi/g	265 889 nCi/g	192 508 nCi/g		
OIER	29.4 kg/m3	14.4 kg/m3	0.0 kg/m3	0.0 kg/m3	0.0 kg/m3		
Sludge treatment							
Number of batches	146.1	24.4	11.2	10.2	22.4		**214.4**
Dry solids per batch	160 kg	160 kg	160 kg	160 kg	160 kg		
Dissolution condition	6.0 M	6.0 M	6.0 M	6.0 M	6.0 M		
Conditionned wastes to ERDF							
Amount of dry residues to be grouted	8,115 kg	297 kg	1,134 kg	150 kg	119 kg	9,815 kg	**9,815 kg**
%	*82.7%*	*3.0%*	*11.6%*	*1.5%*	*1.2%*		
Total amount of grouted wastes produced						65,434 kg	**65,434 kg**
Number of 4.8 m3 liners drums produced						6.7	**6.7**
TRU						31 nCi/g	31 nCi/g
Wastes to TWRS							
Total solution sent to TWRS	965.6 m3	217.4 m3	92.6 m3	107.2 m3	204.5 m3	33.2 m3	**1620 m3**
%	*59.6%*	*13.4%*	*5.7%*	*6.6%*	*12.6%*	*2.0%*	
Ratio Final Vol / Ini Vol	5.4	7.5	6.8	8.9	7.6		7.6
Solid concentration before water adjustem	14 g/l	52 g/l	4.8 g/l	58 g/l	54 g/l	0.01 g/l	17 g/l
Solid concentration after water adjustemen	14 g/l	40 g/l	4.8 g/l	40 g/l	40 g/l	0.01 g/l	22 g/l
PCB liq	0.01 ppb	0.01 ppb	0.00 ppb	0.00 ppb	0.01 ppb	0.00 ppb	0.01 ppb
PCB sol	0.664 ppm	0.005 ppm	0.000 ppm	0.000 ppm	0.008 ppm	0.001 ppm	0.262 ppm
Filters							
Number	40.4	1.3	5.5	0.6	0.6		**48.4**
%	*83.6%*	*2.6%*	*11.4%*	*1.2%*	*1.2%*		
PCB sol	4.870 ppm	53.257 ppm	0.000 ppm	0.000 ppm	152.172 ppm		
TRU Activity	29 nCi/g	6 643 nCi/g	8 nCi/g	5 385 nCi/g	10 386 nCi/g		
Destination	ERDF	?	ERDF	WIPP	?		

APPENDIX B

ENVIRONMENTAL RESTORATION DISPOSAL FACILITY WASTE ACCEPTANCE CRITERIA

(Excerpted From BHI-00139, Rev. 3)

B.1 WASTE ACCEPTANCE CRITERIA

The Environmental Restoration Disposal Facility (ERDF) is authorized to accept waste from Hanford Site environmental restoration activities consistent with the ERDF Record of Decision (ROD) and Explanation of Significant Difference (ESD). Waste entering the ERDF shall be controlled on the basis of source, physical form, and containment levels. A uniform and consistent waste acceptance process shall be implemented to include planning, waste certification, waste shipment, and waste receipt and disposal. Waste that has not been coordinated in accordance with the waste acceptance process defined in BHI-00139 shall not be accepted at the ERDF.

The waste acceptance criteria for disposal of materials resulting from Hanford Site cleanup activities is documented in BHI-00139. This attachment provides a summary of those criteria which will apply to the K Basin sludge treatment secondary waste streams (residuals and filters).

B.1.1 Concentration Limits

Prior to consideration of concentration limits, the site-specific acceptance requirements must be met in accordance with the ERDF ROD and ESD. Concentration limits for chemical constituents, radionuclides, and mixed wastes are provided in the following subsections.

B.1.1.1 Chemical Constituents

The Land disposal restriction (LDR) treatment standards for dangerous/hazardous waste codes are found in Subpart D of 40 CFR 268. Table B-1 provides a partial list, by waste code, of land disposal restrictions (LDR) standards for dangerous/hazardous wastes (lists only those standards most likely to be encountered in the K Basin sludge residuals).

Secondary limits for various chemical constituents are identified in Table B-2. Chemicals should be evaluated against the applicable standards in Table B-1 before being evaluated against Table B-2 criteria. Limits in Table B-2 represent exposure limits determined by risk modeling in the ERDF remedial investigation/feasibility study (RI/FS) (DOE-RL 1994). Liner compatibility and worker exposure limits will be evaluated separately.

B.1.1.2 Radionuclides

Limits established for radionuclides are identified in Table B-3 (this table is not all inclusive of the radionuclides listed in BHI-00139). Where there are two or more radionuclides present in a waste, the "sum of the fractions" method (10 CFR 61.55) shall be used to determine acceptability. Each constituent in the waste mixture must be divided by the appropriate limit form Table B-3, with the sum being less than or equal to 1.0. Additional criteria for smearable surface contamination, fixed contamination, and activity levels are prescribed in the supplemental acceptance criteria (BHI 1997). Certain waste sources may require special handling to accommodate disposal at the ERDF even though the radionuclide concentrations are less than the Table B-3 limits. Handling requirements for these waste sources shall be evaluated on a case-by-case basis.

Table B-1. Land Disposal Restriction Limits for Selected Hazardous Wastes.

Waste Code	Waste Description	Regulated Hazardous Constituent	Regulatory Standard (mg/kg total, unless noted otherwise)
D001	Ignitable characteristic waste except for high TOC subcategory	NA	Deactivate and meet UTS
D001	High TOC ignitable characteristic waste (>10% TOC)	NA	Prohibited from disposal in ERDF
D002	Corrosive characteristic waste	NA	Deactivate and meet UTS
D003	Reactive waste - water reactive subcategory	NA	Deactivate and meet UTS
D004	Waste that are toxic for arsenic based on TCLP	Arsenic	5.0 mg/L TCLP
D005	Wastes that are toxic for barium based on TCLP	Barium	100 mg/L TCLP
D006	Wastes that are toxic for cadmium based on TCLP	Cadmium	1.0 mg/L TCLP
D007	Wastes that are toxic for chromium based on TCLP	Chromium (Total)	5.0 mg/L TCLP
D008	Wastes that are toxic for lead based on TCLP	Lead	5.0 mg/L TCLP
D009	Wastes that are toxic for mercury based on TCLP and that contain less than 260 mg/kg total mercury	Mercury	0.20 mg/L TCLP
D009	Elemental mercury contaminated with radioactive materials	Mercury	Amalgamation
D010	Wastes that are toxic for selenium based on TCLP	Selenium	5.7 mg/L TCLP
D011	Wastes that are toxic for silver based on TCLP	Silver	5.0 mg/L TCLP

NOTE: Table represents a partial list of waste codes most likely to be encountered in sludge residuals. 40 CFR 268 should be consulted to confirm the most current standard.

ERDF=Environmental Restoration Disposal Facility
NA=not applicable
TCLP=toxicity characteristics leachate procedure
TOC=total organic carbon
UTS=universal treatment standards (40 CFR 268.48)

Table B-2. Chemical Concentration Limits.

Constituent Name	Limit (mg/kg)[a]
Semi-Volatile Organic Compounds	
Benzo(a)pyrene	2.5E+04
Benzo(k)fluoranthene	2.5E+04
Pesticides/PCBs	
4,4'DDD	7.6E+05
4,4'DDE	5.4E+05
PCBs	500[b]
Beta-BHC (Lindane)	3.3E+03
Metals	
Antimony	1.9E+04
Arsenic	3.0E+03
Barium	9.4E+05
Cadmium	3.9E+04
Chromium (total)	5.9E+04
Chromium VI	5.9E+04
Manganese	4.4E+05
Selenium	4.0E+05
Silver	3.5E+05
Thallium	5.6E+03
Vanadium	3.3E+05
Zinc	3.0E+05

[a]Public exposure is limiting.
[b]See Section B.2.3
PCB=polychlorinated biphenyl

Table B-3. ERDF-WAC Radionuclide Concentration Limits.

Constituent	Limit (Ci/m³)ᵃ	Notes
Americium-241	5.0E-02	b,e
Americium-243	5.7E-02	c,e
Carbon-14	5.3E+00	c
Carbon-14	5.3E+01	c,d
Cesium-137	3.2E+01	b
Europium-152	2.1E+07	b
Neptunium-237	1.5E-03	b,e
Plutonium-238	1.5E+00	b,e
Plutonium-239	2.9E-02	b,e
Plutonium-240	2.9E-02	b,e
Plutonium-241	6.2E+00	c,e
Plutonium-242	1.1-01	c
Radium-228	2.2E-04	b
Strontium-90	7.0E+03	f
Technetium-99	1.3E+00	c
Thorium-228 + Daughters	1.2E-04	b
Thorium-232	6.0E-03	c
Uranium-233/234	7.4E-02	b
Uranium-235	2.7E-03	b
Uranium-238 + Daughters	1.2E-02	b
Zirconium-93	1.4E+02	c

[A] Radioactive waste Class C limits also apply (10 CFR 61).
[B] *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility* (DOE-RL 1994).
[C] Derived from the *Environmental Restoration Disposal Facility Performance Assessment* (BHI 1995).
[D] Limit if nuclide contained in activated metal.
[E] ERDF limit is lower of indicated value and transuranic limit of 100 nCi/g.
[f] Class C limit per 10 CFR 61.
[G] 100 nCi/g is the Class C limit for alpha-emitting transuranic nuclides with half-lives greater than 5 years.
[H] Limit in nanocuries per gram of waste.

B.2 SPECIAL-CASE WASTE TYPES

Acceptance criteria and/or restrictions associated with special-case waste types are identified in the following subsections. Centralized waste treatment may be performed at the ERDF for specific sources in accordance with the ROD Amendment to render a previously restricted waste acceptable for disposal. In such cases, ERDF users shall obtain authorization for waste treatment at the ERDF from the ERDF management and operations team prior to shipment.

B.2.1 Ion Exchange Resins and Granular Activated Carbon

Ion exchange resins and granular activated carbon must be thoroughly drained and stabilized before they are transported to prevent reaction with their surroundings and the generation of excessive heat. Containers shall be vented and/or a catalyst pack may be required if the material is capable of generating gas. Ion exchange resins and granular activated carbon may be subject to restrictions associated with organic carbonaceous compounds, as specified in Section 1.2.3.

B.2.2 Debris

Special requirements for debris are listed below.

- The initial determination of whether a waste is dangerous/hazardous debris shall be made at the source in accordance with WAC 173-303-040, 40 CFR 268.45 and other applicable waste designation requirements. After waste has been identified as dangerous/hazardous debris, it shall be so stated as part of the waste profile.

- Unless exempted by the U.S. Environmental Protection Agency (EPA), dangerous/hazardous debris shall comply with the debris treatment standards (40 CFR 268.45) or the otherwise applicable LDR treatment standard. Although sampling of treated dangerous/hazardous debris to demonstrate compliance is not required, documentation of conformance with the technology performance and operating or design standards shall be provided. Under the EPA rule, treated dangerous/hazardous debris is excluded from the definition of dangerous/hazardous waste, provided that the dangerous/hazardous debris is treated to the performance or design and operation standards by an extraction or destruction technology and the treated dangerous/hazardous debris does not exhibit a characteristic of dangerous/hazardous waste. An additional option for management of debris is a contained-in determination made by the lead regulatory agency pursuant to 40 CFR 261.3(f)(2). Excluded dangerous/hazardous debris may be disposed of in an industrial landfill (Subtitle D) and shall be accepted for disposal at the ERDF only on a case-by-case basis.

- Waste containing more than one type of debris or one hazardous constituent shall be treated to meet the standards for each hazardous constituent and each type of debris as applicable.

B.2.3 Polychlorinated Biphenyl Compounds

Waste containing polychlorinated biphenyl (PCB) concentrations of greater than 50 parts per million (ppm) shall be managed in accordance with 40 CFR 761. Bulk liquids not exceeding 500 ppm PCB concentrations may be disposed of at the ERDF provided that the waste is pretreated and/or stabilized to eliminate the presence of free liquids prior to final disposal. Containers of liquid PCB concentrations not exceeding 500 ppm may be disposed of at the ERDF provided that each container is surrounded by an amount of inert sorbent material capable of absorbing all of the liquid contents of the container. Liquid waste containing PCB concentrations of greater than 500 ppm cannot be disposed of at the ERDF.

Nonliquid PCBs in the form of contaminated soil, rags, or other debris may be disposed of at the ERDF (this includes nonliquid waste with PCB concentrations greater than 500 ppm).

B.2.4 General Restrictions

The following materials are prohibited from being disposed at the ERDF (the following is not all inclusive of the materials listed in BHI-00139):

- Transuranic waste, as defined in Appendix A (DOE Order 5820.2A II 2.a.).
- Spent nuclear fuel and high-level waste (DOE Order 5820.2A I 3.d.).

The following materials are restricted from disposal at the ERDF until the listed conditions have been met:

- Bulk disposal of waste containing free liquids, unless the free liquids are eliminated by stabilization (adding materials to chemically immobilize the free liquids in the waste) before disposal at the ERDF. Use of sorbent materials to solidify (physically immobilize) the free liquids is not permitted for bulk disposal (WAC 173-303-140[4][b] and 40 CFR 264.314[b]). If necessary, the presence of free liquids shall be determined by EPA Method 9095 ("Paint Filter Liquids Test") (EPA 1986) before shipment to the ERDF (WAC 173-303-140 [4][b] and 40 CFR 264.314[d]).
- Pyrophoric waste, unless treated, prepared, and packaged to be nonflammable prior to being disposed (DOE Order 5820.2A III 3.i.[5][f]).

- Solid acid waste that exhibits the characteristic of low pH under the corrosivity tests of WAC 173-303-090(6)(a)(ii) or (iii), unless exempted pursuant to WAC 173-303-140 or the *Revised Code of Washington* (RCW) 70.105.050(2).

- Dangerous/hazardous waste with greater than 10% organic/carbonaceous compounds, unless exempted pursuant to WAC 173-303-140 or RCW 70.105.050(2).

B.3 PHYSICAL LIMITS

Packaged waste shall be structurally stable (10 CFR 61.56b) for disposal at the ERDF. Packaged waste that is not structurally stable may be accepted at ERDF on a case-by-case basis and stabilized before disposal. Depending on the waste stream, stabilization may be accomplished by using soil, cement-based, or other stabilization agents with acceptable structural characteristics, size reduction, a mixture of biodegradable waste and stabilizing agents, and/or voids filled with stabilization agents. Additional physical limits for waste forms including concrete, steel plate, piping and tube steel, building debris, structural steel, containerized waste, equipment, soft waste, and rebar are defined in the supplemental waste acceptance criteria (BHI 1997).

B.4 DEFINITIONS

Carbonaceous Waste: Dangerous/hazardous waste that contains combined concentrations of greater than 10% organic/carbonaceous constituents. Organic/carbonaceous constituents are those substances that contain carbon-hydrogen, carbon-halogen, or carbon-carbon chemical bonding.

Dangerous/hazardous Debris: Debris that contains a dangerous/hazardous waste listed in Subpart D of 40 CFR 261, or that exhibits a characteristic of dangerous/hazardous waste identified in Subpart C of 40 CFR 261.

Debris: Solid material exceeding a 60-mm particle size that is intended for disposal and is a manufactured object, plant or animal matter, or natural geologic material. However, the following materials are not considered to be debris: any material for which a specific treatment standard is provided in Subpart D of 40 CFR 268, namely lead acid batteries, cadmium batteries, and radioactive lead solids; process residuals, such a smelter slag and residues from the treatment of waste, wastewater, sludges, or air emission residues; and intact containers of dangerous/hazardous waste that are not ruptured and that retain at least 75% of their original volume. A mixture of debris and other material that has not been treated to the standards provided by 40 CFR 268.45 is subject to regulation as debris if the mixture is composed primarily of debris, by volume, based on visual inspection.

Free Liquids: Liquids that can readily separate from the solid portion of a waste under ambient temperature and pressure.

Solidification: A technique that limits the solubility and mobility of dangerous/hazardous waste constituents by bonding or chemically reacting with the stabilizing material.

Structural Stability: A structurally stable waste form will generally maintain its physical dimensions and its form under the expected disposal conditions, such as weight of overburden and compaction equipment, the presence of moisture and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

Supplemental Waste Acceptance Criteria: Acceptance criteria established for operational radiological controls and physical limits for bulk shipments at the ERDF.

Transuranic Waste: Waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

Treatment: Any method, technique, or process designed to change the physical or chemical character of waste to render it less hazardous; make the waste safer to transport, store, or dispose of; or reduce the waste in volume.

B.5 REFERENCES

BHI, 1995, *Environmental Restoration Disposal Facility Performance Assessment*, BHI-00169, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1997, *Supplemental Waste Acceptance Criteria for Bulk Shipments to the Environmental Restoration Disposal Facility*, 0000X-DC-W0001, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1998, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Rev. 3, Bechtel Hanford, Inc., Richland, Washington.

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*, as amended.

DOE-RL, 1994, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, DOE/RL-93-99, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE Order 5820.2A, *Radioactive Waste Management,* as amended, U.S. Department of Energy, Washington, D.C.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

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