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CVP-2007-00001
Rev. 0

# Cleanup Verification Package for the 118-F-1 Burial Ground

Prepared for the U.S. Department of Energy
by Washington Closure Hanford

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# EXECUTIVE SUMMARY

This cleanup verification package documents completion of remedial action for the 118-F-1 Burial Ground on the Hanford Site. The 118-F-1 Burial Ground is a combination of two locations formerly called Minor Construction Burial Ground No. 2 and Solid Waste Burial Ground No. 2. The 118-F-1 site is located in the 100-FR-2 Operable Unit of the 100-F Area, approximately 300 m (1000 ft) southwest of the 105-F Reactor Building. This waste site received radioactive equipment and other miscellaneous waste from 105-F Reactor operations. The burial ground was used between 1954 and 1965, and contained three unlined burial trenches and a burial pit. Waste buried at this site included: dummy elements and irradiated process tubing; gun barrel tips, steel sleeves, and metal chips removed from the reactor; filter boxes containing reactor graphite chips; and miscellaneous construction solid waste.

Remedial action at the 118-F-1 site began on December 27, 2005, and was completed on June 22, 2007. Remedial action activities involved removing the uncontaminated overburden, the buried contaminated debris, and the underlying contaminated soil. All contaminated materials were disposed of at the Environmental Restoration Disposal Facility. Results of the verification sampling, laboratory analyses, and data evaluations for the 118-F-1 site (which includes the remediation footprint, the overburden/below cleanup level and the waste sorting pile areas) indicate that all remedial action objectives and goals for direct exposure, protection of groundwater, and protection of the Columbia River have been met (see Table ES-1).

Soil cleanup levels were established in the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (ROD) (EPA 2000) based on a limited ecological risk assessment. Although not required by the ROD (EPA 2000), a comparison against ecological risk screening levels has been made for the site contaminants of concern/contaminants of potential concern. Screening levels were exceeded for seven site constituents. It is believed that the

exceedance of screening values does not indicate the existence of risk to ecological receptors, as the concentrations for these constituents are within the range of Hanford Site background levels or are consistent with those seen elsewhere at the Hanford Site. The one exception is lead, which is believed to be present due to the historic application of lead-arsenate pesticides. The exceedance of soil screening values by lead at the site will be evaluated in the context of additional lines of evidence for ecological effects. A baseline risk assessment for the river corridor portion of the Hanford Site began in 2004, which includes a more complete, quantitative ecological risk assessment. That baseline risk assessment will be used as part of the final closeout decision for this site.

The site meets cleanup standards and has been reclassified as Interim Closed Out in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and the Waste Site Reclassification Guideline TPA-MP-14 (RL-TPA-90-0001) (DOE-RL 2007). A copy of the waste site reclassification form is included as Attachment ES-1 to this document.

## Table ES-1. Summary of Cleanup Verification Results for the 118-F-1 Burial Ground. (2 pages)

| Regulatory Requirement | Remedial Action Goals | Results | Remedial Action Objectives Attained? | Ref. |
|---|---|---|---|---|
| Direct Exposure – Radionuclides | 1. Attain 15 mrem/yr dose rate above background over 1000 years. | 1. Maximum dose rate calculated by RESRAD is 4.59 mrem/yr. | Yes | e |
| Direct Exposure – Nonradionuclides | 1. Attain individual COC RAGs. | 1. All individual COC concentrations are below the RAGS. | Yes | e, f |
| Meet Nonradionuclide Risk Requirements | 1. Hazard quotient of less than 1 for noncarcinogens. | 1. The hazard quotients for individual nonradionuclide COCs in the shallow zone and overburden are less than 1. | Yes | g |
| | 2. Cumulative hazard quotient of less than 1 for noncarcinogens. | 2. The cumulative hazard quotient is less than 1 for the shallow zone and overburden. | Yes | g |
| | 3. Excess cancer risk of $<1 \times 10^{-6}$ for individual carcinogens. | 3. Excess cancer risk values for individual nonradionuclide COCs are less than $1 \times 10^{-6}$. | Yes | g |
| | 4. Attain a total excess cancer risk of $<1 \times 10^{-5}$ for carcinogens. | 4. Total excess cancer risk is less than $1 \times 10^{-5}$. | Yes | g |
| Groundwater/River Protection – Radionuclides | 1. Attain single COC groundwater and river RAGS. | 1. Cesium-137, cobalt-60, nickel-63, strontium-90, and tritium are calculated to reach groundwater in the 1,000 years of the RESRAD model run. However, none of these constituents is predicted to migrate to groundwater (and thus the Columbia River) at concentrations exceeding groundwater or river criteria within 1,000 years. Therefore, residual concentrations achieve the remedial action objectives for groundwater and river protection. | Yes | b |
| | 2. Attain National Primary Drinking Water Regulations 4-mrem/yr (beta/gamma) dose standard to target receptor/organ.[a] | 2. All organ specific doses are below the 4-mrem/yr dose standard. | | h |
| | 3. Meet drinking water standards for alpha emitters: the more stringent of 15 pCi/L MCL or 1/25th of the derived concentration guide for DOE Order 5400.5.[b] | 3. RESRAD modeling indicates that the alpha emitting COCs will not impact groundwater. Therefore, the alpha activity is 0 pCi/L for all years. | N/A | h |
| | 4. Meet total uranium standard of 21.2 pCi/L.[c] | 4. Isotopic uranium concentrations are below background. | N/A | e |

## Table ES-1. Summary of Cleanup Verification Results for the 118-F-1 Burial Ground. (2 pages)

| Regulatory Requirement | Remedial Action Goals | Results | Remedial Action Objectives Attained? | Ref. |
|---|---|---|---|---|
| Groundwater/River Protection – Nonradionuclides | 1. Attain individual nonradionuclide groundwater and river cleanup requirements. | 1. Residual concentrations of lead exceeded soil RAGs for the protection of groundwater and/or the Columbia River. However, it is predicted that lead will not migrate to groundwater (and thus the Columbia River) at concentrations exceeding groundwater or river criteria within 1,000 years.[d] Therefore, residual concentrations achieve the remedial action objectives for groundwater and river protection. | Yes | e |
| Other Supporting Information | 1. Sample location design calculation brief (Appendix B). | | | i |

[a] "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* 141).

[b] *Radiation Protection of the Public and the Environment* (DOE Order 5400.5).

[c] Based on the isotopic distribution of uranium in the Hanford Site background, the 30 µg/L MCL (40 CFR 141) corresponds to 21.2 pCi/L. Concentration-to-activity calculations are documented in *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Total Uranium of 30 Micrograms per Liter in Groundwater*, 0100X-CA-V0038 (BHI 2001).

[d] *100 Area Analogous Sites RESRAD Calculations*, 0100X-CA-V0050, Rev. 0, Bechtel Hanford, Inc., Richland, Washington (2005).

[e] *118-F-1 Burial Ground Cleanup Verification RESRAD Calculation Brief*, 0100F-CA-V0280, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

[f] *118-F-1 Burial Ground Cleanup Verification 95% UCL Calculations*, 0100F-CA-V0279, Rev. 1, Washington Closure Hanford, Richland, Washington (2007).

[g] *118-F-1 Burial Ground Hazard Quotient and Carcinogenic Risk Calculations*, 0100F-CA-V0283, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

[h] *118-F-1 Burial Ground Comparison to Drinking Water Standards (MCL) Calculation*, 0100F-CA-V0281, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

[i] *118-F-1 Burial Ground Shallow Zone, Process Trenches, and Overburden Sample Design*, 0100F-CA-V0282, Rev. 0, Washington Closure Hanford, Richland, Washington (2007).

COC = contaminant of concern
MCL = maximum contaminant level
N/A = not applicable
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose model)

# Attachment ES-1

## Waste Site Reclassification Form

| | | |
|---|---|---|
| Date Submitted: 10/08/07<br>Originator: L. M. Dittmer<br>Phone: 372-9227 | **WASTE SITE RECLASSIFICATION FORM**<br>Operable Unit(s): 100-FR-2<br>Waste Site Code: 118-F-1<br>Type of Reclassification Action:<br>Closed Out ☐ Interim Closed Out ☒ No Action ☐<br>RCRA Postclosure ☐ Rejected ☐ Consolidated ☐ | Control Number: 2007-019 |

This form documents agreement among parties listed authorizing classification of the subject unit as Closed Out, Interim Closed Out, No Action, RCRA Postclosure, Rejected, or Consolidated. This form also authorizes backfill of the waste management unit, if appropriate, for Closed Out and Interim Closed Out units. Final removal from the NPL of No Action and Closed Out waste management units will occur at a future date.

Description of current waste site condition:

Remedial action at this site has been performed in accordance with remedial action objectives and goals established by the U.S. Environmental Protection Agency and the Washington State Department of Ecology, in concurrence with the U.S. Department of Energy, Richland Operations Office. The selected remedial action involves (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility at the 200 Area of the Hanford Site, and (3) backfilling the site with clean soil to adjacent grade elevations. The excavation and disposal activities have been completed.

Basis for reclassification:

In accordance with this evaluation, the verification sampling results support a reclassification of this site to Interim Closed Out. The current site conditions achieve the remedial action objectives and the corresponding remedial action goals established in the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington*, U. S. Environmental Protection Agency, Region 10, Seattle, Washington. The results of verification sampling show that residual contaminant concentrations do not preclude any future uses (as bounded by the rural-residential scenario) and allow for unrestricted use of shallow zone soils (i.e., surface to 4.6 m [15 ft] deep). The results also demonstrate that residual contaminant concentrations are protective of groundwater and the Columbia River. The 118-F-1 excavation area has a maximum depth of approximately 5.5 m (18 ft), which includes a shallow zone and a deep zone. However, the entire excavation area is considered one decision unit, and is closed out using the more restrictive shallow zone cleanup criteria; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are not required. The basis for reclassification is described in detail in the *Cleanup Verification Package for the 118-F-1 Burial Ground* (CVP 2007-00001), Washington Closure Hanford, Richland, Washington.

Waste Site Controls:
Engineered Controls: Yes ☐ No ☒ Institutional Controls: Yes ☐ No ☒ O&M requirements: Yes ☐ No ☒
If any of the Waste Site Controls are checked Yes specify control requirements including reference to the Record of Decision, TSD Closure Letter, or other relevant documents.

| | | |
|---|---|---|
| S. L. Charboneau<br>DOE Federal Project Director (printed) | Stacy Charboneau<br>Signature | 11/28/07<br>Date |
| N/A<br>Ecology Project Manager (printed) | Signature | Date |
| R. A. Lobos<br>EPA Project Manager (printed) | Signature | 12/20/07<br>Date |

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BCL | below cleanup level |
| COC | contaminant of concern |
| COPC | contaminant of potential concern |
| CVP | Cleanup Verification Package |
| DOE-RL | U.S. Department of Energy, Richland Operations Office |
| DQA | data quality assessment |
| ENRE | ENvironmental REstoration database |
| EPA | U.S. Environmental Protection Agency |
| ERDF | Environmental Restoration Disposal Facility |
| GPERS | Global Positioning Environmental Radiological Surveyor |
| HEIS | Hanford Environmental Information System |
| PAH | polycyclic aromatic hydrocarbon |
| RAG | remedial action goal |
| RDR/RAWP | remedial design report/remedial action work plan |
| RESRAD | RESidual RADioactivity dose assessment model |
| ROD | record of decision |
| SAP | sampling and analysis plan |
| SSNF | suspect spent nuclear fuel |
| TPH | total petroleum hydrocarbons |
| UCL | upper confidence limit |
| VOA | volatile organic analysis |
| WAC | *Washington Administrative Code* |

# 1.0 STATEMENT OF PROTECTIVENESS

This report demonstrates that the 118-F-1 waste site meets the objectives for interim closure as established in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2005) and the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington* (ROD) (EPA 2000). The results of verification sampling show that residual contaminant concentrations do not preclude any future uses (as bounded by the rural-residential scenario) and allow for unrestricted use of shallow zone soils (i.e., surface to 4.6 m [15 ft] deep). The results also demonstrate that residual contaminant concentrations are protective of groundwater and the Columbia River.

# 2.0 BACKGROUND AND GENERAL SITE INFORMATION

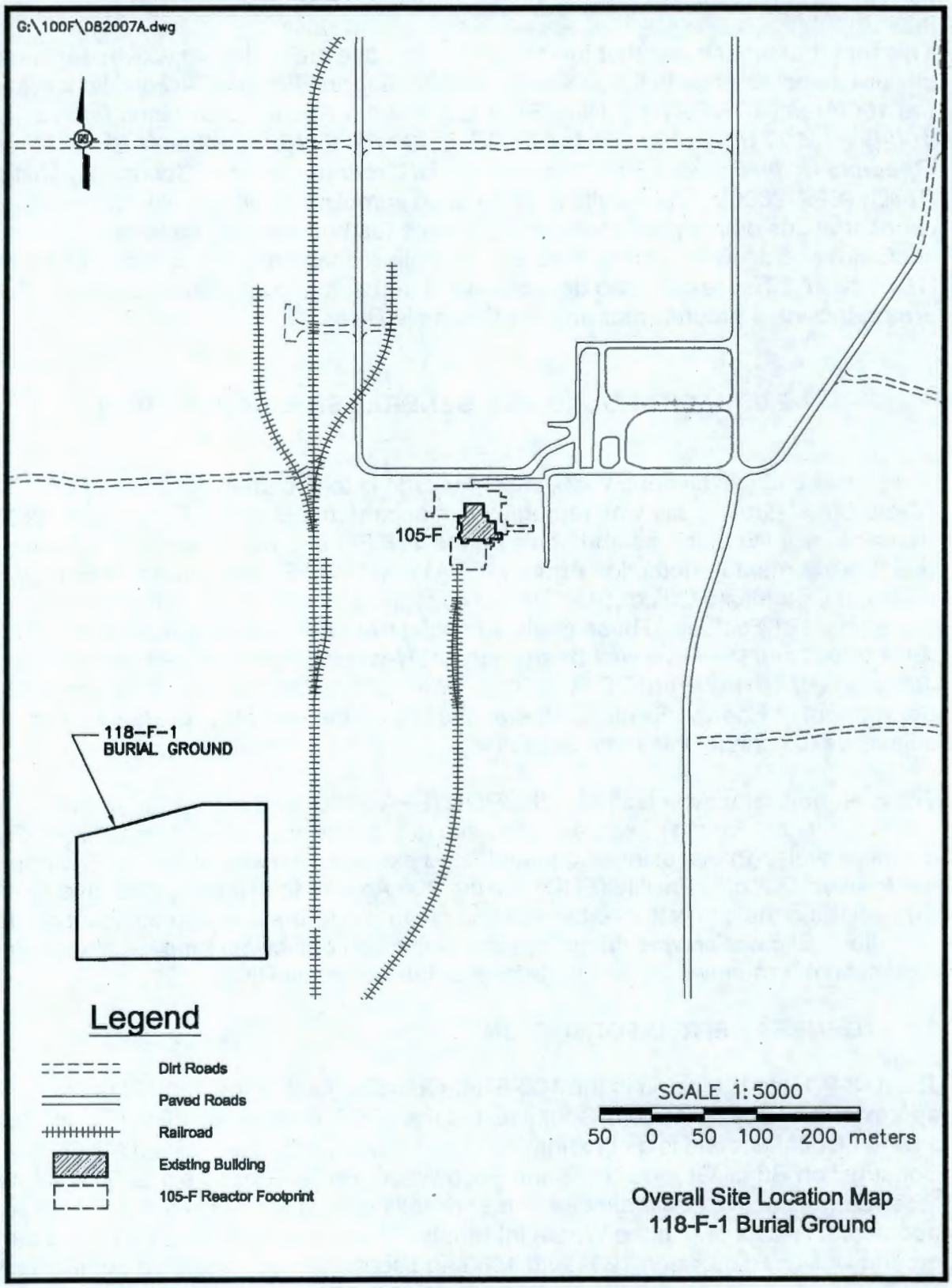
The purpose of this cleanup verification package is to document that the 118-F-1 Solid Waste Burial Ground site was remediated in accordance with the ROD (EPA 2000). Remedial action objectives and goals for the 118-F-1 site were established by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy, Richland Operations Office (DOE-RL), in concurrence with the Washington State Department of Ecology. These goals and objectives are documented in the ROD (EPA 2000) and the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 2005). The ROD (EPA 2000) provides the U.S. Department of Energy, Richland Operations Office, the authority, guidance, and objectives to conduct this remedial action.

The preferred remedy specified in the ROD (EPA 2000) and conducted for the 118-F-1 site included (1) excavating the site to the extent required to meet specified soil cleanup levels, (2) disposing of contaminated excavation materials at the Environmental Restoration Disposal Facility (ERDF) at the 200 Area of the Hanford Site, and (3) backfilling the site with overburden and clean soil to the average adjacent grade elevation. Excavation was driven by remedial action objectives for direct exposure, protection of groundwater, and protection of the Columbia River.

## 2.1 GENERAL SITE INFORMATION

The 118-F-1 site is located in the 100-FR-2 Operable Unit of the 100-F Area approximately 300 m (1000 ft) southwest of the 105-F Reactor Building (Figure 1). The 118-F-1 Burial Ground is a combination of two locations formerly called Minor Construction Burial Ground No. 2 and Solid Waste Burial Ground No. 2. This waste site received radioactive equipment and other miscellaneous waste from 105-F Reactor operations. According to the Waste Information Database System (WIDS), the burial ground was used between 1954 and 1965 and contained three unlined burial trenches

**Figure 1. Hanford Site Map and 118-F-1 Site Plan.**



and a burial pit. A geophysical investigation was conducted at the 118-F-1 Burial Ground in 2002, with results indicating that the footprint of buried debris was less than what was indicated in WIDS (BHI 2002a). Test pitting was conducted to augment the geophysical data and provide a more conclusive data set regarding the boundaries of the buried debris. The test pitting activities were conducted in representative areas where the geophysical investigation did not detect buried debris or potential trench boundaries. The excavations confirmed these areas do not contain debris (BHI 2002b).

Wastes buried at this site included: dummy elements and irradiated process tubing; gun barrel tips, steel sleeves, and metal chips removed from the reactor; filter boxes containing reactor graphite chips; and miscellaneous construction solid waste.

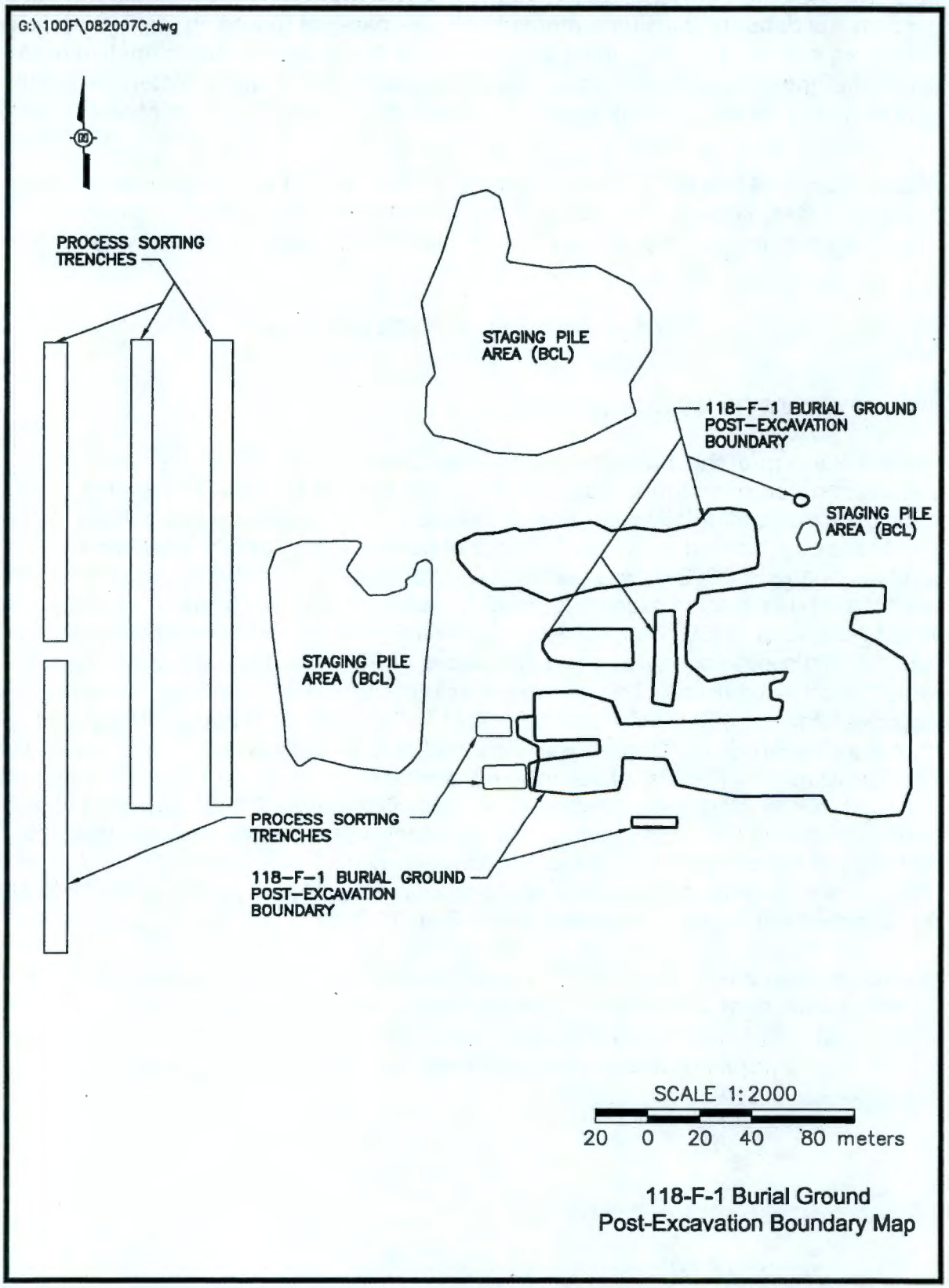
# 3.0 REMEDIAL ACTION SUMMARY

## 3.1 EXCAVATION AND DISPOSAL

Remedial action at the 118-F-1 site began on December 27, 2005. Removal of the uncontaminated overburden was completed on January 6, 2006. On August 7, 2006, excavation and sorting of contaminated material from the areas within the three trenches and burial pit indicated within the footprint of buried debris, per the geophysical investigation (BHI 2002a), was initiated. Contaminated material was placed in trenches west of the burial ground excavation areas for waste sorting. All contaminated materials were disposed at ERDF. Suspect Spent Nuclear Fuel (SSNF) was discovered during the waste debris sorting operation, and eight pieces of SSNF are to be dispositioned. All remedial activities (excavation, sorting, and load-out) were completed on June 22, 2007. Approximately 88,800 metric tons (97,900 U.S. tons) of waste and contaminated soil from the 118-F-1 Burial Ground was disposed of at ERDF and approximately 13,400 bank cubic meters (BCMs) of soil (overburden/below contaminant level [BCL] stockpile material) was segregated for use as clean backfill material. The post-remediation boundary map is shown in Figure 2. At the conclusion of excavation activities, the elevation at the deepest part of the remedial excavation was 117 m (384 ft) above sea level. The remediation excavation was approximately 11,600 $m^2$ (125,000 $ft^2$) in area with a maximum depth of approximately 5.5 m (18 ft).

Wastes encountered in the 118-F-1 Burial Ground included reactor related waste including aluminum fuel spacers, splines, reactor hardware, equipment, piping, graphite dust, sheet metal, concrete, cardboard, wood timbers, other miscellaneous debris, and SSNF. Photographs of waste excavated from the 118-F-1 Burial Ground are provided in Appendix A.

**Figure 2. 118-F-1 Burial Ground Post-Excavation Boundary Map.**



# 4.0 SAMPLING ACTIVITIES

## 4.1 CONTAMINANTS OF CONCERN FOR VERIFICATION SAMPLING

The *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2001) identified contaminants of concern (COCs) (Table A-1, page A-21) for the 118-F-1 Burial Ground include tritium (H-3), carbon-14, cobalt-60, nickel-63, strontium-90, silver-108m, cesium-137, europium-152, europium-154, cadmium, lead, and mercury. In addition, because SSNF was encountered in the 118-F-1 Burial Ground, americium-241, plutonium-238, plutonium-239, plutonium-240, and uranium-238 were added to the list of COCs for the site.

During excavation, in-process samples were collected as necessary and analyzed for the identified COCs and for a wide range of metals, semi-volatile organic compounds, polychlorinated biphenyls, pesticides, gamma energy emitting isotopes, gross alpha radiation, and gross beta radiation. Based on the results of this sampling, no additional COCs beyond those listed above have been identified for the burial ground. The COCs/contaminants of potential concern (COPCs) detected at the 118-F-1 Burial Ground and their respective points of compliance, and the remedial action goals (RAGs), are summarized in Tables 3 through 5 (Section 5.0) of this Cleanup Verification Package.

## 4.2 VERIFICATION SAMPLING DESIGN

This section describes the basis for selection of an appropriate sample design and the determination of the number of verification samples to collect at the 118-F-1 Burial Ground.

### 4.2.1 Decision Unit Sampling

The sample strategy for the 118-F-1 Burial Ground is identified in the Burial Ground SAP (DOE-RL 2001) and specifies the site to be divided into decision units (e.g., shallow zone and deep zone) based on the size of the site. The SAP also specifies the number of verification samples to collect in each decision unit. The division of the site into decision units is also a function of the applicable RAGs. The direct exposure, groundwater protection, and river protection RAGs are applicable to soils within 4.6 m (15 ft) of the ground surface. This soil zone is referred to as the shallow zone. The groundwater protection and river protection RAGs are applicable to soils greater than 4.6 m (15 ft) below the ground surface. This soil zone is referred to as the deep zone. The 118-F-1 excavation area has a maximum depth of approximately 5.5 m (18 ft), which includes a shallow zone and a deep zone. However, the entire excavation area is considered one decision unit, and will be closed out using the more restrictive shallow zone cleanup criteria.

The 118-F-1 Burial Ground contains three decision units as follows: (1) shallow zone excavation decision unit, which includes the nine trench excavations and area between them, (2) overburden/BCL stockpile, which combines three overburden stockpile areas

into one decision unit, and (3) staging pile (labeled process or waste sorting trenches in remediation and sampling documentation) that includes the area where the waste was staged prior to removal for disposal. The calculation of the number of verification samples to collect in each of the decision units is four composite samples. This calculation, and the sample locations, is located in the sample design calculation in Appendix B. All of these decision units will be closed out using the more restrictive shallow zone cleanup criteria.

**Table 1. Number of Verification Samples for the 118-F-1 Burial Ground.**

| Decision Unit | Waste Site Footprint ($ft^2$) | Size Classification ($ft^2$) | Decision Subunits | Verification Samples |
|---|---|---|---|---|
| Excavation Shallow Zone | 125,000 | Medium (>100,000 to 400,000) | 4 | 17 composite |
| Overburden/BCL pile | 117,500 | Medium (>100,000 to 400,000) | 4 | 16 composite |
| Waste Sorting Trenches | 58,500 | Small (<100,000) | 1 | 5 composite |

BCL = below cleanup level

## 4.3 FIELD SCREENING

### 4.3.1 Radiological Surveys

Radiological field screening was conducted during the site remedial actions as specified in the SAP (DOE-RL 2001). The field screening campaign was used to guide the excavation to quickly assess the presence and level of radiological contamination. Field screening at the site included radiological mapping over more than 50% of the site excavation and waste sorting trench surface area using a Global Positioning Environmental Radiological Surveyor (GPERS) with instrumentation specific to the detection of radiation associated with gamma emitting radionuclides. Any radiological "hot spots" identified as requiring additional remediation were targeted and soil (containing scattered metal debris) was removed until the radiation was no longer detected at the location. These areas were resurveyed to confirm that waste site excavation was complete. The GPERS surveys are provided in Figures C1-C26 of Appendix C. The overburden/BCL material was surveyed for radioactivity using GPERS throughout the remedial process, as shown in Figures C27-C29 of Appendix C. No contamination was identified for the overburden/BCL material.

## 4.4 FOCUSED SAMPLING

Focused samples are collected to verify the absence of contamination in residual soil beneath locations exhibiting visual stains, locations of buried liquid wastes or equipment, mercury-containing piping, or large inventories of dangerous/hazardous

wastes (e.g., lead bricks). Additionally, focused samples may be collected from locations where process knowledge indicates the potential for elevated concentrations of alpha or beta contamination, or where waste characterization sampling results indicate elevated concentrations of chemical contaminants above the RAGs.

Three areas of the 118-F-1 Burial Ground excavation were identified with anomalous or distinctive type waste forms. These include a steel canister of radiologically contaminated graphite chips or dust that appeared to be from reactor core boring operations. A photograph of the canister is provided in Appendix A. The canister was approximately 4 ft in diameter and approximately 6 ft long and was likely a vacuum canister used to remove waste graphite during reactor core boring operations. The canister was open at one end. The other two areas noted were excavated asbestos concrete siding or roofing (transite) materials. Transite volumes in each area were relatively low. Approximately one ERDF container of asbestos transite material was removed from each location.

Three focused samples associated with the graphite chips/dust area were analyzed for carbon-14 and tritium (H-3). Analyte selection was based on in-process characterization data of the graphite waste. The six focused samples associated with the asbestos material were analyzed for asbestos. Focused sample locations are shown on Figure 3.

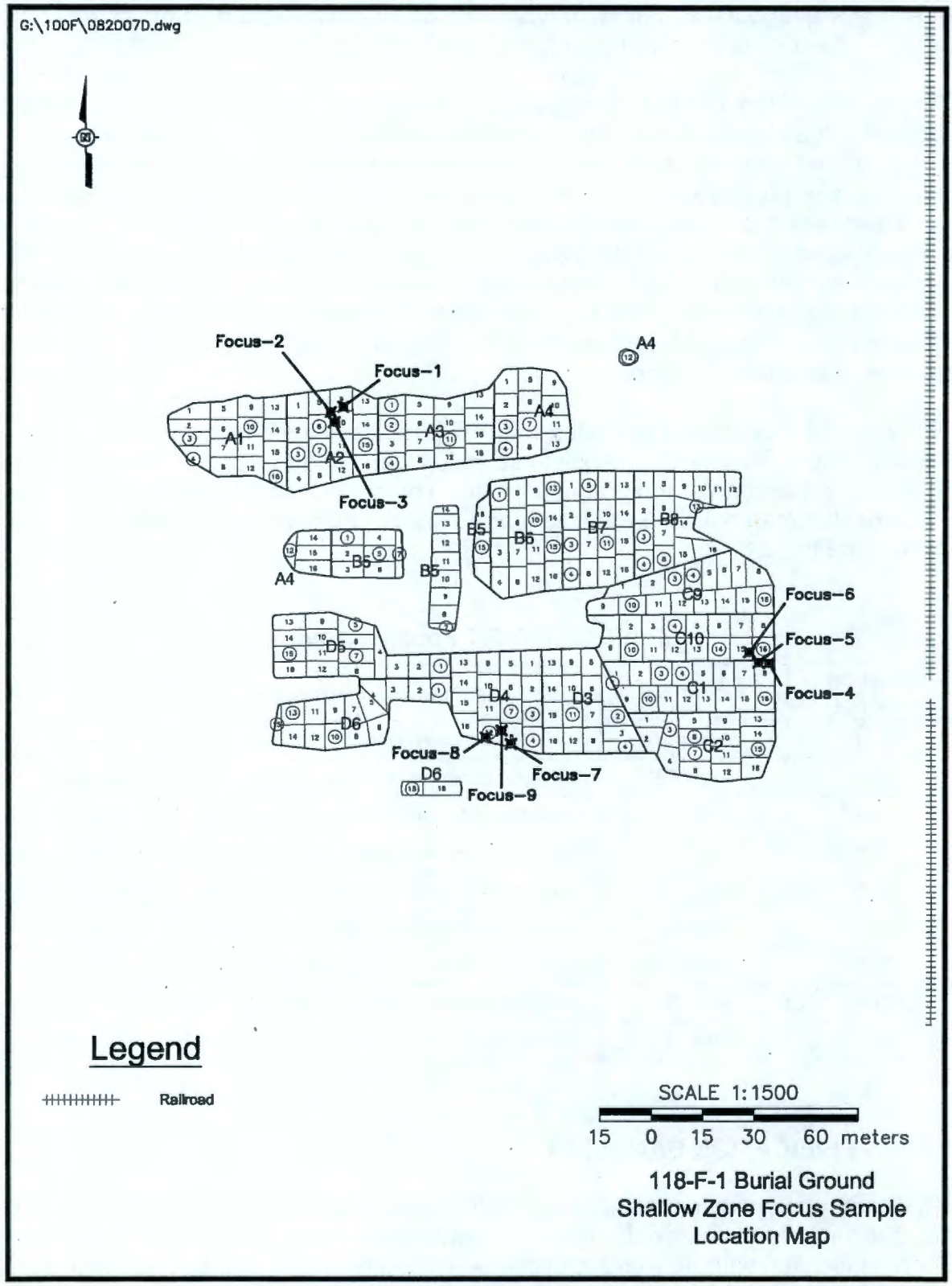
**Table 2. 118-F-1 Focused Samples.**

| Focused Sample | Location | Associated Anomaly | COCs |
|---|---|---|---|
| FS-1 | Area A2 | Asbestos concrete siding or roofing (transite) | Asbestos |
| FS-2 | Area A2 | Asbestos concrete siding or roofing (transite) | Asbestos |
| FS-3 | Area A2 | Asbestos concrete siding or roofing (transite) | Asbestos |
| FS-4 | Area C10 | Open canister with graphite chips or dust | Carbon-14, tritium |
| FS-5 | Area C10 | Open canister with graphite chips or dust | Carbon-14, tritium |
| FS-6 | Area C10 | Open canister with graphite chips or dust | Carbon-14, tritium |
| FS-7 | Area D4 | Asbestos concrete siding or roofing (transite) | Asbestos |
| FS-8 | Area D4 | Asbestos concrete siding or roofing (transite) | Asbestos |
| FS-9 | Area D4 | Asbestos concrete siding or roofing (transite) | Asbestos |

## 4.5 VERIFICATION SAMPLING

Final cleanup verification samples were collected in May 2007 and June 2007 to confirm acceptability of residual contaminant concentrations in the soil at the 118-F-1 waste site. Each verification sample was a composite formed by combining soil collected at four randomly selected nodes within each of the sampling decision subunits. The verification samples were submitted to offsite laboratories for analysis using approved EPA

**Figure 3. 118-F-1 Focused Sampling Locations for Remediation Footprint.**



analytical methods, as required per the SAP (DOE-RL 2001). The sample design methodology and sample location figures are presented in the calculation brief for verification sample design in Appendix B. An aerial photograph of the 118-F-1 Burial Ground, post-excavation, is presented in Appendix A.

## 5.0 SAMPLING RESULTS

Verification samples were analyzed using U.S. EPA-approved analytical methods. The 95% upper confidence limit on the true population mean for residual concentrations of COCs and COPCs was calculated for the excavation area as specified by the RDR/RAWP (DOE-RL 2005), with calculations provided in Appendix B. When a nonradionuclide COC or COPC was detected in fewer than 50% of the verification samples collected, the maximum detected value was used for comparison against the RAGs. If no detections for a given COC/COPC were reported in the data set, then no statistical evaluation or calculations were performed for that COC/COPC.

Comparisons of the statistical and maximum results for COCs and COPCs with the site RAGs for the excavation area, waste sorting trenches, and overburden/BCL piles are summarized in Tables 3 through 5, respectively. Contaminants that were not detected by laboratory analysis are excluded from these tables. Calculated cleanup levels are not presented in the *Cleanup Levels and Risk Calculations Database* (Ecology 2005) under *Washington Administrative Code* (WAC) 173-340-740(3) for aluminum, calcium, iron, magnesium, potassium, silicon, and sodium; therefore, these constituents are not considered site COPCs. The laboratory-reported data results for all constituents are stored in the Environmental Restoration (ENRE) project-specific database prior to archival in Hanford Environmental Information System (HEIS) and are presented in Appendix B.

**Table 3. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-F-1 Excavation Shallow Zone Verification Sampling. (2 Pages)**

| COC/COPC | Statistical Result (pCi/g) | Generic Site Lookup Values[a] (pCi/g) | | | Does the Statistical Result Exceed Lookup Values? | Does the Statistical Result Pass RESRAD Modeling? |
|---|---|---|---|---|---|---|
| | | Shallow Zone Lookup Value[b] | Groundwater Protection Lookup Value | River Protection Lookup Value | | |
| Americium-241 | 0.063 | 31.1 | --[c] | --[c] | No | Yes[e] |
| Carbon-14 | 0.83 | 5.16 | --[c] | --[c] | No | |
| Cesium-137 | 0.21 | 6.2 | 1,465[d] | 1,465[d] | No | |
| Cobalt-60 | 0.038 | 1.4 | 13,900[d] | 13,900[d] | No | |
| Europium-152 | 0.054 | 3.3 | --[c] | --[c] | No | |
| Europium-154 | 0.053 | 3.0 | --[c] | --[c] | No | |
| Nickel-63 | 2.3 | 83[d] | 83[d] | 83[d] | No | |

## Table 3. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-F-1 Excavation Shallow Zone Verification Sampling. (2 Pages)

| COC/COPC | Statistical Result (pCi/g) | Generic Site Lookup Values[a] (pCi/g) | | | Does the Statistical Result Exceed Lookup Values? | Does the Statistical Result Pass RESRAD Modeling? |
|---|---|---|---|---|---|---|
| | | Shallow Zone Lookup Value[b] | Groundwater Protection Lookup Value | River Protection Lookup Value | | |
| Plutonium-238 | 0.028 | 37.4 | --[c] | --[c] | No | |
| Plutonium-239/240 | 0.11 | 33.9 | --[c] | --[c] | No | |
| Silver-108m | 0.017 | 2.38 | --[c] | --[c] | No | |
| Strontium-90 | 0.38 | 4.5 | 27.6[d] | 27.6[d] | No | Yes[e] |
| Tritium | 1.4 | 15.8 | 15.8 | 15.8 | No | |
| Uranium-238 | 0.0 (<BG) | 1.1[f] | 1.1[f] | 1.1[f] | No | |
| **COC/COPC** | **Statistical Result (mg/kg)** | **Remedial Action Goals[a] (mg/kg)** | | | **Does the Statistical Data Set Exceed RAGs?** | **Does the Statistical Result Pass RESRAD Modeling?** |
| | | **Direct Exposure** | **Soil Cleanup Level for Groundwater Protection** | **Soil Cleanup Level for River Protection** | | |
| Cadmium | 0.10 | 13.9[g] | 0.81[h] | 0.81[h] | No | -- |
| Lead | 5.4 | 353[i] | 10.2[h] | 10.2[h] | No | -- |
| Mercury | 0.0076 | 24[i] | 0.33[h] | 0.33[h] | No | -- |

[a] Lookup values and remedial action goals (RAGs) obtained from the *100 Area Remedial Action Sampling and Analysis Plan* (RDR/RAWP) (DOE-RL 2005) or calculated per *Washington Administrative Code* (WAC) 173-340-720, 730, and 740, Method B, 1996, unless otherwise noted.

[b] Activity corresponding to a single-radionuclide 15 mrem/yr exposure as calculated using a generic RESidual RADioactivity (RESRAD) model (DOE-RL 2005).

[c] No value—RESRAD modeling predicts the contaminant will not reach groundwater within 1,000 years.

[d] Revised lookup value per *100 Area Radionuclide and Nonradionuclide Lookup Values for the 1995 Interim Remedial Action Record of Decision* (BHI 2004).

[e] *118-F-1 Burial Ground Cleanup Verification RESRAD Calculation Brief* (Appendix B).

[f] The calculated lookup value is below the Hanford-specific statistical soil background activity. The value presented is the Hanford-specific statistical soil background activity (DOE-RL 1996).

[g] Carcinogenic cleanup level calculated based on the inhalation exposure pathway per WAC 173-340-750[3], 1996 (Method B for air quality) and an airborne particulate mass loading rate of 0.0001 g/m$^3$ (WDOH 1997).

[h] Where cleanup levels are less than background, cleanup levels default to background or required detection limits per Ecology 1996, WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively.

[i] Use EPA, 1994, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication No. 9285.7, U.S. Environmental Protection Agency, Washington, D.C.

[j] Remedial action goal established in the 100 Area Remedial Design Report/Remedial Action Work Plan.

-- = not applicable
BG = background (obtained from DOE-RL [1996] and DOE-RL [2001], unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

**Table 4. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-F-1 Waste Sorting Trench Shallow Zone Verification Sampling). (2 Pages)**

| COC/COPC | Statistical Result (pCi/g) | Generic Site Lookup Values[a] (pCi/g) | | | Does the Statistical Result Exceed Lookup Values? | Does the Statistical Result Pass RESRAD Modeling? |
|---|---|---|---|---|---|---|
| | | Shallow Zone Lookup Value[b] | Groundwater Protection Lookup Value | River Protection Lookup Value | | |
| Americium-241 | 0.089 | 31.1 | --[c] | --[c] | No | Yes[c] |
| Carbon-14 | 0.32 | 5.16 | --[c] | --[c] | No | |
| Cesium-137 | 0.45 | 6.2 | 1,465[d] | 1,465[d] | No | |
| Cobalt-60 | 0.074 | 1.4 | 13,900[d] | 13,900[d] | No | |
| Europium-152 | 0.14 | 3.3 | --[c] | --[c] | No | |
| Europium-154 | 0.063 | 3.0 | --[c] | --[c] | No | |
| Nickel-63 | 4.4 | 83[d] | 83[d] | 83[d] | No | |
| Plutonium-238 | 0.10 | 37.4 | --[c] | --[c] | No | |
| Plutonium-239/240 | 0.13 | 33.9 | --[c] | --[c] | No | |
| Silver-108m | 0.013 | 2.38 | --[c] | --[c] | No | |
| Strontium-90 | 0.22 | 4.5 | 27.6[d] | 27.6[d] | No | |
| Tritium | 2.0 | 15.8 | 15.8 | 15.8 | No | |
| Uranium-238 | 0.0 (<BG) | 1.1[e] | 1.1[e] | 1.1[e] | No | |
| **COC/COPC** | **Statistical Result (mg/kg)** | **Remedial Action Goals[a] (mg/kg)** | | | **Does the Statistical Data Set Exceed RAGs?** | **Does the Statistical Result Pass RESRAD Modeling?** |
| | | **Direct Exposure** | **Soil Cleanup Level for Groundwater Protection** | **Soil Cleanup Level for River Protection** | | |
| Cadmium | 0.10 | 13.9[f] | 0.81[g] | 0.81[g] | No | -- |
| Lead | 18 | 353[h] | 10.2[g] | 10.2[g] | Yes | Yes[k] |
| Mercury | 0.020 | 24[i] | 0.33[g] | 0.33[g] | No | -- |

[a] Lookup values and remedial action goals (RAGs) obtained from the *100 Area Remedial Action Sampling and Analysis Plan* (RDR/RAWP) (DOE-RL 2005) or calculated per *Washington Administrative Code* (WAC) 173-340-720, 730, and 740, Method B, 1996, unless otherwise noted.

[b] Activity corresponding to a single-radionuclide 15 mrem/yr exposure as calculated using a generic RESidual RADioactivity (RESRAD) model (DOE-RL 2005).

[c] No value—RESRAD modeling predicts the contaminant will not reach groundwater within 1,000 years.

[d] Revised lookup value per *100 Area Radionuclide and Nonradionuclide Lookup Values for the 1995 Interim Remedial Action Record of Decision* (BHI 2004).

[e] *118-F-1 Burial Ground Cleanup Verification RESRAD Calculation Brief* (Appendix B).

[f] The calculated lookup value is below the Hanford-specific statistical soil background activity. The value presented is the Hanford-specific statistical soil background activity (DOE-RL 1996).

[g] Carcinogenic cleanup level calculated based on the inhalation exposure pathway per WAC 173-340-750[3], 1996 (Method B for air quality) and an airborne particulate mass loading rate of 0.0001 g/m$^3$ (WDOH 1997).

[h] Where cleanup levels are less than background, cleanup levels default to background or required detection limits per Ecology 1996, WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively.

[i] Use EPA, 1994, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication No. 9285.7, U.S. Environmental Protection Agency, Washington, D.C.

[j] Remedial action goal established in the 100 Area Remedial Design Report/Remedial Action Work Plan.

[k] Based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005), residual concentrations are not expected to migrate more than 2 m (6.6 ft) vertically in 1,000 years (based on the lowest soil-partitioning distribution coefficient [lead] of 30 mL/g). The vadose zone underlying the remediation footprint is approximately 7.8 m (25 ft) thick. Therefore, residual concentrations of all contaminants are predicted to be protective of groundwater and the Columbia River.

-- = not applicable

## Table 4. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-F-1 Waste Sorting Trench Shallow Zone Verification Sampling). (2 Pages)

BG = background (obtained from DOE-RL [1996] and DOE-RL [2001], unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose assessment model

## Table 5. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-F-1 Overburden-Below Cleanup Level Verification Sampling. (2 Pages)

| COC/COPC | Statistical Result (pCi/g) | Generic Site Lookup Values[a] (pCi/g) | | | Does the Statistical Result Exceed Lookup Values? | Does the Statistical Result Pass RESRAD Modeling? |
|---|---|---|---|---|---|---|
| | | Shallow Zone Lookup Value[b] | Groundwater Protection Lookup Value | River Protection Lookup Value | | |
| Americium-241 | 0.23 | 31.1 | --[c] | --[c] | No | Yes[e] |
| Cesium-137 | 0.0 (<BG) | 5.16 | --[c] | --[c] | No | |
| Cobalt-60 | 0.0075 | 6.2 | 1,465[d] | 1,465[d] | No | |
| Europium-152 | 0.041 | 1.4 | 13,900 | 13,900 | No | |
| Europium-154 | 0.018 | 3.3 | --[c] | --[c] | No | |
| Nickel-63 | 2.5 | 3.0 | --[c] | --[c] | No | |
| Plutonium-238 | 0.16 | 83[d] | 83[d] | 83[d] | No | |
| Plutonium-239/240 | 0.13 | 37.4 | --[c] | --[c] | No | |
| Silver-108m | 0.011 | 33.9 | --[c] | --[c] | No | |
| Strontium-90 | 0.0 (<BG) | 4.5 | 27.6[d] | 27.6[d] | No | |
| Tritium | 2.5 | 15.8 | 15.8 | 15.8 | No | |
| Uranium-238 | 0.0 (<BG) | 15.8 | 15.8 | 15.8 | No | |
| **COC/COPC** | **Statistical Result (mg/kg)** | **Remedial Action Goals[a] (mg/kg)** | | | **Does the Statistical Data Set Exceed RAGs?** | **Does the Statistical Result Pass RESRAD Modeling?** |
| | | **Direct Exposure** | **Soil Cleanup Level for Groundwater Protection** | **Soil Cleanup Level for River Protection** | | |
| Cadmium | 0.0 | 13.9[f] | 0.81[g] | 0.81[g] | No | -- |
| Lead | 12 | 353[h] | 10.2[g] | 10.2[g] | Yes | Yes[j] |
| Mercury | 0.0076 | 24[i] | 0.33[g] | 0.33[g] | No | -- |

[a] Lookup values and remedial action goals (RAGs) obtained from the *100 Area Remedial Action Sampling and Analysis Plan* (RDR/RAWP) (DOE-RL 2005) or calculated per *Washington Administrative Code* (WAC) 173-340-720, 173-340-730, and 173-340-740, Method B, 1996, unless otherwise noted.

[b] Activity corresponding to a single-radionuclide 15 mrem/yr exposure as calculated using a generic RESidual RADioactivity (RESRAD) model (DOE-RL 2005).

[c] No value—RESRAD modeling predicts the contaminant will not reach groundwater within 1,000 years.

[d] Revised lookup value per *100 Area Radionuclide and Nonradionuclide Lookup Values for the 1995 Interim Remedial Action Record of Decision* (BHI 2004).

[e] *118-F-1 Burial Ground Cleanup Verification RESRAD Calculation Brief* (Appendix B).

[f] Carcinogenic cleanup level calculated based on the inhalation exposure pathway per WAC 173-340-750[3], 1996 (Method B for air quality) and an airborne particulate mass loading rate of 0.0001 g/m$^3$ (WDOH 1997).

[g] Where cleanup levels are less than background, cleanup levels default to background or required detection limits per Ecology 1996, WAC 173-340-700(4)(d) and WAC 173-340-707(2), respectively.

[h] Use EPA, 1994, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication No. 9285.7, U.S. Environmental Protection Agency, Washington, D.C.

**Table 5. Comparison of Statistical Contaminant Concentrations to Action Levels for the 118-F-1 Overburden-Below Cleanup Level Verification Sampling. (2 Pages)**

[i] Remedial action goal established in the 100 Area Remedial Design Report/Remedial Action Work Plan.
[j] Based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005), residual concentrations are not expected to migrate more than 2 m (6.6 ft) vertically in 1,000 years (based on the lowest soil-partitioning distribution coefficient [lead] of 30 mL/g). The vadose zone underlying the remediation footprint is approximately 7.8 m (25 ft) thick. Therefore, residual concentrations of all contaminants are predicted to be protective of groundwater and the Columbia River.

-- = not applicable
BG = background (obtained from DOE-RL [1996] and DOE-RL [2001], unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual RADioactivity (dose-assessment model)

## 5.1 FOCUSED SAMPLE RESULTS

Nine focused samples were collected from the 118-F-1 waste site. The sample locations are shown in Figure 3. Six of the focused samples were of suspect asbestos-containing material. The asbestos sample results were reported as either less than 1% or none detected.

The three remaining focused samples were collected of soil underlying anomalous media found within the trenches during the remedial excavations. Statistical analysis (e.g., calculation of a 95% UCL value) is inappropriate to use for evaluation of focused samples; therefore, the sample results for each focused sample are evaluated using the maximum detected activity for each COC/COPC and comparing the value directly to the cleanup level. Table 6 provides a comparison of the maximum result of the three focused samples against the cleanup criteria. Individual sample results are provided in Appendix B.

**Table 6. Comparison of Maximum Contaminant Concentrations to Action Levels for the 118-F-1 Focused Verification Sampling Event. (2 Pages)**

| COC/COPC | Maximum Result (pCi/g) | Generic Site Lookup Values[a] (pCi/g) | | | Does the Statistical Result Exceed Lookup Values? | Does the Statistical Result Pass RESRAD Modeling? |
|---|---|---|---|---|---|---|
| | | Shallow Zone Lookup Value[b] | Groundwater Protection Lookup Value | River Protection Lookup Value | | |
| Carbon-14 | 1.67 (ND) | 5.16 | --[c] | --[c] | No | Yes[d] |
| Tritium | 0.541 (ND) | 15.8 | 15.8 | 15.8 | No | |

**Table 6. Comparison of Maximum Contaminant Concentrations to Action Levels for the 118-F-1 Focused Verification Sampling Event. (2 Pages)**

[a] Lookup values and remedial action goals (RAGs) obtained from the *100 Area Remedial Action Sampling and Analysis Plan* (RDR/RAWP) (DOE-RL 2005) or calculated per *Washington Administrative Code* (WAC) 173-340-720, 173-340-730, and 173-340-740, Method B, 1996, unless otherwise noted.

[b] Noncarcinogenic cleanup level calculated from WAC 173-340-740(3), 1996 (Method B for soils) (as presented in the RDR/RAWP [DOE-RL 2005]). Updated oral reference dose values (as provided in the Integrated Risk Information System [IRIS]) yield Method B direct exposure RAG values of 16,000 mg/kg and 120,000 mg/kg for barium and chromium, respectively.

[c] No value—RESRAD modeling predicts the contaminant will not reach groundwater within 1,000 years.

[d] *118-F-1 Burial Ground Cleanup Verification RESRAD Calculation Brief* (Appendix B).

-- = not applicable
BG = background (obtained from DOE-RL [1996] and DOE-RL [2001], unless otherwise noted)
COC = contaminant of concern
COPC = contaminant of potential concern
ND = not detected
RESRAD = RESidual RADioactivity (dose-assessment model)

## 5.2 DATA QUALITY ASSESSMENT PROCESS

A data quality assessment (DQA) is performed to compare the verification sampling approach, the field logbooks (WCH 2007a, b), and resulting analytical data with the sampling and data quality requirements specified by the project objectives and performance specifications.

The DQA for the 118-F-1 site established that the data are of the right type, quality, and quantity to support site verification decisions within specified error tolerances. All analytical data were found to be acceptable for decision-making purposes. The evaluation verified that the sample design was sufficient for the purpose of clean site verification. The cleanup verification sample analytical data are stored in the ENRE project-specific database for data evaluation prior to its archival in the HEIS and are summarized in Appendix B. The detailed DQA is presented in Appendix D.

# 6.0 CLEANUP VERIFICATION DATA EVALUATION

This section demonstrates that remedial actions at the 118-F-1 site have achieved the applicable RAGs. Sections 5.4 and 5.5 address attainment of direct exposure RAGs and groundwater and Columbia River protection RAGs, respectively. Section 5.6 summarizes the results of the WAC 173-340 three-part test performed in the 95% UCL calculation brief (Appendix B). This test is required for nonradionuclide COCs only and is based on the most restrictive RAG (defined as the lowest of the direct exposure, groundwater protection, and river protection RAGs).

## 6.1 DIRECT EXPOSURE SOIL REMEDIAL ACTION GOALS ATTAINED

### 6.1.1 Radionuclides

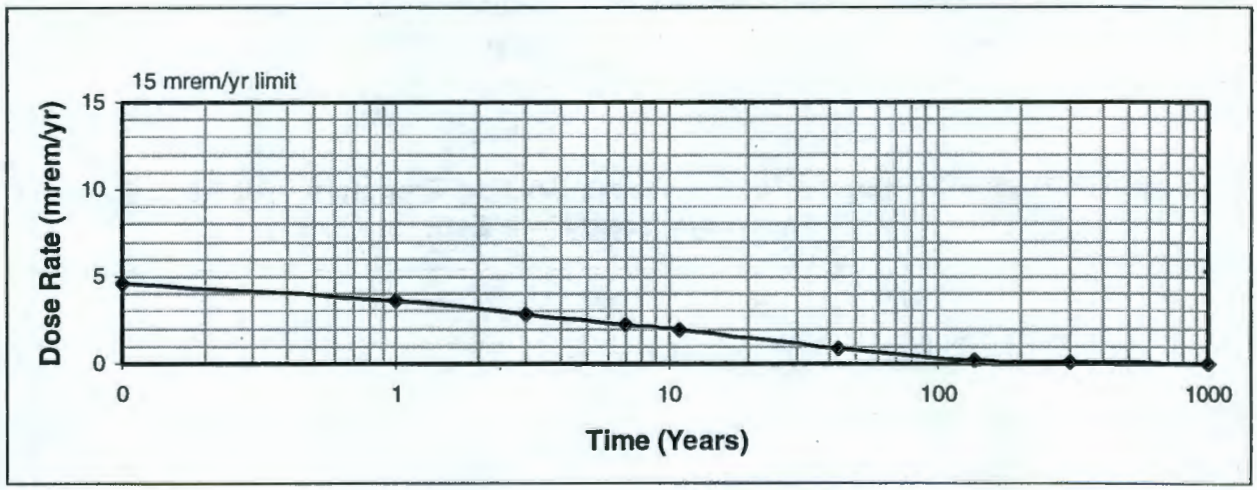
The individual radionuclide cleanup verification statistical values (Tables 3 through 5) were entered into the RESRAD computer code, Version 6.30 (ANL 2005), to estimate the dose rate and the impact on groundwater and the river from residual COC

concentrations. Separate RESRAD runs were performed for the excavation area, the overburden/BCL decision unit, and the waste sorting trenches.

The results of the 118-F-1 RESRAD dose rate estimates for the all-pathways scenarios for the excavation area, the overburden/BCL, and the waste sorting trenches are shown in Figures 4 through 6. These dose rates represent the dose contributions from soils at relevant time periods. The 2018 date corresponds to the 30-year site cleanup schedule of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). All dose rate estimates are less than the 15 mrem/yr RAG. The RESRAD computations are shown in detail in the calculation briefs presented in Appendix B.

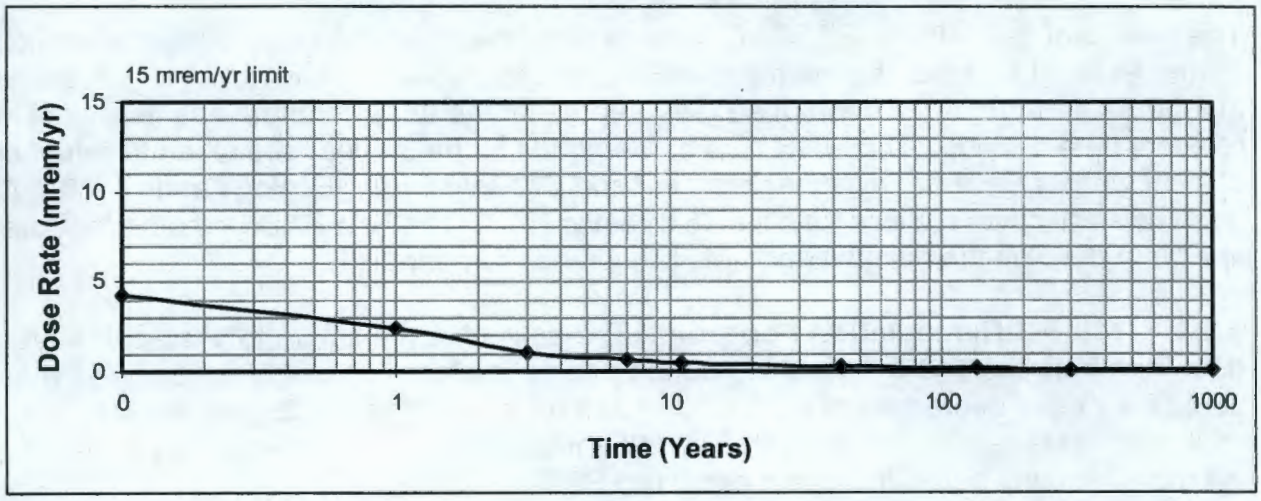
**6.1.1.1 118-F-1 Remediation Footprint.** The estimated maximum total all-pathways dose rate from the 118-F-1 Burial Ground remediation footprint is 4.59 mrem/yr at year zero (2007) and decreases to $4.73 \times 10^{-2}$ mrem/yr in 1,000 years (Figure 4). The estimated dose rate in the year 2018 is 1.95 mrem/yr. The all-pathways dose rate estimate remains below the direct exposure RAG.

**Figure 4. RESRAD Analysis for the Remediation Footprint– All Radionuclides, All-Pathways Dose Rate Estimate.**



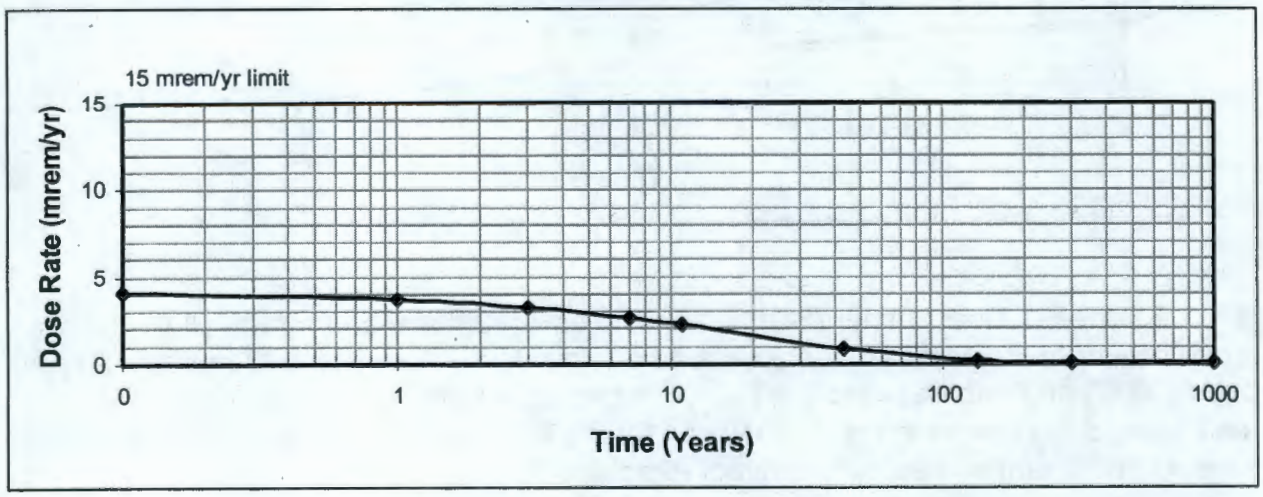

**6.1.1.2 118-F-1 Overburden/BCL Soil.** The estimated maximum total all-pathways dose rate from the 118-F-1 Burial Ground overburden/BCL soil is 4.23 mrem/yr at year zero (2007) and decreases to $7.36 \times 10^{-2}$ mrem/yr in 1,000 years (Figure 5). The estimated dose rate in the year 2018 is $4.69 \times 10^{-1}$ mrem/yr. The all-pathways dose rate estimate remains below the direct exposure RAG.

**Figure 5. RESRAD Analysis for the Overburden/BCL soil– All Radionuclides, All-Pathways Dose Rate Estimate.**




**6.1.1.3 118-F-1 Waste Sorting Trenches.** The estimated maximum total all-pathways dose rate from the 118-F-1 Burial Ground waste sorting trenches is 4.06 mrem/yr at year zero (2007) and decreases to 6.01 x $10^{-2}$ mrem/yr in 1,000 years (Figure 6). The estimated dose rate in the year 2018 is 2.21 mrem/yr. The all-pathways dose rate estimate remains below the direct exposure RAG.

**Figure 6. RESRAD Analysis for the Waste Sorting Trenches– All Radionuclides, All-Pathways Dose Rate Estimate.**




### 6.1.2 Nonradionuclides

**6.1.2.1 Direct Comparison to RAGs.** Tables 3 through 5 compare the cleanup verification statistical values to the direct exposure RAGs. All nonradionuclides are below the direct exposure cleanup criteria and, therefore, all applicable RAGs are met.

**6.1.2.2 Noncarcinogenic Hazard Quotient RAG Attained.** For noncarcinogenic COCs, WAC 173-340-740(3)(a)(iii)(A) and (B) specify the evaluation of the hazard quotient which is given as a daily intake divided by a reference dose. Both individual and cumulative hazard quotient values must be less than 1.0. Hazard quotient calculations were performed for the 118-F-1 Burial Ground using the highest statistical value from all sampling areas.

The details and results of the hazard quotient calculations are provided in the hazard quotient and carcinogenic risk calculation brief (Appendix B). Results of the hazard quotient calculations show that all individual hazard quotients are less than one and the cumulative hazard quotient for the 118-F-1 waste site is $1.1 \times 10^{-1}$ (Appendix B). Therefore, the noncarcinogenic hazard quotient RAG has been attained for the 118-F-1 waste site.

**6.1.2.3 Carcinogenic Risk RAG Attained.** For individual nonradionuclide carcinogenic COCs, the WAC 173-340 Method B cleanup limits are based on an incremental cancer risk of $1 \times 10^{-6}$. For nonradionuclide carcinogenic COCs, the total excess cancer risk must be less than $1 \times 10^{-5}$. Carcinogenic risk calculations were performed for the 118-F-1 Burial Ground using the highest statistical value from all sampling areas for the nonradionuclide carcinogenic COCs. The details and results of the hazard quotient calculations are provided in the hazard quotient and carcinogenic risk calculation brief (Appendix B).

Results of the carcinogenic risk calculations show that all individual nonradionuclide carcinogenic COCs have an incremental cancer risk below $1 \times 10^{-6}$ (Appendix B). The calculated total excess cancer risk for the 118-F-1 waste site is zero, which is below the Remedial Action Objective (RAO) of $1 \times 10^{-5}$. The nonradionuclide carcinogenic risk RAG has been attained for the 118-F-1 waste site.

## 6.2 GROUNDWATER AND COLUMBIA RIVER REMEDIAL ACTION GOALS ATTAINED

### 6.2.1 Radionuclides

The estimated groundwater concentrations for all of the radionuclide COCs contributed by the site soils are shown in the RESRAD calculation brief (Appendix B). Among the radionuclide contaminants of concern, only cesium-137, cobalt-60, nickel-63, strontium-90, and tritium are calculated to reach groundwater (and, therefore, the Columbia River) in 1,000 years at concentrations significantly below the RAGs. Table 7 gives the total peak concentrations predicted for each radionuclide COC along with the individual RAGs for comparison. The peak concentration for each COC is the maximum value, as predicted by RESRAD modeling, from the sampling areas (i.e., remediation footprint, overburden/BCL, and waste sorting pile area). No COC concentration is predicted to exceed the RAGs; therefore, the groundwater and Columbia River protection RAOs are attained.

Figure 7 shows the individual organ dose rate for beta- and gamma-emitting radionuclides predicted over 1,000 years as shown in the comparison to drinking water standards calculation brief (MCL calculation brief in Appendix B). The cumulative dose for each total body, bone, liver, and gastrointestinal tract for all beta- and gamma-emitting COCs is less than the 4 mrem/yr standard over 1,000 years. Results of the RESRAD calculations are shown in the MCL calculation brief (Appendix B).

Non-uranium, alpha-emitting radionuclide COCs/COPCs were not detected in the verification soil samples and no uranium isotopes were detected above background levels in the verification soil samples. Therefore, the drinking water concentration standard for non-uranium alpha emitters and the uranium standard of 30 µg/L have been met.

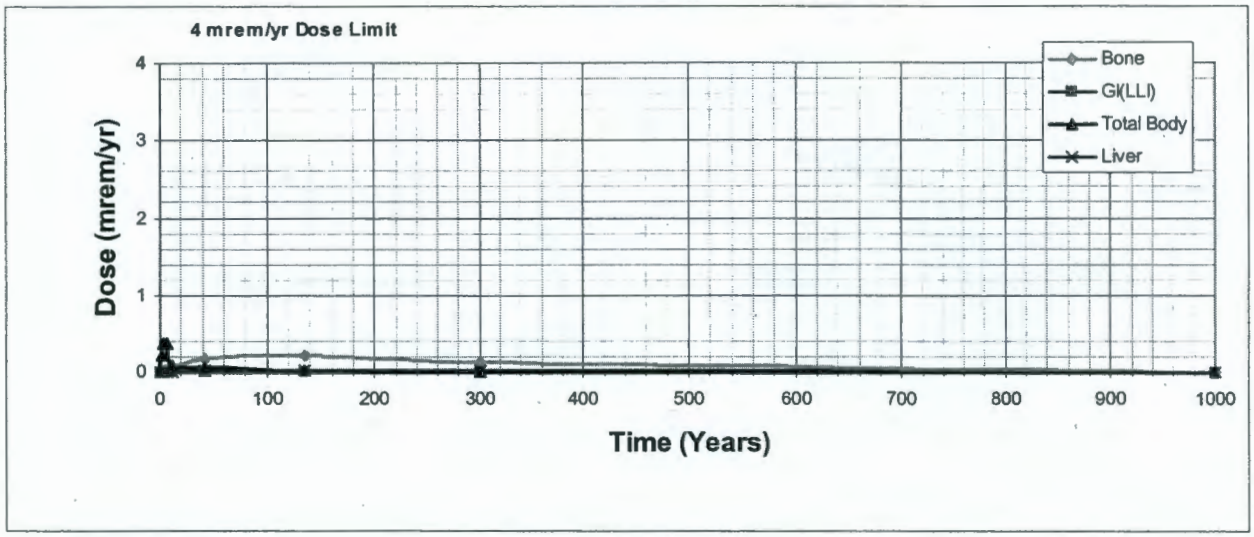
**Table 7. Estimated Peak Radionuclide Groundwater Concentrations in the Soils for 118-F-1.**

| Radionuclide | Peak Concentration (pCi/L) [a] | RAG (pCi/L) | RAGs Attained? (Yes/No) |
|---|---|---|---|
| Cobalt-60 | 0.000531 | 100[b] | Yes |
| Cesium-137 | 0.0184 | 60[b] | Yes |
| Nickel-63 | 2.63 | 50[b] | Yes |
| Strontium-90 | 0.11 | 8[c] | Yes |
| Tritium | 1,800 | 20,000[c] | Yes |

[a] The peak concentration is the maximum predicted value from the three sampling areas (remediation footprint, overburden/BCL, and waste sorting pile area). All results are presented in the MCL calculation brief (Appendix B).
[b] Lookup value corresponding to a dose rate of 4 mrem/yr.
[c] EPA drinking water promulgated MCL (40 CFR 141.66).

CFR = *Code of Federal Regulations*
EPA = U.S. Environmental Protection Agency
MCL = maximum cleanup level
RAG = remedial action goal

**Figure 7. Dose Rate to Organs from Groundwater.**




### 6.2.2 Nonradionuclides

Tables 3 through 5 compare the statistical verification results to the groundwater protection RAGs for all sampling areas. The tables show that the statistical results for lead exceed the soil RAGs for the protection of groundwater. The residual concentrations of lead, however, are not predicted to reach groundwater (and, therefore, the Columbia River) in 1,000 years based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) and their contaminant-specific soil partitioning coefficient ($K_d$) values. Given the soil-partitioning coefficients of lead (30 mL/g) the results of RESRAD modeling (BHI 2005) indicate that these constituents will not migrate vertically more than 3 m (10 ft) in 1,000 years. The vadose zone underlying the 118-F-1 site is greater than 3 m (10 ft) thick and, as such, these contaminants will not reach groundwater (and, therefore, the Columbia River) in 1,000 years.

## 6.3 WAC 173-340 THREE-PART TEST FOR NONRADIONUCLIDES

Sections 5.4 and 5.5 looked separately at compliance with direct exposure RAGs and groundwater and Columbia River protection soil RAGs, respectively. When using a statistical sampling approach, a RAG requirement for nonradionuclides is the WAC 173-340-740(7)(e) three-part test. The WAC 173-340 three-part test consists of the following criteria: (1) the cleanup verification statistical value must be less than the cleanup level, (2) no single detection can exceed two times the cleanup criteria, and (3) the percentage of samples exceeding the cleanup criteria must be less than 10%.

The application of the three-part test for the 118-F-1 waste site is included in the 95% UCL calculation brief (Appendix B). Only the COCs/COPCs that failed one or more parts of the WAC 173-340 three-part test are provided in Table 8. The table lists the most restrictive RAG, the maximum detected value, the total number of samples

collected, and the percentage of samples exceeding the RAG. The final column of the table describes the result of applying the three WAC 173-340-740(7)(e) criteria using the values listed in the preceding columns.

Residual concentrations of lead fail the three-part test in comparison against the soil RAGs for the protection of groundwater and/or the Columbia River. Based on RESRAD modeling (BHI 2005) and contaminant-specific soil-partitioning coefficient values, these constituents will not vertically migrate more than 3 m (10 ft) in 1,000 years. Given a vadose zone thickness greater than 3 m (10 ft) thick underlying the 118-F-1 waste site, residual concentrations are not predicted to reach groundwater (and, therefore, the Columbia River) within 1,000 years. As such, all non-radionuclide statistical verification data sets pass the WAC 173-340 three-part test.

**Table 8. Summary of the WAC 173-340 Three-Part Test for the 118-F-1 Burial Ground[a].**

| COC/COPC | Most Restrictive Applicable RAG | Statistical Cleanup Verification Value (mg/kg)[b] | Maximum Detected Cleanup Verification Value (mg/kg)[c] | Total Number of Samples[d] | Percentage of Cleanup Verification Data Set Exceeding RAG[e] | Cleanup Criteria Attained? |
|---|---|---|---|---|---|---|
| **Waste Sorting Trenches** | | | | | | |
| Lead | 10.2[g] | 18 | 32 | 5 | 20% | Yes[f] |
| **Overburden/BCL Piles** | | | | | | |
| Lead | 10.2[g] | 12 | 22.8 | 16 | 37.5% | Yes[f] |

[a] Only the COCs/COPCs that failed the WAC 173-340 Three-Part Test are presented.
[b] Criterion is statistical value cannot exceed most restrictive applicable RAG.
[c] Criterion is no single detection can exceed two times the most restrictive applicable RAG.
[d] Total number of samples in the decision unit may include field duplicate samples, which are included in the evaluation as separate samples.
[e] Criterion is percentage of data set exceeding the most restrictive applicable RAG cannot exceed 10%.
[f] Based on the *100 Area Analogous Sites RESRAD Calculations* (BHI 2005) and contaminant-specific soil-portioning coefficient ($K_d$) value, contaminant will not migrate vertically more than 3 m (10 ft) in 1,000 years. As the vadose zone underlying the site is greater than 3 m (10 ft) thick, the contaminant will not reach groundwater (and thus the Columbia River) in 1,000 years.
[g] Where cleanup levels are less than background, cleanup levels default to background (WAC 173-340-700[4][d]) (1996).

COC = contaminant of concern
COPC = contaminant of potential concern
RAG = remedial action goal
RESRAD = RESidual Radioactivity (dose model)
WAC = *Washington Administrative Code*

## 6.4 COMPARISON OF SAMPLE DATA TO ECO-SCREENING LEVELS

Soil cleanup levels were established in the ROD (EPA 2000) based on a limited ecological risk assessment. Although not required by the ROD (EPA 2000), a comparison against ecological risk screening levels has been made for the site COCs/COPCs. Screening levels were not exceeded for the site constituents, with the exception of antimony, arsenic, boron, lead, selenium, silver, and vanadium. Exceedance of screening values does not necessarily indicate the existence of risk to

ecological receptors. It is believed that the presence of these constituents does not pose a risk to ecological receptors as concentrations of antimony, arsenic, selenium, silver, and vanadium are within the range of Hanford Site background levels and boron concentrations are consistent with those seen elsewhere at the Hanford Site (no established background value is available for boron). The presence of lead is believed to be due to historic application of lead-arsenate pesticides. The exceedance of soil screening values by lead at the site will be evaluated in the context of additional lines of evidence for ecological effects. A baseline risk assessment for the river corridor portion of the Hanford Site began in 2004, which includes a more complete quantitative ecological risk assessment. That baseline risk assessment will be used as part of the final closeout decision for this site.

## 7.0 RADIONUCLIDE RISK INFORMATION

The radionuclide RAG for direct exposure is derived from the ROD (EPA 2000) and is expressed in terms of an allowable radiation dose rate above background (i.e., 15 mrem/yr). The RAG evaluation (Section 5.0) involved using the RESRAD model to estimate total annual radiation dose rates for 1,000 years for comparison to the RAG. Radiation presents a carcinogenic risk, and the RESRAD model also calculates the excess lifetime cancer risk (ELCR) associated with the estimated radiation dose rates using the EPA's Health Effects Assessment Summary Tables (update dated April 16, 2001, "Update of Radionuclide Carcinogenicity Slope Factors," available on the Internet at www.epa.gov/radiation/heast). The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 *Code of Federal Regulations* 300) presents a target range for residual risk of $10^{-4}$ to $10^{-6}$.

Figures 8 through 10 illustrate ELCR for the remediation footprint, overburden/BCL, and waste sorting pile area as estimated using the RESRAD model. Because of radioactive decay, the risk decreases over time. The maximum predicted ELCR occurs at present (year 2007). The maximum ELCR is $9.95 \times 10^{-5}$ for the remediation footprint, $5.42 \times 10^{-5}$ for the overburden/BCL soil and $1.55 \times 10^{-4}$ for the waste sorting pile area. The ELCR predicted for the year 2018 is $3.79 \times 10^{-5}$ for the remediation footprint, $4.10 \times 10^{-5}$ for the overburden/BCL soil and $9.57 \times 10^{-5}$ for the waste sorting pile footprint. All three sampling areas meet the target risk range of $10^{-4}$ to $10^{-6}$.

**Figure 8. RESRAD Analysis – Radionuclide Risk, All Pathways – Remediation Footprint.**

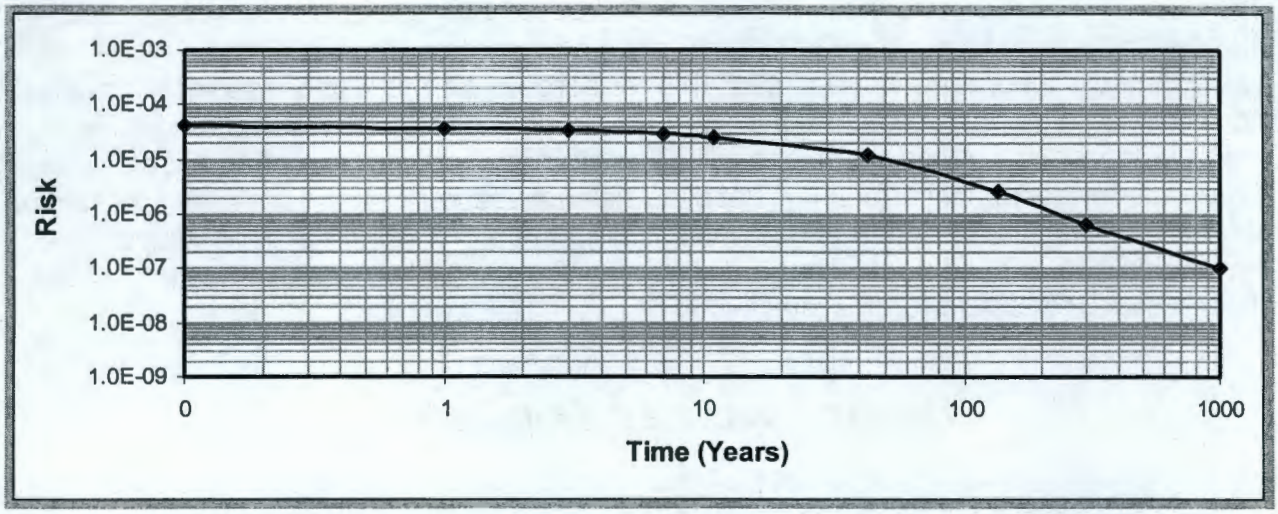



**Figure 9. RESRAD Analysis – Radionuclide Risk, All Pathways – Waste Sorting Trenches.**

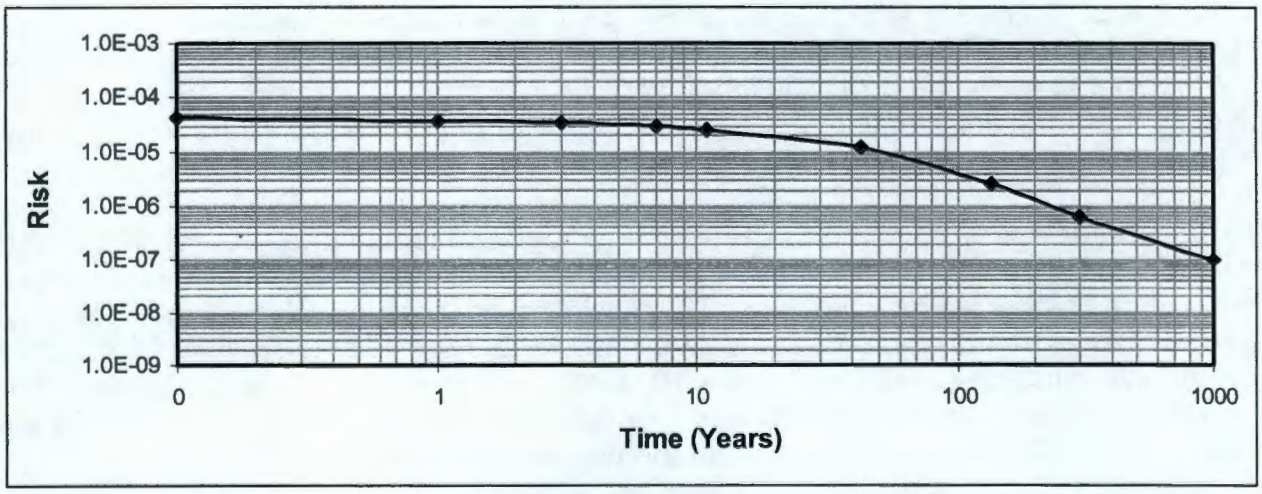
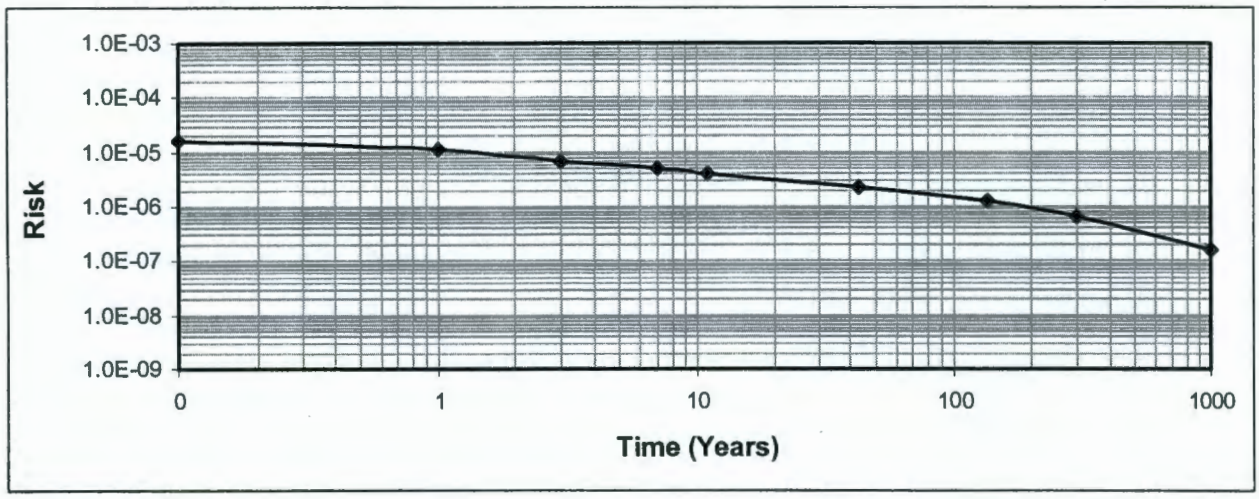


**Figure 10. RESRAD Analysis – Radionuclide Risk, All Pathways – Overburden/BCL.**




## 8.0 SUMMARY FOR WASTE SITE RECLASSIFICATION

This cleanup verification package demonstrates that remedial action at the 118-F-1 site has achieved the RAOs and corresponding RAGs established in the ROD (EPA 2000) and RDR/RAWP (DOE-RL 2005). The remaining soils at the 118-F-1 site have been sampled, analyzed, and modeled. The results of this effort indicate that the materials from the 118-F-1 site containing COCs at concentrations exceeding RAGs have been excavated and disposed of at ERDF. These results also indicate that residual concentrations will support future land uses that can be represented (or bounded) by a rural-residential scenario and that residual concentrations throughout the site pose no threat to groundwater or the Columbia River. The 118-F-1 excavation area has a maximum depth of approximately 5.5 m (18 ft), which includes a shallow zone and a deep zone. However, the entire excavation area is considered one decision unit, and will be closed out using the more restrictive shallow zone cleanup criteria; therefore, institutional controls to prevent uncontrolled drilling or excavation into the deep zone are not required. The 118-F-1 site is verified to be remediated in accordance with the ROD (EPA 2000) and may be backfilled.

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# APPENDIX A

## 118-F-1 WASTE SITE REMEDIATION PHOTOGRAPHS

(See attached CD for Complete File)

# APPENDIX B

## RESRAD INPUT PARAMETERS AND CALCULATION BRIEF EXCERPTS

(See attached CD for Complete File)

# APPENDIX C

## GPERS RADIOLOGICAL SURVEY GAMMA TRACK MAPS

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# APPENDIX D

## DATA QUALITY ASSESSMENT

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