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Rev. 5

# 100 Area Remedial Action Sampling and Analysis Plan



United States
Department of Energy

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# 100 Area Remedial Action Sampling and Analysis Plan

September 2009

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

# EXECUTIVE SUMMARY

This sampling and analysis plan (SAP) presents the rationale and strategies for the sampling, onsite measurements, and analyses that will be conducted on 100 Area waste sites excluding burial grounds, which are addressed in a separate plan. These waste sites are past-practice waste sites in the Environmental Restoration Contractor and River Corridor Closure Contractor scope for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-FR-1, 100-FR-2, 100-KR-1, 100-KR-2, 100-IU-2, and 100-IU-6 Operable Units. Although the 200-CW-3 Operable Unit is included in the applicable Interim Action Record of Decision, it is not within the scope of this SAP. The sites are being remediated in accordance with the following records of decision and record of decision amendment: *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA 1995); *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1997a); and *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (EPA 1999).

This SAP is organized into three parts:

| | |
|---|---|
| **PART I** | Part I presents the project background and rationale for sampling and analytical strategies that will be used to provide cost-effective and timely data to support remediation and disposal activities. |
| **PART II** | The quality assurance project plan, Part II, presents the activities and guidelines to provide for data of known and appropriate quality. |
| **PART III** | The field sampling plan, Part III, provides field procedures for sampling to ensure representative data of known quality. |

This SAP also includes the following appendices:

A Statistical Approach for Determining the Number of Samples for Verification and Overburden/Layback for Radioactive Liquid Effluent Waste Sites

B Analytical Standard Operating Procedures

C Leachability of 100 Area Soils

D 116-C-5 Leachability Study

E Debris Identification and Sampling Strategy

F Sample Design Information

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CFR | *Code of Federal Regulations* |
| COC | contaminant of concern |
| COPC | contaminant of potential concern |
| CRDL | contract required detection limit |
| DOE | U.S. Department of Energy |
| DOE-RL | U.S. Department of Energy, Richland Operations Office |
| DQA | data quality assessment |
| DQO | data quality objective |
| Ecology | Washington State Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| ERDF | Environmental Restoration Disposal Facility |
| ESD | explanation of significant difference |
| HEIS | Hanford Environmental Information System |
| HGIS | Hanford Geographic Information System |
| HPGe | high-purity germanium |
| LDR | land disposal restriction |
| MCL | maximum contaminant level |
| MDA | minimum detectable activity |
| NaI | sodium iodide |
| OU | operable unit |
| PCB | polychlorinated biphenyl |
| QA | quality assurance |
| QAPjP | quality assurance project plan |
| QC | quality control |
| QTL | quick-turnaround laboratory |
| RAG | remedial action goal |
| RAO | remedial action objective |
| RDL | required detection limit |
| RDR/RAWP | remedial design report/remedial action work plan |
| RESRAD | RESidual RADioactivity (dose model) |
| ROD | record of decision |
| RPD | relative percent difference |
| RSVP | remaining sites verification package |
| RTD | remove, treat, and dispose |
| SAP | sampling and analysis plan |
| SFL | standard fixed laboratory |
| SIS | Stewardship Information System |
| SOP | standard operating procedure |
| SRM | standard reference material |
| TCLP | toxicity characteristic leaching procedure |

## Acronyms and Abbreviations

| | |
|---|---|
| UCL | upper confidence limit |
| WAC | *Washington Administrative Code* |
| WI | work instruction |
| WIDS | Waste Information Data System (database) |
| WCH | Washington Closure Hanford |
| XRF | x-ray fluorescence |

# METRIC CONVERSION CHART

| Into Metric Units | | | Out of Metric Units | | |
|---|---|---|---|---|---|
| *If You Know* | *Multiply By* | *To Get* | *If You Know* | *Multiply By* | *To Get* |
| **Length** | | | **Length** | | |
| inches | 25.4 | millimeters | millimeters | 0.039 | inches |
| inches | 2.54 | centimeters | centimeters | 0.394 | inches |
| feet | 0.305 | meters | meters | 3.281 | feet |
| yards | 0.914 | meters | meters | 1.094 | yards |
| miles | 1.609 | kilometers | kilometers | 0.621 | miles |
| **Area** | | | **Area** | | |
| sq. inches | 6.452 | sq. centimeters | sq. centimeters | 0.155 | sq. inches |
| sq. feet | 0.093 | sq. meters | sq. meters | 10.76 | sq. feet |
| sq. yards | 0.0836 | sq. meters | sq. meters | 1.196 | sq. yards |
| sq. miles | 2.6 | sq. kilometers | sq. kilometers | 0.4 | sq. miles |
| acres | 0.405 | hectares | hectares | 2.47 | acres |
| **Mass (weight)** | | | **Mass (weight)** | | |
| ounces | 28.35 | grams | grams | 0.035 | ounces |
| pounds | 0.454 | kilograms | kilograms | 2.205 | pounds |
| ton | 0.907 | metric ton | metric ton | 1.102 | ton |
| **Volume** | | | **Volume** | | |
| teaspoons | 5 | milliliters | milliliters | 0.033 | fluid ounces |
| tablespoons | 15 | milliliters | liters | 2.1 | pints |
| fluid ounces | 30 | milliliters | liters | 1.057 | quarts |
| cups | 0.24 | liters | liters | 0.264 | gallons |
| pints | 0.47 | liters | cubic meters | 35.315 | cubic feet |
| quarts | 0.95 | liters | cubic meters | 1.308 | cubic yards |
| gallons | 3.8 | liters | | | |
| cubic feet | 0.028 | cubic meters | | | |
| cubic yards | 0.765 | cubic meters | | | |
| **Temperature** | | | **Temperature** | | |
| Fahrenheit | subtract 32, then multiply by 5/9 | Celsius | Celsius | multiply by 9/5, then add 32 | Fahrenheit |
| **Radioactivity** | | | **Radioactivity** | | |
| picocuries | 37 | millibecquerel | millibecquerel | 0.027 | picocuries |

# PART I

## PROJECT BACKGROUND AND RATIONALE FOR SAMPLING AND ANALYTICAL STRATEGIES

Part I presents the project background and rationale for sampling and analytical strategies that will be used to provide cost-effective and timely data to support confirmatory sampling efforts, remediation, and disposal activities.

# I.1 PROJECT BACKGROUND

The purpose of the background discussion is to describe how the 100 Area past-practice waste disposal sites (excluding burial grounds) became contaminated, what contamination can be documented, which constituents are eliminated from further consideration, and which constituents are the subject of this sampling and analysis design. The background discussion lays the framework for the strategies and procedures in the sampling and analysis design for the radioactive liquid effluent disposal sites addressed in *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (hereinafter referred to as the Interim Action Record of Decision [ROD]) (EPA 1995) and *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (hereinafter referred to as the ROD Amendment) (EPA 1997a). Site-specific work instructions (WIs) will detail implementation procedures for the remaining sites addressed in *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (hereinafter referred to as the Remaining Sites ROD) (EPA 1999).

The decisions regarding the final values that describe closeout are discussed in the Interim Action ROD (EPA 1995), the ROD Amendment (EPA 1997a), and the Remaining Sites ROD (EPA 1999). The *Explanation of Significant Difference for the 100 Area Remaining Sites ROD* (EPA 2000a), issued in June 2000, includes adding the 600-23 and JA Jones No. 1 waste sites into the Remaining Sites ROD using the plug-in approach. Another 28 waste sites were added to the Remaining Sites ROD by an explanation of significant difference (ESD) issued in March 2004 (EPA 2004). A pending ESD is expected to add additional waste sites for confirmatory sampling and/or remove, treat, and dispose (RTD) to the Remaining Sites ROD and, potentially, address other administrative issues related to remedial actions. Target cleanup levels presented in this sampling and analysis plan (SAP) for radionuclides and other contaminants are screening level values applicable to any waste site. If these cleanup values are not met during cleanup verification, site-specific evaluations of compliance with remedial action goals or additional remediation may be performed.

Information presented in this SAP was prepared based on the data quality objectives (DQOs) and remediation planning for the Hanford Site's 100 Area past-practice waste disposal sites and underground effluent pipelines. A summary of the key historical information for each of these 100 Area waste sites is documented in the Waste Information Data System (WIDS) database.

Revision 0 of the 100 Area SAP (DOE-RL 1996a) was written in 1996 to address the sampling requirements associated with the cleanup of high-priority radioactive liquid effluent waste sites to be remediated under the Interim Action ROD (EPA 1995). It was revised three times to update the sampling plan as experience was gained with the remedial action and cleanup verification process and to include additional sites (ROD Amendment [EPA 1997a]). A fourth revision added the remaining sites to the SAP (Remaining Sites ROD [EPA 1999] and ESD [EPA 2004]), encompassing a variety of miscellaneous liquid and nonliquid waste disposal sites, dump sites, burn pits, debris piles, french drains, and unplanned releases. Unlike the high-priority radioactive liquid effluent waste sites, some of the remaining sites may not require remediation. This fifth revision updates the sampling design requirements for Washington State Department of Ecology (Ecology) lead liquid effluent sites and updates references to the primary contractor procedures.

For the radioactive liquid effluent waste sites, of which most have been remediated, the decision-making process is relatively simple, and environmental sampling is used as follows:

- Guide excavation and support waste management
- Verify that remedial action objectives (RAOs) specified in the RODs have been met after remediation is completed.

In contrast, the decision-making process for the remaining sites is performed on a site-specific basis, and environmental sampling is used as follows:

- Determine if remedial action is needed
- Determine which portions of a waste site exhibiting discrete areas (strata) of contamination (e.g., pockets of debris or chemical spills) require remediation
- Verify that the RAOs have been met after remediation has been completed.

### I.1.1 100 AREA HISTORICAL OVERVIEW

The operation of nine water-cooled, graphite-moderated, plutonium-production reactors in the 100 Areas of the Hanford Site resulted in releases of radionuclides and other chemicals to the soil and groundwater in the vicinity of the reactors. Waste sites resulting from the releases generally fall into one of the following three categories:

1. **Radioactive liquid effluent sites**, which consist of sites where there were high-volume releases of spent reactor cooling water. The releases resulted from leaks in the reactor effluent transfer systems and intentional disposal of effluent and sludge derived from effluent in cribs and trenches.

2. **Remaining sites**, which encompass a variety of miscellaneous liquid and nonliquid waste disposal sites, including dump sites, burn pits, debris piles, french drains, and unplanned releases.

3. **Burial grounds**, where significant volumes of contaminated equipment and debris were land disposed.

The primary source of contaminants at the radioactive liquid effluent sites was cooling water that flowed through the reactor core. The spent cooling water contained radionuclides from the activation of impurities and corrosion products and from leakage of fission products and transuranic elements from reactor fuel. The cooling water also contained nonradioactive contaminants including lead, chromium, and mercury from both liquid and solid waste sources. Lead was present as solid shielding and as a component or impurity of various chemicals used in industrial processes. Chromium, in the form of sodium dichromate, was added to the reactor coolant to inhibit corrosion in the aluminum process tubes. Mercury contamination is attributed to its use in various electrical, chemical, and processing applications. Polychlorinated biphenyls (PCBs) from electrical components, lubricating and hydraulic oils, and various sealants have been found in many waste sites.

Contamination sources at the remaining sites were varied. Some sites were associated with the reactor effluent system and, thus, the contaminants at these sites are similar to the radioactive liquid effluent sites. Other contamination sources included facility maintenance (organic solvents and degreasers, acids, asbestos), corrosion of painted surfaces (heavy metals), disposal of contaminated equipment and debris (radionuclides), spills and leaks of oils (PCBs), and disposal of laboratory waste (various chemicals). Many of the newly identified sites are the direct result of historical research and extensive field reconnaissance.

Unlike the radioactive liquid effluent sites that are already slated for remediation, remaining sites generally require sampling to determine if remediation is required. These sites are referred to as "candidate sites" and are listed in the Remaining Sites ROD (EPA 1999).

Contamination at the burial grounds is addressed in the *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (100 Area Burial Grounds SAP) (DOE-RL 2001).

### I.1.2 100-BC-1 AND 100-BC-2 OPERABLE UNITS

The 100-B/C Area contains two reactors that contributed to soil and groundwater contamination at the Hanford Site (the B and C Reactors). To effectively address the remediation efforts, the 100-B/C Area was divided into three operable units (OUs). The 100-BC-1 OU (associated with the B Reactor) and the 100-BC-2 OU (associated with the C Reactor) are source units containing waste sites associated with reactor operation. The 100-BC-5 OU addresses the groundwater beneath the 100-B/C Area. Appendix A of the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (100 Area RDR/RAWP) (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

### I.1.3 100-DR-1 AND 100-DR-2 OPERABLE UNITS

The 100-D Area contains two reactors (D and DR Reactors) that contributed to soil and groundwater contamination at the Hanford Site. To effectively address the remediation efforts, the 100-D Area was divided into three OUs. The 100-DR-1 OU (associated with the D Reactor) and the 100-DR-2 OU (associated with the DR Reactor) are source units containing waste sites associated with reactor operation. The 100-HR-3 OU addresses the groundwater beneath the 100-D and the 100-H Areas. Appendix A of the 100 Area RDR/RAWP (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

## I.1.4 100-HR-1 AND 100-HR-2 OPERABLE UNITS

The 100-H Area contains the H Reactor that contributed to soil and groundwater contamination at the Hanford Site. To effectively address the remediation efforts, the 100-H Area was divided into three OUs. The 100-HR-1 and 100-HR-2 OUs are source units containing waste sites associated with reactor operations. The 100-HR-3 OU addresses the groundwater beneath the 100-D and the 100-H Areas. Appendix A of the 100 Area RDR/RAWP (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

## I.1.5 100-FR-1 AND 100-FR-2 OPERABLE UNITS

The 100-F Area contains the F Reactor that contributed to soil and groundwater contamination at the Hanford Site. To effectively address the remediation efforts, the 100-F Area was divided into three OUs. The 100-FR-1 and 100-FR-2 OUs are source units containing waste sites associated with reactor operations. The 100-FR-3 OU addresses the groundwater beneath the 100-F Area. Appendix A of the 100 Area RDR/RAWP (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

## I.1.6 100-KR-1 AND 100-KR-2 OPERABLE UNITS

The 100-K Area contains two reactors that contributed to soil and groundwater contamination at the Hanford Site (KE and KW Reactors). To effectively address the remediation efforts, the 100-K Area was divided into three OUs. The 100-KR-1 and 100-KR-2 OUs are source units containing waste sites associated with reactor operations. The 100-KR-4 OU addresses the groundwater beneath the 100-K Area. Appendix A of the 100 Area RDR/RAWP (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

## I.1.7 100-IU-2 AND 100-IU-6 OPERABLE UNITS

The 600 Area contains construction support facilities that were used during the Hanford Works Project. To effectively address the remediation efforts, the 600 Area was originally divided into 13 OUs. Six of those OUs have been redesignated as 200 Areas' waste site groupings, three of the OUs have been deleted from the National Priorities List, and two of the OUs have been remediated. The remaining OUs are 100-IU-2 and 100-IU-6. Appendix A of the 100 Area RDR/RAWP (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

## I.1.8 ADDITIONAL CANDIDATE SITES FOR POTENTIAL REMEDIAL ACTION

The Remaining Sites ROD (EPA 1999), the 2004 ESD (EPA 2004), and a pending ESD identify waste sites that have been determined to require remediation and additional candidate sites for potential action, provided the site can be "plugged into" the remedial action program. This provision is authorized if the sites contain constituent levels that exceed the RAOs and remedial action goals (RAGs) set forth in the Remaining Sites ROD (EPA 1999). Appendix A of the 100 Area RDR/RAWP (DOE-RL 2009) presents all of the 100 Area waste sites that have been identified in the RODs and ESDs.

## I.1.9 RECORD OF DECISION SUMMARY AND REMEDIAL ACTION GOALS

### I.1.9.1 Remedial Action Objectives

The RAOs are set forth in the Interim Action ROD (EPA 1995) and in the Remaining Sites ROD (EPA 1999). The RAOs are narrative statements that define the extent to which the sites require cleanup to meet the objective to protect human health and the environment. The RAOs apply to contaminated near-surface and subsurface soils, structures, and debris. The Interim Action ROD specifically defines these three RAOs. The Remaining Sites ROD defines two RAOs, which are the same as the first two in the Interim Action ROD. The RAOs are as follows:

1. *Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics or organics* (EPA 1995, page 25).

2. *Control the sources of groundwater contamination to minimize impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions* (EPA 1995, pages 25 and 26).

3. *To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required* (EPA 1995, page 26).

The first RAO will be achieved by meeting the following requirements:

- *Washington Administrative Code* (WAC) 173-340-740(3)(a), residential soil cleanup standards for organic and inorganic constituents

- Radionuclide soil cleanup standard of a dose rate of 15 mrem/yr above site background levels to support unrestricted (residential) land use.

The second RAO will be achieved by meeting the following requirements:

- Protecting the groundwater
- Protecting the Columbia River.

The third RAO will be achieved by meeting the following requirements:

- Meeting the first two RAOs as defined above
- Removing waste sites to the bottom of the engineered structure[1]
- Providing institutional controls, as required, in the event that the U.S. Department of Energy (DOE) relinquishes the site
- Balancing factors.

### I.1.9.2 Remedial Action Goals

The RAGs are contaminant-specific numerical cleanup criteria developed for use in remedial design and to verify that remedial action has achieved the RAOs. Two sets of RAGs are required to achieve the RAOs listed above. The first set is concerned with direct exposure to residual contamination in soils, and the second set is concerned with residual contamination levels in soil with respect to protection of groundwater and the Columbia River.

A summary of target soil cleanup levels corresponding to the RAGs is presented in Table I-1 for contaminants that were found at levels that require remediation. Additional details on the RAGs, their sources, derivations, and applications are provided in the 100 Area RDR/RAWP (DOE-RL 2009).

**Table I-1. Soil Cleanup Level Summary: Contaminant-Specific Concentrations. (6 Pages)**

| Contaminant | $K_d$ Value (mL/g) | Back-ground (pCi/g) | RDL (pCi/g) | Soil Cleanup Levels (pCi/g)[a] | | |
|---|---|---|---|---|---|---|
| | | | | Direct Exposure | Ground-water Protection | River Protection |
| ***Radionuclides*** | | | | | | |
| Ag (silver)-108m | 90 | -- | 0.1 | 2.38 | -- | -- |
| Americium-241 | 200 | -- | 1 | 32.1 | -- | -- |
| Carbon-14 | 200 | -- | 2 | 8.69 | -- | -- |
| Cesium-137 | 50 | 1.1 | 0.1 | 6.2 | 1,465 | 2,930 |
| Cobalt-60 | 50 | 0.008 | 0.05 | 1.4 | 13,900 | 27,800 |
| Curium-243 | 200 | -- | 1 | 22.1 | -- | -- |
| Europium-152 | 200 | -- | 0.1 | 3.3 | -- | -- |
| Europium-154 | 200 | 0.033 | 0.1 | 3.0 | -- | -- |
| Europium-155 | 200 | 0.054 | 0.1 | 125 | -- | -- |
| Iodine-129 | 1 | -- | 0.25 | 0.25[b] | 0.25[b] | 0.25[b] |
| Neptunium-237 | 15 | -- | 0.5 | 2.44 | 0.90 | 1.80 |
| Nickel-63 | 30 | -- | 30 | 4,013 | 83 | 166 |
| Niobium-94 | 200 | -- | 0.2 | 2.43 | -- | -- |

[1] For remaining sites, the engineered structure may be left in place if the first two RAOs are met.

**Table I-1. Soil Cleanup Level Summary: Contaminant-Specific Concentrations. (6 Pages)**

| Contaminant | $K_d$ Value (mL/g) | Back-ground (pCi/g) | RDL (pCi/g) | Soil Cleanup Levels (pCi/g)[a] | | |
|---|---|---|---|---|---|---|
| | | | | Direct Exposure | Ground-water Protection | River Protection |
| Plutonium-238 | 200 | 0.004 | 1 | 38.8 | -- | -- |
| Plutonium-239/240 | 200 | 0.025 | 1 | 35.1 | -- | -- |
| Potassium-40 | 5.5 | 16.6 | 0.5 | 16.6[c] | 16.6[c] | 16.6[c] |
| Radium-226 | 200 | 0.815 | 0.1 | 1.05 | -- | -- |
| Radium-228 | 200 | -- | 0.2 | 1.69 | -- | -- |
| Strontium-90 | 25 | 0.18 | 1 | 4.5 | 27.6 | 55.2 |
| Technetium-99 | 0 | -- | 0.25 | 5.8 | 0.46 | 0.92 |
| Thorium-228 | 200 | -- | 1 | 2.26 | -- | -- |
| Thorium-230 | 200 | -- | 1 | 2.96 | -- | -- |
| Thorium-232 | 200 | 1.3 | 1 | 1.3[c] | -- | -- |
| Tritium (H-3)[d] | 0 | -- | 10 | 459 | 12.6 | 25.2 |
| Uranium-233/234 | 2 | 1.1 | 1 | 1.1[c] | 1.1[c] | 1.1[c] |
| Uranium-235 | 2 | 0.11 | 0.5 | 0.61 | 0.5[b] | 0.5[b] |
| Uranium-238 | 2 | 1.1 | 1 | 1.1[c] | 1.1[c] | 1.1[c] |
| **Contaminant** | **$K_d$ Value (mL/g)** | **Back-ground (mg/kg)** | **RDL (mg/kg)** | **Soil Cleanup Levels (mg/kg)** | | |
| | | | | **Direct Exposure** | **Ground-water Protection** | **River Protection** |
| ***Metals*** | | | | | | |
| Antimony | 3.76 | 5 | 0.6 | 32 | 5[c] | 5[c] |
| Arsenic | 3 | 6.5 | 10 | 20[c] | 20[c] | 20[c] |
| Barium | 25 | 132 | 2 | 5,600 | 200 | 400 |
| Beryllium | 790 | 1.51 | 0.5 | 10.4[e] | 1.51[c] | 1.51[c] |
| Boron | 3 | --[f] | 2 | 7,200 | 320 | -- |
| Cadmium | 30 | 0.81[g] | 0.5 | 13.9[e] | 0.81[c] | 0.81[c] |
| Chromium, Total | 200 | 18.5 | 1 | 80,000 | 18.5[c] | 18.5[c] |
| Chromium VI | 0 | --[f] | 0.5 | 2.1[e] | 4.8 | 2 |
| Cobalt | 50 | 15.7 | 2 | 24 | 15.7[c] | -- |
| Copper | 22 | 22.0 | 1 | 2,960 | 59.2 | 22.0[c] |
| Lead | 30 | 10.2 | 5 | 353 | 10.2[c] | 10.2[c] |
| Lithium | 50 | 33.5 | 2.5 | 160 | 33.5[c] | -- |
| Manganese | 50 | 512 | 5 | 3,760 | 512[c] | 512[c] |
| Mercury | 30 | 0.33 | 0.2 | 24 | 0.33[c] | 0.33[c] |
| Methyl Mercury | 0.014 | --[f] | -- | 8 | 0.16 | 0.16 |
| Molybdenum | 20 | --[f] | 2 | 400 | 8 | -- |
| Nickel | 65 | 19.1 | 4 | 1,600 | 19.1[c] | 27.4 |
| Selenium | 5 | 0.78[g] | 1 | 400 | 5 | 1 |
| Silver | 90 | 0.73 | 0.2 | 400 | 8 | 0.73[c] |
| Strontium | 25 | --[f] | 1 | 48,000 | 960 | -- |
| Tin | 130 | --[f] | 10 | 48,000 | 960 | -- |
| Uranium (soluble salts) | 2 | 3.21 | 1 | 240 | 3.21[c] | 3.21[c] |
| Vanadium | 1,000 | 85.1 | 2.5 | 560 | 85.1[c] | -- |
| Zinc | 30 | 67.8 | 1 | 24,000 | 480 | 67.8[c] |

**Table I-1. Soil Cleanup Level Summary: Contaminant-Specific Concentrations. (6 Pages)**

| Contaminant | $K_d$ Value (mL/g) | Back-ground (mg/kg) | RDL (mg/kg) | Soil Cleanup Levels (mg/kg) | | |
|---|---|---|---|---|---|---|
| | | | | Direct Exposure | Ground-water Protection | River Protection |
| ***Inorganic Anions and Total Petroleum Hydrocarbons*** | | | | | | |
| Chloride | 0 | 100 | 2 | -- | 25,000 | -- |
| Cyanide | 0 | -- [f] | 0.5 | 1,600 | 20 | 1.04 |
| Fluoride | 150 | 2.81 | 5 | 4,800 | 96 | 400 |
| Nitrate (as Nitrogen) | 0 | 11.8 | 0.75 | 128,000 | 1,000 | 2,000 |
| Nitrite (as Nitrogen) | 0 | -- [f] | 0.75 | 8,000 | 100 | 200 |
| Sulfate | 0 | 237 | 5 | -- | 25,000 | -- |
| Sulfide | 0 | -- [f] | 5 | -- | -- | -- |
| TPH | 50 | -- | 5 | 200 | 200 | 200 |
| ***VOAs*** | | | | | | |
| Acetone | 0.0006 | -- | 0.02 | 72,000 | 720 | -- |
| Carbon Tetrachloride | 0.152 | -- | 0.005 | 7.69 | 0.0337 | 0.05 |
| Methylene Chloride | 0.01 | -- | 0.005 | 133 | 0.5 | 0.94 |
| Toluene | 0.14 | -- | 0.005 | 6,400 | 64 | 1,360 |
| Xylene | 0.233 | -- | 0.001 | 16,000 | 160 | -- |
| ***Semivolatiles*** | | | | | | |
| Acenapthene | 4.9 | -- | 0.33 | 4,800 | 96 | 129 |
| Acenapthylene [h] | 6.12 | -- | 0.33 | 4,800 | 96 | 129 |
| Anthracene | 23.5 | -- | 0.33 | 24,000 | 240 | 1,920 |
| Benzo(a)anthracene | 360 | -- | 0.015 | 1.37 | 0.015 [b] | 0.015 [b] |
| Benzo(a)pyrene | 5,500 | -- | 0.015 | 0.137 | 0.015 [b] | 0.015 [b] |
| Benzo(b)fluoranthene | 803 | -- | 0.015 | 1.37 | 0.015 [b] | 0.015 [b] |
| Benzo(k)fluoranthene | 1,230 | -- | 0.015 | 1.37 | 0.015 [b] | 0.015 [b] |
| Benzo(g,h,i)perylene [h] | 2,680 | -- | 0.33 | 2,400 | 48 | 192 |
| Bis(2-chloro-1-methylethyl) ether | 0.0392 | -- | 0.33 | 14.3 | 0.33 [b] | 7.50 |
| Bis(2-chloroethoxy)methane [h] | 0.00277 | -- | 0.33 | 0.909 | 0.33 [b] | 0.33 [b] |
| Bis(2-chloroethyl) ether | 0.0760 | -- | 0.33 | 0.909 | 0.33 [b] | 0.33 [b] |
| Bis(2-ethylhexyl)phthalate | 110 | -- | 0.33 | 71.4 | 0.6 | 0.36 |
| Bromophenylphenyl ether; 4- | 4.16 | -- | 0.33 | -- | -- | -- |
| Butylbenzylphthalate | 13.8 | -- | 0.33 | 16,000 | 320 | 250 |
| Carbazole | 3.39 | -- | 0.33 | 50 | 0.438 | -- |
| Chloro-3-methylphenol; 4- [h] | -- | -- | 0.33 | 4,000 | 80 | -- |
| Chloroanilene; 4- | 0.0725 | -- | 0.33 | 320 | 6.4 | -- |
| Chloronaphthalene; 2- | 2.98 | -- | 0.33 | 6,400 | 64 | 206 |
| Chlorophenol;2- | 0.388 | -- | 0.33 | 400 | 4.00 | 19.34 |
| Chlorophenylphenyl ether; 4- | -- | -- | 0.33 | -- | -- | -- |
| Chrysene | 200 | -- | 0.1 | 13.7 | 0.12 | 0.1 [b] |
| Dibenz(a,h)anthracene | 1,790 | -- | 0.03 | 1.37 | 0.03 [b] | 0.03 [b] |
| Dibenzofuran | 11.3 | -- | 0.33 | 160 | 3.20 | -- |
| Dichlorobenzene; 1,2- | 0.379 | -- | 0.33 | 7,200 | 60.0 | 540 |
| Dichlorobenzene; 1,3- | 0.434 | -- | 0.33 | 2,400 | 24.0 | 80 |
| Dichlorobenzene; 1,4- | 0.616 | -- | 0.33 | 41.7 | 0.33 [b] | 0.972 |
| Dichlorobenzidine; 3,3- | 0.724 | -- | 0.33 | 2.22 | 0.33 [b] | 0.33 [b] |
| Dichlorophenol; 2,4- | 0.147 | -- | 0.33 | 240 | 4.80 | 18.6 |

**Table I-1. Soil Cleanup Level Summary: Contaminant-Specific Concentrations. (6 Pages)**

| Contaminant | $K_d$ Value (mL/g) | Back-ground (mg/kg) | RDL (mg/kg) | Soil Cleanup Levels (mg/kg) | | |
|---|---|---|---|---|---|---|
| | | | | Direct Exposure | Ground-water Protection | River Protection |
| Diethylphthalate | 0.0820 | -- | 0.33 | 64,000 | 1,280 | 4,600 |
| Dimethylphthalate | 0.0371 | -- | 0.33 | 80,000 | 1,600 | 14,400 |
| Dimethylphenol; 2,4- | 0.209 | -- | 0.33 | 1,600 | 32.0 | 110.6 |
| Di-n-butylphthalate | 1.57 | -- | 0.33 | 8,000 | 160 | 540 |
| Di-n-octylphthalate | 83,200 | -- | 0.33 | 1,600 | 32 | -- |
| Dinitro-2-methylphenol; 4,6- | 0.6015 | -- | 0.33 | 8.00 | 0.33 [b] | -- |
| Dinitrophenol; 2,4- | 0.00001 | -- | 0.825 | 160 | 3.20 | 14 |
| Dinitrotoluene; 2,4- | 0.0955 | -- | 0.33 | 160 | 3.20 | 0.33 [b] |
| Dinitrotoluene; 2,6- | 0.0692 | -- | 0.33 | 80.0 | 1.60 | 136 |
| Ethylene glycol | 0.001 | -- | 5 | 160,000 | 320 | -- |
| Fluoranthene | 49.1 | -- | 0.33 | 3,200 | 64 | 18.0 |
| Fluorene | 7.71 | -- | 0.33 | 3,200 | 64 | 260 |
| Hexachlorobenzene | 80 | -- | 0.33 | 0.625 | 0.33 [b] | 0.33 [b] |
| Hexachlorobutadiene | 53.7 | -- | 0.33 | 12.8 | 0.33 [b] | 0.33 [b] |
| Hexachlorocyclopentadiene | 200 | -- | 0.33 | 480 | 5 | 48 |
| Hexachloroethane | 1.78 | -- | 0.33 | 71.4 | 0.313 | 0.38 |
| Hydrazine | 0.0143 | -- | 0.33 | 0.333 | 0.33 [b] | -- |
| Indeno(1,2,3-cd) pyrene | 3,470 | -- | 0.33 | 1.37 | 0.33 [b] | 0.33 [b] |
| Isophorone | 0.0468 | -- | 0.33 | 1,050 | 9.21 | 1.68 |
| Methylnaphthalene; 2- | 2.98 | -- | 0.33 | 320 | 3.2 | -- |
| Methylphenol; 2- (cresol;o-) | 0.434 | -- | 0.33 | 4,000 | 80.0 | -- |
| Methylphenol; 4- (cresol;p-) | 0.434 | -- | 0.33 | 400 | 8.00 | -- |
| Naphthalene | 1.19 | -- | 0.33 | 1,600 | 16.0 | 988 |
| Nitroaniline; 2- | 0.0527 | -- | 0.33 | 240 | 2.4 | -- |
| Nitroaniline; 3- | 0.0516 | -- | 0.33 | 24 | 0.33 [b] | -- |
| Nitroaniline; 4- | 0.0516 | -- | 0.33 | 47.6 | 0.33 [b] | -- |
| Nitrobenzene | 0.191 | -- | 0.33 | 160 | 1.6 | 3.4 |
| Nitrophenol; 2- | 0.309 | -- | 0.66 | -- | -- | -- |
| Nitrophenol; 4- | 0.309 | -- | 0.66 | 640 | 12.8 | 1,254 |
| Nitroso-di-n-propylamine;N- | 0.0240 | -- | 0.33 | 0.33 | 0.33 [b] | 0.33 [b] |
| Nitrosodiphenylamine;N- | 1.29 | -- | 0.33 | 204 | 1.79 | 1.946 |
| Pentachlorophenol | 0.592 | -- | 0.33 | 8.33 | 0.33 [b] | 0.33 [b] |
| Phenanthrene [h] | 23.5 | -- | 0.33 | 24,000 | 240 | 1,920 |
| Phenol | 0.0288 | -- | 0.33 | 24,000 | 480 | 4,200 |
| Pyrene | 68 | -- | 0.33 | 2,400 | 48 | 192 |
| Tributyl Phosphate | 1.89 | -- | 3.3 | 185 | 3.3 [b] | -- |
| Trichlorobenzene; 1,2,4- | 1.66 | -- | 0.33 | 800 | 7 | 45.4 |
| Trichlorophenol; 2,4,5- | 1.60 | -- | 0.33 | 8,000 | 80 | -- |
| Trichlorophenol; 2,4,6- | 0.381 | -- | 0.33 | 90.9 | 0.795 | 0.42 |

**Table I-1. Soil Cleanup Level Summary: Contaminant-Specific Concentrations. (6 Pages)**

| Contaminant | $K_d$ Value (mL/g) | Back-ground (mg/kg) | RDL (mg/kg) | Soil Cleanup Levels (mg/kg) | | |
|---|---|---|---|---|---|---|
| | | | | Direct Exposure | Ground-water Protection | River Protection |
| ***Pesticides and PCBs*** | | | | | | |
| Aldrin | 48.7 | -- | 0.00165 | 0.0588 | 0.00165 [b] | 0.00165 [b] |
| BHC, alpha | 1.76 | -- | 0.00165 | 0.159 | 0.00165 [b] | 0.00165 [b] |
| BHC, beta | 2.14 | -- | 0.00165 | 0.556 | 0.00486 | 0.00554 |
| BHC, delta | 3.38 | -- | 0.00165 | -- | -- | -- |
| BHC, gamma (Lindane) | 1.35 | -- | 0.00165 | 0.769 | 0.00673 | 0.0038 |
| Chlordane (alpha, gamma) | 51 | -- | 0.0165 | 2.86 | 0.025 | 0.0165 [b] |
| Dalapon | 0.00274 | -- | 0.1 | 2,400 | 20 | -- |
| Db; 2,4- | 0.1 | -- | 0.1 | 640 | 12.8 | -- |
| DDD, 4,4'- | 45.8 | -- | 0.0033 | 4.17 | 0.0365 | 0.0033 [b] |
| DDE, 4,4'- | 86.4 | -- | 0.0033 | 2.94 | 0.0257 | 0.0033 [b] |
| DDT, 4,4'- | 678 | -- | 0.0033 | 2.94 | 0.0257 | 0.0033 [b] |
| Dicambra | 0.0288 | -- | 0.1 | 2,400 | 48 | -- |
| Dichlorophenoxyacetic acid; 2,4- | 0.0294 | -- | 0.4 | 640 | 7 | -- |
| Dichloroprop [h] | 0.0294 | -- | 0.1 | 640 | 7 | -- |
| Dieldrin | 25.6 | -- | 0.0033 | 0.0625 | 0.0033 [b] | 0.0033 [b] |
| Dinoseb (DNBP) | 3.54 | -- | 0.01 | 80 | 0.7 | -- |
| Endosulfan (I, II, sulfate) | 2.04 | -- | 0.003 | 480 | 9.6 | 0.0112 |
| Endrin (and ketone, aldehyde) | 10.8 | -- | 0.003 | 24 | 0.2 | 0.039 |
| Heptachlor | 9.53 | -- | 0.002 | 0.222 | 0.002 [b] | 0.002 [b] |
| Heptachlor epoxide | 83.2 | -- | 0.002 | 0.11 | 0.002 [b] | 0.002 [b] |
| Methoxychlor | 80 | -- | 0.02 | 400 | 4 | 1.67 |
| Polychlorinated Biphenyls | 309 | -- | 0.017 | 0.5 [i] | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1016 | 107 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1221 | 10.3 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1232 | 10.3 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1242 | 44.8 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1248 | 43.9 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1254 | 75.6 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| PCB Aroclor-1260 | 822 | -- | 0.017 | 0.5 | 0.017 [b] | 0.017 [b] |
| Silvex (tp;2,4,5-) | 0.08 | -- | 0.02 | 640 | 5 | -- |

**Table I-1. Soil Cleanup Level Summary: Contaminant-Specific Concentrations. (6 Pages)**

| Contaminant | $K_d$ Value (mL/g) | Back-ground (mg/kg) | RDL (mg/kg) | Soil Cleanup Levels (mg/kg) | | |
|---|---|---|---|---|---|---|
| | | | | Direct Exposure | Ground-water Protection | River Protection |
| Toxaphene | 95.8 | -- | 0.2 | 0.909 | 0.2 [b] | 0.2 [b] |
| Trichlorophenoxyacetic acid;2,4,5- | 0.049 | -- | 0.02 | 800 | 16 | -- |

[a] Soil cleanup levels in this table are obtained from Table B-4 and B-7 of Appendix B of this document. Radionuclide soil activities protective of groundwater and the river were calculated using RESRAD Version 6.4 (ANL 2007) assuming that no uncontaminated vadose zone exists between the contaminated zone and groundwater. Nonradionuclide soil concentrations protective of groundwater and the river are based upon application of the "100 times" rule (Ecology 1996).

[b] Where cleanup levels are less than RDLs, cleanup levels default to RDLs per WAC 173-340-707(2) (Ecology 1996). The cited RDLs are based on EPA-approved analytical methods that may not be available for rapid turnaround analyses. Prior notification and concurrence with the laboratory may be necessary to analyze to meet this RDL. Actual detection limits may differ from any RDL.

[c] Where cleanup levels are less than background, cleanup levels default to background per WAC 173-340-700[4][d] (1996). The arsenic cleanup level of 20 mg/kg has been agreed to by the Tri-Party Agreement Project Managers as discussed in Section 2.1.2.1 of this document.

[d] Tritium samples will be taken 15.2 cm (6 in.) below the excavation surface. If tritium is detected, a path forward will be developed with the lead regulatory agency for appropriate cleanup verification sampling (per TPA-CN-177).

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

[f] No Hanford Site-specific or Washington State background value is available.

[g] Hanford Site-specific background not available. Value is Washington State background from Ecology (1994).

[h] Toxicity data for this chemical are not available. Cleanup levels are based on surrogate chemicals:
Contaminant: acenapthylene; surrogate: acenapthene
Contaminant: benzo(g,h,i)perylene; surrogate: pyrene
Contaminant: bis(2-chloroethoxy)methane; surrogate: bis(2-chloroethyl)ether
Contaminant: chloro-3-methylphenol; 4-; surrogate: methylphenol; 3-
Contaminant: dichloroprop (pesticide); surrogate: dichlorophenoxyacetic acid; 2,4-; (2,4-D)
Contaminant: phenathrene; surrogate: anthracene

[i] The soil cleanup value for PCBs is based on the formula presented in WAC 173-340-740(3)(a)(iii)(B) (1996), and the cancer potency factor for ingestion of PCBs of 2.0 kg-day/mg (soils) from the EPA Integrated Risk Information System (IRIS) on the internet at < http://www.epa.gov/iris >.

-- = not available
EPA = U.S. Environmental Protection Agency
$K_d$ = Distribution coefficient discussed in Appendix E. $K_d$ values also found in the Ecology CLARC Database at < http://www.ecy.wa.gov > or from the Risk Assessment Information System database maintained by the Oak Ridge National Laboratory at < http://risk.lsd.ornl.gov >.
PCB = polychlorinated biphenyl
RDL = required detection limit
RESRAD = RESidual RADioactivity
TPH = total petroleum hydrocarbon
VOA = volatile organic analysis
WAC = *Washington Administrative Code*

### I.1.9.3 Direct Exposure Remedial Action Goals

Two classes of constituents are addressed: chemical and radionuclide. Chemical constituent RAGs are defined by WAC 173-340, 1996. The radionuclide soil cleanup standard of 15 mrem/yr above background residential dose level is based on draft U.S. Environmental Protection Agency (EPA) and U.S. Nuclear Regulatory Commission guidance cited in the

Interim Action ROD, the ROD Amendment, and the Remaining Sites ROD (EPA 1995, 1997a, 1999).

**Chemical Constituent RAGs:** Cleanup standards in soil are specified under the WAC 173-340 cleanup regulations (WAC [Methods A, B, and C] 173-340-704 through 706 [1996]). Method B (WAC 173-340-705, 1996) describes cleanup levels for groundwater, surface water, soil, and air.

When a hazardous waste site involves multiple hazardous substances and/or multiple pathways of exposure, Method B cleanup levels for individual substances must be modified in accordance with the human health risk assessment procedures outlined in WAC 173-340-708, 1996.

Cleanup levels for some contaminants may be less than area background values or required detection limits (RDLs). Where WAC 173-340, 1996 Method B cleanup levels are less than area background concentrations and/or less than RDLs, cleanup levels will be set at the background concentration or the RDL, whichever is higher (EPA 1995, WAC 173-340-706[1][a], 1996). Where achievable, RDLs exceeding calculated cleanup levels are used. Periodic evaluations will be performed to determine if improved or alternate analytical technology that yield lower RDL values have become available.

**Radionuclide Constituent RAGs:** For radiological constituents, the Interim Action ROD would limit radiation doses from contaminated sites to 15 mrem/yr above natural background for 1,000 years following completion of cleanup.

Limiting exposure levels to 15 mrem/yr above background acknowledges that background varies from site to site. As a result, radionuclide measurement techniques must distinguish site contamination from naturally occurring radionuclides (background). The radionuclides of concern at the 100 Area waste sites (e.g., cobalt-60, cesium-137, and europium-152) are present at very low concentrations in background soils. Naturally occurring radionuclides that pose the largest contributions to background dose, such as potassium-40, radium-226, radium-228, thorium-228, and thorium-232, are not considered contaminants of potential concern (COPCs) for purposes of this remedial action.

To determine when remedial action has achieved the 15 mrem/yr above background cleanup level, radionuclide concentrations (in pCi/g) in soil must be converted to a dose rate (in mrem/yr) using a dose assessment model. The model selected is the RESidual RADioactivity (RESRAD) dose model (ANL 2007), which was developed by the Argonne National Laboratory for implementing DOE guidelines for residual radioactive material in soil. The RESRAD model has been evaluated by the EPA for use in performing dose assessments. The code is periodically updated and the most current version (at present, version 6.4) is used for site assessment. Details of the calculations involved and the assumptions used in the RESRAD model are summarized in the 100 Area RDR/RAWP (DOE-RL 2009). Site-specific assumptions will be used in RESRAD to verify that residual radionuclide concentrations achieve cleanup standards.

### I.1.9.4 Groundwater/Columbia River Protection Remedial Action Goals

Protecting the groundwater and the Columbia River requires meeting RAGs for water and associated RAGs for residual soil contaminants. Concentrations of contaminants reaching the groundwater and the Columbia River cannot exceed the RAGs for water, and concentrations of residual soil contaminants cannot exceed the RAGs established as protective of the groundwater and Columbia River. As with direct exposure, two classes of constituents are addressed: chemical and radionuclide.

**Chemical Constituent RAGs in Water:** For protecting groundwater, RAGs for nonradioactive contaminants in water are based on maximum contaminant levels (MCL) (40 *Code of Federal Regulations* [CFR] 141) and WAC 173-340-720(3), 1996 Method B levels. For protecting the Columbia River, RAGs for nonradioactive contaminants in water are based on MCLs, WAC 173-340-730(3), 1996 Method B levels, and ambient water quality criteria developed under the *Clean Water Act of 1977* and/or promulgated by the state of Washington (WAC 173-201A). Protection is achieved by meeting the most restrictive contaminant-specific value from these standards.

**Radionuclide Constituent RAGs in Water:** For protecting groundwater and the Columbia River, RAGs for radionuclides in water are based on the "National Primary Drinking Water Regulations" (40 CFR 141). Protection is achieved by meeting the most restrictive contaminant-specific value based on these regulations.

**Residual Soil Contaminant RAGs:** Residual contaminants remaining in soil after remediation must be at levels such that concentrations of contaminants reaching the unconfined aquifer and, eventually, the Columbia River, by migration through the soil column do not exceed RAGs considered protective of the groundwater and the Columbia River. The RESRAD model is used to demonstrate if specific residual soil contaminants will reach groundwater within 1,000 years (DOE-RL 2009). For those contaminants demonstrated to reach groundwater, the process for determining soil concentrations that are protective of groundwater and the river depends on if the contaminant is nonradioactive or a radionuclide.

For nonradioactive contaminants, WAC 173-340-740(3)(a)(ii)(A), 1996, specifies that concentrations of residual contaminants are considered protective of groundwater at levels equal to or less than 100 times the groundwater cleanup levels (groundwater RAGs discussed above). This regulation does not apply to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using the RESRAD model (DOE-RL 2009).

To achieve protection of the Columbia River, the calculation of RAGs for residual soil contamination must consider two additional transport steps beyond the migration of contaminants through the soil column. The additional contaminant transport steps are (1) the transportation, from beneath the waste site to near-river wells, of contaminants that have leached to groundwater; and (2) the mixing of groundwater contaminant concentrations with river water within the substrate at the groundwater/river interface. The model that accounts for these two transportation steps is the dilution attenuation factor model presented in the 100 Area

RDR/RAWP (DOE-RL 2009). The dilution attenuation factor model uses a 1:1 dilution factor applied to contaminant concentrations measured in near-river wells.

### I.1.9.5 Contaminant-Specific Concentrations in Soil

Contaminant-specific concentrations in soil have been calculated that correspond to the RAGs. These contaminant-specific concentrations are used to provide the following:

- Identify target volumes in soil that require remediation for purposes of remedial design
- Identify minimum quantitation limits for contaminants in soil that must be achieved by analytical systems used during remedial action
- Provide tables of cleanup levels for use in the field to rapidly evaluate analytical data collected during remedial action.

These contaminant-specific concentrations correspond to the RAGs, but are not intended for use in verifying that remedial action is complete at a site. The process for developing and using these contaminant-specific concentrations is discussed in Section 2.0 of the 100 Area RDR/RAWP (DOE-RL 2009).

## I.2 CONTAMINANTS OF POTENTIAL CONCERN

The COPC lists for waste sites were derived from the Interim Action ROD (EPA 1995), the ROD Amendment (EPA 1997a), and the Remaining Sites ROD (EPA 1999), as well as site-specific process knowledge and DQO considerations. Some contaminants have been eliminated from further consideration and are listed in Table I-2.

**Table I-2. Excluded Contaminants of Potential Concern for 100 Area Waste Sites. (2 Pages)**

| COPC | Exclusion | Justification[a] |
|---|---|---|
| **Radionuclides** | | |
| Cobalt-58 | All | Short half-life isotope [b] never found in significant quantities in 100 Area waste sites. |
| Cesium-134 | All | Short half-life isotope [b] never found in significant quantities in 100 Area waste sites. |
| Potassium-40 | All | Naturally occurring. Site processes did not contribute to accumulations of this isotope. No basis for inclusion as a COPC. |
| Sodium-22 | All | Short half-life isotope.[b] |
| Plutonium-241 | All | A neutron activation product that is less abundant than the other plutonium isotopes. Insignificant dose contributor due to very weak beta emissions. |

**Table I-2. Excluded Contaminants of Potential Concern for 100 Area Waste Sites. (2 Pages)**

| COPC | Exclusion | Justification[a] |
|---|---|---|
| Radium-226 | All | Naturally occurring. Site processes did not contribute to accumulations of this isotope. No basis for inclusion as a COPC. |
| Technetium-99 | All | Tc-99 constitutes a very small fraction of the fission product and none of the activation product yield. If RAGs are met for all other contaminants, Tc-99 will not be present in detectable quantities. Tc-99 will be evaluated in the soil in areas where it is known to be a groundwater contaminant. |
| Thorium -228 | All | A daughter product of, and in secular equilibrium with, Th-232, which is primarily a naturally occurring isotope in the 100 Areas of the Hanford Site. |
| Thorium-232 | All | A daughter product of, and in secular equilibrium with, Th-228, which is primarily a naturally occurring isotope in the 100 Areas of the Hanford Site. |
| **Inorganics** | | |
| Aluminum | All | Not a human or ecological risk driver. Aluminum analyses are provided as part of the Method 6010 ICP Metals analyses and are included with the data in the cleanup documentation. |
| Calcium | All | Not a human or ecological risk driver. Essential nutrient. |
| Iron | All | Not a human or ecological risk driver. Essential nutrient. Iron assays are provided as a part of the general Method 6010, ICP Metals, and included with the data in the cleanup documentation. |
| Magnesium | All | Not a human or ecological risk driver. Essential nutrient. |
| Potassium | All | Not a human or ecological risk driver. Essential nutrient. |
| Silicon | All | Not a human or ecological risk driver. |
| Sodium | All | Not a human or ecological risk driver. Essential nutrient. |

[a] Justification for excluding COPCs was developed in data quality objectives summary reports for 100 Area waste sites (BHI 2003; DOE-RL 1996b, 1997a, 1997b).

[b] For the purposes of this evaluation, 3 years is regarded as a short half-life, although the U.S. Nuclear Regulatory Commission (NRC) views a 5-year half-life as short and radioactive decay for more than five half-lives results in de minimis residual radionuclide concentrations.

COPC = contaminant of potential concern
ICP = inductively coupled plasma
RAG = remedial action goal

Cleanup verification and confirmatory sampling concentrations of COPCs are compared to cleanup levels with the results summarized in a table. The results of the comparisons will be summarized in tables that will appear in (1) the cleanup verification package (CVP) for liquid waste sites included in the Interim Action RODs (EPA 1995, 1997a) or (2) the remaining sites verification package (RSVP) for remaining sites included in the Remaining Sites ROD (EPA 1999), in associated subsequent ESDs (EPA 2000a, EPA 2004), and in the pending ESD. COPCs that were not detected by laboratory analysis are excluded from this comparison. Constituents that exceed cleanup levels are evaluated further. Calculated cleanup levels for aluminum, calcium, iron, magnesium, potassium, silicon, and sodium are not presented in the *Cleanup Levels and Risk Calculations Database* (Ecology 2005) under WAC 173-340-740(3); therefore, these constituents are not considered waste site contaminants of concern (COCs)/COPCs. The radionuclides potassium-40, radium-226, radium-228, thorium-228, and thorium-232 are not considered in the comparison table, as these isotopes are not related to the operational history of the Hanford Site and are usually below background levels (based on an assumption of secular equilibrium, the background activities for radium-228 and thorium-228 are equal to the statistical background activity of 1.32 pCi/g for thorium-232 provided in DOE-RL [1996c]). Constituents are evaluated separately if background levels are exceeded.

## I.3 REMEDIATION ACTIVITIES

Remediation of waste sites involves a phased approach where waste sites are grouped by geographic locations and manageable work packages. Activities include soil and waste removal, segregation, storage, transportation, disposal primarily at the Environmental Restoration Disposal Facility (ERDF), site cleanup verification in accordance with an approved sampling work instruction, and backfilling. For the remaining sites, these activities may be preceded by confirmatory sampling to determine if remediation is required. The process for remaining sites is described further in Section I.6.

## I.4 OVERVIEW OF SAMPLING AND ANALYTICAL STRATEGIES

There are two key features to the sampling and analytical strategies for 100 Area remedial action. The first is an emphasis on concurrent site excavation and characterization, which allows remedial action to proceed more quickly. The second is the need to tailor strategies based on commonality in media, contaminants, objectives, and associated activities. To implement these features effectively, the 100 Area remedial action sites have been divided into three categories for purposes of remedial action sampling and analysis. These categories are as follows:

- Radioactive liquid effluent waste sites (those sites identified in the Interim Action ROD [EPA 1995] and ROD Amendment [EPA 1997a])

- Remaining sites (those sites identified in the Remaining Sites ROD [EPA 1999, EPA 2004, and upcoming ESD] and any newly discovered sites)

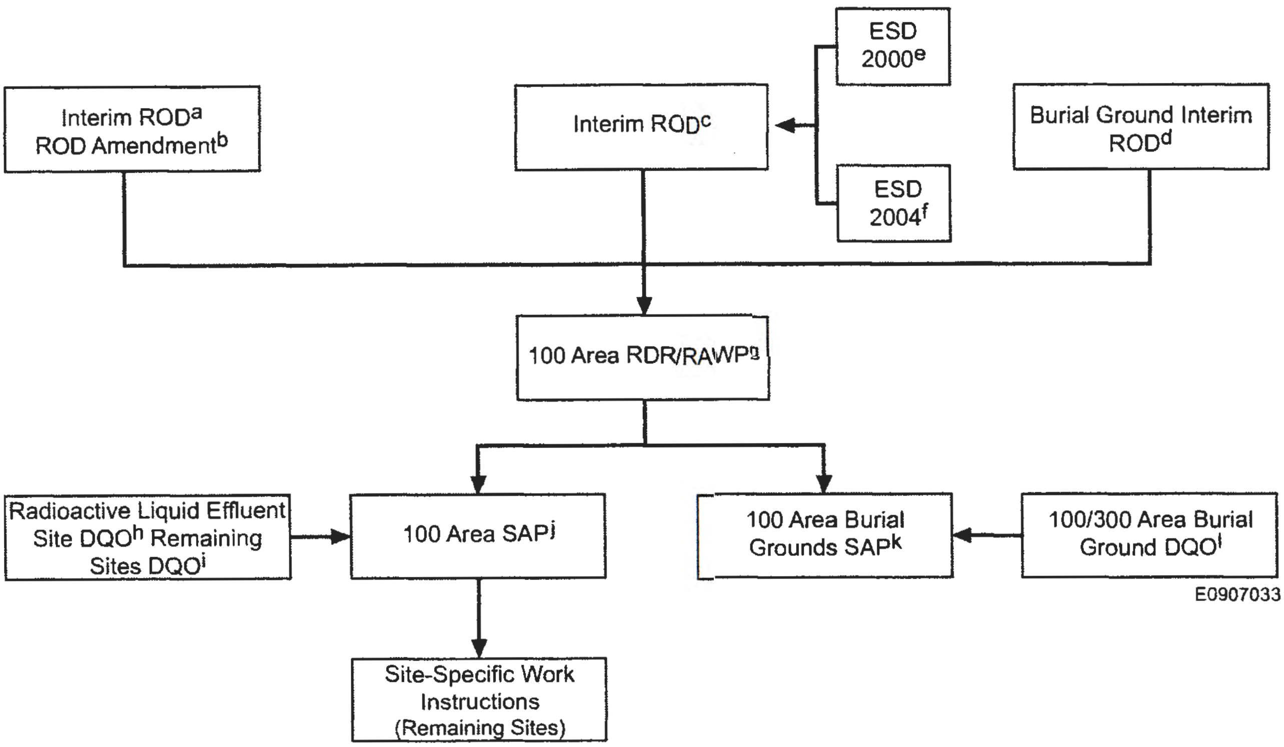
- Burial grounds (those sites identified in the *Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units (100 Area Burial Grounds), Hanford Site, Benton County, Washington* [EPA 2000b]).

This division was originally made because specific characteristics shared by sites within each of the three groups influence the selection of appropriate sampling and analytical methods. The radioactive liquid effluent sites typically received large volumes of contaminated reactor cooling water. These sites are similar in that gamma-emitting radionuclides tend to be the primary COCs, contaminant distributions are relatively predictable, and pre-remediation characterization data exist. This combination of features allows for relatively simple field screening to guide excavation. The remaining sites group, on the other hand, shares the characteristics of having a wide range of COPCs (including nonradioactive contaminants), less predictable contaminant profiles, and little or no pre-remediation characterization data. Finally, the burial grounds are distinguished by the presence of significant quantities of heterogeneous solid waste composed of hazardous and/or radioactive constituents with less potential for contamination of environmental media such as soil.

The substantial similarities among the radioactive liquid effluent waste sites allow a single sampling and analytical process and field sampling plan to be used for many of the sites. The sampling and analytical process for these sites is presented in Section I.5 and the field sampling plan is presented in Part III. However, liquid effluent sites under the purview of Ecology will be evaluated individually. These waste sites will have site-specific sampling plans developed using the same approach as that for the remaining sites.

The diverse nature of the remaining sites requires an individualized approach for those sites. The decision logic for developing site-specific WIs for the remaining sites is presented in Section I.6 and the field sampling process is summarized in Part III. The quality assurance (QA) requirements applicable to radioactive liquid effluent waste sites and remaining sites are presented in Part II. Sampling and analysis of burial grounds is detailed in the 100 Area Burial Grounds SAP (DOE-RL 2001). The relationship between the 100 Area RDR/RAWP (DOE-RL 2009) and the various sampling and analysis documents is shown in Figure I-1.

**Figure I-1. 100 Area Records of Decision and Implementing Documents.**




**NOTE:** The 100-N Area is not included in these documents.

[a] *Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA 1995).

[b] *Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units* (EPA 1997a)

[c] *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington* (EPA 1999).

[d] *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 (100 Area Burial Grounds), Hanford Site, Benton County, Washington* (EPA 2000b).

[e] *Explanation of Significant Difference for the 100 Area Remaining Sites ROD* (EPA 2000a).

[f] *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action ROD* (EPA 2004).

[g] *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2009).

[h] *Data Quality Objectives Summary Report for the 100-FR-1, 100-FR-2, 100-HR-1, 100-KR-1, and 100-KR-2 Group 4 Waste Sites* (DOE-RL 1997b); *Data Quality Objectives Summary Report for the 100-BC-1, 100-BC-2, 100-DR-1, and 100-DR-2 Group 3 Waste Sites* (DOE-RL 1997a); *Data Quality Objectives for the 100-D Group 2 Waste Sites* (DOE-RL 1996b).

[i] *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites* (BHI 2003).

[j] *100 Area Remedial Action Sampling and Analysis Plan* (DOE-RL 2000 and this document).

[k] *100 Area Burial Grounds Remedial Action Sampling and Analysis Plan* (DOE-RL 2001).

[l] *Data Quality Objective Summary Report for the 100 Area Burial Grounds and 300-FF-2 Operable Unit Waste Sites* (BHI 2001).

# I.5 SAMPLING AND ANALYSIS OF RADIOACTIVE LIQUID EFFLUENT WASTE SITES

The following is a description of the sampling and analytical strategy and associated process that applies to radioactive liquid effluent waste sites. This strategy will be used to support ongoing remedial action at all subject sites and subsequent verification sampling at the EPA lead waste sites. Verification sampling at Ecology lead sites will be performed using a site-specific WI as is prepared for remaining sites. Verification sampling is used to verify attainment of the RAOs in support of interim closure. The media of interest are residual soil within the site excavation and the overburden for use as backfill material.

Figure I-2 depicts the overall remedial action process for the radioactive liquid effluent waste sites. Figures I-3 through I-6 illustrate decision processes flow diagrams related to different elements of the remedial action process. The relationships between the primary decisions and the required supporting radiological surveys are also discussed in the 100 Area RDR/RAWP (DOE-RL 2009).

## I.5.1 EXCAVATION

The objectives for analyses during excavation are to provide the following:

- Ongoing guidance with regard to the extent of excavation
- Waste characterization for segregation, transportation, and disposal.

For the radioactive liquid effluent waste sites, radionuclides are the primary COCs and are a good indicator of the extent of contamination. Onsite radiological measurements for excavation guidance will be performed with sodium iodide (NaI) detectors to estimate if contamination levels are within allowable limits. If the onsite radiological measurements indicate acceptable levels of contamination for release, variance samples will be collected for high-purity germanium (HPGe) analysis. If the NaI and HPGe analyses both indicate that cleanup levels have been met, the verification release process will be initiated.

If the NaI surveys indicate that the general excavation area exceeds release levels, samples will not be collected because additional excavation is required. If, however, the general area contamination levels are deemed acceptable but discrete hot spots are noted, these discrete hot spots may require additional excavation, and samples will be collected from the hot spots for HPGe, x-ray fluorescence (XRF), or other analyses (contingent on the site COC list).

**Figure I-2. Overall Remedial Action Process for Radioactive Liquid Effluent Waste Sites.**

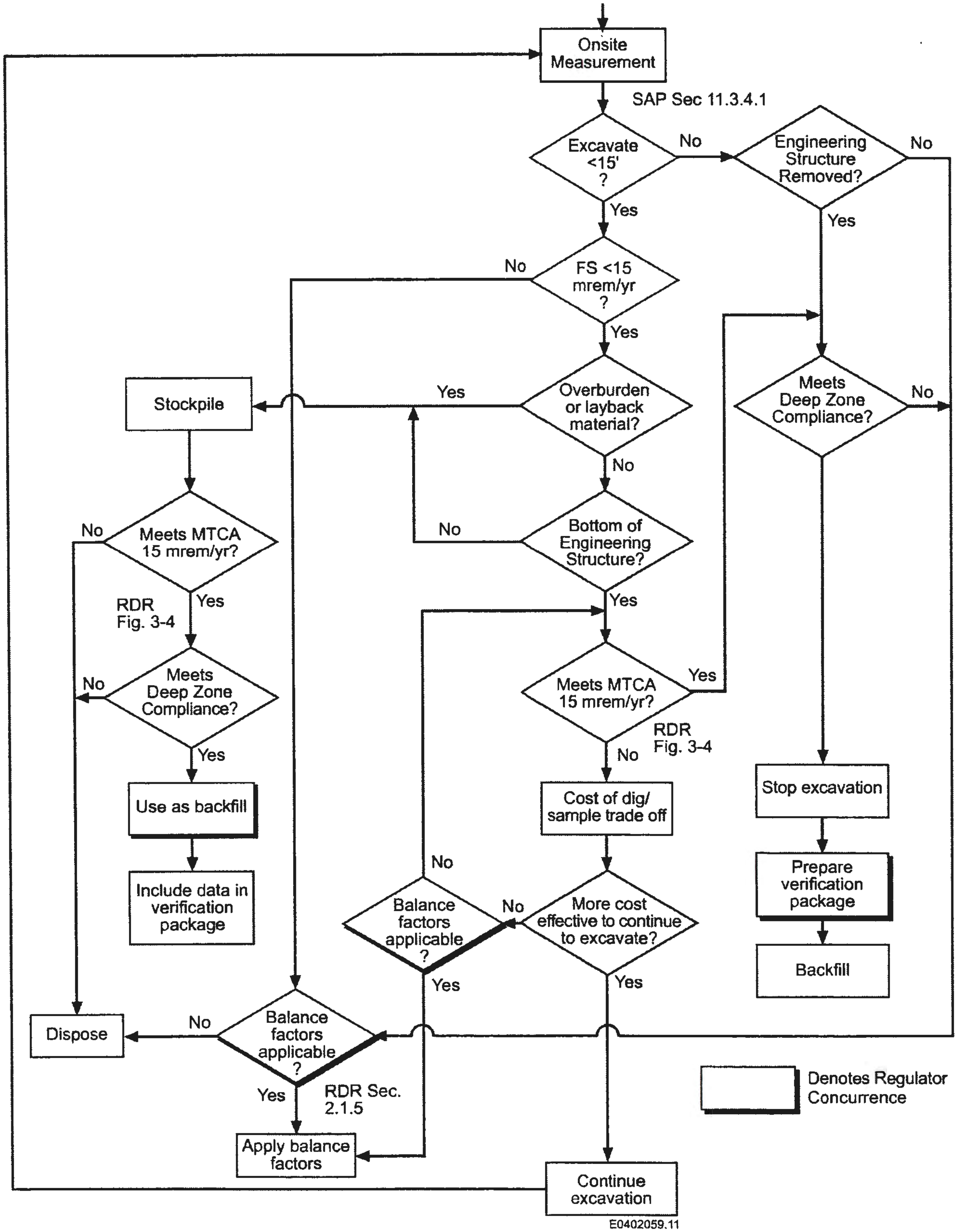
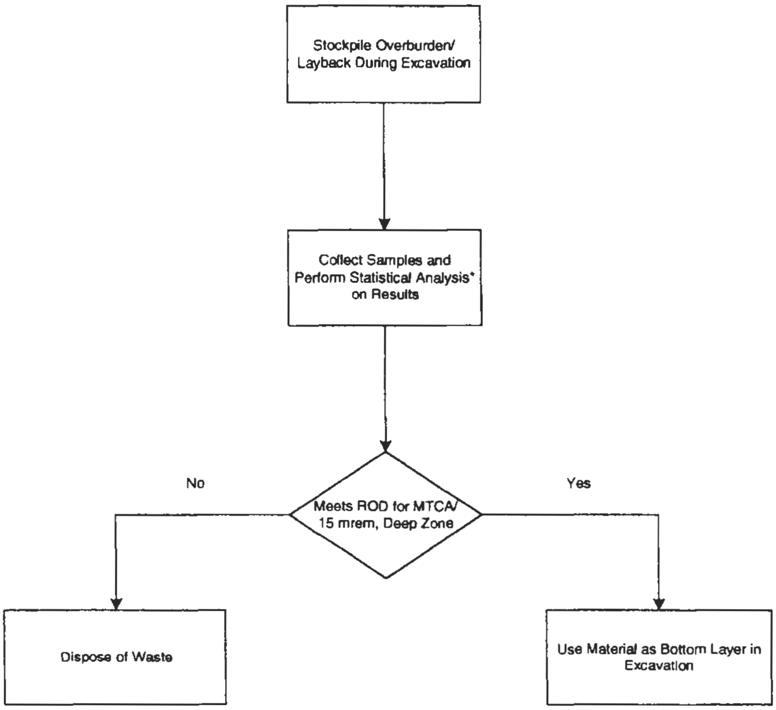


**Figure I-3. Excavation Guidance Process Flow for Radioactive Liquid Effluent Waste Sites.**




Key:
MTCA - Model Toxics Control Act
ROD - Record of Decision
mrem - millirem

*Based on field screening standard error and desired false positive/false negative error rates.

**Figure I-4. Overburden/Layback Process Flow for Radioactive Liquid Effluent Waste Sites.**

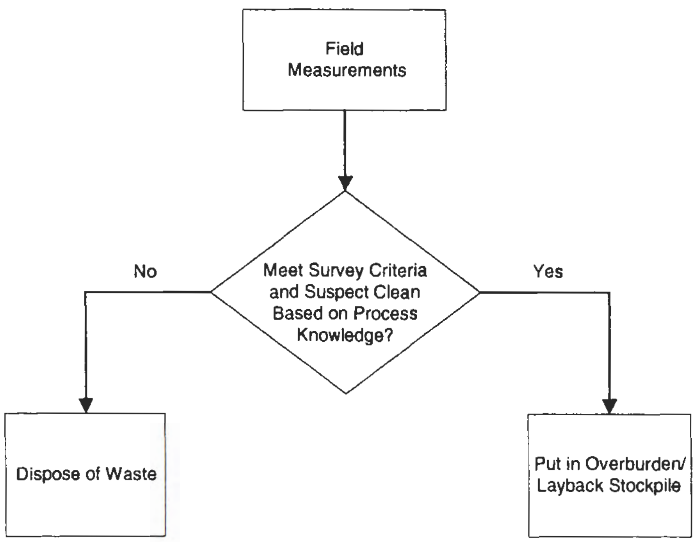
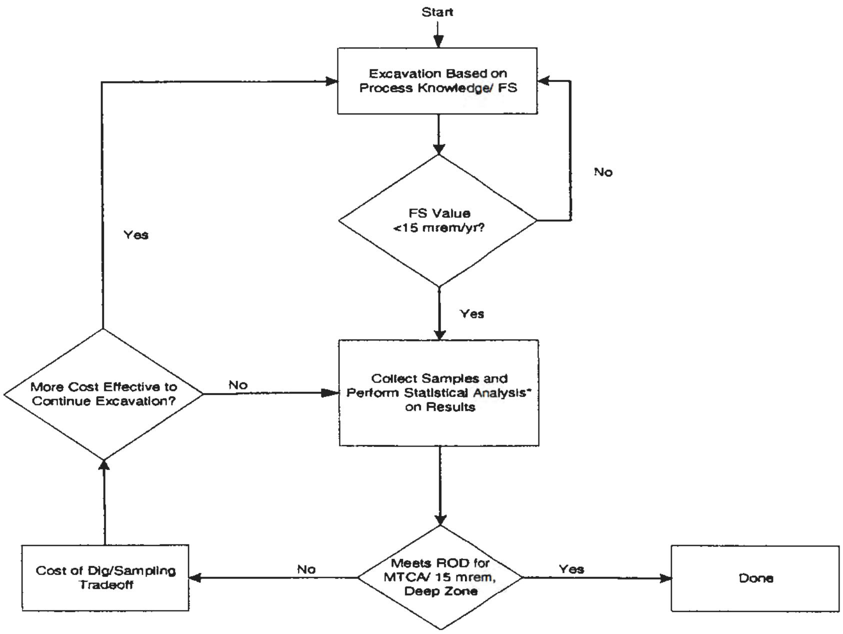
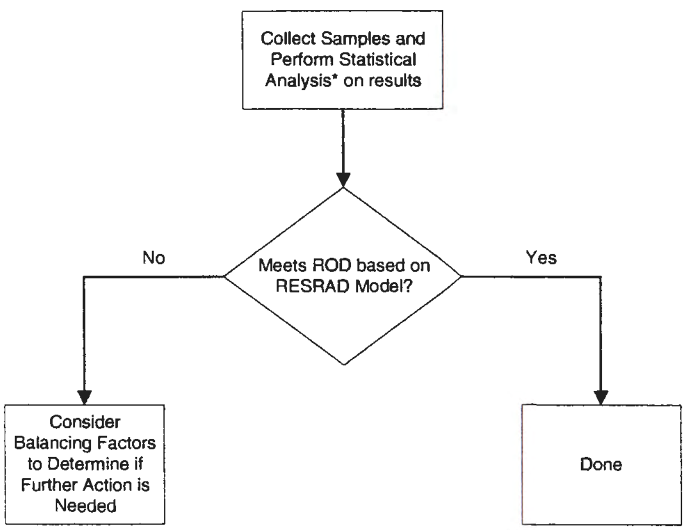


**Figure I-5. Shallow Zone Decisional Unit Process Flow for Radioactive Liquid Effluent Waste Sites.**




Key:
FS - Field Sampling
mrem/yr - millirem per year
ROD - Record of Decision
*Based on field screening standard error, and desired false positive/false negative error rates.

**Figure I-6. Deep Zone Decisional Unit Process Flow for Radioactive Liquid Effluent Waste Sites.**




Key:
ROD - Record of Decision

*Based on variability of Dorian and Richards historical data (1978)

In lieu of a quantified discrete sampling and fixed laboratory analysis approach during excavation, ongoing excavation guidance at radioactive liquid effluent waste sites and waste identification for segregation, transportation, and disposal will rely primarily on onsite measurement techniques and data as described above. Discrete sampling or a more quantified systematic sampling approach will be implemented if field conditions warrant such sampling. Examples of field conditions that may warrant a sampling effort are as follows:

- Health and safety action levels are approached (e.g., levels requiring respirators)
- Visual anomalies are encountered
- Waste profiles approach ERDF waste acceptance criteria
- Increase in contamination levels encountered determined by onsite measurement
- Insufficient data to support development of waste profile.

If action levels for health and safety are approached that require increased environment and worker protection, a sampling effort will be initiated. Action levels are defined in the appropriate documents (e.g., radiation work permit, health and safety plan, site-specific work instruction).

If visual anomalies are encountered during the excavation, a sampling effort may be initiated. Visual anomalies include discoloration of soils, appearance of a sheen on soil particles, obvious change in soil textural characteristics, containers that contain or may have contained liquid or solid waste, structural materials that are uncovered unexpectedly, or other unexpected changes in site conditions.

Other field conditions may be encountered in which additional sampling may be required. All sampling efforts will be evaluated by project and/or technical personnel to ensure that representative and quality samples and analyses are taken and performed to specifically address the field condition and in a cost-effective manner.

### I.5.2 DISPOSAL

Waste monitoring will use onsite measurements gathered during excavation as described in Section I.4. The data will be compared to the current waste profile. Time and cost constraints dictate real-time measurements whenever possible. The strategy is based on an assumption that site soils do not exceed characteristic dangerous waste land disposal restriction (LDR) criteria as determined using past site process knowledge and biased sampling for the Hanford Site's 100 Area past-practice liquid waste disposal sites. In these 100 Area waste sites, metals are the primary chemical contaminants that could exceed LDR limits. The results of 261 samples for waste designation show that these metals rarely leach at levels that exceed LDR limits. This is based on metals data that are detailed in Appendices C and D as well as more recent comparison samples collected during remedial actions.

Periodic sampling for quick-turnaround laboratory (QTL) analyses of nonradiological COCs may be performed to verify waste profiles as directed by the resident engineer.

### I.5.3 OVERBURDEN/LAYBACK

Overburden is defined as material previously placed on top of the waste site. Layback is defined as "clean" material resulting from excavation. The objective for sampling and analyses of overburden and layback is to verify that the soil piles do not contain COCs that are above remediation levels. This decision process is shown in Figure I-4. Verification is accomplished by onsite radiological measurements during excavation, followed by discrete sampling and laboratory analyses, if needed, for waste designation for LDR as detailed in Parts II and III of this SAP. Samples will be analyzed for all COCs by the standard fixed laboratory (SFL) with 5% validated data packages.

Sampling of overburden/layback piles will be based on a statistical approach presented in the EPA guidance document *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989).

### I.5.4 IMPORTED BACKFILL

Imported backfill is soil taken from noncontaminated borrow sites. Acceptance or rejection of soils for backfill material will be based on existing knowledge of the prospective borrow areas. Occasionally, locally generated clean rubble and other noncontaminated material from the 100 Area may be used for backfill provided prior regulator approval is received.

### I.5.5 SITE VERIFICATION

At the end of excavation, the objective will be to verify that residual soils and materials do not contain COCs above the remediation goals (data obtained as shown in Figures I-5 and I-6). This verification will be accomplished by standard analytical methods addressed in Part II. All samples will be analyzed for COCs by the SFL with 5% validated data packages.

Sampling strategy will be based on the same EPA guidance (EPA 1989) as for the overburden/layback described above. Sample methods are discussed in Section II-3.

### I.5.6 PERIPHERAL STRUCTURES

Any structures such as utility pipes, boundary walls, areas surrounding tanks, and wood timbers will be segregated, if possible, and evaluated separately from the other soils. The soils from these areas may exhibit properties that exceed LDR criteria. An example is the annular ring of soil around the 116-C-5 Retention Basin. In development of the leachability criteria (Appendix D), soil from this annular ring was characterized for leachability using the toxicity characteristic leaching procedure (TCLP). It was determined that the TCLP results from this soil did not exceed the LDR criteria. As shown in Appendix D, the characterization has already been carried out. At this time, no further sampling and analysis for LDR is planned for the 100 Area liquid waste disposal sites.

A sampling strategy that addresses debris is provided in Appendix E.

### I.5.7 WORKER HEALTH AND SAFETY

Health and Safety personnel will use data collected during the remediation as input to determine exposure levels to workers and to conduct health and safety assessments in accordance with the health and safety plan.

## I.6 SAMPLING AND ANALYSIS OF REMAINING SITES

The remaining sites consist of a variety of miscellaneous liquid and nonliquid waste disposal sites, dump sites, burn pits, debris piles, french drains, and unplanned releases. Since these different types of sites have different physical and chemical characteristics, a single sampling approach that is appropriate for the residual soils of the radioactive liquid effluent waste sites is not appropriate for most of the remaining sites. Because of the diversity of characteristics among the remaining sites, an agreement was made with the regulators to provide the details of the sample design for each site in a site-specific WI rather than in this SAP. Instead of approving a single SAP that applies to multiple sites (such as Revisions 0 through 4 of the 100 Area SAP for the radioactive liquid effluent waste sites), the lead regulatory agency will approve the individual WIs for the remaining sites. Based on the lead regulatory agency review, these WIs may be modified as appropriate, prior to approval.

The purpose of this section is to outline the structure of the decision-making process, which may include environmental sampling and laboratory analyses for the remaining sites. The details of the sampling approach for each individual waste site will be documented in the site-specific WIs.

As previously mentioned, the decision-making process for the remaining sites is different than the one for the radioactive liquid effluent waste sites. Figure 1-7 shows the process, with an emphasis on the role of environmental sampling in the decision-making process.

The right side of Figure I-7 (RTD with Verification Sampling) deals with remaining sites that have already been slated for remediation in the remaining sites ROD. Those sites are listed in the first part of Table A-1 of the Remaining Sites ROD (EPA 1999). In conjunction with the development of the remedial design/remedial action plan for the waste site, a site-specific WI (describing how the cleanup verification sampling will be performed to demonstrate compliance with the RAOs) is prepared for approval by the regulators. Site-specific verification sample designs are also prepared for Ecology lead radioactive liquid effluent waste sites. Depending on the characteristics of the site, the sampling design can either be focused, some type of statistical design (e.g., random, systematic), or a combination of both. If the cleanup verification sampling shows that the RAOs are met, this is documented in an RSVP. If the verification sampling shows that the RAOs have not been met, then the site goes back to remedial action for additional remediation followed by additional verification sampling.

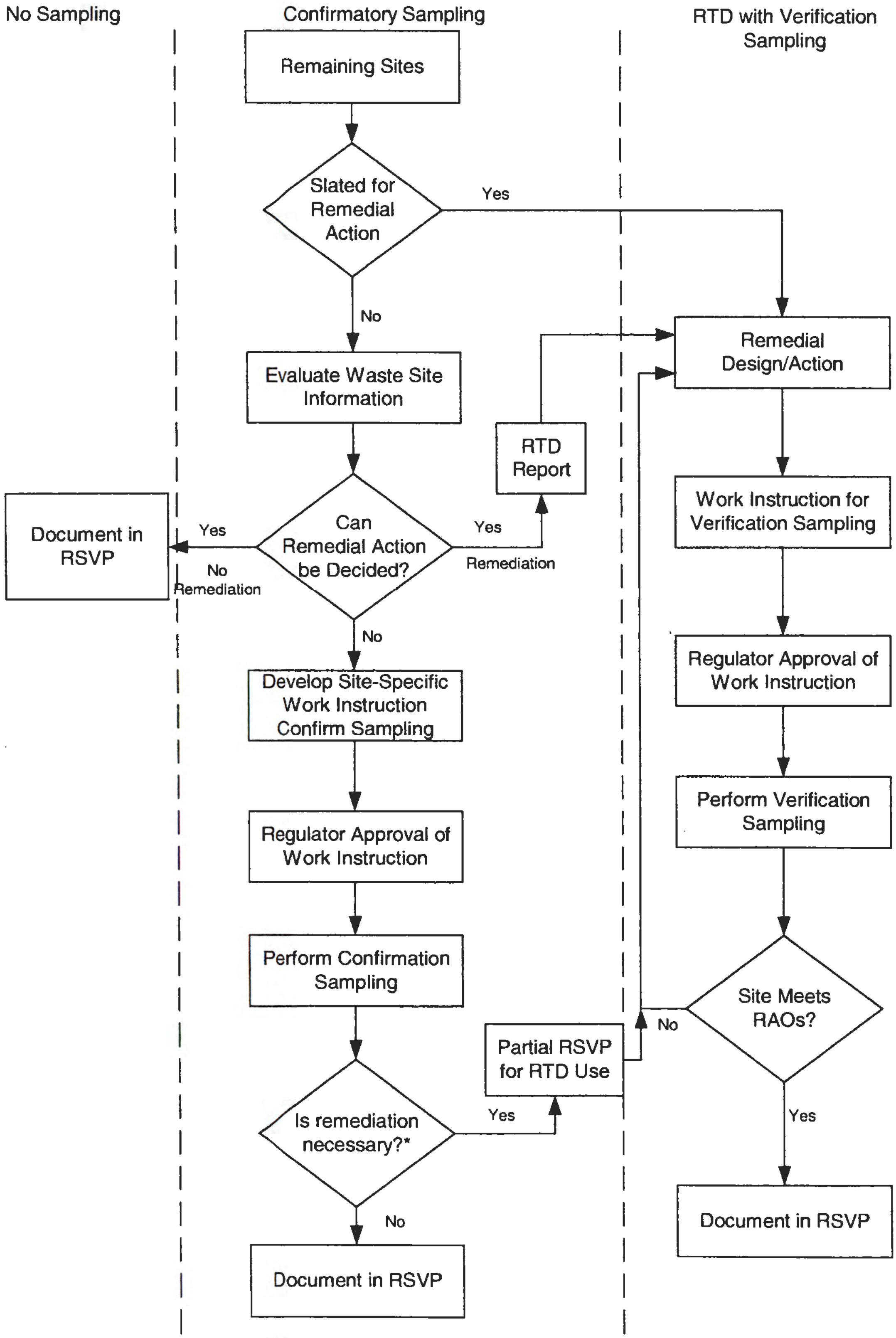
The RSVP contains the site location and description, historical information including the results of site walkdowns; geophysical, cultural, and ecological surveys; a summary of the remedial action activities; the site-specific verification sample design and field sampling activities; the COPCs, the verification sample results and data quality assessment (DQA); and the documentation of compliance with the RAOs of the Remaining Sites ROD. The RSVP, along with the TPA-MP-14 (DOE-RL 2007) waste site reclassification form, is then submitted to the U.S. Department of Energy, Richland Operations Office (DOE-RL) and the lead regulatory agency for approval and signature.

The center part of Figure I-7 describes the disposition of confirmatory sampling sites, where remaining sites are not automatically slated for remedial action. Those sites are given in the second part of Table A-1 of the Remaining Sites ROD (EPA 1999). All of the information about the sites as well as relevant information from analogous sites is evaluated. Based on this information, the decision will be remedial action, no action, or confirmatory sampling. The decision for the sites slated for remedial action will be documented in RTD reports. For the no-action sites, the decision will be documented in RSVP reports (left site of Figure 1-7).

The RTD reports consist of a few pages that summarize the information gathered during the waste site evaluation. The type of information that is normally included is location; site description; historical data; and the results of site walkdowns and geophysical, cultural, and ecological surveys. Also included is the basis for the remediation RTD decision and the recommended list of COPCs, COCs, or both. The report is issued to the remedial design project for use in planning remediation.

For the no-action sites, the information gathered during the waste site evaluation is documented in an RSVP that accompanies the TPA-MP-14 waste site reclassification form. The type of information included in the RSVP includes location; site description; historical data; and results of site walkdowns and geophysical, cultural, and ecological surveys. It also includes the basis and supporting documentation for making the no-action decision. A no-action decision can be made for sites if during the evaluation process it is determined that existing historical data, process knowledge, geophysical survey data, site walkdown information, or a combination thereof support that remediation is not required and no further sampling is needed to support that decision. This RSVP, and accompanying reclassification form, is then submitted to DOE-RL and the lead regulatory agency for approval and signature.

**Figure I-7. Sampling and Analysis Process for Remaining Sites.**




* Determined by criteria in ROD.

If a decision for either remediation or no action cannot be made at this point, the waste site is slated for confirmatory sampling. A WI for confirmatory sampling must be prepared for regulator approval. The WI contains information such as historical data, the results of site walkdowns, and geophysical surveys. The locations of surface anomalies, such as debris and stained soil, are mapped and overlaid with the results of the geophysical survey. Depending on the results of the walkdown and geophysical survey, areas (strata) may be identified for sampling. The sample location within each strata would usually be based on focused sampling.

- If one or more of the strata do not meet the RAOs, then the information is documented in a partial RSVP and the site is given over to the Field Remediation Closure Project.

The objective of the partial RSVP is to compile and document all information and activities that have been performed at the waste site to aid the remedial design project in planning the remediation. A partial RSVP summarizes the information gathered during the waste site evaluation (i.e., location, site description, historical, site walkdown, geophysical, cultural, and ecological surveys). It also summarizes the confirmatory sampling efforts, including the site specific sample design and the field sampling activities, and confirmatory sample results and DQA. Additionally, it provides the basis for the remediation decision, the recommended list of COPCs, and any other recommendations to be considered during remedial design such as a reduction of the site footprint.

Once the site is remediated, the partial RSVP is supplemented with additional information that includes a summary of the field remediation activities, the site-specific verification sample design and field sampling activities, the COCs, the verification sample results and DQA, and the documentation of compliance with the RAOs of the Remaining Site ROD. The completed RSVP, along with the reclassification form, is submitted to DOE-RL and the lead regulatory agency for approval and signature.

- If the site is determined to not need remediation based on the confirmatory sampling results, then the information is documented in an RSVP.

The information in this RSVP is essentially the same as in a partial RSVP, with the following exceptions: there is no remediation discussion, but there is documentation of compliance with the RAOs of the Remaining Sites ROD. The RSVP and reclassification form are then submitted to DOE-RL and the lead regulatory agency for approval and signature.

# PART II

## QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan presents the activities and guidelines to provide for data of known and appropriate quality.

# II.1 INTRODUCTION

This Quality Assurance Project Plan (QAPjP) presents the objectives, functional activities, methods, and QA/quality control (QC) procedures associated with the collection and analyses of samples during remedial activities in the 100 Areas. Where appropriate, existing QA/QC guidelines, policies, and programs will be incorporated by reference. This QAPjP follows EPA guidelines contained in *EPA Requirements for Quality Assurance Project Plans* (EPA 2001).

# II.2 PROJECT MANAGEMENT/DATA QUALITY OBJECTIVES

## II.2.1 PROJECT/TASK ORGANIZATION

Project/task organization is described in Section 3.3, "Project Team," of the 100 Area RDR/RAWP (DOE-RL 2009). Additional responsibilities are discussed in the "Analytical Standard Operating Procedures" referenced in Appendix B.

## II.2.2 PROBLEM DEFINITION/BACKGROUND

Problem definition/background has been presented in Part I of this document.

## II.2.3 PROJECT/TASK DESCRIPTION

Project/task description, including the schedule, is provided in the 100 Area RDR/RAWP (DOE-RL 2009).

## II.2.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

A summary showing analytical methods, performance parameters, data uses, and applicable detection levels for the contaminants in 100 Area waste sites is presented in Table II-1, which is based on calculation brief number 0100X-CA-V0046 (BHI 2004). For the remaining sites, an evaluation of the performance of analytical methods for contaminants not presented in Table II-1 will be conducted prior to confirmatory or verification sampling.

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by representativeness, comparability, accuracy, precision, and completeness. Definitions of these parameters, applicable guidelines, and level of effort are described below. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the

## Table II-1. Analytical Performance Requirements. (3 Pages)

| Data Type | Analyte | Analytical Method | Detection Limit Requirements[a] | Accuracy Req't (% Recovery) | Precision Req't (% RPD) |
|---|---|---|---|---|---|
| *Performance Requirements for Field Measurements*[b] | | | | | |
| Rad | Gross cesium-137 counts | Portable NaI detector | 5 | NA | ±50[b] |
| Rad | Gross alpha | Portable contamination detector | 100 dpm/100 $cm^2$ | NA | ±50[b] |
| Rad | Gross beta/gamma | Portable contamination detector | 5,000 dpm/100 $cm^2$ | NA | ±50[b] |
| Chem | Volatile organic analysis | Organic vapor monitor | NA | NA | NA |
| *Performance Requirements for Laboratory Measurements* | | | | | |
| Rad | Americium-241 | AmAEA | 1 | 70-130[c] | ±30[c] |
| Rad | Carbon-14 | Chem sep/liq scintillation | 1[d] | 70-130[c] | ±30[c] |
| Rad | Cobalt-60 | GEA (HPGe or GeLi) | 0.05 | 70-130[c] | ±30[c] |
| Rad | Cesium-137 | GEA (HPGe or GeLi) | 0.05 | 70-130[c] | ±30[c] |
| Rad | Europium-152 | GEA (HPGe or GeLi) | 0.1 | 70-130[c] | ±30[c] |
| Rad | Europium-154 | GEA (HPGe or GeLi) | 0.1 | 70-130[c] | ±30[c] |
| Rad | Europium-155 | GEA (HPGe or GeLi) | 0.1 | 70-130[c] | ±30[c] |
| Rad | Tritium (H-3) | Distillation liq scintillation | 10 | 70-130[c] | ±30[c] |
| Rad | Nickel-63 | Chem sep/liq scintillation | 30 | 70-130[c] | ±30[c] |
| Rad | Plutonium-238 | PuAEA | 1 | 70-130[c] | ±30[c] |
| Rad | Plutonium -239/240 | PuAEA | 1 | 70-130[c] | ±30[c] |
| Rad | Strontium-90 | Rad-Sr | 1 | 70-130[c] | ±30[c] |
| Rad | Technetium-99 | Chem sep/liq separation | 1 | 70-130[c] | ±30[c] |
| Rad | Thorium-232 | Th AEA | 1 | 70-130[c] | ±30[c] |
| Rad | Uranium-233/234 | UAEA | 1 | 70-130[c] | ±30[c] |
| Rad | Uranium-235 | UAEA | 1 | 70-130[c] | ±30[c] |
| Rad | Uranium-238 | UAEA | 1 | 70-130[c] | ±30[c] |
| Chem | Silver | EPA 1311[e]/6010 | 0.5 | 70-130[f] | ±30[f] |
| | | EPA 6010 – Trace[g] | 0.2 | 70-130[f] | ±30[f] |
| Chem | Arsenic | EPA 1311/6010 | 0.5 | 70-130[f] | ±30[f] |
| | | EPA 6010 | 10 | 70-130[f] | ±30[f] |

**Table II-1. Analytical Performance Requirements. (3 Pages)**

| Data Type | Analyte | Analytical Method | Detection Limit Requirements[a] | Accuracy Req't (% Recovery) | Precision Req't (% RPD) |
|---|---|---|---|---|---|
| Chem | Barium | EPA 1311/6010 | 10 | 70-130[f] | ±30[f] |
| | | EPA 6010 | 2 | 70-130[f] | ±30[f] |
| Chem | Cadmium | EPA 1311/6010 | 0.1 | 70-130[f] | ±30[f] |
| | | EPA 6010 – Trace[g] | 0.2 | 70-130[f] | ±30[f] |
| Chem | Total chromium | EPA 1311/6010 | 0.015 | 70-130[f] | ±30[f] |
| | | EPA 6010 | 1 | 70-130[f] | ±30[f] |
| Chem | Chromium (VI) | EPA 7196 | 0.5 | 70-130[f] | ±30[f] |
| Chem | Mercury | EPA 1311/7470 | 0.02 | 70-130[f] | ±30[f] |
| | | EPA 7471 | 0.2 | 70-130[f] | ±30[f] |
| Chem | Lead | EPA 1311/6010 | 0.5 | 70-130[f] | ±30[f] |
| | | EPA 6010 | 5 | 70-130[f] | ±30[f] |
| Chem | Antimony | EPA 6010 – Trace[g] | 0.6 | 70-130[f] | ±30[f] |
| Chem | Selenium | EPA 1311/6010 | 0.1 | 70-130[f] | ±30[f] |
| | | EPA 6010 – Trace[g] | 1 | 70-130[f] | ±30[f] |
| Chem | Zinc | EPA 6010 | 1 | 70-130[f] | ±30[f] |
| Chem | Cyanide | EPA 9010 | 0.5 | 70-130[f] | ±30[f] |
| Chem | Sulfide | EPA 9030 | 5 | 70-130[f] | ±30[f] |
| Chem | Sulfate | EPA 300.0 | 5 | 70-130[f,e] | ±30[f] |
| Chem | Pesticides | EPA 1311/8081 | Compound-specific[h] | 50-150[i] | ±30[i] |
| | | EPA 8081 | 0.005[j] | 50-150[i] | ±30[i] |
| Chem | Herbicides | EPA 1311/8150 | Compound-specific[h] | 50-150[i] | ±30[i] |
| | | EPA 8150 | 0.1[k] | 50-150[i] | ±30[i] |
| Chem | Ethylene glycol | EPA 8015 | 5 | 50-150[i] | ±30[i] |
| Chem | Total petroleum hydrocarbons | EPA 8015/418.1 | 5 | 50-150[i] | ±30[i] |
| Chem | Polychlorinated biphenyls | EPA 8082 | 0.02[d] | 50-150[i] | ±30[i] |
| Chem | Polynuclear aromatic hydrocarbons | EPA 8310 | 0.015[k] | 50-150[i] | ±30 |

### Table II-1. Analytical Performance Requirements. (3 Pages)

| Data Type | Analyte | Analytical Method | Detection Limit Requirements[a] | Accuracy Req't (% Recovery) | Precision Req't (% RPD) |
|---|---|---|---|---|---|
| Chem | Semivolatile organic analysis | EPA 1311/8270 | Compound-specific[h] | 50-150[i] | ±30[i] |
| | | EPA 8270 | 0.66[k] | 50-150[i] | ±30[i] |
| Chem | Volatile organic analysis | EPA 1311/8260 | Compound-specific[h] | 50-150[i] | ±30[i] |
| | | EPA 8260 | 0.01[k] | 50-150[i] | ±30[i] |

[a] Units are in pCi/g or mg/kg unless otherwise specified. Units for TCLP-based analyses are mg/L. Detection limits shown are for SFL methods. When analyzed under quick-turnaround protocols, RDLs are 2 times the values shown except as follows: VOA – no change, GEA – 5 times values shown, AEA – 20 times values shown.

[b] Rad detection limit achieved with static survey. The precision criteria show is for replicate field readings.

[c] The accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA analysis, additional accuracy criteria include analysis-specific evaluations preformed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown is for batch laboratory replicate sample RPDs.

[d] The calculated action level is below established analytical methodology capabilities. The analytical detection limits will be used for working action levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

[e] Methods containing "1311" are TCLP.

[f] The accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples is also performed. The precision criteria shown is for batch laboratory replicate matrix spike or replicate sample RPDs.

[g] In order to meet or approach action levels, laboratories must use axial based ("Trace") ICP analytical methods. The laboratory may also substitute (with prior approval) graphite furnace or ICP/MS methods if required analytical detection limit, precision, and accuracy criteria are met.

[h] TCLP action levels are compound specific. Laboratory detection limits will be less than 1/10 of the associated action limit.

[i] The accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based controls if more stringent. Additional accuracy criteria include analyte-specific evaluations preformed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criteria shown is for batch laboratory replicate matrix spike analysis RPDs.

[j] Maximum detection limit for pesticides except for chlordanes and toxaphene. Chlordane detection limits are 0.02 and the toxaphene limit is 0.2 mg/kg.

[k] Herbicide, PAH, SVOA, and VOA detection limits shown are "nominal" maximums. Most analytes will achieve this or a lower detection limit. A limited number of analytes will have higher detection limits. Detection limit goals for any potential contaminants of concern higher than the values shown will be defined in project-specific documentation.

AEA = chemical separation followed by alpha energy analysis
EPA = EPA SW-846 (EPA 1997b) methodology except for 300.0 and 418.1, which are from 600/4-79-020
GEA = gamma energy analysis
GeLi = lithium-drifted germanium (detector)
HPGe = high-purity germanium (detector)
ICP = inductively coupled plasma
MS = matrix spike
NA = not applicable
NaI = sodium iodide (detector)
PAH = polycyclic aromatic hydrocarbons
RDL = required detection limit
RPD = relative percent difference
SFL = standard fixed laboratory
SVOA = semivolatile organic analysis
TCLP = toxicity characteristic leaching procedure
VOA = volatile organic analysis

nature of the analytical methods. Analytical methodology and specific QC procedures are discussed in Section II.3. The following is a description of the data quality parameters.

Representativeness is a measure of how closely the results reflect the actual concentration or distribution of the chemical compounds in the matrix sampled. Sampling plan design, sampling techniques, and sample handling protocols (e.g., storage, preservation, transportation) have been developed and are discussed in subsequent sections of this document. The proposed documentation will establish that protocols have been followed and sample identification and integrity ensured. Field duplicates, collected at a minimum frequency of 5% of the samples per sampling event, will be used to assess field and transport contamination and method variation. To assess laboratory contamination, laboratory method blanks will be run at a minimum frequency of 5% of the samples.

Comparability expresses the confidence with which one data set can be compared to another. Data comparability will be maintained using standard procedures, when available, and using consistent methods and units. Table II-1 lists specific parameters and applicable methods for analytes and required detection limits. Actual detection limits will depend on the sample matrix and will be reported as defined for the specific samples.

Accuracy is an assessment of the closeness of the measured value to the true value. Accuracy of chemical test results is assessed by spiking samples with known standards and establishing the average recovery. For a matrix spike, known amounts of a standard compound identical to the compounds being measured are added to the sample. For some radionuclide measurements, method calibrations against known standards are used to establish accuracy.

A quantitative definition of average recovery (accuracy) is given in Section II.5.2. Accuracy measurement will be carried out with a minimum frequency of 1 in 20 samples analyzed. Target quantitative accuracy objectives are listed, as applicable, in Table II-1.

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference (RPD) for duplicate measurements. A quantitative definition of the RPD is given in Section II.5.2. The level of effort for precision measurements will be a minimum of 1 in 20 samples.

Completeness is a measure of the amount of valid data obtained from the analytical measurement system and the complete implementation of defined field procedures. The quantitative definition of completeness is given in Section II.5.2. The target completeness objective for this project is 95%.

## II.2.5 PROJECT NARRATIVE

The following is a list of objectives and the associated methods (incorporated by reference) to achieve that objective:

- Measuring (quantitatively or qualitatively) the success of the project or task will be determined by methods defined in Section II.2.4
- Determining design requirements and description (Section II.3.1)
- Determining sampling methods (Section III.3)
- Determining sample handling and custody requirements (Section III.5)
- Analytical method requirements (Section II.3.4)
- Quality control requirements sampling and analytical methods used (Section II.3.5)
- Determining sampling or analytical instrumentation requirements (Section II.3.6)
- Maintaining ongoing assessments during operation (oversight) (Section II.4.1).

## II.2.6 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

Training or certification requirements needed by personnel are described in BSC-1, *Business Services and Communication*, Section 2, "Training." Field personnel shall have completed the following mandatory training before starting work:

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training
- Radiation Worker Training
- Hanford General Employee Training.

Personnel conducting sampling, radiological surveys, and chemical field screening shall meet additional training and certification requirements as specified in *Sampling and Characterization Quality Assurance Program Plan* (WCH 2009).

# II.3 MEASUREMENT/DATA ACQUISITION

## II.3.1 SAMPLING PROCESS DESIGN

### II.3.1.1 Sampling Process Design for the Remaining Sites

As mentioned in Section I-6, the diverse characteristics of the remaining sites make it infeasible to develop a single sampling design that is appropriate for each site. Therefore, by agreement with DOE-RL and the regulatory agencies, a waste site-specific WI will be prepared for those remaining sites that require sampling. Each WI will be approved by the lead regulatory agency prior to sampling. This approach is also used for verification sampling of Ecology lead radioactive liquid effluent sites.

The site-specific approach to the sample designs is flexible to adequately address the unique characteristics of each of the applicable sites, and to the extent practicable, the WI will utilize focused sampling. However, statistical sampling designs (e.g., random, systematic), and possibly a combination of statistical and focused sampling, will be used as appropriate.

### II.3.1.2 Sampling Process Design for EPA Lead Radioactive Liquid Effluent Waste Sites

A statistically based sampling process design is presented in Appendix A, and an overview is presented in Section I-5. This design incorporates results from the DQO process.

A combined statistical and judgmental sampling design strategy was developed for the excavation, overburden/layback, site verification, and impacted backfill decision boundaries as described below. The following sampling design is based on the DQO process for the 100 Area past-practice liquid waste disposal sites (DOE-RL 1996b, 1997a, 1997b).

**II.3.1.2.1 Excavation.** The excavation guidance process flow is depicted in Figure I-3. The overall strategy for material disposition decisions is to use information from process knowledge, historical data, radiation screening, and XRF. Specific sampling may be performed dependent on field conditions as defined in Section I.5.1. Process knowledge and historical information are used to define the expected concentration ranges of specific constituents on the waste profile form.

**II.3.1.2.2 Overburden/Layback.** The approach for verification sampling of the overburden/layback will follow a statistically based design identical to the verification of the shallow zone. The overburden/layback process flow is summarized in Figure I-4. The number of samples will be calculated by using the minimum detectable difference procedure that is given in the EPA guidance document *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989).

The minimum detectable difference approach requires the following specifications. First, specify the desired tolerances of false-positive and false-negative errors. Second, determine the target cleanup levels. Third, estimate the variability within the decision unit. The size of the decision unit is not explicitly included in this approach. Default sample sizes were calculated from the observed variability of historical data (Dorian and Richards 1978).

Definitions and specifications are as follows:

1. False-positive error: The false-positive error is defined as the probability that the decision unit will be declared clean when it is actually dirty. A 5% false-positive error rate is consistent with the need to calculate a 95% upper confidence limit (UCL) of the mean and was selected for the statistical calculations.

2. False-negative error: The false-negative error is defined as the probability that the decision unit will be declared dirty when it is actually clean. A false-negative error rate of 20% will be used in the statistical calculations.

3. The target cleanup levels are the RAGs for the radionuclide and other COCs.

4. The default number of samples per decision unit is calculated based on the information in 1, 2, and 3 above, and the variability of radionuclide COC concentrations in the 100 Areas (Dorian and Richards 1978). The default sampling strategy and summary of statistical assumptions are presented in Table II-2. Existing data for europium-152 were used as the limiting case for the statistical design. The basis for the limiting case is discussed in Appendix A. The detailed basis of the number of samples is also in Appendix A. Deviations from the default number of samples will be determined based on the calculations presented in Appendix A. For sites without radionuclide COCs, using Appendix A calculations to develop the site-specific numbers of verification samples is appropriate. Appendix A also presents a simple cost of sampling and analysis versus cost of excavation and removal trade-off analysis to assist field management decision makers.

5. Overburden/layback from multiple waste sites within a reactor area may be combined to make material handling more cost effective. Each waste site that contributes overburden/ layback to a common overburden pile(s) will bring its entire COC list to the final common overburden pile COC list. It is expected that onsite measurement information for the overburden/layback soil piles will be available, and will be evaluated in the site-specific number of sample calculation. This calculation is presented in Appendix A.

**Table II-2. Summary of the Default Statistical Design for the Overburden/Layback Decision Units for the EPA Lead Radioactive Liquid Effluent Waste Site.**

| | |
|---|---|
| ***Statistical Design*** | |
| Number of aliquots per composite sample | 4 |
| Number of composite samples per decision subunit | 4 |
| Number of analyses per composite sample | 1 |
| ***Statistical Assumptions*** | |
| False-positive error rate | 5% |
| False-negative error rate | 20% |
| Remedial action goal of limiting COC (Eu-152) | 3.8 pCi/g[a] |
| Variability of limiting COC (Eu-152) | Coefficient of variation = 57% |

[a] Initial cleanup value used for statistical evaluation. Actual cleanup values will vary from this number, but that does not affect the initial statistical design.
COC = contaminant of concern
EPA = U.S. Environmental Protection Agency

### II.3.1.2.3 Site Verification

**II.3.1.2.3.1 Shallow Zone and Overburden Verification.** The approach for shallow zone and overburden verification sampling is based on the strategy outlined in Figure I-5. Verification sampling starts after onsite measurements and process knowledge have provided reasonable confidence that the RAGs have been met. Project personnel decide when to initiate verification sampling. The minimum number of samples needed for each decision unit is calculated based on the minimum detectable difference approach presented in the EPA guidance document (EPA 1989).

The minimum detectable difference approach requires the following specifications. First, specify the desired tolerances of false-positive and false-negative errors. Second, determine target cleanup levels. Third, estimate the variability within the decision unit. The size of the decision unit is not explicitly included in this approach. Typically, the variability of the COCs within the decision unit will be related to the physical size of the unit; therefore, size is considered implicit. The default number of samples was calculated from the observed variability of historical data (Dorian and Richards 1978) and is presented in Appendix A.

Two types of error are associated with each decision. In general, these errors can be stated as (1) mistakenly concluding that the action limit has been met, and (2) mistakenly concluding that the action limit has not been met. An evaluation of the consequences of these decision errors led to the designation of the null hypotheses: the site is contaminated. Definitions and specifications are as follows:

1. False-positive error: The false-positive error is defined as the probability that the decision unit will be declared clean when it is actually dirty. A 5% false-positive error rate is consistent with the need to calculate a 95% UCL of the mean and was selected for the statistical calculations.

2. False-negative error: The false-negative error is defined as the probability that the decision unit will be declared dirty when it is actually clean. A false-negative error rate of 20% will be used in the statistical calculations.

3. The target cleanup levels are the RAGs for the radionuclide and other COCs.

4. The default number of samples per decision unit is calculated based on the information in 1, 2, and 3 above, and the variability of radionuclide COC concentrations in the 100 Areas (Dorian and Richards 1978). The default sampling strategy and summary of statistical assumptions are presented in Table II-3. Existing data for europium-152 were used as the limiting case for the statistical design. The basis for the limiting case is discussed in Appendix A. The detailed basis of the number of samples is presented in Appendix A. Analysis of historical data indicates that a minimum of four samples per decision unit is sufficient. Deviations from the default number of samples will be determined based on the variance calculations presented in Appendix A. For sites without radionuclide COCs, using Appendix A calculations to develop the site-specific numbers of verification samples is appropriate. Appendix A also presents a simple cost of sampling and analysis versus cost of excavation and removal trade-off analysis to assist field management decision makers.

5. It is assumed that the shallow zone will be sampled as a single decision unit for each site, and that sampling of this material will occur once the removal is thought to be complete. Thus, it is expected that the onsite radiological measurement information for the shallow zone will be available, and these onsite measurements will be evaluated in the site-specific number of sample calculation (variance calculation). This variance calculation is presented in Appendix A. It is also assumed that resampling or further excavation is logistically feasible for the shallow zone (see Figure I-2).

**Table II-3. Summary of the Default Statistical Design for the Shallow Zone Verification Decision Units for EPA Lead Radioactive Liquid Effluent Waste Sites.**

| | |
|---|---|
| ***Statistical Design*** | |
| Number of aliquots per composite samples | 4 |
| Number of composite samples per decision subunit | 4 |
| Number of analyses per composite sample | 1 |
| ***Statistical Assumptions*** | |
| False-positive error rate | 5% |
| False-negative error rate | 20% |
| Remedial action goal of limiting COC (Eu-152) | 3.8 pCi/g[a] |
| Variability of limiting COC (Eu-152) | Coefficient of variation = 57% |

[a] Initial cleanup value used for statistical evaluation. Actual cleanup values will vary from this number, but that does not affect the initial statistical design.
COC = contaminant of concern
EPA = U.S. Environmental Protection Agency

**II.3.1.2.3.2 Deep Zone Verification.** The approach for closeout sampling of the deep zone will follow a statistically-based design similar to the verification of the shallow zone. The deep zone decision unit closure process is summarized in Figure I-6. This approach will differ from the verification of the shallow zone in two respects. First, the verification criteria differ for the deep zone and are based on protection of groundwater and Columbia River. Second, logistical constraints (e.g., potential excavation limited access) limit the ability to apply the iterative statistical approach used for verification of the shallow zone. Therefore, a default number of samples have been allocated for the deep zone verification. The number of samples has been calculated by using the minimum detectable difference procedure provided in the EPA guidance document (EPA 1989).

The minimum detectable difference approach requires the following specifications. First, specify the desired tolerances of false-positive and false-negative errors. Second, determine target cleanup levels. Third, estimate the variability within the decision unit. The size of the decision unit is not explicitly included in this approach. Typically, the variability of the COCs within the decision unit will be related to the physical size of the unit; therefore, the size is considered implicit. The default number of samples was calculated from the observed variability of historical data (Dorian and Richards 1978).

Two types of error are associated with each decision. In general, these errors can be stated as (1) mistakenly concluding that the action limit has been met, and (2) mistakenly concluding that the action limit has not been met. An evaluation of the consequences of these decision errors led to the designation of the null hypotheses: the site is contaminated. Definitions and specifications are as follows:

1. False-positive error: The false-positive error is defined as the probability that the decision unit will be declared clean when it is actually dirty. A 5% false-positive error rate is consistent with the need to calculate a 95% UCL of the mean and was selected for the statistical calculations.

2. False-negative error: The false-negative error is defined as the probability that the decision unit will be declared dirty when it is actually clean. A false-negative error rate of 20% will be used in the statistical calculations.

3. The target cleanup levels are the RAGs for the radionuclide and other COCs.

4. The default number of samples per decision unit is calculated based on the information in 1, 2, and 3 above, and the variability of radionuclide COC concentrations in the 100 Areas (Dorian and Richards 1978). The default sampling strategy and summary of statistical assumptions are presented in Table II-4. Existing data for cesium-137 were used as the limiting case for the statistical design; the basis for the limiting case is discussed in Appendix A. Analysis of historical data indicates that a minimum of three samples per decision unit is sufficient. The detailed basis of the number of samples is presented in Appendix A.

**Table II-4. Summary of the Default Statistical Design for the Deep Zone Verification Decision Units for EPA Lead Radioactive Liquid Effluent Waste Sites.**

| | |
|---|---|
| ***Statistical Design*** | |
| Number of aliquots per composite samples | 4 |
| Number of composite samples per decision subunit | 3 |
| Number of analyses per composite sample | 1 |
| ***Statistical Assumptions*** | |
| False-positive error rate | 5% |
| False-negative error rate | 20% |
| Remedial action goal of limiting COC (Cs-137) | 2,400 pCi/g[a] |
| Variability of limiting COC (Cs-137) | Coefficient of variation = 137% |

[a] Initial cleanup value used for statistical evaluation. Actual cleanup values will vary from this number, but that does not affect the initial statistical design.
COC = contaminant of concern
EPA = U.S. Environmental Protection Agency

**II.3.1.2.4 Sampling Contingencies.** The default number of samples is based on an evaluation of site historical sample data for specific radioisotopes. A fundamental assumption in this approach is that the specific isotopes can be used to accurately estimate the site variability for application of the minimal detectable difference approach. When the site of interest does not share the radioisotopes used in the development of the default number of samples (e.g., the primary COC is a nonradionuclide), the default number of samples may not be applicable.

Several options exist to overcome the limitations of the statistically based sampling designs. The default number of verification samples required may be taken. However, it is important for the project decision makers to understand the fundamental assumptions within the statistically derived sample approach, and how modifications can nullify assumptions possibly leading to decision errors. Project decision makers must be cognizant of these risks when considering the contingencies discussed in the text that follows. Fortunately, the costs of confirmation sampling can be weighed against the cost of remedial action to determine the appropriate actions.

1. **Calculate the Number of Samples:** Using the formula presented in Appendix A, calculate the number of samples.

2. **Analogous Site Approach:** For many sites, analogous site data have been used to determine the COCs. This logic may be further extended to assess the contaminant variability of the analogous site and apply it to the site of interest. Project decision makers should verify that the analogous site shares the same process history and similar media as the site of interest. The standard deviation of the analogous site may then be used in the minimal detectable difference approach to calculate the required number of samples.

3. **Phased Sampling Approach:** The number of samples needed to determine the population mean is highly dependent on contaminant variability. Contaminant variability may be determined based on default assumptions, analogous site data, or determined with field

measurements. For the latter, potential logistical constraints exist that may result in unusable field data (e.g., with greater than 50% nondetect values or matrix interference sample representativeness is questionable).

In such cases, the default number samples may be taken for immediate analysis (Phase I), with a remaining number of samples archived for later (Phase II) analysis, or the site excavation left open for future sample collection, if needed.

Evaluation of the Phase I sample results leads to one of several determinations as follows:

- The site is contaminated and a statistical power analysis indicates that the proper number of samples were collected and analyzed. Therefore, remedial action will be continued.

- The site is contaminated and a statistical power analysis indicates that additional samples are required. The Phase II samples may then be submitted for analysis (collect additional samples or retrieve archived material). Remedial action could continue or stop contingent on Phase II results.

- The site is not contaminated and statistical power analysis indicates that additional samples are not required. Therefore, no additional analyses are required and interim closure will proceed.

To properly support implementation of the phased approach, all sample locations should be randomly located per guidelines in Part III to obtain a representative standard deviation for each decision unit of interest.

**II.3.1.2.5 Imported Backfill.** The sampling strategy of the backfill material is based on the process knowledge of the source borrow pits. These borrow pits will be located in uncontaminated areas, so there is no need for detailed sampling and analysis of this material. Occasionally, locally generated clean rubble, and other noncontaminated material from the 100 Area, may be used for backfill provided prior regulator approval is received.

## II.3.2 SAMPLING METHOD REQUIREMENTS

Sampling methodology is described in Part III, "Field Sampling Plan," Section III.3.

## II.3.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Requirements are described in Part III, "Field Sampling Plan," Section III.5.

## II.3.4 ANALYTICAL METHOD REQUIREMENTS

Analytical parameters and methods are listed in Table II-1. Laboratory-specific standard operating procedures (SOPs) for the analytical methods are in place or will be prepared, as necessary. A reference list is included in Appendix B. The following is an overview of the proposed methods for the 100 Area waste sites. Changes or additional methods identified during future engineering or planning will be presented in page changes, addenda, or revisions to this SAP, as appropriate.

### II.3.4.1 Onsite Measurements

**II.3.4.1.1 Radiological Measurements.** Onsite radiological measurements will be performed with portable NaI detectors at the work site and with HPGe detectors at the onsite Radiological Counting Facility. The SOPs are listed in Appendix B. Alpha and beta emissions will be monitored with available instrumentation to be calibrated for site-specific conditions prior to the start of onsite measurements. Alpha monitoring will be performed continuously at sites where alpha emitters may constitute more than 2% of the total radioactive inventory, and intermittently at other sites when there is an indication of a change in conditions such as an increase in activity or at boundaries where beta contamination drops below detectable levels. Initial determination of the alpha-emitter inventory is based on actual site data, survey results from the site, or analogous site information.

The purpose of onsite radiological measurements is to support the excavation efforts during the remediation. To this end, the two types of information provided by the onsite measurements are gross-gamma count rates and radionuclide-specific concentrations (pCi/g). Field measurements will be calibrated against known standards.

Two types of detectors will be used to generate radiological measurements and guide the excavation. NaI detectors will be used in a scan mode to provide gross count rate information to guide the excavation to near-clean contaminant concentrations. NaI detectors may be used in a static mode to provide radionuclide-specific concentrations (pCi/g). The HPGe detectors tied to a multi-channel analyzer will be used to provide nuclide-specific information to better define the boundaries and demonstrate compliance with final RAGs. The length of time required is dependent on the user requirements for minimum detectable activity (MDA) concentrations in the soil and the detector's efficiency and field of view. Longer count times may result in MDAs of tenths to hundredths of a pCi/g, dependent on the ambient soil background. At these levels, detection capability is lower than the required RAGs for gamma emitters.

**II.3.4.1.2 Metals Measurements.** Field screening may be performed using onsite XRF measurements. The instrument will be calibrated per site conditions prior to analysis. If XRF field screening methods are not suitable for supporting the waste designation decisions required, then arrangements will be made for analysis at an offsite contracted laboratory.

**II.3.4.1.3 Volatile Organic Compounds.** Onsite organic vapor monitor measurements will be made for volatile organic analytes when required for particular waste sites to identify their presence.

#### II.3.4.2 Quick-Turnaround Laboratory Measurements

The QTL measurements will be for all COCs. The QTL analyses will be per standard methodology identical to off-location SFL analyses (Table II-1). Quick turnaround and cost savings will be achieved by reducing documentation frequency of the QC runs and increased detection levels. Five percent of the QTL samples will be split and have SFL analyses with higher-level documentation and a higher frequency of QC verification. The QTL analysis results are not used for verification samples.

The SOPs are listed in Appendix B.

#### II.3.4.3 Standard Fixed Laboratory Measurements

The SFL analyses will be for all COCs. The SFL analyses will be accompanied by a higher-level documentation and higher frequency of QC verification. The SFL SOPs will also be available prior to analysis as referenced in Appendix B.

### II.3.5 QUALITY CONTROL REQUIREMENTS

The following QC requirements are detailed in the SOPs, which are listed in Appendix B:

- Specific QC procedures
- Level of effort (frequency of runs)
- QC limits
- Corrective action requirements.

### II.3.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

Inspection and maintenance requirements will be per manufacturers' instrument manuals and the applicable QA plan.

### II.3.7 INSTRUMENT CALIBRATION AND FREQUENCY

Instrument calibration will be according to the referenced standard methods and SOPs listed in Appendix B.

### II.3.8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

Procurement activities will meet the requirements of Washington Closure Hanford (WCH) procurement with procedures found in BSC-1, Section 4.0, "Procurement." Received items and reagents will be inspected for conformance with specifications set in the procurement requisition. If the items or reagents do not meet specifications, the items/reagents will be dispositioned through the nonconformance system.

New standards acceptability will be determined by comparing the new standard with previous acceptable standards. Reagent acceptability will be determined by running blanks on the new reagents. New reagents and standards will be separated from other standards and reagents until they have been checked and accepted.

### II.3.9 DATA ACQUISITION REQUIREMENTS (NONDIRECT MEASUREMENTS)

Nondirect data are obtained from three database/information management systems, which are the WIDS database, the Hanford Geographic Information System (HGIS) database, and the Hanford Environmental Information System (HEIS) database. WIDS is the official Hanford Site resource for waste site name, waste type, site description, past-practice history, and documentation available for each waste site, including documents, drawings, photographs, etc. The HGIS maintains the baseline maps for the Hanford Site. Maps of the waste sites, facilities, services, and key environmental features are maintained. The HEIS database is used to maintain electronic access to the available chemical and radiochemical analytical data for the Hanford waste sites and for the Hanford Site groundwater.

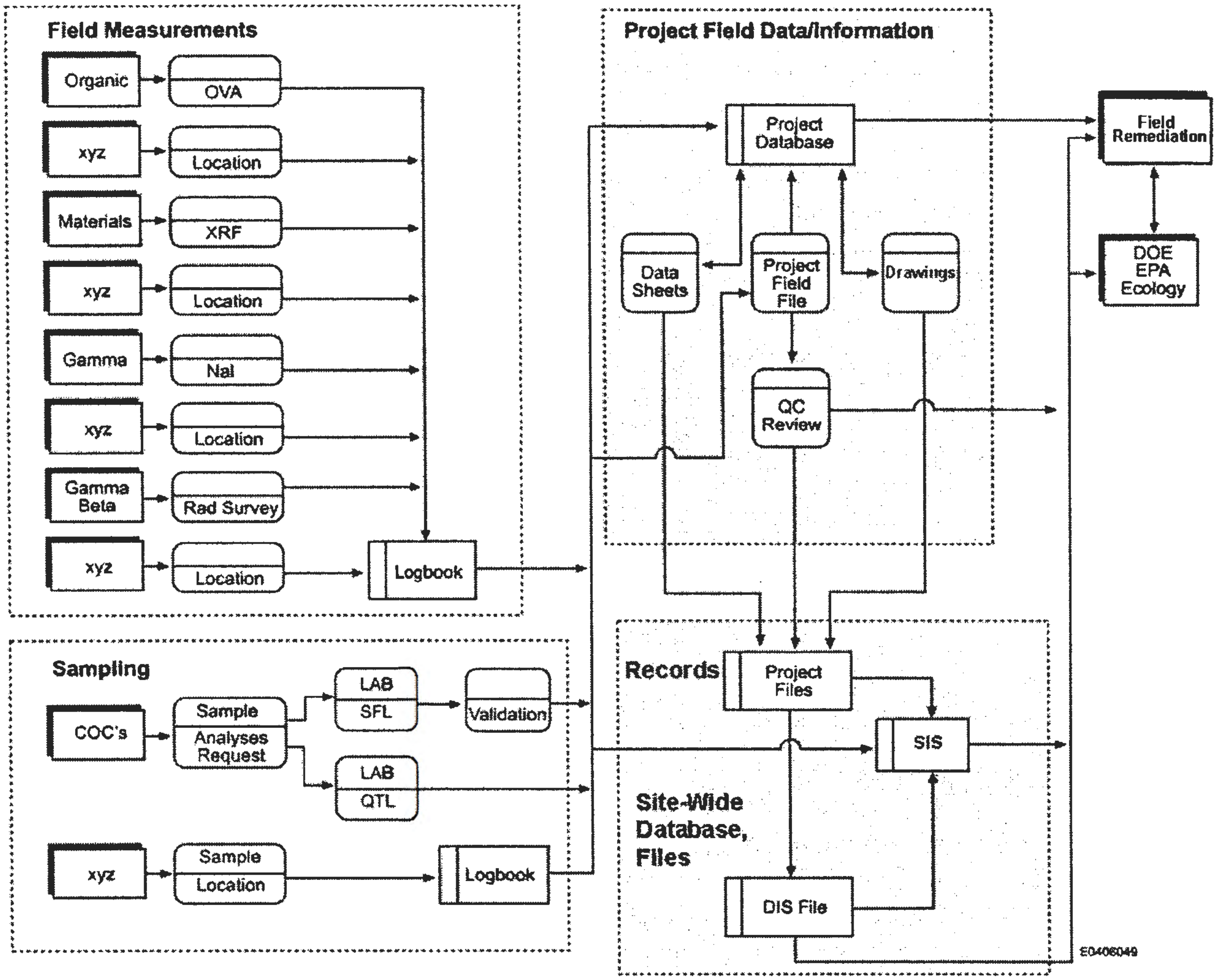
### II.3.10 DATA MANAGEMENT

The sample and data management process will use the project's historical data as input to the DQO process to define the COC list. Figure II-1 tracks sample data flow through collection, analysis, verification/validation, and storage in the three data management databases discussed in Section II.3.9. Both the past-practice and current project data are managed under documented configuration control procedures.

The sample and data management process will be used to manage onsite HPGe, QTL, and SFL analyses, and process data as shown in the logic diagram to develop data tables and maps to guide the remediation. The data process control system will also be used to obtain and communicate data results to support interim closure decisions. Verification data will be stored in the Stewardship Information System (SIS) and eventually entered into the HEIS database.

Laboratory data resulting from the implementation of this SAP will be managed and stored by the WCH sample management organization in accordance with ENV-1-2.10, "Sample Event Coordination."

**Figure II-1. Sample and Data Management Process Flow.**




All analytical data packages shall be subject to final technical review by qualified reviewers before submittal to regulatory agencies or inclusion in reports or technical memoranda, at the direction of the WCH project manager. Electronic data access, when appropriate, shall be through computerized databases (e.g., SIS, HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

# II.4 ASSESSMENT/OVERSIGHT

## II.4.1 ASSESSMENTS AND RESPONSE ACTIONS

The WCH QA staff will conduct random surveillance and audits to verify compliance with the requirements outlined in this QAPjP, the project work packages, the WCH Quality Management Plan, WCH procedures, and regulatory requirements. Data collection, processing, validation, management, self-assessment, and QA programs will collectively address quality-affecting activities, which include, but are not limited to, measurement system accuracies.

Random surveillance and audits will be structured to meet the following system and performance audit classification. System audits consist of the evaluation of the components of the measurement systems to determine their proper selection and use. Performance audits ensure the accuracy of the total system and its individual parts.

## II.4.2 REPORTS TO MANAGEMENT

Corrective action required as a result of surveillance reports, nonconformance reports, or audit activities will be documented and dispositioned as required by QA-1, *Quality Assurance*, QA-1-1.2, "Corrective Action Management and Tracking." Other measurement systems, procedures, or plan corrections that may be required as a result of routine review processes will be resolved, as required, by governing procedures.

Project activities will be regularly assessed by random audits, surveillance, and assessments. All findings from audits, surveillance, and assessments will be transmitted to the project manager and the WCH QA department for program-related tracking and trending. Otherwise, the routine evaluation of data quality described throughout this QAPjP will be documented and filed with the data in the project file.

# II.5 DATA VALIDATION AND USABILITY

## II.5.1 DATA REVIEW, VALIDATION, AND VERIFICATION REQUIREMENTS

For SFL analyses, a minimum of 5% of the data packages will be validated. All coordination of validation services, execution of data validation activities, and handling/storage of deliverables will be in accordance with ENV-1-2.12, "Data Package Validation."

Routine data verification shall be performed in accordance with ENV-1-2.11, "Sampling Documentation Processing." Data validation will be in accordance with *Data Validation Procedure for Radiochemical Analysis* (BHI 2000b) and *Data Validation Procedure for Chemical Analysis* (BHI 2000a). Onsite and QTL data reviews will be according to method requirements. The validated data qualifier results shall be entered into the HEIS database.

Onsite measurements and QTL analysis data will not undergo a formal validation. The QA/QC processes used in SOPs will be followed to ensure useable data. These include the use of blanks, duplicates, splits, and measurement of known standards. The data will be reviewed by analytical personnel and the project team.

## II.5.2 DATA QUALITY ASSESSMENT

For interim closure verification data, a DQA will be performed to verify that the verification SFL data are suitable for their intended purpose to support site closure. The DQA shall include a review of the data validation results and a review of the laboratory data to the PARCC parameters (i.e., precision, accuracy, representativeness, completeness, and comparability). As a minimum, the laboratory QA/QC data shall be evaluated for adequacy to meet the requirements for precision, accuracy, completeness, and RDLs as defined below.

**Precision**

If calculated from duplicate measurements:

$$\mathrm{RPD} = \frac{(C_1 - C_2) \times 100}{(C_1 + C_2)/2} \qquad (1)$$

where:

RPD = relative percent difference
$C_1$ = larger of the two observed values
$C_2$ = smaller of the two observed values.

If calculated from three or more replicates, use relative standard deviation rather than RPD:

$$\mathrm{RSD} = (s/\bar{y}) \times 100 \qquad (2)$$

where:

RSD = relative standard deviation
s = standard deviation
$\bar{y}$ = mean of replicate analyses.

Standard deviation, s, is defined as follows:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(y_i - \bar{y})^2}{n-1}} \qquad (3)$$

where:

s = standard deviation
$y_i$ = measured value of the i[th] replicate
$\bar{y}$ = mean of replicate measurements
n = number of replicates.

**Accuracy** (4)

For measurements where matrix spikes are used:

$$\% R = 100 \text{ x} \left[ \frac{S - U}{C_{sa}} \right]$$

where:

%R = percent recovery
S = measured concentration in spiked aliquot
U = measured concentration in unspiked aliquot
$C_{sa}$ = actual concentration of spike added.

(5)

For situations where a standard reference material (SRM) is used instead of or in addition to matrix spikes:

$$\% R = 100 \text{ x} \left[ \frac{C_m}{C_{srm}} \right]$$

where:

%R = percent recovery
$C_m$ = measured concentration of SRM
$C_{srm}$ = actual concentration of SRM.

(6)

### Completeness

Defined as follows for all measurements:

$$\% C = 100 \text{ x} \left[ \frac{V}{T} \right]$$

where:

| | | |
|---|---|---|
| %C | = | percent completeness |
| V | = | number of measurements judged valid |
| T | = | total number of measurements. |

### Method Detection Limit

Defined as follows for nonradionuclide measurements:

$$MDL = t_{(n-1, 1-\alpha = 0.99)} \text{ x } S \qquad (7)$$

where:

| | | |
|---|---|---|
| MDL | = | method detection limit |
| S | = | standard deviation of the replicate analyses |
| $t_{(n-1, 1-\alpha = 0.99)}$ | = | students' t-value appropriate to a 99% UCL and a standard deviation estimate with n-1 degree of freedom. |

For radionuclides, the method detection limit will be per Currie calculations (Currie 1968).

## II.5.3 SPLIT SAMPLES

Split samples will be collected at frequencies described in Part III of this SAP. Split samples may be collected by regulatory agencies at any time deemed appropriate by the agencies.

Verification split sample data (both Hanford Site and regulator data) will undergo data analysis to assist in determining verification data usability. The EPA Contract Laboratory program duplicate sample comparison methodology *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 1994) will be used as an initial test. Specifically:

- A control limit of ±35% for the RPD shall be used for samples greater than or equal to five times the contract required detection limit (CRDL)

    or

- A control limit of ± two times CRDL shall be used if either the sample or a split sample value is less than five times the CRDL. In a case where only one result is above the five times CRDL level and the other is below, the ± two times CRDL criteria applies. If both samples are less than detectable, the RPD is not calculated.

If the data fall within one of the control limits listed above, then the split data correlate and no review is required. If the data do not fall within one of the control limits, additional data review is required. A qualified person will review the split sample data in detail. This review will include detection levels, internal laboratory split and internal laboratory duplicate values, validation reports, and other data deemed relevant. A narrative will be written describing why the original data should (or should not) be used. This narrative will be included in the CVP and RSVP and will be one of the elements reviewed by regulators prior to their approval of the cleanup documentation.

# PART III

## FIELD SAMPLING PLAN

The field sampling plan provides field procedures to ensure representative data of known quality.

# III.1 SAMPLING OBJECTIVES

The objectives of each sampling event are described in the following subsections. Confirmatory sampling applies only to the remaining sites. Sampling during excavation; sampling of overburden, layback, and imported backfill; and sampling for site verification and worker health and safety apply to the radioactive liquid effluent waste sites and to the remaining sites as appropriate. Additional sampling guidance will be found in the site-specific WIs for confirmation and verification sampling for the remaining sites.

## III.1.1 CONFIRMATORY SAMPLING

Confirmatory sampling is performed for remaining sites that require additional information to decide if the site needs to be remediated (Figure 1-7). Samples will be analyzed by a SFL for radionuclide and nonradionuclide COPCs to determine if the concentrations are above the RAG.

## III.1.2 EXCAVATION

The excavation will be monitored for radiological constituents using a variety of detectors including NaI detectors, photoionization detectors, organic vapor monitors, Geiger-Mueller detectors, or plastic scintillators, as appropriate. HPGe analyses require discrete samples. Discrete samples for nonradionuclides will be collected for metals analysis, as required. The data results will be used for material disposition decisions.

## III.1.3 OVERBURDEN AND LAYBACK

Overburden and layback soils will be sampled and analyzed to verify suitability for use as backfill. Samples will be analyzed for applicable COCs for evaluation against the limiting of shallow zone or deep zone verification criteria.

## III.1.4 IMPORTED BACKFILL

Imported backfill is soil taken from noncontaminated borrow sites. Acceptance or rejection of soils for backfill material will be based on existing knowledge of the prospective borrow areas.

## III.1.5 SITE VERIFICATION

At the end of excavation, site verification sampling will be conducted to verify that site soils do not contain COCs above the RAGs. Samples will be analyzed by an SFL for COC radionuclides and nonradionuclides.

### III.1.6 WORKER HEALTH AND SAFETY

Health and safety personnel will use data collected during the remediation as input to determine exposure levels to workers and to conduct health and safety assessments in accordance with the health and safety plan.

## III.2 SAMPLING LOCATIONS AND FREQUENCIES

### III.2.1 SAMPLING LOCATIONS

#### III.2.1.1 Sampling Locations for Remaining Sites

The development of specific sample locations will be presented in the site-specific WIs.

#### III.2.1.2 Sampling Locations for the Radioactive Liquid Effluent Waste Sites

The development of specific sample locations will be presented in the site-specific WIs.

### III.2.2 SAMPLING FREQUENCIES

#### III.2.2.1 Sampling Locations for Remaining Sites

The sampling frequencies for the remaining sites will be presented in the site-specific WIs.

#### III.2.2.2 Sampling Frequencies for the Radioactive Liquid Effluent Waste Sites

Table III-1 presents the sampling frequencies for excavation, overburden, imported backfill, and site verification for EPA lead radioactive liquid effluent waste sites. Overall frequencies and analytical methods are presented in Tables III-2, III-3, and III-4. Appendix F, specifically Table F-1, provides decision unit sizes in the shallow and deep zones.

Sampling locations for Ecology lead radioactive liquid effluent waste sites are site specific and will be documented in site specific-WIs.

## Table III-1. Sample Locations, Frequencies, and Sampling Methods for EPA Lead Radioactive Liquid Effluent Sites.

| Decision Objectives | Decision Boundaries | Physical Samples | |
|---|---|---|---|
| | | Number of Samples | Sampling Methods |
| 1. Excavation and disposal | Per Section I.5.1 | As site warrants | Grab from backhoe or in the excavation |
| 2. Overburden/layback | Appendix F, Table F-1 | Four composite samples per decision subunit:[a] divide subunits into four sections, collect four samples/quadrant, and composite to one sample[b] | Composite[b] |
| 3a. Site verification (shallow) (0 to 4.5 m [0 to 15 ft]) | Appendix F. Table F-1 | Four composite samples per decision subunit:[a] divide decision unit into four sections, collect four samples per section, and composite to one sample per section[c] | Composite[b] |
| 3b. Site verification (deep) (>4.5 m [>15 ft]) | Table III-6 | Three composite samples per decision subunit:[a] divide decision subunit into three sections, collect four samples per section, and composite to one sample | Composite[b] |
| 4. Backfill | Entire borrow pit | No samples | NA |

NOTE: Table III-1 is based on the DQO process for the first six 100-BC-1 waste sites to be remediated. Sampling locations (etc.) for Ecology lead radioactive liquid effluent waste sites are site specific and will be documented in site-specific work instructions.

[a] Decision subunits are defined in Appendix F.

[b] Tritium samples will be taken 15 cm (6 in.) below the excavation surface. If tritium is detected, a path forward will be developed with the lead regulatory agency for appropriate cleanup verification sampling (DOE-RL et al. 2007).

[c] Default plan; number of total samples may be revised per Appendix A.

DQO = data quality objective
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
NA = not applicable

## Table III-2. Sampling Frequencies and Analytical Methods for Excavation. (2 Pages)

| Field Activity | Analysis Objective | Analytical Parameters | Routine Sample Frequency[a] | Duplicates/ Splits | Laboratory Method |
|---|---|---|---|---|---|
| Sampling during excavation | Per Section I.5.1 | COCs | Per site conditions | 5% each | QTL/Table II-1 SFL/Table II-1 |
| Onsite measurements | Guide excavation | COCs (gamma) | 50% surface coverage (boundary)[b] | NA | Field instruments (NaI, HPGe) (Table II-1) |
| | | COCs (gamma) | 20% surface coverage (internal)[b] | NA | Field instruments (NaI, HPGe) (Table II-1) |
| | | COCs (alpha, beta) | As required | NA | Field instruments (Table II-1) |

**Table III-2. Sampling Frequencies and Analytical Methods for Excavation. (2 Pages)**

| Field Activity | Analysis Objective | Analytical Parameters | Routine Sample Frequency[a] | Duplicates/ Splits | Laboratory Method |
|---|---|---|---|---|---|
| | | Metals | As required | NA | XRF (Table II-1) |
| Sampling during excavation | Health and safety monitoring | Per health and safety requirements | Per health and safety requirements | Per health and safety requirements | Per health and safety requirements |

NOTE: Table III-2 is based on the DQO process for the first six 100-BC-1 waste sites to be remediated.
[a] The values presented are starting point and may be adjusted up or down dependent on site conditions.
[b] Boundary includes sides, laybacks, and bottom of contaminated excavations; internal is during mass excavation.
COCs = contaminants of concern
DQO = data quality objective
NA = not applicable
QTL = quick-turnaround laboratory
SFL = standard fixed laboratory
XRF = x-ray fluorescence

**Table III-3. Sampling Frequencies and Analytical Methods for Overburden/ Backfill and Imported Backfill at EPA Lead Sites.**

| Field Activity | Analysis Objective | Analytical Parameters | Routine Sample Frequency | Duplicates/ Splits | Laboratory/ Method |
|---|---|---|---|---|---|
| Overburden/ layback sampling | Meet RAGs | COCs | Four composite samples/Table III-1 approximately 5%/SFL | 5% each; minimum of one per waste site | QTL/Table II-1 SFL/Table II-1 |

NOTE: Table III-1 is based on the DQO process for the first six 100-BC-1 waste sites to be remediated. Sampling locations (etc.) for Ecology lead radioactive liquid effluent waste sites are site specific and will be documented in site-specific work instructions.
COC = contaminant of concern
DQO = data quality objective
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
QTL = quick-turnaround laboratory
RAG = remedial action goal
SFL = standard fixed laboratory

**Table III-4. Sampling Frequencies and Analytical Methods for Site Verification for EPA Lead Radioactive Liquid Effluent Sites.**

| Field Activity | Analysis Objective | Analytical Parameters | Routine Sample Frequency | Duplicates/ Splits | Laboratory/ Method |
|---|---|---|---|---|---|
| **Site Verification 0 to 4.5 m (0 to 15 ft) Shallow Zone** | | | | | |
| Verification sampling | Meet RAGS | COCs | Table III-1 | 5% each; minimum of one per waste site | SFL/Table II-1 |
| **Site Verification >4.5 m (15 ft) Deep Zone** | | | | | |
| Verification sampling | Meet RAGS | COCs | Table III-1 | 5% each; minimum of one per waste site | SFL/Table II-1 |

NOTE: Sampling locations (etc.) for Ecology lead radioactive liquid effluent waste sites are site specific and will be documented in site-specific work instructions.

COC = contaminant of concern
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
RAG = remedial action goal
SFL = standard fixed laboratory

## III.3 SAMPLING METHODS

Sampling methods for EPA lead radioactive liquid effluent waste sites are shown in Table III-1. Sampling will follow SOPs per ENV-1.

Sampling methods for the remaining sites and Ecology lead radioactive liquid effluent waste sites are site specific and will be documented in site-specific WIs. All verification samples for tritium will be taken 15 cm (6 in.) below the excavation surface. If tritium is detected, a path forward will be developed with the lead regulatory agency for appropriate cleanup verification sampling.

## III.4 FIELD QUALITY CONTROL SAMPLING

Field QC sampling requirements for the remaining sites and the radioactive liquid effluent waste sites are summarized in Tables III-5 and III-6, respectively.

**Table III-5. Field Quality Control Sampling Requirements Summary for Remaining Sites.**

| QC Sample Type | Application | Frequency Reference |
|---|---|---|
| Trip blanks | Not applicable; volatile organic sampling only | -- |
| Equipment rinsates (blanks) | All sampling | One sample per waste site |
| Field source water blanks | Not applicable; field water or steam cleaning equipment only | -- |
| Field duplicates | All sampling | 5% of all samples or a minimum of one sample per waste site |

-- = not applicable
QC = quality control

**Table III-6. Field Quality Control Sampling Requirements Summary for Radioactive Liquid Effluent Sites.**

| QC Sample Type | Application | Frequency Reference |
|---|---|---|
| Trip blanks | Not applicable; volatile organic sampling only | -- |
| Equipment rinsates (blanks) | All sampling | One sample per waste site |
| Field source water blanks | Not applicable; field water or steam cleaning equipment only | -- |
| Field duplicates | All sampling | 5% of all samples or a minimum of one sample per sampling unit[a] |
| Field splits | All sampling | 5% of all samples or a minimum of one sample per sampling unit[a] |

[a] Sampling unit is the decisional unit (e.g., overburden/layback, deep zone, or shallow zone)
-- = not applicable
QC = quality control

# III.5 SAMPLE MANAGEMENT

This section applies to both radioactive liquid effluent waste sites and the remaining sites.

## III.5.1 SAMPLE CUSTODY

### III.5.1.1 Field Custody

All samples obtained during the course of this project will be controlled from the point of origin to the analytical laboratory as required by ENV-1, ENV-1-2.13, "Chain of Custody."

### III.5.1.2 Laboratory Custody Procedures

Sample custody during laboratory analysis will be addressed in the applicable laboratory SOPs. Laboratory custody procedures will ensure the maintenance of sample integrity and identification throughout the analytical process.

## III.5.2 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES

Sample preservation and container details will be addressed in the sample authorization form in accordance with ENV-1, ENV-1-2.10, "Sample Event Coordination."

## III.5.3 SAMPLE SHIPPING

Sample packaging and shipping will be performed in accordance with ENV-1, ENV-1-2.14, "Sample Packaging and Shipping."

## III.5.4 FIELD DOCUMENTATION

All relevant documents, records, reports, logs, field notebooks, pictures, subcontract reports, and analytical reports will be submitted, secured, and stored in accordance with ENV-1, ENV-1-2.5, "Field Logbooks."

## III.5.5 SAMPLE WASTE MANAGEMENT

Waste generated by sampling activities will be managed in accordance with WMT-1, *Waste Management and Transportation,* and the site-specific waste management instruction. Unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. Pursuant to 40 CFR 300.440(a)(5), Remedial Action project manager approval is required before returning unused samples or waste from offsite laboratories.

Approval of this SAP constitutes Remedial Action project manager approval for shipment of offsite and onsite laboratory sample waste back to the waste site or origin.

# III.6 REFERENCES

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# APPENDIX A

# STATISTICAL APPROACH FOR DETERMINING THE NUMBER OF SAMPLES FOR VERIFICATION AND OVERBURDEN/LAYBACK FOR RADIOACTIVE LIQUID EFFLUENT WASTE SITES

# APPENDIX A

# STATISTICAL APPROACH FOR DETERMINING THE NUMBER OF SAMPLES FOR VERIFICATION AND OVERBURDEN/LAYBACK FOR RADIOACTIVE LIQUID EFFLUENT WASTE SITES

## A.1 GENERAL DISCUSSION OF THE STATISTICAL MODEL

The statistical approach for determining the number of samples for verification and overburden/layback sampling is based on the minimum detectable difference approach presented in the U.S. Environmental Protection Agency (EPA) guidance document *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989). This statistical procedure is based on classical statistical hypothesis tests, which also form the basis for the primary statistic calculated to support the verification decisions. This statistic is the 95% upper confidence limit (UCL) of the mean. The underlying statistical distribution is typically assumed to be a normal distribution when calculating the number of samples to be collected. The benefit of the assumption of normality is that relatively simple formulae can be used to calculate the number of samples needed to meet statistical performance requirements (false-positive and false-negative error rates). The formulae are based on the Student's "t-test." Further details are provided in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987).

The minimum detectable difference approach requires the following specifications. First, the desired rates of false-positive and false-negative errors are selected. Second, the target cleanup levels are established. Third, the null hypothesis must be designated. The null hypothesis can be viewed as the working hypothesis regarding the state of nature. Based on the EPA guidance document (EPA 1989), the null hypothesis assumes that the site is dirty, and environmental data will be collected to show that the site has attained the cleanup goals. Fourth, the hypothesis testing value is specified. In this case, the hypothesis testing value is selected as the concentration in soil equal to the remedial action goal (lookup value). The reason for selecting the lookup value as the hypothesis testing value is to be consistent with the comparison used to document site closeout where the UCL must be less than the lookup value. Fifth, the variability within the decision units must be estimated. Readers should note that the size of the decision unit is not explicitly included in this approach, but typically the variability of the contaminants of concern (COCs) within the decision unit will be related to the physical size of the unit; therefore, it considers size implicitly. Historical data obtained from *Radiological Characterization of the Retired 100 Areas* (Dorian and Richards 1978) were used to estimate variability and likely residual concentrations.

## A.2 CALCULATION OF THE STATISTICAL PERFORMANCE OF ALTERNATE DESIGNS

The generic design strategy included collecting either grab or composite samples. The general design strategy also evaluates performing a number of laboratory analyses on these samples, assuming a normal contaminant distribution. Given the general statistical model described above, statistical performance was evaluated using historical data for limiting COCs (Dorian and Richards 1978) by calculating the power of a design of grab (NC=1) or composite (NC=4,8) samples, and NA analyses for the decision unit (4,8,16). For example, a design of NC=1 and NA=4 represents four analyses of grab samples from the site. Alternately, a design of NC=1 and NA=8 represents eight analyses of grab samples. Microsoft® Excel was used for the power calculations, and the formulae used are summarized by the following:

tquan = (HT-LV)/SQRT((AE*LV/SQRT(NA))^2+(SE*LV/SQRT(NC))^2)-TINV(2*alpha,NA-1)

power = 1-TDIST(ABS(*tquan*,*NA*-1,1)

where:

| | | |
|---|---|---|
| HT | = | hypothesis testing value (equal to the lookup value) |
| AE | = | analytical error, as a relative percent difference |
| NA | = | number of analyses for the closeout decision unit |
| SE | = | sampling error, as a relative variability (standard deviation/mean calculated from historical data) |
| NC | = | number of aliquots in each composite sample, where NC=1 is a grab sample |
| alpha | = | alpha level = 0.05 |
| LV | = | likely value (the mean calculated from historical data) |
| SQRT | = | Excel square root function |
| TINV,TDIST | = | Excel Students T - distribution function |
| False-negative error rate | = | 1 – power. |

Designs were deemed to be acceptable if the power at the likely value was 80% or greater. This corresponds to a false-negative rate of 20% or less.

## A.3 DEFINITIONS AND SPECIFICATIONS OF KEY DESIGN INPUTS

1. Null hypothesis: The site is contaminated.

2. False-positive error: The false-positive error is defined as the probability that the decision unit will be declared clean when it is actually dirty. A 5% false-positive rate is consistent

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with the need to calculate a 95% UCL of the mean and was selected for the statistical calculations.

3. False-negative error: The false-negative error is defined as the probability that the decision unit will be declared dirty when it is actually clean. A false-negative error rate of 20% will be used in the statistical calculations.

4. The target cleanup levels are summarized in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (100 Area RDR/RAWP) (DOE-RL 2009).

5. The standard deviation used in the calculations is based on radionuclide sample data for specific isotopes (cobalt-60, cesium-137, and europium-152) as presented in Dorian and Richards (1978).

6. The assumed analytical variability was defined as two values (10% and 50% relative standard errors) that are expected to span the range of analytical performance for field, quick-turnaround laboratory, and standard fixed laboratory methods.

7. The likely value expected for the COCs are points used to determine if the design meets the statistical decision performance requirements. The likely value is calculated as the mean value of indicator radionuclides from data presented in Dorian and Richards (1978).

## A.4 STATISTICAL PERFORMANCE OF THE SHALLOW ZONE VERIFICATION AND OVERBURDEN/LAYBACK SAMPLING

The shallow zone statistical design was based on historical data for three radionuclides: cobalt-60, cesium-137, and europium-152. These radionuclides were chosen because of the following factors: (1) their contribution to risk at these sites, (2) the availability of historical data, and (3) the ability to obtain quantitative measures of their abundance with onsite measurement instruments during excavation. The distribution of the data was assumed to be normal.

The statistical performance of alternate designs for the shallow zone verification and overburden/layback sampling is summarized in Table A-1. There are two important findings evident in this table. First, the variability of the analytical method has little impact on the expected statistical performance. Second, making composite samples with more aliquots is an efficient way to improve statistical performance. Thus, a design that uses a composite sampling approach versus a design that emphasizes collection of more grab samples will be more cost efficient. The limiting radionuclide in the design calculation was cesium-137. To meet the requirement of 80% power for this radionuclide would require four sets of analyses of four-aliquot composite samples (78% for NA=4, NC=4 for the cesium-137 design). Project engineers

**Table A-1. Summary of the Statistical Performance of Alternate Designs for the Shallow Zone Verification and Overburden/Layback Sampling.**

| COC | Likely Value (pCi/g) | Sampling Error | Design Option | | Power | |
|---|---|---|---|---|---|---|
| | | | NA[a] | NC[b] | AE=10% | AE=50% |
| Co-60 | 0.3 | 167% | 4 | 1 | 0.299 | 0.291 |
| | | | | 4 | 0.930 | 0.914 |
| | | | | 8 | 0.987 | 0.981 |
| | | | 8 | 1 | 0.588 | 0.582 |
| | | | | 4 | 0.987 | 0.985 |
| | | | | 8 | 0.999 | 0.999 |
| | | | 16 | 1 | 0.675 | 0.673 |
| | | | | 4 | 0.996 | 0.996 |
| | | | | 8 | >0.999 | >0.999 |
| Cs-137[c] | 2 | 105% | 4 | 1 | 0.169 | 0.160 |
| | | | | 4 | 0.781 | 0.679 |
| | | | | 8 | 0.958 | 0.898 |
| | | | 8 | 1 | 0.380 | 0.370 |
| | | | | 4 | 0.936 | 0.913 |
| | | | | 8 | 0.994 | 0.988 |
| | | | 16 | 1 | 0.467 | 0.462 |
| | | | | 4 | 0.966 | 0.959 |
| | | | | 8 | 0.999 | 0.998 |
| Eu-152 | 1.4 | 57% | 4 | 1 | 0.307 | 0.248 |
| | | | | 4 | 0.930 | 0.752 |
| | | | | 8 | 0.986 | 0.883 |
| | | | 8 | 1 | 0.600 | 0.557 |
| | | | | 4 | 0.988 | 0.963 |
| | | | | 8 | 0.999 | 0.993 |
| | | | 16 | 1 | 0.687 | 0.667 |
| | | | | 4 | 0.996 | 0.992 |
| | | | | 8 | >0.999 | >0.999 |

[a] Number of analyses for the decision unit.
[b] Number of aliquots per composite samples.
[c] Cs-137 was identified as the limiting COC for the default design.
COC = contaminant of concern

should note that performance for the default eight-aliquot composite sample design shows greater power, and meets the 20% false-negative error rate for the high analytical measurement error scenarios (AE=50%). Thus, forming composite samples with more aliquots should be considered for some sites.

The data presented in Table A-2 and summarized in Table A-1 are based on historical data collected by Dorian and Richards (1978). Although the historical data were used to develop the verification sampling design, it should be noted that the number of verification samples to be taken for each site is reevaluated based on post-excavation variance sampling as described in Section G.4.3 of the 100 Area RDR/RAWP (DOE-RL 2009).

## A.5 STATISTICAL PERFORMANCE OF THE DEEP ZONE VERIFICATION SAMPLING

As noted in Section A.4, the statistical design for the shallow zone was based on three radionuclides: cobalt-60, cesium-137, and europium-152. A different strategy for the statistical assessment of the deep zone closeout design is necessitated by the lack of quantitative lookup values for cobalt-60, cesium-137, europium-152, and most other COCs. The deep zone closeout criteria are limited to three constituents: hexavalent chromium, uranium-233/234, and uranium-238 (the other constituents with deep zone cleanup criteria were eliminated from the COC list based on the exclusions noted in Table I-2).

There are limited historical data for these COCs in the 100 Area Group 1 and Group 2 sites, and these COCs will not be directly measured by in situ gamma measurements. The lookup value for hexavalent chromium is a river protection remedial action goal that is based on the ambient water quality criteria applied to a dilution/attenuation factor. The lookup values for uranium-233/234 and uranium-238 were developed using the RESRAD analytical model (ANL 2007).

The hexavalent chromium lookup value is approximately 20 times the detection limit, and the uranium lookup values are approximately 2 times the background value. The default sampling strategy selected for the deep zone is recommended as three sets of four-aliquot composite samples. The reason for selecting three composite samples is that it is the minimum number required to statistically estimate the mean and standard deviation. Project engineers may have to develop contingency sampling plans for sites where hexavalent chromium and uranium-238 are measured above the deep zone lookup values. The EPA guidance document (EPA 1989) contains useful information on the application of statistics to attainment of cleanup standards.

### Table A-2. 100-BC-1 Data from Dorian and Richards (1978).

| Site | ID[a] | Depth | Type | Co-60 (pCi/g) | Cs-137 (pCi/g) | Eu-152 (pCi/g) |
|---|---|---|---|---|---|---|
| 116-B-5 | V-25 | 7.6 m (25 ft) | Perimeter | 0.06[a] | 18 | |
| | X-0 | 0 | Perimeter | 4.5 | 5.7[a] | 17 |
| | Y-0 | 0 | Perimeter | 2.3 | 1.4[a] | 2.4[a] |
| | Y-20 | 6.1 m (20 ft) | Perimeter | 1.9 | 11 | 1.6[a] |
| | Z-0 | 0 | Perimeter | 11 | 13 | 48 |
| | AA-0 | 0 | Perimeter | 14 | 20 | 63 |
| | AA-5 | 1.5 m (5 ft) | Perimeter | 21 | 0.59[a] | 0.89[a] |
| | CC-0 | 0 | Perimeter | 51 | 20 | 33 |
| | CC-5 | 1.5 m (5 ft) | Perimeter | 13 | 4.6[a] | 1.4[a] |
| | CC-10 | 3 m (10 ft) | Perimeter | 1.5[a] | | 0.43[a] |
| 116-B-11 | F-20 | 6.1 m (20 ft) | Perimeter | 0.12[a] | 0.07[a] | |
| | B-20 | 6.1 m (20 ft) | Perimeter | 0.05[a] | 0.1[a] | |
| | P-5 | 1.5 m (5 ft) | Perimeter | 2.1 | 1.4[a] | 2.6[a] |
| | P-15 | 4.5 m (15 ft) | Perimeter | 0.44[a] | 2[a] | 1.2[a] |
| | P-25 | 7.6 m (25 ft) | Perimeter | 0.08[a] | 18 | |
| | S-25 | 7.6 m (25 ft) | Perimeter | 0.16[a] | 13 | 0.28[a] |
| | C-0 | 0 | Perimeter | 24 | 4.1[a] | 550 |
| | C-10 | 3 m (10 ft) | Perimeter | 0.08[a] | 0.18[a] | 1.4[a] |
| | O-9 | 2.7 m (9 ft) | Sludge | 160 | 81 | 99 |
| | 0-12 | 3.7 m (12 ft) | Sludge | 38 | 47 | 27 |
| | 0-18 | 5.5 m (18 ft) | Sludge | 12 | 30 | 13 |
| | R-5 | 1.5 m (5 ft) | Sludge | 2.9 | 100 | 2 |
| | R-25 | 7.6 m (25 ft) | Sludge | 0.08 | 3.6 | 0.28 |
| | G-10 | 3 m (10 ft) | Sludge | 54 | 130 | 31 |
| | G-15 | 4.5 m (15 ft) | Sludge | 260 | 90 | 150 |
| | G-20 | 6.1 m (20 ft) | Sludge | 10 | 39 | 7.1 |
| | K-20 | 6.1 m (20 ft) | Sludge | 1.4 | 0.48 | 0.64 |

[a] These data were used to estimate the likely value and sampling error for the shallow zone statistical design analysis.

## A.6 DEVELOPING SITE-SPECIFIC NUMBERS OF VERIFICATION SAMPLES

Sections A.4 and A.5 described the default number of verification samples. When feasible, Equation A-1 should be used to determine if the default verification sampling plan is adequate. This computation uses the site variance to determine the number of samples that should be collected for site verification. However, at a minimum the default number of samples should be collected even in cases where Equation A-1 yields a number of samples less than the default number.

The number of samples computed using Equation A-1 is strongly dependent on the variability of the target compounds used to approximate the standard deviation of the site. For this reason, the number of samples computation is commonly referred to as "variance assessment," and the corresponding data are derived from discrete "variance samples." Typically, cobalt-60, cesium-137, and europium-152 are chosen as target compounds for variance analysis; however, other target compounds may be more appropriate. The project will determine the appropriate target compounds for variance analysis and document, as appropriate, in the clean site verification documentation.

The formula for estimating the number of samples is as follows:

$$n = \frac{\left(z_{1-\alpha} + z_{1-\beta}\right)^2}{\left(\frac{HT - LV}{S}\right)^2} \qquad \text{(Equation A-1)}$$

where:

| | | |
|---|---|---|
| $n$ | = | number of samples for decision unit |
| $LV$ | = | likely value (the mean calculated from data) |
| $\alpha$ | = | tolerable decision error for mistakenly concluding the site is clean |
| $z_{1-\alpha}$ | = | the quantile from the standard normal distribution such that $\Pr(z > Z_{1-\alpha}) = \alpha$; $= 1.645$ for $\alpha = 5\%$ |
| $\beta$ | = | tolerable decision error for mistakenly concluding the site is dirty |
| $z_{1-\beta}$ | = | the quantile from the standard normal distribution such that $\Pr(z > Z_{1-\beta}) = \beta$; $= 0.842$ for $\beta = 20\%$ |
| $HT$ | = | hypothesis testing value (equal to the lookup value) |
| $S$ | = | standard deviation of site. |

This formula is an adaptation of Equation 6.6 in the EPA guidance document (EPA 1989).

The spreadsheet setup for computing the required number of samples per Equation A-1 is as follows:

= ROUNDUP((1.645+0.842)^2/(((***HT-LV***)/***S***)^2),0)
(for $\alpha$= 5%, $\beta$ = 20%)

If the number of samples is significantly greater than the default number planned for verification sampling, do a rough cost comparison. This cost comparison will trade off the cost of sampling (estimated as $2,100 per analysis) versus the cost of additional removal (estimated at $62 per cubic yard). If the cost of sampling is greater than the cost of additional remediation, consider continuing to remove contamination to reduce either the mean or the standard deviation. Reduction in the statistical parameters will reduce the sampling needed to show attainment of the cleanup standards.

## A.7 SUMMARY OF DATA USED TO SUPPORT THE STATISTICAL PERFORMANCE CALCULATIONS

See Table A-2 for a summary of the 100-BC-1 data collected by Dorian and Richards (1978) that supports the statistical performance calculations.

## A.8 REFERENCES

40 CFR 141, "Federal Safe Drinking Water Act," *Code of Federal Regulations*, as amended.

ANL, 2007, *RESRAD for Windows*, Version 6.4, Argonne National Laboratory, Environmental Assessment Division, Argonne, Illinois.

DOE-RL, 2009, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 6, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Dorian, J. J. and V. R. Richards, 1978, *Radiological Characterization of the Retired 100 Areas*, UNI-946, United Nuclear Industries, Richland, Washington.

EPA, 1989, *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media*, EPA 230/02-89-042, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication Number 9285.7, U.S. Environmental Protection Agency, Washington, D.C.

Gilbert, R. O., 1987, *Statistical Methods for Environmental Pollution Monitoring*, John Wiley & Sons, New York, New York.

WAC 246-290, "Public Water Supplies," *Washington Administrative Code*, as amended.

# APPENDIX B

# ANALYTICAL STANDARD OPERATING PROCEDURES

# APPENDIX B

# ANALYTICAL STANDARD OPERATING PROCEDURES

## ONSITE MEASUREMENTS

| | |
|---|---|
| ENV-1-2.24 | Routine Field Screening |
| WCH-314 | Sampling and Characterization Quality Assurance Program Plan |

## QUICK TURNAROUND LABORATORY

| | |
|---|---|
| HNF-SD-CP-QAPP-017 | WSCF Quality Assurance Plan |
| Test America[a] | Corporate Analytical Procedures and Quality Assurance Plan |
| Eberline Services/Lionville Laboratory Inc. | Corporate Analytical Procedures and Quality Assurance Plan |
| HNF-SD-CP-QAPP-019 | WSCF IH Quality Assurance Plan (asbestos) |

## STANDARD FIXED LABORATORY

| | |
|---|---|
| Eberline Services/ Lionville Laboratory Inc. | Corporate Analytical Procedures and Quality Assurance Plan |
| Test America[a] | Corporate Analytical Procedures and Quality Assurance Plan |

[a] The Test America Laboratory was formerly Severn Trent Laboratory.

## REFERENCE

ENV-1, *Environmental Monitoring & Management*, Washington Closure Hanford, Inc., Richland, Washington.

WCH-314, *Sampling and Characterization Quality Assurance Program Plan*, 2009, Rev. 0, 3 vols., Washington Closure Hanford, Richland, Washington.

# Appendix B – Analytical Standard Operating Procedures

# APPENDIX C

# LEACHABILITY OF 100 AREA SOILS

# APPENDIX C

# LEACHABILITY OF 100 AREA SOILS

## C.1 INTRODUCTION

The Environmental Restoration Contractor conducted leachability tests of the 100 Area soils. The goal of the tests was to determine the land disposal restriction (LDR) status of the worst-case waste form. The decision logic was as follows:

- If worst-case waste did not contain characteristic dangerous waste, then none of the liquid waste sites would contain characteristic dangerous waste. Characteristic dangerous waste results in waste exceeding LDR criteria.

- Additional project constraints included the need for rapid analysis results to support excavation and a need to minimize analytical costs. The toxicity characteristic leaching procedure (TCLP) used to test for characteristic dangerous waste is costly and requires at least 3 days of analysis time.

## C.2 BACKGROUND

A significant aspect of monitoring in the 100 Area remediation projects is demonstration of compliance with the *Environmental Restoration Disposal Facility Waste Acceptance Criteria* (WCH 2008) and LDR treatment standards. In order for waste to be placed in the Environmental Restoration Disposal Facility (ERDF), the metals concentration must be less than the ERDF waste acceptance criteria, which includes the LDR criteria. The LDR limits are based on waste leachability. The LDR status may only be determined by TCLP analysis (characteristic dangerous wastes per 40 *Code of Federal Regulations* 261.24).

## C.3 HISTORICAL DATA AND PROCESS KNOWLEDGE

The limited field investigation (LFI) data identify the locations of a worst-case waste form. As shown in Table C-1, the metals concentration from the LFI for the sites of interest was lower than the LDR indicator levels, except for the 116-C-5 sludge (as indicated by bold borders), which showed the potential presence of LDR materials in the 116-C-5 Retention Basin.

Further investigation of the two aboveground, steel retention basin tanks in 116-C-5 was performed. The tank supplier was called. The supplier indicated that the steel retention basin tank walls had been painted with a lead-based primer on the outside wall of the tanks. The sides of the tanks were cut and removed, leaving a metal pan on a concrete pad.

**Table C-1. 100-BC-1 Operable Unit Waste Site Remediation Limited Field Investigation Data Comparison – Metals Totals (mg/kg).**

| LDR 20 x TCLP Values | Ag | As | Ba | Cd | Cr | Hg | Pb | Se |
|---|---|---|---|---|---|---|---|---|
| | 100 | 100 | 2,000 | 20 | 100 | 4.0 | 100 | 20 |
| 116-B-1 (15 ft) | ND | -- | 104.0 | -- | 33.0 | ND | 5.8 | -- |
| 116-B-1 (17.5 ft) | ND | -- | 64.4 | -- | 6.9 | ND | 5.2 | -- |
| 116-B-1 (20 ft) | ND | -- | 79.9 | -- | 22.0 | ND | 5.6 | -- |
| 116-B-1 (25 ft) | ND | -- | 55.1 | -- | 10.2 | ND | 4.0 | -- |
| 116-C-5 (0 ft) | 1.3 | -- | 260.0 | -- | 15.1 | ND | 12.6 | -- |
| 116-C-5 (10 ft) | 1.7 | -- | 97.6 | -- | 11.8 | ND | 6.8 | -- |
| 116-C-5 (20 ft) | 1.9 | -- | 113.0 | -- | 16.6 | ND | 7.0 | -- |
| 116-C-5E Sludge | 1.3 | -- | 97.0 | -- | **609** | 3.4 | **564** | -- |
| 116-C-5W Sludge | 1.23 | -- | 91.4 | -- | **270** | **4.3** | **180** | -- |

NOTE: Bold indicates the metals concentration was higher than the LDR indicator levels.
LDR = land disposal restricted
ND = not detected
TCLP = toxic characteristic leaching procedure

## C.4 LEACHABILITY STUDY

After recognizing the existence of a worst-case waste form and the need to verify its LDR status, the Environmental Restoration Contractor initiated a sludge sampling and analysis effort. Data from this study are presented in Table C-2, and data from the 116-C-5 Retention Basin are presented in Table C-3.

Sampling was initially planned for the 116-C-5 Retention Basin and the 116-B-13 and 116-B-14 Trenches. Before sampling was initiated, high radiological levels were reported in the fine-grained sands under the discharge pipe at the 116-C-1 demonstration project. Therefore, 116-C-1 Trench sand was added to the sludge sampling effort.

The analytical results are summarized in Tables C-2 and C-3. Of the samples, 15 cases occurred where the total metals concentration exceeded the LDR indicator values of 20 times TCLP leachate concentration (indicated by double-lined cell borders). As shown in Table C-3, only two TCLP results exceeded LDR limits. These two samples were taken from a location outside the tank boundary and against the concrete pad.

**Table C-2. Toxicity Characteristic Leachate Procedure Characterization Analytical Results Totals (mg/kg) (TCLP [mg/L]).**

| 20 x TCLP/ LDR Limit | Ag | As | Ba | Cd | Cr | Hg | Pb | Se |
|---|---|---|---|---|---|---|---|---|
| | 100/5.0 | 100/5.0 | 2,000/100 | 20/1.0 | 100/5.0 | 4.0/0.2 | 100/5.0 | 20/1.0 |
| 116-C-1 (Z7) | 2.1/<0.5 | 17.1/<1.0 | 95.3/<10 | 5.9/<0.1 | 681/<0.5 | 18.4/<0.02 | 182/<1.0 | 6.2/<0.1 |
| 116-C-1 (Z8) | 2.1/<0.5 | 16.1/<1.0 | 80.2/<10 | 8.1/<0.1 | 2,190/<0.5 | 46/<0.02 | 337/<1.0 | 6.4/<0.1 |
| 116-C-1 (Z9) | 1.0/<0.5 | 3.3/<1.0 | 72.5/<10 | 1.8/<0.1 | 107/<0.5 | 9.8/<0.02 | 37/<1.0 | 3.1/<0.1 |
| C-107 Diver Box (K3) | 2.5/0.003 | 20.7/0.66 | 54.0/0.36 | 11.2/0.02 | 2,360/0.04 | 4.0/0.0001 | 1,960/0.23 | 0.12 /0.05 |
| C-107 Diver Box (K4) | 0.5/0.005 | 2.4/0.66 | 79.1/0.77 | 2.5/0.02 | 97.3/0.006 | 0.36/0.0001 | 88.3/0.03 | 0.11/0.04 |
| C-107 Diver Box (K5) | 0.5/0.005 | 4.6/0.066 | 206/0.68 | 4.9/0.017 | 267/0.017 | 2.4 /0.0001 | 116/0.038 | 0.15 /0.047 |
| 116-C-5 E (L1) | 2.5/0.005 | 39.8/0.06 | 51.3/0.5 | 1.7/0.006 | 574/0.02 | 1.9/0.00 | 587/4.2 | 0.1/0.04 |
| 116-C-5W (L3) | 2.5/0.005 | 4.0/0.06 | 42.5/0.46 | 5.7/0.01 | 3,910/0.04 | 1.7/0.00 | 3,080/1.3 | 0.1/0.04 |
| 116-C-5W (J8) | 2.5/0.005 | 2.5/0.06 | 36.7/0.48 | 4.4/0.01 | 2,890/0.03 | 1.8/0.00 | 2,540/0.48 | 0.1/0.04 |
| 116-C-5W (K0) | 2.5/0.005 | 3.4/0.06 | 12.5/0.31 | 3.8/0.01 | 3,230/0.13 | 3.8/0.00 | 2,000/1.2 | 0.1/0.04 |
| 116-C-5W (K2) | 2.5/0.005 | 4.0/0.06 | 46.0/0.46 | 5.7/0.01 | 2,550/0.05 | 1.3/0.00 | 2,130/1.2 | 0.1/0.04 |
| 116-B-14 (K4) | 2.5/0.02 | 2.5/0.2 | 139/0.26 | 3.2/0.02 | 1,640/0.04 | 0.34/0.00 | 82.2/0.14 | 0.1/0.19 |
| 116-B-14 (K6) | 2.5/0.02 | 2.2/0.26 | 185/0.29 | 4.0/0.02 | 1,450/0.05 | 0.29/0.00 | 49.5/0.14 | 0.1/0.19 |
| 116-B-14 (K8) | 2.5/0.02 | 2.6/0.26 | 131/0.25 | 2.2/0.01 | 1,200/0.04 | 0.23/0.00 | 26.2/0.14 | 0.1/0.19 |

NOTE: Double-lined cell borders indicate the total metals concentration exceeded the LDR indicator values.
LDR = land disposal restricted
TCLP = toxic characteristic leaching procedure

**Table C-3. Toxicity Characteristic Leachate Procedure Characterization Analytical Results from 116-C-5 E Totals (mg/kg) (TCLP [mg/L]).**

| | Ag | As | Ba | Cd | Cr | Hg | Pb | Se |
|---|---|---|---|---|---|---|---|---|
| **20 x TCLP/ LDR Limit** | **100/5.0** | **100/5.0** | **2,000/10 0** | **20/1.0** | **100/5.0** | **4.0/0.2** | **100/5.0** | **20/1.0** |
| **116-C-5 E** (K7) | 0.5/0.01 | 3.0/0.06 | 249/0.55 | 1.6/0.007 | 53.3/0.006 | 0.43/0.00 | 1,110/8.1 | 0.1/.047 |
| **116-C-5 E** (K9) | 2.5/0.005 | 6.0/0.06 | 73.7/1.1 | 5.1/0.03 | 1,900/0.06 | 33.1/0.001 | 2,500/11.5 | 0.1/0.04 |

LDR = land disposal restricted
TCLP = toxic characteristic leaching procedure

## C.5 CONCLUSIONS

The conclusions are as follows:

- The media examined in leachability tests demonstrated the physical characteristics of 100 Area soils and are worst-case examples of materials that would be expected to be contained in 100 Area soils. It has been established that general waste forms at the 100 Area reactor sites are analogous. Therefore, what has been determined for materials found in the 100-BC-1 Operable Unit may be applied (with confirmation, as necessary) to analogous sites at other 100 Area operable units with concurrence of the lead regulatory agency. The leachability study results are applicable to waste characterization for disposal at ERDF, and are not applicable to remediation samples for cleanup verification.

- It is evident from the LFI and the leachability results that there is a worst-case waste form in comparison with the typical 100-BC-1, Group 1, contaminated soils (Table C-1). This worst-case waste included retention basin sludge, reactor coolant diversion/junction box sludge, and fine-grained bedding sand under liquid discharge pipes.

- TCLP data from worst-case waste, shown in Table C-2, indicate that the waste exhibiting metals concentrations above the LDR indicator values does not leach and is not LDR waste.

- Table C-3 and the process knowledge of the 116-C-5 Retention Basin indicate that this waste is not typical of the other processes and potentially exceeds LDR limits. This waste will be removed, treated, and disposed separately before general remediation. This waste only consists of the material surrounding the two tanks in 116-C-5 and contains residuals from the lead-based paint.

## C.6 REFERENCES

40 CFR 261.24, "Toxicity Characteristics," *Code of Federal Regulations*, as amended.

WCH, 2008, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, WCH-191, Washington Closure Hanford, Richland, Washington.

# APPENDIX D

# 116-C-5 LEACHABILITY STUDY

# APPENDIX D

# 116-C-5 LEACHABILITY STUDY

## D.1 INTRODUCTION

The following discussion of a leachability study conducted on waste materials from a specific site is included as an example of leach testing subsequently performed in support of waste characterization on analogous waste forms at other 100 Area operable units. The information included in this appendix is considered valuable as historical information for characterization of waste materials disposed of at the Environmental Restoration Disposal Facility (ERDF).

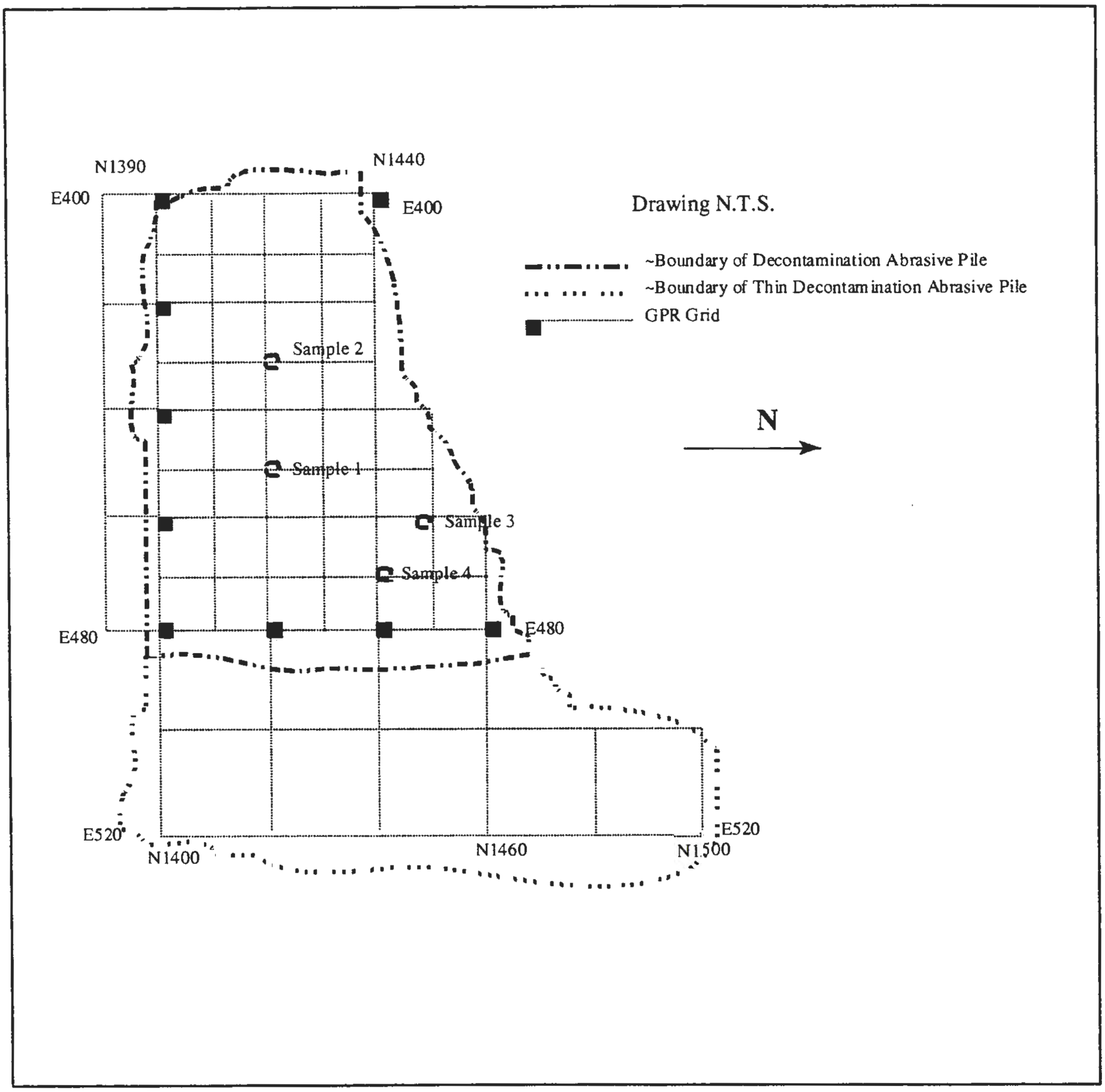
Previous sampling of the 116-C-5 Retention Basin and associated sites for bounding case characterization found that concentrations of leachable lead in two samples determined by the toxicity characteristic leaching procedure (TCLP) exceeded the dangerous waste designation limit (which is also the land disposal restriction treatment standard) of 5.0 mg/L lead. The two samples exceeding the land disposal restriction limits for lead were collected from the east basin between the outer edge of the retention basin bottom steel plate and its concrete foundation (samples E3 and E4 shown in Figure D-1).

It was determined additional data were needed to determine the extent of the leachable lead discovered during the bounding case characterization. The *Sampling and Analysis Plan for the 116-C-5 Retention Basins Characteristic Dangerous Waste Determination* (116-C-5 SAP) (BHI 1996) was developed using the U.S. Environmental Protection Agency (EPA) seven-step data quality objectives (DQO) guidance (EPA 1994). The DQO participants included an Environmental Restoration Contractor (ERC) DQO facilitator, the ERC project engineer, task manager, and representatives from ERC regulatory support and environmental sciences and engineering. The resulting sampling design was refined by using the guidance presented in Chapter 9.0 of *Test Methods for Evaluating Solid Waste* (EPA 1989). The number of samples to be collected and sample locations were determined using the EPA (1989) guidance.

As part of the DQO process, it was decided that only one basin would be sampled. It was determined that data collected from one basin would be representative of the other since both the east and west basins received the same waste and were the same design. Because the information provided by the existing data from the east basin (discussed above) would be used in the data analysis from this sampling event, samples were to again be collected from the east basin.

Sampling was conducted in accordance with the 116-C-5 SAP (BHI 1996) in and around the east 116-C-5 Retention Basin and in the decontamination abrasive pile in the west basin to determine the degree of lead contamination in the material between the tank base plate and concrete foundation (foundation samples), in the soils surrounding the perimeter of the basins, and in the decontamination abrasive.

**Figure D-1. Decontamination Abrasive Sample Locations.**



## D.2 FIELD ACTIVITIES

Field activities were conducted over two days during April 1996. The decontamination abrasive was sampled first, followed by the foundation samples, and finally, the soil surrounding the east basin perimeter was sampled. Documentation of sampling and recording of radiological measurements were documented in accordance with BHI-EE-01, *Environmental Investigations Procedures*, Procedure 1.5, "Field Logbooks." Photographs were taken of the sample locations and sampling material. These photographs are contained in the project files. A brief discussion of each of the sampling activities follows.

### D.2.1 Decontamination Abrasive Samples

Four samples of the decontamination abrasive were collected. Sample locations were chosen using a simple random selection method. A grid was set up over the decontamination abrasive using the existing ground-penetrating radar grid, which had 3-m (10-ft) spacings both north-south and east-west (see Figure D-1). The ground-penetrating radar grid had been established over the entire 116-C-5 Retention Basin site for geophysical testing in support of the remedial design. The sample grid extent had to be shortened after finding the east end of the abrasive pile was very thin. This area appeared to be abrasive that had been windblown from the main pile. The boundaries of the abrasive are included in Figure D-1. A spreadsheet random number generator was used to choose the northing and easting coordinates for each of the four sample locations.

The abrasive samples were collected by scraping approximately 2.5 cm (1 in.) deep into the pile, compositing in place, and then bottling the samples. The abrasive appeared to be homogeneous and contained small specks of rust.

### D.2.2 Foundation Samples

Five samples were collected of the material between the tank base plate and concrete foundation. For simplicity, these samples will be referred to as foundation samples. The sample locations were the same relative location as the first five soil samples. As discussed in Section D.2.3, the soil samples were chosen by a systematic random method. Before the locations of the soil samples were identified, it was decided the foundation samples would be collected at the anchor point of the soil samples, and the next four locations in the clockwise direction.

Samples were collected by scooping the material, consisting of silty sand, with a stainless-steel spoon into a stainless-steel bowl (both spoon and bowl were decontaminated as specified in BHI-EE-01, Procedure 4.0, "Soil and Sediment Sampling." The material in the bowl was then homogenized and bottled.

### D.2.3 Soil Samples

Soil samples were collected at seven locations around the east basin perimeter. A systematic random method was used to locate the sample points. With this method, an anchor point was chosen randomly, and the rest of the sample points were then placed at equal intervals from the anchor point. To choose the anchor point, the circumference of the basin was divided into fifty 6-m (20-ft) sections. The sections were numbered starting at the 1.5-m (5-ft)-diameter vertical pipe on the northeast section of the basin, counting up in a clockwise direction. A section number was then chosen with a spreadsheet random number generator. This point became the anchor point, which, in this case, was 134 m (440 ft) from the vertical pipe. The other six sample locations were then placed at 45.7-m (150-ft) intervals (see Figure D-2).

Test pits (approximately 2.4 to 3 m [8 to 10 ft] long, approximately 1.8 m [6 ft] wide, and approximately 0.9 to 1.1 m [3 to 3.5 ft] deep) were dug at each of the seven chosen locations. The sampling strategy was designed so that initially seven surface samples would be collected and analyzed. The surface was considered to be the elevation of the top surface of the concrete foundation. The data were compared to the action level, and if the action level was exceeded, samples from each of the seven test pits were collected at the 0.3-m (1-ft) depth. This process was repeated at 0.3-m (1-ft) intervals, as needed.

The surface samples exceeded the action level (discussed in Section D.3), so seven samples were collected at the 0.3-m (1-ft) depth. No additional samples were collected because no lead was detected in the samples from 0.3 m (1 ft).

Surface samples were collected by first scraping the test pit wall to remove any material that might have contacted the trackhoe bucket. Soil was then scraped at the 0- to 0.6-m (0- to 2-in.) depth from the edge of the concrete to 0.6 m (2 ft) radially outward. Next, the soil was homogenized in a stainless-steel bowl and bottled. Soil mainly consisted of silty sand with small cobble.

Samples from the 0.3-m (1-ft) depth were collected in the same manner as the surface samples. The samples consisted of the same silty sand with small cobble. However, in test pit 4, a lithology change (i.e., darker, coarser sand) that extended to the bottom of the test pit was noted at approximately the 0.6-m (2-ft) depth. A sample was collected at this depth for informational purposes, but a Hanford Environmental Information System number was not assigned.

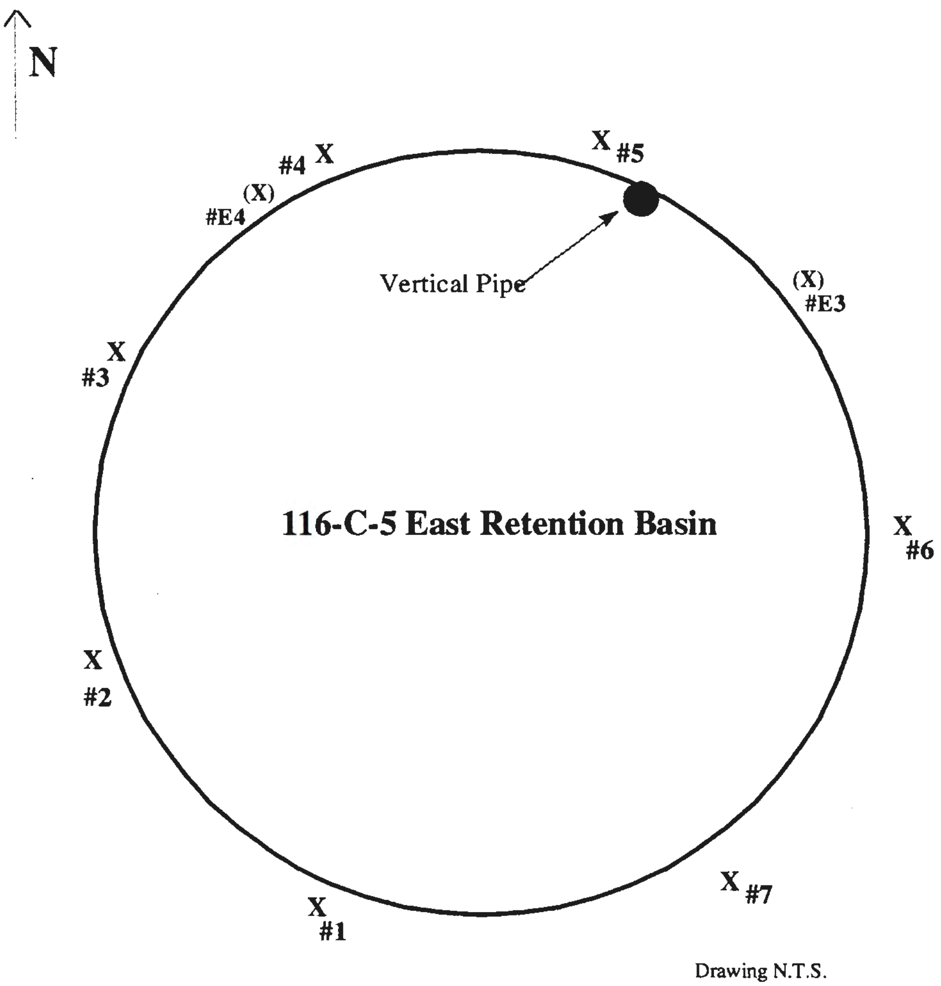
## D.3 RESULTS

The DQO process had defined the decision rule for this sampling activity as follows:

If the mean and confidence interval obtained from the x-ray fluorescence (XRF) readings for total lead exceed 340 mg/kg, then the waste material will require further evaluation, and possibly treatment, prior to disposal at ERDF (BHI 2002).

The action level was developed by using the minimum ratio (most conservative) of the total lead to leachable lead concentrations from the previous sampling of the 116-C-5 Retention Basin. The minimum ratio was 137.0, which happened to be foundation sample E3, and when multiplied by 5 mg/L lead, an action level of approximately 680 mg/kg lead was obtained. Factoring a potential 50% error factor for the XRF readings into the action level, a final action level of 340 mg/kg was calculated.

**Figure D-2. Soil Sample Locations.**




Note: Locations for #E3 and #E4 are included for reference and are estimated from the Letter Rep contained in the SAP (BHI 1996), Appendix A.

In other words, the data from previous sampling show that if the material contains total lead values <680 mg/kg, the leachable lead will not exceed the waste designation limit of 5 mg/L lead. If the material contains total lead concentrations >680 mg/kg, the leachable lead may or may not exceed the waste designation limit of 5 mg/L lead and would, therefore, require further evaluation. The 50% error factor is incorporated to cover any potential error in the XRF measurements, so the 680 mg/kg lead action level is then decreased to the more conservative value of 340 mg/kg. Additional explanation can be found in Appendix A of the 116-C-5 SAP (BHI 1996).

The sampling strategy was designed so that if the action level was exceeded, samples would be sent to an offsite laboratory, in this case Quanterra Environmental Services (Quanterra), which is now known as Severn Trent, for TCLP and confirmatory total lead analyses. TCLP results will supersede the total lead values (when these values exceed the action level) to determine if regulated levels of lead (>5 mg/L) exist within the sampled material. The total lead analyses are intended to confirm the XRF data. The ERC provided the XRF, mobile laboratory, and expertise to analyze samples at the field site to provide real-time results. This process enabled the project team to make timely decisions as to whether additional samples needed to be collected and which samples needed to be sent to the established offsite laboratory for confirmatory total lead and TCLP analyses. The following sections discuss the analytical results for each of the three sampled regions.

### D.3.1 Decontamination Abrasive Samples

Lead concentrations measured by the XRF in the decontamination abrasive samples were below the method detection limit (MDL) for all four samples. The reported concentrations are shown in Table D-1, but the only definitive conclusion that can be reached from the XRF data is that the values were <150 mg/kg, which is well below the action level.

Radiological data are also shown in Table D-1. Geiger-Mueller (GM) readings ranged from below detection to 3,500 dpm. Dose rates were <0.5 mR/hr. No alpha contamination was detected with the portable alpha monitor.

The action level was based on data from a soil matrix. Therefore, for the following reasons, one sample was sent to Quanterra to determine any possible leachable lead concentrations: (1) the decontamination abrasive is a different matrix than soil, and (2) no post-use decontamination abrasive data are available. The results from this sample are also shown in Table D-1. The total lead value is 47.3 mg/kg, well below the action level. This is confirmed by the TCLP result that gives a leachable lead concentration of 0.44 mg/L.

**Table D-1. Decontamination Abrasive Analytical Results.**

| Sample Location | Sample No. | XRF MDL Lead (mg/kg) | XRF | Quanterra[a] | | Sample in Bowl | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total Lead (mg/kg) | Total Lead (mg/kg) | Leachable Lead (mg/L) | mR/hr | GM (dpm) | PAM (dpm) |
| 1 | B0HCH8 | 150 | 14.4[b] | 47.3 | 0.44 | <0.5 | <1,000 | <20 |
| 2 | B0HCH9 | 150 | 3.3[b] | NS | NS | <0.5 | 1,000 | <20 |
| 3 | B0HCJ0 | 150 | 3.8[b] | NS | NS | <0.5 | 3,500 | <20 |
| 4 | B0HCJ1 | 150 | 0.0[b] | NS | NS | <0.5 | <1,000 | <20 |
| Mean | Variance $s^2$ | Standard Deviation s | Standard Error $s=s/(n)^{.5}$ | Degrees of Freedom n-1 | $t_{.05}$ | CI Factor $s * t_{.05}$ | Confidence Interval ±CI factor | |
| 150 | 0 | 0 | 0 | 3 | 2.353 | 0 | 150 | 150 |

[a] Quanterra's name has been changed to Severn Trent.
[b] Values reported are below the MDL and are *estimated* values only (as measured by the XRF).
GM = Geiger-Mueller
MDL = method detection limit
NS = not submitted for analysis
PAM = portable alpha monitor
XRF = x-ray fluorescence

### D.3.2 Foundation Samples

The XRF measured lead concentrations in the foundation samples ranging from 468.6 mg/kg to 1020.7 mg/kg (see Table D-2). The mean was calculated to be 699.8 mg/kg with a 95% upper confidence limit (UCL) of 924.0 mg/kg lead, which is well above the action level.

Therefore, all five samples were sent to Quanterra for TCLP and total lead analyses. The duplicate sample result when compared to the sample result (519.7 mg/kg and 468.6 mg/kg, respectively) is within the ±35% precision tolerance as specified in the 116-C-5 SAP (BHI 1996).

Radiological data are also given in Table D-2. For this sampling event, GM readings ranged from below detection to 8,000 dpm. The GM readings for the two samples from previous characterization work were 60,000 dpm. According to the radiological control technician, higher activity appeared to be associated with chunks of rusty scale. Dose rates were <0.5 mR/hr, and no alpha contamination was detected in any of the samples.

In most cases, the total lead results from Quanterra agreed with the XRF data (see Table D-2). The greatest discrepancy was with the results associated with sample B0HCJ4. The Quanterra result was nearly twice that of the XRF (873.0 mg/kg and 468.6 mg/kg, respectively). The mean was calculated to be 795.6 mg/kg, which was greater than the XRF data mean of 699.8 mg/kg. The 95% UCL was also greater than the XRF results with a value of 1,022.3 mg/kg compared to the XRF value of 924.0 mg/kg. With the amount of data available, the definite reason for this difference is difficult to determine. However, both data sets show concentrations of lead above the action level.

**Table D-2. Foundation Samples Analytical Results.**

| Sample Location | Sample No. | XRF | | Quanterra | | Sample in Bowl | | |
|---|---|---|---|---|---|---|---|---|
| | | XRF MDL Lead (mg/kg) | Lead (mg/kg) | Lead (mg/kg) | Leachable Lead (mg/L) | mR/hr | GM (dpm) | PAM (dpm) |
| E3 | B0GZK7 | 150 | -- | 1,110 | 8.1 | <0.5 | 60,000 | <20 |
| E4 | B0GZK9 | 150 | -- | 2,500 | 11.5 | <0.5 | 60,000 | <20 |
| 1 | B0HCJ2 | 150 | 721.2 | 790 | 0.39 | <0.5 | <1,000 | <20 |
| 2 | B0HCJ4 | 150 | 468.6 | 873 | 1.0 | <0.5 | 3,000 | <20 |
| 2a (Dup) | B0HCJ5 | 150 | 519.7 | -- | -- | <0.5 | 3,000 | <20 |
| 3 | B0HCJ6 | 150 | 814.8 | 844 | 0.083 | <0.5 | 8,000 | <20 |
| 4 | B0HCJ7 | 150 | 1020.7 | 1,060 | 0.88 | <0.5 | 4,000 | <20 |
| 5 | B0HCJ8 | 150 | 473.5 | 411 | 0.54 | <0.5 | 4,000 | <20 |

| Mean | Variance $s^2$ | Standard Deviation s | Standard Error $s = s/(n)^{.5}$ | Degrees of Freedom n-1 | $t_{.05}$ | CI Factor $s * t_{.05}$ | Confidence Interval ∀ CI factor | |
|---|---|---|---|---|---|---|---|---|
| | | | | *XRF Data Analysis* | | | | |
| 699.76 | 55331.22 | 235.23 | 105.20 | 4 | 2.132 | 224.28 | 475.48 | 924.04 |
| | | | | *Quanterra Total Lead Data Analysis* | | | | |
| 795.6 | 56547.30 | 237.80 | 106.35 | 4 | 2.132 | 226.73 | 568.87 | 1022.33 |
| | | | | *Quanterra Leachable Lead Data Analysis* | | | | |
| 0.5786 | 0.14 | 0.37 | 0.17 | 4 | 2.132 | 0.35 | 0.22 | 0.93 |

GM = Geiger-Mueller
MDL = method detection limit
NS = not submitted for analysis
PAM = portable alpha monitor
XRF = x-ray fluorescence

The TCLP results for the foundation samples ranged from 0.083 mg/L to 1.0 mg/L leachable lead (see Table D-2). The mean was calculated to be 0.58 mg/L with a 95% UCL of 0.93 mg/L. Both of these values are well below the dangerous waste designation limit of 5 mg/L leachable lead.

The two data points from the previous sampling event were not included in the total lead or TCLP statistical analyses. These data points are believed to be representative of worst cases, or "hot spots." The sample locations were not chosen randomly, but rather they were chosen based on high counts read on a GM. These hot spots were found while the radiological control technician was inspecting the edge of the foundation during the previous sampling event. These two samples, therefore, are not representative of the entire population of the foundation material. The five samples collected for this sampling event were chosen randomly. Using the variance from the five samples and following the procedure in EPA (1989), the five samples are representative of the population and no additional samples need to be collected. In summary, the data collected during this sampling effort are representative of the entire population and show that the foundation material, as a whole, does not contain regulated levels of lead.

### D.3.3 Soil Samples

Lead concentrations measured by the XRF in the surface soil are summarized in Table D-3. Values ranged from <150 mg/kg (63.2 mg/kg) to 635.9 mg/kg. The calculated mean is 332.6 mg/kg lead, barely below the action level, but the 95% UCL was calculated to be 484.8 mg/kg lead, which is above the action level. Therefore, all seven surface soil samples were sent to Quanterra for TCLP and total lead analyses. The duplicate sample collected from test pit 7 contained 325.8 mg/kg lead, and when compared to the test pit 7 sample result of 345.7 mg/kg lead, it is within the ±35% precision tolerance specified in the 116-C-5 SAP (BHI 1996).

**Table D-3. Surface Soil Sample Analytical Results. (2 Pages)**

| Test Pit | Sample No. | XRF MDL Lead (mg/kg) | XRF | Quanterra | | Sample in Bowl | | |
|---|---|---|---|---|---|---|---|---|
| | | | Lead (mg/kg) | Lead (mg/kg) | Leachable Lead (mg/L) | mR/hr | GM (dpm) | PAM (dpm) |
| 1 | B0HCJ9 | 150 | 635.9 | 681 | 1.9 | <0.5 | 1,500 | <20 |
| 2 | B0HCK0 | 150 | 63.2[a] | 101 | 0.84 | <0.5 | 3,500 | <20 |
| 3 | B0HCK1 | 150 | 215.8 | 235 | 0.29 | <0.5 | 3,000 | <20 |
| 4 | B0HCK2 | 150 | 583.5 | 397 | 0.83 | <0.5 | <1,000 | <20 |
| 5 | B0HCK3 | 150 | 244.4 | 310 | 0.39 | <0.5 | <1,000 | <20 |
| 6 | B0HCK4 | 150 | 239.9 | 29.5 | 0.15 | <0.5 | <1,000 | <20 |
| 7 | B0HCK5 | 150 | 345.7 | 407 | 0.38 | <0.5 | 6,000 | <20 |
| 7a (Dup) | B0HCK6 | 150 | 325.8 | -- | -- | <0.5 | 6,000 | <20 |
| 1a | -- | 150 | 628.0 | NS | NS | NA | NA | NA |
| 4a | -- | 150 | 104.1 | NS | NS | NA | NA | NA |
| **Mean** | **Variance $s^2$** | **Standard Deviation s** | **Standard Error $s=s/(n)^{.5}$** | **Degrees of Freedom n-1** | **$t_{.05}$** | **CI Factor $s * t_{.05}$** | **Confidence Interval ± CI factor** | |
| | | | | *XRF Data Analysis* | | | | |
| 332.63 | 42950.74 | 207.25 | 78.33 | 6 | 1.943 | 152.20 | 180.43 | 484.83 |

**Table D-3. Surface Soil Sample Analytical Results. (2 Pages)**

| Test Pit | Sample No. | XRF MDL Lead (mg/kg) | XRF | Quanterra | | Sample in Bowl | | |
|---|---|---|---|---|---|---|---|---|
| | | | Lead (mg/kg) | Lead (mg/kg) | Leachable Lead (mg/L) | mR/hr | GM (dpm) | PAM (dpm) |
| *Quanterra Total Lead Data Analysis* | | | | | | | | |
| 308.64 | 47098.73 | 217.02 | 82.03 | 6 | 1.943 | 159.38 | 149.26 | 468.02 |
| *Quanterra Leachable Lead Data Analysis* | | | | | | | | |
| 0.68 | 0.36 | 0.6 | 0.23 | 6 | 1.943 | 0.44 | 0.24 | 1.12 |

[a] Values reported are below the MDL and are *estimated* values only (as measured by the XRF).

GM = Geiger-Mueller
MDL = method detection limit
NA = not available
NS = not submitted for analysis
PAM = portable alpha monitor
XRF = x-ray fluorescence

Radiological data are also given in Table D-3. For this sampling event, GM readings ranged from below detection to 6,000 dpm. Dose rates were <0.5 mR/hr, and no alpha contamination was detected in any of the samples.

A second set of samples was collected from test pits 1 and 4 to determine if the initial readings were outliers. The data from the second set were not included in the statistical analysis. The lead concentration measured by the XRF in the second sample from test pit 1 was reported to be 628.0 mg/kg, which is relatively consistent with the first sample concentration of 635.9 mg/kg. However, the second sample from test pit 4 contained 104.1 mg/kg lead compared to 583.5 mg/kg in the first sample. These data, along with the sample standard deviation, may indicate the lead was not deposited evenly within the soil.

Total lead results from Quanterra agreed with the XRF data in most cases (see Table D-3), with the one exception of sample B0HCK4. The Quanterra result is an order of magnitude less than the XRF result (29.5 mg/kg and 239.9 mg/kg, respectively). With the data available, the definite reason for this difference is difficult to determine. The mean was calculated to be 308.6 mg/kg, which is comparable to the XRF data mean of 332.6 mg/kg. The 95% UCL was also comparable to the XRF results with a value of 468.0 mg/kg compared to the XRF value of 484.8 mg/kg.

The TCLP results for the surface samples ranged from 0.15 mg/L to 1.9 mg/L leachable lead (see Table D-3). The mean was calculated to be 0.68 mg/L with a 95% UCL of 1.12 mg/L. Both of these values are well below the dangerous waste designation limit of 5 mg/L leachable lead.

Samples at the 0.3-m (1-ft) depth were collected and analyzed by the XRF. Table D-4 presents the results. All seven samples were below the MDL (<150 mg/kg), so none of these samples were sent to Quanterra. No further sampling was conducted at deeper intervals.

**Table D-4. One-Foot Depth Soil Sample Analytical Results.**

| Test Pit | Sample No. | XRF MDL Lead (mg/kg) | XRF | Quanterra | | Sample in Bowl | | |
|---|---|---|---|---|---|---|---|---|
| | | | Lead (mg/kg) | Lead (mg/kg) | Leachable Lead (mg/L) | mR/hr | GM dpm | PAM dpm |
| 1 | B0HCK8 | 150 | 8.2[a] | NS | NS | <0.5 | <1,000 | <20 |
| 2 | B0HCK9 | 150 | 0[a] | NS | NS | <0.5 | <1,000 | <20 |
| 3 | B0HCL0 | 150 | 0[a] | NS | NS | <0.5 | <1,000 | <20 |
| 4 | B0HCL1 | 150 | 0[a] | NS | NS | <0.5 | <1,000 | <20 |
| 5 | B0HCL2 | 150 | 0[a] | NS | NS | <0.5 | <1,000 | <20 |
| 6 | B0HCL3 | 150 | 0[a] | NS | NS | <0.5 | <1,000 | <20 |
| 7 | B0HCL4 | 150 | 0[a] | NS | NS | <0.5 | <1,000 | <20 |
| **Mean** | **Variance $s^2$** | **Standard Deviation s** | **Standard Error $s=s/(n)^{.5}$** | **Degrees of Freedom n-1** | **$t_{.05}$** | **CI Factor $s * t_{.05}$** | **Confidence Interval ± CI factor** | |
| 150 | 0 | 0 | 0 | 6 | 1.943 | 0 | 150.00 | 150.00 |

[a] Values reported are below the MDL and are *estimated* values only (as measured by the XRF).

GM = Geiger-Mueller
MDL = method detection limit
NS = not submitted for analysis
PAM = portable alpha monitor
XRF = x-ray fluorescence

## D.4 CONCLUSIONS

The strategy for this sampling event, as outlined in the 116-C-5 SAP (BHI 1996), was to determine the extent of the leachable lead discovered during the bounding case characterization. The resulting sampling design was refined using the guidance presented in Chapter 9.0 of EPA (1989). The XRF data were used to determine if total lead concentrations exceeded the action level and to determine which samples were to be sent to the offsite laboratory for TCLP and confirmatory total lead analyses. The following sections discuss the conclusions reached for each of the sampled regions.

### D.4.1 Decontamination Abrasive Samples

The XRF data indicated that the lead concentrations from each of the four samples were less than the MDL of 150 mg/kg lead. Following the guidance in EPA (1989), the four samples are representative of the entire pile of decontamination abrasive, and no additional samples needed to be collected. Therefore, the XRF data, together with the confirmatory Quanterra data, show the decontamination abrasive does not contain regulated levels of lead and, therefore, does not require further analysis or treatment prior to disposal at ERDF.

### D.4.2 Foundation Samples

All five foundation samples were found to exceed the established dangerous waste criteria for total lead as determined by the XRF. Therefore, all five samples were sent to Quanterra for TCLP and confirmatory total lead analyses.

The mean and 95% UCL calculated from Quanterra total lead data (795.6 mg/kg and 1,022.3 mg/kg, respectively) were greater than that of the XRF data (699.8 mg/kg and 924.02 mg/kg, respectively) because one of the Quanterra measurements was nearly twice that of the XRF. With the data available, the definite reason for this difference is difficult to determine. Nevertheless, both data sets indicated concentrations of total lead above the action level in the foundation material. Therefore, TCLP results are used to determine if the foundation material is truly regulated based on concentrations of leachable lead.

The TCLP results for the five foundation samples were well below the dangerous waste designation limit of 5 mg/L lead. The mean was calculated to be 0.58 mg/L with a 95% UCL of 0.93 mg/L.

As explained in Section D.3.2, the two data points from the previous sampling event were not included in the total lead or TCLP statistical analyses. It was originally thought that these data would be included, but this was assuming the samples are representative of the entire population. However, upon reviewing the data from this sampling event, it appears that the previous two data points are representative of a worst case and are not representative of the entire population. The sample locations were not chosen randomly, but rather were found by chasing contamination.

The five samples collected for this sampling event were chosen randomly to ensure that the samples would be representative of the entire population. Using the variance calculated from the five sample results and following the procedure in EPA (1989), no additional samples needed to be collected. The five samples were sufficient to represent the entire population; consequently, the foundation material, as a whole, does not contain regulated levels of lead. Therefore, the foundation material does not require further analysis or treatment prior to disposal at ERDF.

### D.4.3 Soil Samples

Soil samples were collected from seven test pits surrounding the east retention basin at the surface (elevation at the top of the concrete foundation) and at the 0.3-m (1-ft) depth. The XRF was used to analyze the samples to determine if samples needed to be sent to Quanterra for TCLP and confirmatory total lead analyses and the depth at which samples needed to be collected.

The 95% UCL (484.8 mg/kg lead) of the seven surface samples exceeded the action level of 340 mg/kg, so these samples were sent to Quanterra. Additionally, samples were collected at the 0.3-m (1-ft) depth from each of the seven test pits. Each of these samples was below the XRF MDL (<150 mg/kg), so none were sent to Quanterra. No further sampling was conducted at deeper intervals.

The mean of the Quanterra total lead measurements was comparable to that of the XRF data, 308.6 mg/kg and 332.6 mg/kg, respectively. The 95% UCL of the Quanterra data was also comparable to the XRF results with a value of 468.0 mg/kg compared to the XRF value of 484.8 mg/kg. Referring back to the development of the action level, a 50% error factor was incorporated to cover any error in XRF readings. Because of the relative comparability of the two data sets, the 50% error factor can be removed from the action level (340 mg/kg ) 50% = 680 mg/kg) for comparison. Therefore, according to the 95% UCL of the total lead data, the soil did not contain concentrations of total lead above the action level and, therefore, would not contain leachable lead concentrations >5 mg/L.

The TCLP data confirm this conclusion. A mean of 0.68 mg/L with a 95% UCL of 1.12 mg/L was calculated from the TCLP data. Both of these values are well below the dangerous waste designation limit of 5 mg/L leachable lead. Using the sample variance calculated from the seven samples and following the procedure in EPA (1989), no additional samples needed to be collected. This means the seven samples were representative of the soil surrounding the retention basins.

The XRF data, combined with the confirmatory total lead and TCLP results from Quanterra, showed that the soil surrounding the retention basins did not contain regulated levels of lead. Therefore, the soil did not require further analysis or treatment prior to disposal at ERDF.

## D.5 REFERENCES

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# APPENDIX E

# DEBRIS IDENTIFICATION AND SAMPLING STRATEGY

# APPENDIX E

# DEBRIS IDENTIFICATION AND SAMPLING STRATEGY

## E.1 SUMMARY

The following debris identification and handling approach applies only to manufactured objects that are anomalous or unexpected, and discovered during remediation of liquid waste disposal sites and remaining sites (candidate sites) covered by this sampling and analysis plan.

As waste sites are excavated, anomalous materials could be encountered that may qualify as hazardous debris. In order to ensure compliance with the *Environmental Restoration Disposal Facility Waste Acceptance Criteria* (WCH 2008), *Supplemental Waste Acceptance Criteria for Bulk Shipments to the Environmental Restoration Disposal Facility* (BHI 2003), and regulatory requirements, the excavation effort must include practices to prevent placement of restricted debris in the Environmental Restoration Disposal Facility (ERDF).

Remediation waste is expected to consist predominantly of the following items:

- Contaminated soil, with a much smaller percentage of nonsoil debris such as scrap metal
- Miscellaneous construction materials not associated with the waste site structure
- Piping and associated construction materials identified for removal (e.g., steel, concrete, vitrified clay)
- Concrete with steel reinforcing and other miscellaneous construction materials from associated junction boxes, manholes, thrust blocks, and other structures.

Reasonable efforts will be made to identify unexpected materials during the normal course of waste processing by application of the observational approach at the visible and discernible face of the excavation, at the surface of interim storage stockpiles, and at the visible and discernible surface of materials within containers at the frisking station or queue. In the event that unexpected wastes are observed, such as the sighting of a lead brick in soil waste matrix, the matrix shall be designated as outlined in Section E.4.

Sampling and analysis will be based on the form of waste encountered, taking into account process knowledge with emphasis on compliance with the ERDF waste acceptance criteria. Analyses may include additional parameters (radiological and other) outside of the onsite contaminants of concern. Based on test results, the material will be sent to ERDF or stored for treatment and disposal. All sampling and testing will follow best engineering judgement and be in compliance with appropriate procedures contained in ENV-1, *Environmental Monitoring & Management*, and Part III of this document.

## E.2 BACKGROUND

The U.S. Environmental Protection Agency (EPA) has defined debris as "a solid material exceeding 60 mm (2.5 in.) particle size that is: (1) a manufactured object; or (2) plant or animal matter; or (3) natural geologic material (e.g., cobbles and boulders), except that any material for which a specific treatment standard is provided in Subpart D, part 268.2, is not debris [e.g., lead acid or cadmium batteries, radioactive lead solids, have specific treatment standards]. A mixture of debris and other material such as soil or sludge is also subject to regulation as debris if the mixture is comprised primarily of debris by volume, based on visual inspection" (57 *Federal Register* 37194). The EPA further defines "solid material" as a material that retains its volume at room temperature without the need for support by a container. Examples of solid materials are glass, concrete, crushed drums, tanks, pipes, scrap metal, cobbles, boulders, paper, plastic, and rubber. Additionally, the regulation stipulates mixtures of debris with other materials are subject to regulation as debris if debris is the primary material present (i.e., at least 50% by volume). This determination may be done by visual inspection.

Various waste sites in the 100 Areas contain hazardous debris mixed with a matrix of nonhazardous debris or soil. Often, these debris materials are integral parts of the overall waste matrix so that separation of the material from the matrix is difficult or impossible from the worker radiation exposure, safety, and cost standpoint. This appendix provides guidance for determining the practicality of separating hazardous materials and the recommended procedures for characterizing and profiling the waste.

## E.3 SCOPE

This appendix shall be used by remedial action projects as a guide in determining the appropriate method for characterization and disposal of debris, which contains toxicity characteristic hazardous waste.

## E.4 DESIGNATION OF THE WASTE MATRIX

The entire matrix needs to be assessed to determine if it is hazardous and requires treatment before being disposed of at ERDF. The determination of whether or not the matrix is hazardous is, conceptually, based on taking the matrix as a whole, homogenizing it, and taking samples of the matrix for toxicity characteristic leaching procedure analysis. However, this conceptual approach is generally not feasible in practice. In such instances, the methodology to be employed is to sample and analyze individual components of the matrix, and to combine the results, using appropriate weighting, to represent the matrix as a whole. There is no specific EPA guidance for this procedure, but the guidance given in Chapter 9.0 of *Test Methods for Evaluating Solid Wastes* (EPA 1997) for stratified random sampling is quite similar to the situation described.

Care should be taken in defining what constitutes the matrix. The matrix is generally the materials that are integral with, or in close proximity to, the hazardous component. The matrix cannot be arbitrarily defined so large that enough nonhazardous material is present to effectively dilute the hazardous component. Segregation of the hazardous components from the rest of the matrix should be done, if feasible, particularly when the hazardous component is sufficiently large to render the entire matrix hazardous.

If anomalous waste is easily removed by mechanical means, it is defined as a separate waste stream. The determination of whether hazardous debris can be segregated from the rest of the matrix is based on many factors, including the relative volumes of hazardous and nonhazardous debris, the potential exposure of workers to increased radiation doses and/or industrial hazards, and the incremental cost to the project. In general, the determination can be qualitative in nature. The decision is primarily a field-based decision, and should be based on the relative ease with which the separation operation can be performed with regard to worker safety. A simple cost-benefit analysis may be appropriate for decision making.

Once the matrix is defined, representative samples of the matrix components need to be taken. The sampling process involves six steps as outlined below:

1. Categorize materials
2. Determine the relative quantities of materials
3. Perform sampling to determine whether or not the various categories are potentially hazardous
4. Determine representative numbers of samples for each category that will produce results with the required level of confidence.
5. Perform secondary sampling and analysis (if needed)
6. Analyze the data and report the results.

These steps are explained in more detail in the following sections.

### E.4.1 Categorize Materials

The categorization of hazardous/dangerous waste materials is generally based on process knowledge, as-built drawings, and field observations. This step is an attempt to determine the different types of materials present that should be sampled. Some materials may not need to be sampled if they are generally regarded as nonhazardous (e.g., steel-reinforcing bars). Other materials may not need to be sampled if they are known to be hazardous (e.g., lead solids and obvious asbestos materials).

### E.4.2 Determine Relative Quantities of Materials Present

An estimate of the relative quantities of different materials present can be based on a number of different methods such as estimates from as-built drawings, process history, or field observations. The goal is to quantify the amount of each component that comprises the entire matrix. The quantity of materials is used, in part, to determine the number of samples of each material type and then in the final calculation of the matrixed result of the laboratory analyses.

### E.4.3 Sampling

Sampling and analysis will be based on the form of waste encountered, taking into account process knowledge with emphasis on compliance with the ERDF waste acceptance criteria (WCH 2008). Multiple samples will be taken, based on material variability or the need to develop mean/variance information to support waste management decisions. Analyses may include additional parameters (radiological and other) outside of the onsite contaminants of concern. Based on test results, the material will be sent to ERDF (contingent on meeting waste acceptance criteria) or stored for treatment and disposal. All sampling and testing will follow best engineering judgement and be in compliance with appropriate procedures contained in ENV-1 and Part III of this document.

### E.4.4 Data Analysis and Reporting

Evaluate the laboratory data to ensure that it is suitable for supporting hazardous waste decisions. Compare the results against waste designation criteria. Document the waste material category results in an internal office memorandum to the project environmental lead and waste management specialist.

## E.5 REFERENCES

57 FR 37194, "Land Disposal Restrictions for Newly Listed Wastes and Hazardous Debris," *Federal Register*, Vol. 57, No. 160, August 18, 1992.

BHI, 2003, *Supplemental Waste Acceptance Criteria for Bulk Shipments to the Environmental Restoration Disposal Facility*, 0000X-DC-W0001, Rev. 5, Bechtel Hanford, Inc., Richland, Washington.

ENV-1, *Environmental Monitoring & Management*, Washington Closure Hanford, Richland, Washington.

EPA, 1997, *Test Methods for Evaluating Solid Wastes*, SW-846, 3rd edition, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

WCH, 2008, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, WCH-191, Rev. 0, Washington Closure Hanford, Richland, Washington.

# APPENDIX F

# SAMPLE DESIGN INFORMATION

# APPENDIX F

# SAMPLE DESIGN INFORMATION

## F.1 INTRODUCTION

The specific detailed approach for determining the size of decision units will be documented in site specific work instructions (WIs).

## F.2 SAMPLE DESIGN – SIZE OF DECISION SUBUNITS

The sample design divides the site into decision units (e.g., overburden, shallow zone, deep zone). One decision unit is the overburden material removed from the excavation during remedial action. The objective for sampling and analyses of overburden and layback is to verify that the suspected clean soil piles do not contain contaminants of concern above remediation levels. Another decision unit is the exposed dig face and excavation floor between the original surface elevation and 4.6 m (15 ft) below original ground surface (i.e., shallow zone). If the depth of the excavation is greater than 4.6 m (15 ft) below the original surface elevation, this forms another decision unit (i.e., deep zone).

These decision units are broken into smaller subunits based on surface area. The basis for the number of area-based subunits is summarized in Table F-1. For small sites, a decision unit will encompass only a single subunit. Typically, each subunit is divided into four (shallow zone) or three (deep zone) sample areas, which are in turn divided into 16-node sample grids.

For each site, it will be possible to plan the expected number of decision units and subunits based on the footprint area of the engineered structures and existing data. Sampling and analysis protocols will be identical for any subunits within the decision unit categories (e.g., overburden, shallow zone, deep zone). If contamination is found beyond the engineered structure and excavation of this contamination causes the surface area to expand, then additional decision units may be needed to provide required coverage of the expansion area.

In the overburden and shallow zone, each subunit will initially be divided into four equal size sample areas. In the deep zone, each subunit will be initially divided into three equal size sample areas. Each sample area will be represented by a single verification sample that is a composite sample, with composite aliquots collected from four nodes determined by using a random number table. Each sample area will be divided into a sample grid consisting of 16 sequentially numbered equal-area sample nodes. The six variance samples (overburden and shallow zone only) will come from six randomly determined nodes.

**Table F-1. Number of Decision Subunits Based on Area.**

| Area of Primary Decision Unit | Number of Subunits |
|---|---|
| *Small Site* | |
| ≤1,394 m² (15,000 ft²) | 1 |
| *Medium Site* | |
| >1,394 m² (15,000 ft²) to ≤2,326 m² (25,000 ft²) | 2 |
| >2,326 m² (25,000 ft²) to ≤3,256 m² (35,000 ft²) | 3 |
| >3,256 m² (35,000 ft²) to ≤4,186 m² (45,000 ft²) | 4 |
| *Large Site* | |
| >4,186 m² (45,000 ft²) to ≤9,303 m² (100,000 ft²) | 2 |
| >9,303 m² (100,000 ft²) to ≤13,024 m² (140,000 ft²) | 3 |
| >13,024 m² (140,000 ft²) to ≤16,745 m² (180,000 ft²) | 4 |
| >16,745 m² (180,000 ft²) to ≤20,466 m² (220,000 ft²) | 5 |
| >20,466 m² (220,000 ft²) | ROUND[a] (area in m²/3,720)<br>(area in ft²/40,000) |

NOTE: The Tri-Parties, as part of the data quality objectives process, approved the decrease in the sampling frequency for the large sites because they determined that the sampling coverage was adequate and cost effective.

[a] ROUND is an integer rounding function.

## F.3 EXCEPTIONS TO STANDARD SAMPLE DESIGN APPROACH

### F.3.1 Sample "As-You-Go" for Large Sites Such as Pipelines

For very large sites, the terminal rate of sampling is established from the start. From Table F-1, the terminal rate of sampling is set at one decision subunit per 3,720 m² (40,000 ft²). Since this key parameter is established from the start, the remediation team can conduct cleanup verification sampling as soon as the real estate becomes available. Demonstration that cleanup has been achieved is then based on standard calculations (using the data available) and/or comparisons to analogous sites. These "interim" demonstrations of cleanup can be documented via interim cleanup verification calculation packages and backfill concurrence forms. The final cleanup verification packages may be prepared either annually or at relevant stages of the large site remediation. The final cleanup verification packages may be a compilation of a number of interim calculation packages.

### F.3.2 Remaining Site Sampling

Site-specific WIs, or sample designs, are developed to support a no action or remedial action decision for waste sites, as required by the sampling and analysis plan. The WI includes a detailed description of the waste site, including location, historical background, current description, and ecological and cultural considerations. Historical data, process knowledge, geophysical survey results, site walkdown observations, and other available information (e.g., prior sampling data, if available) are used to define the sample design. The geophysical surveys indicate subsurface anomalies to better identify subsurface structure, pipes, debris, etc. From this information, a list of contaminants of potential concern is developed and the laboratory analytical methods identified for each. The information is used to determine whether focused or statistical sampling is appropriate, as well as the number and location of samples to be taken. The detailed sample design includes sampling protocols, monitoring, and quality control requirements. The sample results are then evaluated against cleanup criteria, as specified in the remedial design report/remedial action work plan, to lead to a no action or remedial action decision. The lead regulatory agency reviews and approves the decision.

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