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Near Term Data Quality Objectives for Vadose Zone Characterization Waste Management Area C

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Abstract: This document describes the WMA C DQO process that will be implemented to ensure appropriate data are collected to support characterization of the vadose zone and covers the associated sampling and analytical activities for that purpose. This DQO supports the initial near term characterization efforts but does not address data needs for making final decisions concerning the remediation and closure of soil in WMA C including contamination risks to humans through direct contact and ecological receptors. This DQO will be revised at a future date to address these data needs.

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NEAR TERM DATA QUALITY OBJECTIVES FOR VADOSE ZONE CHARACTERIZATION WASTE MANAGEMENT AREA C

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LIST OF TERMS

Abbreviations and Acronyms

AOI	area of interest
bgs	below ground surface
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	*Code of Federal Regulations*
CH2M HILL	CH2M HILL Hanford Group, Inc.
CLARC	Cleanup levels and risk calculations
CMS	Corrective Measures Study
COPC	contaminate of potential concern
CVAA	cold vapor atomic absorption
DF	dilution factor
DOE	U.S. Department of Energy
DQO	Data quality objective
Ecology	State of Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
EDTA	ethylene diamine tetra acetic acid
EQL	estimated quantitation limit
FSAP	field sampling and analysis plan
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GEA	gamma energy analysis
GPR	ground penetrating radar
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
IC	ion chromatography
ICM	interim corrective measure
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectrometry
IDL	instrument detection limit
IMUST	inactive miscellaneous underground storage tank
IPT	integrated planning team
ISE	ion-specific electrode
LCS	laboratory control sample
LDMM	leak detection monitoring and mitigation
MDL	method detection limit
MTCA	Model Toxics Control Act
N/A	not applicable
NP	not performed
ORP	U.S. Department of Energy, Office of River Protection
OU	operable unit
PA	performance assessment
Part A	Single-Shell Tank Part A Permit
PCB	polychlorinated biphenyls

PNNL	Pacific Northwest National Laboratory
PSQ	principal study question
PUREX	plutonium-uranium extraction
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RESRAD	Residual Radioactivity Modeling
RFI	RCRA Facility Investigation
RPD	relative percent difference
SGE	Surface Geophysical Exploration
SGLS	spectral gamma logging system
SIM	soil inventory model
SST	single-shell tank
SVOC	semi volatile organic compound
TGA	thermogravimetric analysis
TIC	tentatively identified compound
TSD	treatment, storage and disposal
UHC	underlying hazardous constituent
UPR	unplanned release
VOA	Volatile organic analysis
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WIDS	waste information data system
WMA	waste management area
WP/SAP	work plan/sampling and analysis plan

Units

Ci	Curies
ft^3	cubic feet
g	grams
M	molarity of moles per liter
mg/g	milligrams per gram
mg/L	miligrams per liter
mg/kg	milligrams per kilograms
mL	milliliters
%	percent
Ci/m^3	Curies per cubic meter
nCi/g	Nanocuries per gram
pCi/g	picocuries per gram
pCi/mL	picocuries per milliliter
µg	micrograms
µL	microliters

Glossary

A	Identifies constituents from the Part A Permit
R	Identifies constituents requested by the risk assessment group
U	Identifies constituents as Underlying Hazardous Constituents

1.0 INTRODUCTION

The Resource Conservation and Recovery Act (RCRA) corrective action process at the Hanford site consists of a Phase 1 RCRA Facility Investigation (RFI) and a Phase 2 RFI/Corrective Measures Study (RFI/CMS). These studies will be completed for each tank farm Waste Management Area (WMA). Figure 1-1 illustrates the logic flow diagram of the RCRA Facility Investigation /Corrective Measures Study (RFI/CMS) process and how these efforts integrate with the CERCLA OUs being conducted on the Central Plateau. Data are collected to support an assessment of risk from past releases from tank farms and evaluation of corrective measure alternatives in the CMS. This information will lead to a decision in the RCRA Site-Wide Permit that selects and implements corrective measures as part of final closure.

The initial field characterization of the Phase 1 RFI is complete and the results will be presented in the Phase 1 RFI Report which is to be released in January 2008. In Phase 1, the emphasis was to confirm where significant releases had occurred in tank farms. Phase 2 will complete vadose zone characterization activities required to fully develop the WMA CMS and select alternatives. This will include characterization of additional release sites. In addition, Phase 2 characterization will support continued assessment of interim measures necessary for protection of human health and the environment.

The DQO Team (See Section 1.5 for a discussion of the DQO Team) determined that characterization in WMA C should continue while the Phase 1 RFI report is being finalized and prior to the development of the Phase 2 RFI/CMS DQO and Work Plan. This transitional characterization effort is defined as Near-Term characterization. This Near-Term characterization effort will contribute to an understanding of the lateral extent and magnitude of migration of technetium-99 and other contaminants of potential concern (COPC) associated with tanks and Unplanned Release Sites (UPRs) not investigated during the Phase 1 investigation at WMA C. The Near-Term sampling effort will involve collection of samples through the soil column to a depth of approximately 100 feet bgs at select locations and at depths of known or suspected contamination. The depth of this Near-Term investigation is limited by the Direct Push technology to be used to collect soil samples at WMA C. A broader range of sampling depths will be conduct during the Phase 2 RFI field investigations using additional contaminant assessment technologies.

This transitional characterization field work is scheduled to begin in the fall of 2007 and be completed at the end of FY-2008. Work will transition from the Near-Term characterization efforts into the Phase 2 RFI characterization work once Phase 2 has been fully defined to support vadose zone corrective action decisions for all exposure pathways. It is anticipated that data collected during this Near-Term characterization effort will be integrated with the Phase 2 RFI data. This Near-Term characterization effort has been approved by Ecology (Washington Department of Ecology, 31 July 2007).

1.1 DQO GOALS

A tank farm will undergo closure activities in accordance with SST Closure Plans which will be in compliance with RCRA and DOE 435.1 closure plan requirements. The RCRA closure plans will be the basis for modification of the Dangerous Waste Portion of the RCRA Site-wide Permit. Required information to support closure decisions through the RCRA corrective action process includes but is not limited to the volume, nature and extent of contaminated soil in the tank farm and the concentration of certain constituents in the vadose zone. The volume, nature, extent and concentration of contaminated soil will provide the inventory of the constituents in the vadose zone.

The primary goal of this data quality objective (DQO) document is to ensure that Near-Term vadose zone data at known or suspected release sites are collected that will support the Phase 2 RFI/CMS; decisions on vadose zone remediation; WMA C RCRA Treatment Storage and Disposal (TSD) facility closure and Department of Energy Order 435.1 (DOE O 435.1) closure. Phase 2 goals are to obtain understanding, information, and data to support evaluations leading to the decisions to remediate the vadose zone and final closure of WMA C. Phase 2 data will provide inputs to the CMS including a baseline risk assessment, the WMA C Performance Assessment, (PA), the final Single-Shell Tank (SST) PA (DOE/ORP-2003-11, Rev.0), and the corrective measures alternatives analysis. During Phase 2 additional data will be collected on known or suspected releases and data will be provided to allow alternatives to be evaluated using the criteria defined below. Alternative evaluation criteria in the Phase 2 RFI/CMS process will consider:

- Long-term protection and permanence
- Use of treatment to maximize reduction of toxicity, mobility, or volume
- Compliance with applicable regulations
- Short-term protection and effectiveness
- Implementability of alternatives to be evaluated
- Cost of alternatives to be evaluated

Based upon the evaluation of alternatives in relation to these criteria, corrective measures will be selected for implementation.

Secondary DQO goals include providing data to support decisions associated with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Operable Units (OU) for groundwater (OU 200-BP-5) and non-WMA tank farm facilities (OU 200-IS-1) as well as the Leak Detection Monitoring and Mitigation (LDMM) evaluations that will be conducted during WMA C tank retrievals. Support of these secondary goals involves identifying integrated sampling opportunities with 200-IS-1 and 200-BP-5, and ensuring that identification of COPC and quality assurance/quality control requirements are consistent with the Single-Shell Tank Component Closure Data Quality Objectives (RPP-23403, Rev. 3), Data Quality Objectives Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process (WMP-28945, Rev. 0) and Data Quality

Objectives Summary Report for the 200-IS-1 Operable Unit Pipelines and Appurtenances (D&D-30262, Rev.0).

These goals can be achieved through the evaluation of existing data (archived samples and process knowledge), currently planned vadose zone characterization activities, and coordination of information needs with tank waste retrieval and WMA Closure. This DQO establishes broader data requirements for the Near-Term characterization efforts so that the data collected can be integrated with the Phase 2 RFI data. The characterization data will be collected through the implementation of a WMA C vadose zone characterization work plan/sampling and analysis plan (WP/SAP) and a field sampling and analysis plan (FSAP).

1.1.1 DQO Framework

The RFI process is iterative. Figure 1-2 illustrates the framework for how this DQO will evolve in this iterative process for defining data needed to characterize the nature and extent of contamination in the vadose zone at WMA C. This will form a template for vadose zone data collection to support the RFI/CMS process at all WMAs.

This DQO for Near-Term vadose zone characterization at WMA C supports the Near-Term Work Plan/Sampling and Analysis Plan (WP/SAP). The Near-Term WP/SAP will present a foundation for the execution of the work with the detailed protocols of the sampling and analysis described in a specific Field SAP (FSAP).

The FSAP will be developed based upon the site specific conditions of the area in which sampling is to occur (see Chapter 8 for a description of how sampling locations will be selected and sampling will be optimized). In addition to considering site constraints in preparing the FSAP there will be an assessment of the opportunity to integrate other data requirements that would support other data needs that are not directly related to the RFI/CMS. These other data needs may include filling data gaps identified in the DQO for Operable Units 200-BP-5 and 200-IS-1, any vadose zone and groundwater Treatability Studies, suggested inputs from the Integration Planning Team (IPT) and Pacific Northwest National Laboratories (PNNL) opportunistic studies. Accommodating these other data needs will take into account the cost and schedule implications to the scheduled RFI field work before committing to include these data collection efforts in the FSAP.

It is anticipated that the understanding of contaminated sites will improve as information is collected during the Near-Term and Phase 2 field investigations. As characterization of the vadose zone progresses and as analytical data are evaluated data needs may be modified. These supplemental data requirements will result in a revision to this DQO if the requirements have not been previously defined. Additional vadose zone characterization may be required to: 1) fill any remaining data gaps, 2) support vadose zone treatability studies, or 3) support further integration needs with groundwater Operable Units for achieving closure. This may lead to refining or revising data quality requirements. Therefore, changes to this document may be made, as required, during the time the DQO is in effect (through closure of the WMA).

Figure 1-1. Logic Flow Diagram for WMA C RFI/CMS.

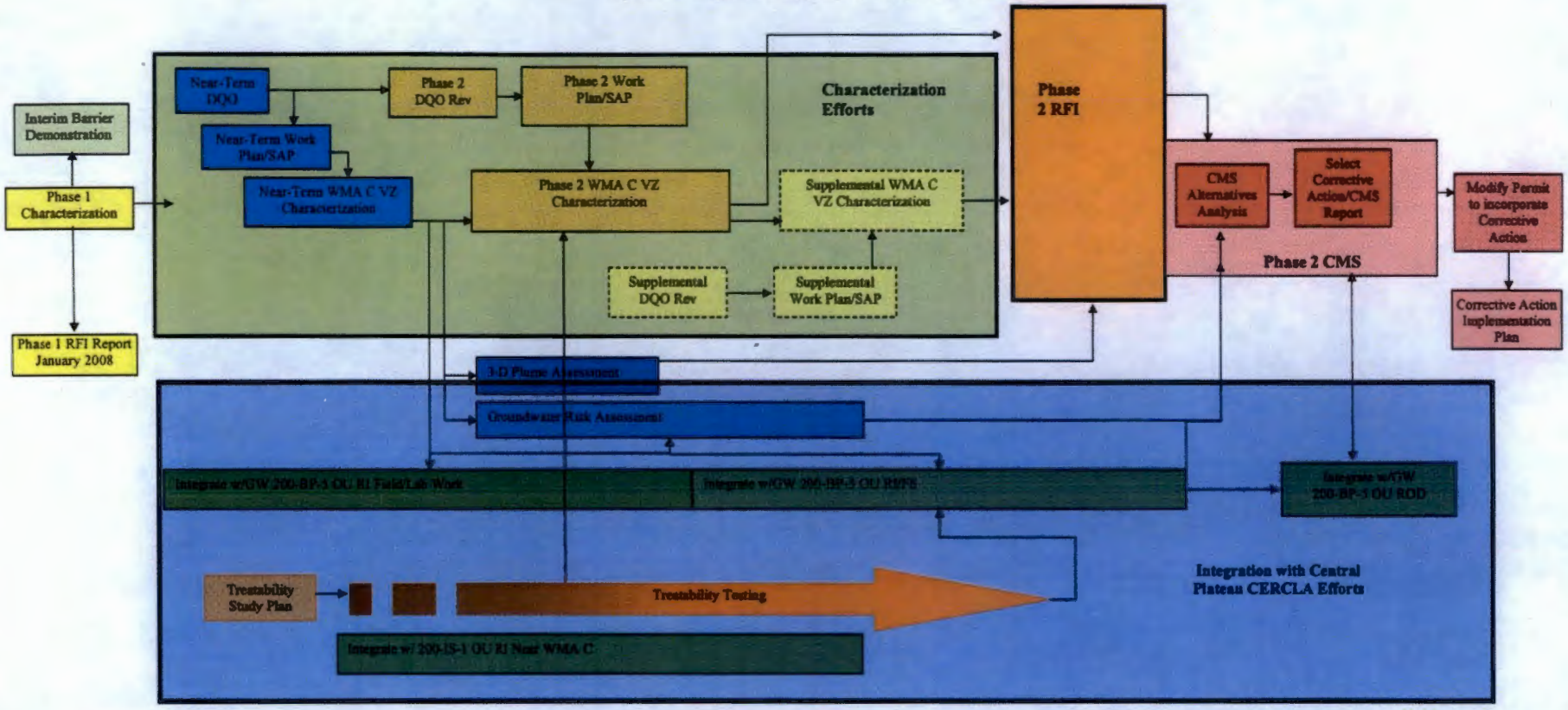
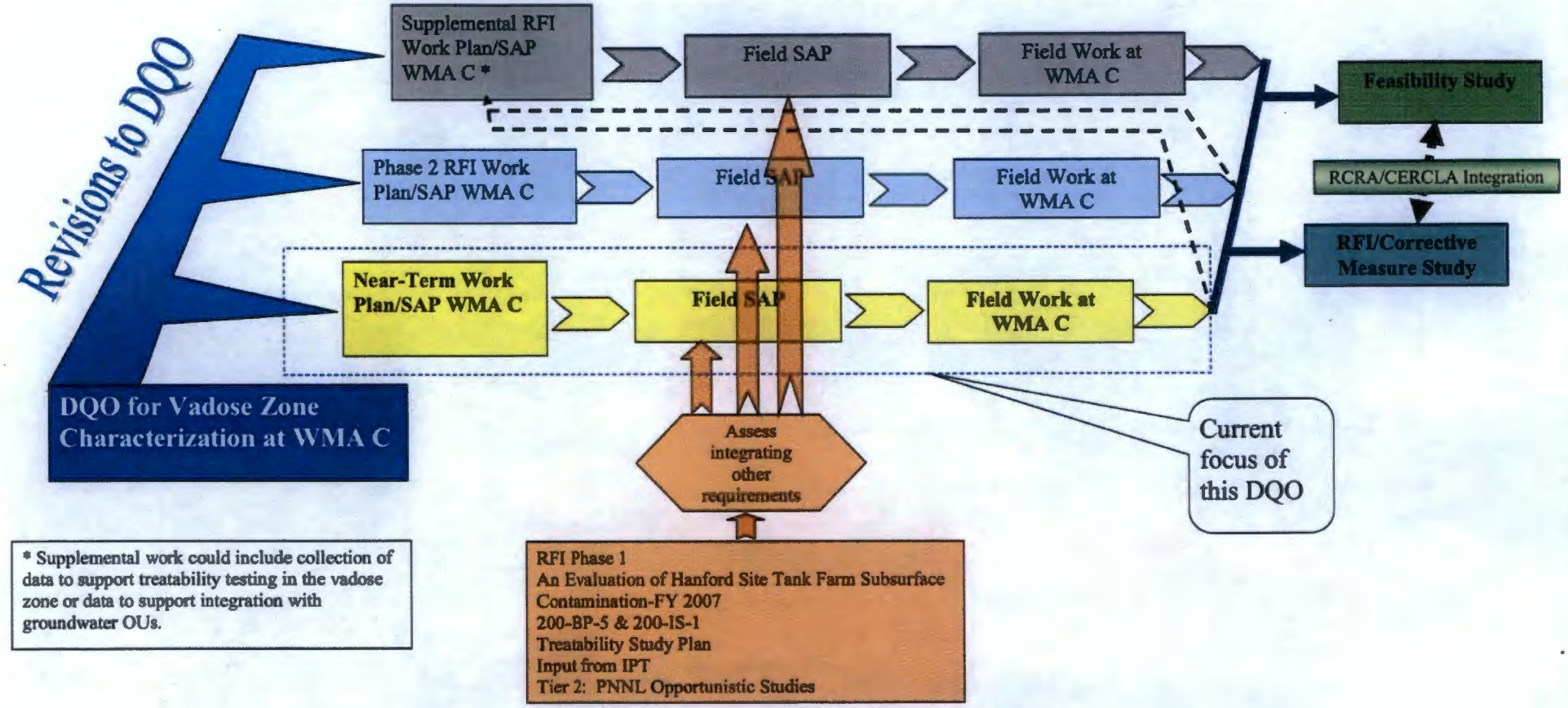


Figure 1-2. Development Process of DQOs for Vadose Characterization at Waste Management Areas (WMA C DQO will form template for other WMAs)



* Supplemental work could include collection of data to support treatability testing in the vadose zone or data to support integration with groundwater OUs.

The DQO will be updated when requirements change (e.g., addition or deletion of constituents to be analyzed), changes in equipment, changes in sample collection methods, etc. The DQO would be revised to meet the data requirements of these additional study needs with the development of subsequent Work Plans and SAPs and site specific FSAPs. Changes to the DQO document can be initiated by involved or affected groups (i.e., Ecology, the U.S. Department of Energy, Office of River Protection [ORP], and the Tank Farm Contractor (currently CH2M HILL Hanford Group, Inc.). In addition, these groups will be informed of all changes that occur prior to the action taking effect.

This document describes the DQO process that will be implemented to ensure appropriate data are collected to support characterization of the vadose zone at WMA C and covers the associated sampling and analytical activities for that purpose. This DQO also discusses the deployment of surface geophysical exploration (SGE) as a technology to aid in optimizing sample locations and support 2-D and 3-D plume characterization. This DQO supports the initial near term characterization efforts but does not address data needs for making final decisions concerning the remediation and closure of soil in WMA C including contamination risks to humans through direct contact and ecological receptors. This DQO will be revised at a future date to address these data needs. The DQO process was implemented in accordance with TFC-ENG-CHEM-C-16, Rev. A, *Data Quality Objectives for Sampling and Analyses,* and the U.S. Environmental Protection Agency (EPA) QA/G-4, *Guidance for the Data Quality Objectives Process* (EPA 2000), with some modifications to accommodate project or tank farm requirements and constraints.

1.2 REGULATORY BACKGROUND FOR CHARACTERIZATION

This section describes the regulatory background for the DQO. The regulatory framework underlying this DQO has been established to satisfy closure of the tank farm system including the corrective action requirements of RCRA, the State of Washington *Hazardous Waste Management Act of 1976* (HWMA) *(Revised Code of Washington* [RCWI 70.105), the *Hanford Federal Facility Agreement and Consent Order (HFFACO or Tri-Party Agreement)* (Ecology et al. 1998), and the Hanford Facility RCRA Permit. It is also intended to achieve equivalency to CERCLA, as required by the Tri-Party Agreement. As necessary to support closure, the framework also incorporates elements related to the *Atomic Energy Act of 1954* (AEA) as implemented through DOE Order 435.1 and other environmental laws that may affect decisions.

Ecology is the lead regulatory agency for the SST system. The SST system is regulated under RCRA and the HWMA as interim status Treatment, Storage, and Disposal (TSD) tank systems, and will be closed as RCRA TSD units. Final decision concerning the vadose zone contaminated by releases from the SSTs will be addressed during closure of WMA C.

Two major environmental regulatory programs govern cleanup of waste sites at the Hanford Site: RCRA (including the corresponding state law, the HWMA) and CERCLA. RCRA was enacted to manage and prevent releases of hazardous materials at active facilities that generate, store, treat, transport, or dispose of hazardous wastes or hazardous constituents. RCRA was amended to provide for corrective action for past and current releases at RCRA-permitted facilities. CERCLA was enacted to investigate and respond to past releases and potential releases of

hazardous substances at inactive sites. In addition to these statutes there are requirements under the Atomic Energy Act and DOE O 435.1 which must be addressed as part of the closure process. These multiple requirements create redundant and possibly conflicting administrative requirements. To address this issue, the Tri-Party Agreement signatories (DOE, EPA, and Ecology) established a single, unified closure process that incorporated the substantive elements of each regulation and DOE O 435.1. The Tri-Party Agreement was developed to establish how the RCRA and CERCLA programs will be applied at the Hanford Site. The agreement was designed for the following reasons:

- To ensure that environmental impacts associated with activities at the Hanford Site are investigated and that appropriate response actions are taken
- To ensure compliance with RCRA and the HWMA and provide a procedural framework for permitting RCRA TSD units
- To establish a procedural framework for developing, prioritizing, implementing, and monitoring appropriate response actions in accordance with RCRA and CERCLA.

Under Appendix I of the Tri-Party Agreement, Ecology is to involve the EPA for the purpose of ensuring work is consistent with future CERCLA remedial decisions, and to provide the EPA and DOE with a basis to evaluate the need for additional work that might be required if the closure activities were conducted under CERCLA remedial action authority.

Other key regulatory programs that directly affect corrective actions in a WMA are the AEA, the National Environmental Policy Act of 1969 (NEPA), and the Washington State Environmental Policy Act (SEPA) (RCW 43.21c). The AEA governs management of radioactive wastes. Requirements deriving from the AEA play an important role in the safe management and eventual closure of the WMAs. Where information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the Atomic Energy Act of 1954, as amended) has been incorporated into this document, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of "Hazardous Waste Management Act," Chapter 70.105, Revised Code of Washington and its implementing regulations but is provided for information purposes only.

The NEPA requires Federal agencies, including DOE, to evaluate any actions they plan to undertake for potential environmental and community impacts and to mitigate impacts as appropriate. Under NEPA, federal agencies must assess the impacts of proposed projects and alternatives prior to making a significant commitment of resources. Thus, any corrective action activities must be evaluated to determine what impacts would result from those activities. Similarly, SEPA requires Washington State agencies to evaluate state agency actions for potential environmental and community impacts and to mitigate impacts. DOE is in the process of preparing the Waste Management and Tank Closure Environmental Impact Statement (TC & WM EIS which is evaluating alternatives for the closure of the Hanford Tank Farms. The Record of Decision for TC & WM EIS is currently scheduled to be completed in 2009.

1.2.1 HFFACO Milestones

The HFFACO establishes a high-level schedule for overall SST system closure activities. The milestones that have been negotiated in the HFFACO provide a structure for developing detailed plans that specify activities and requirements for SST system closure. A summary of key HFFACO milestones pertinent to characterization of WMA C are presented in Table 1-1.

Table 1-1. Summary of Milestone

Milestone	
M-45-00	Complete closure of all SSTs and requirement that all SST retrieval and closure actions be conducted in compliance with the HFFACO Appendix I process
M-045-00B	Complete retrieval of all WMA C SSTs
M-045-06-T03	Initiate closure actions of one WMA
M-045-06-T04	Complete closure actions of one WMA
M-045-55	Submittal to Ecology of Phase 1 RFI Report for all WMAs
M-045-58	Submittal to Ecology of CMS for interim corrective measures for all WMAs
M-045-60	Submittal to Ecology of RFI/CMS Work Plan for interim corrective measures for all WMAs

The HFFACO milestones are the performance measures of compliance and document that progress is being made toward closure. These milestones are currently (as of October 2007) being renegotiated by the Tri-Parties.

1.2.2 Resource Conservation and Recovery Act (RCRA) and Hazardous Waste Management Act

Congress passed the Resource Conservation and Recovery Act ("RCRA") in 1976 to ensure the proper management of newly generated wastes. Congress then amended RCRA with the Hazardous and Solid Waste Amendments ("HSWA") of 1984, to include requirements for the cleanup of contamination in the environment from improper waste management. HSWA requires all facilities seeking a permit to treat, store, or dispose of hazardous wastes to clean up environmental contaminants at their site regardless of the time of release. The State of Washington has been delegated the authority from EPA to implement RCRA through the State of Washington "Hazardous Waste Management Act".

RCRA requirements, as implemented through "Dangerous Waste Regulations" (WAC 173-303) will be specified in the RCRA Site-Wide Permit. The permit will specify closure actions that must be performed to comply with RCRA requirements, whether the closure action is defined in association with tanks or ancillary equipment under a RCRA closure plan, or with contaminated soil and associated components under a RCRA corrective measures study (CMS).

The RCRA closure requirements call for meeting both the general closure performance standards of WAC 173-303-610 and the landfill closure performance standards of WAC 173-303-665(6) (as specified in WAC 173-303-640[8][b]). In planning integrated closure actions within the WMA, these standards will determine how closure is achieved under RCRA requirements. The

general closure performance standards of WAC 173-303-610(2) require that the facility be closed in a manner that:

- Minimizes the need for further maintenance;
- Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of dangerous waste, dangerous constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere;
- Returns the land to the appearance and use of surrounding land areas to the degree possible, given the nature of the previous dangerous waste activity.

Closure plans will describe how these performance objectives will be met. The closure plan will result in a modification to the Site-Wide Permit authorizing closure actions to proceed.

The SST system closure process, pursuant to HFFACO Appendix I, emphasizes closure at the WMA level. Modifications are expected to bring more information into the closure plan and permit actions for groups of components within the WMA by way of common and systematic implementation of retrieval, characterization, and closure.

There are two primary steps in the WMA C soil component closure activities: (1) characterizing and analyzing risk associated with contamination in the soil column, and (2) performing necessary cleanup as specified in the Site-Wide Permit. The RCRA Corrective Action process for Hanford's WMAs has the following major steps as defined in HFFACO Appendix I:

- Complete the RCRA Facility Investigation (RFI),
- Conduct a Corrective Measures Study (CMS), as appropriate, followed by
- Corrective Measures Implementation (CMI).

A summary of the overall Corrective Action Process is discussed below.

1.2.3 RCRA Corrective Action Requirements

A RCRA Facility Investigation (RFI) is conducted to verify release(s), and to characterize the nature, extent and rate of migration for releases of concern. The RFI initially involves verification of suspected releases. The Phase 1 RCRA Facility Investigation/Corrective Measures Work Plan for Single-Shell Tank Waste Management Areas (DOE-RL-99-36) and its implementation led to the identification and confirmation of major release sites in the WMAs. These findings for WMA C are documented in *Field Investigation Report for Waste Management Areas C and AX*. Confirmed sites and known or suspected release sites not confirmed in Phase 1 require further characterization in order to prepare the baseline risk assessment, complete the assessment of risk to groundwater, and to perform the corrective measures alternatives evaluation in the CMS.

The CMS will identify and evaluate specific measures to ensure protection of human health and the environment from releases based on the risks associated with contaminated soil. Decisions

concerning appropriate soil cleanup or corrective measures would be determined through the RFI/CMS process as defined in HFFACO Appendix I and associated milestones. Information generated during the Phase 2 RFI will be used not only to determine the potential need for corrective measures (i.e., the baseline risk assessment as incorporated into the WMA C PA), but also to aid in the selection and implementation of any measures.

Following the CMS, the selected remedy is implemented through the Corrective Measures Implementation (CMI) Plan. This plan includes designing, constructing, operating, maintaining and monitoring the corrective measures.

1.2.4 CERCLA Remedial Action Requirements for Groundwater

As indicated in HFFACO Appendix I, if it is determined that groundwater remedial actions associated with WMA C are necessary, groundwater remediation may be performed pursuant to a CERCLA ROD (interim and final) developed for the associated groundwater operable unit (OU) (200-BP-5 or 200-PO-1). Groundwater monitoring and response actions are integrated within the context of HFFACO Milestones M-24 and M-45 and, as feasible, would be integrated with, but separate from, the WMA C and Central Plateau regional closure strategy. Such remediation is the responsibility of DOE/RL and its contractor.

Releases from ancillary equipment such as pipelines and diversion boxes that are part of the tank farm system but outside of the WMA fenceline are part of OU 200-IS-1. This OU is addressing the ancillary equipment and contaminated soil in and around the release site. Section 4.2 discusses integration with Central Plateau OUs in more detail.

1.2.5 Atomic Energy Act of 1954 and DOE Order 435.1 Requirements

The closure of the tank farm system must also integrate the applicable requirements of DOE Order 435.1 (DOE O 435.1). DOE Manual 435.1-1 provides direction for waste characterization of radioactive waste and that the characterization is documented to ensure safe management and disposal of radioactive waste. The characterization process is to use a DQO process (or a comparable process) to identify characterization parameters and the acceptable uncertainty in characterization data. Each waste site will be characterized to include information on types and quantities of radioactive and hazardous chemicals from process knowledge. This information is then verified by appropriate sampling/analysis/monitoring techniques. The characterization and verification activities will also include determination of waste migration and potential environmental and health impacts. This information will be used to develop a closure strategy for the waste site(s), utilizing the waste characterization data. The SST PA and the WMA C PA will assess risk using this characterization data for both radiological and non radiological contaminants and therefore will serve multiple regulatory functions including those under RCRA, CERCLA, HWMA, Clean Water Act, Safe Drinking Water Act, and the AEA.

1.3 WMA C BACKGROUND

WMA C encompasses the C tank farm, including soil and groundwater contaminated by C tank farm operations. WMA C is located in the east-central portion of the 200 East Area (Figures 1-3 and 1-4). The WMA C boundary is represented by the fenceline surrounding the C tank farm. The C tank farm 100-series tanks are 23 m (75 ft) in diameter, have a 5 m (15-ft) operating depth, and an operating capacity of 1.89 million L (530,000 gal) each. The 200-series tanks are 6 m (20 ft) in diameter with a 5-m (17-ft) operating depth and an operating capacity of 208,000 L (55,000 gal) each. The tanks sit below grade with at least 2 m (7 ft) of soil cover to provide shielding from radiation exposure to operating personnel. Tank pits are located on top of six of the 100-series tanks and all four of the 200-series tanks and provide access to the tanks and their operating equipment (e.g., pumps and monitoring equipment).

The SSTs were constructed in place with carbon steel (ASTM A 283 Grade C) lining the bottom and sides of the interior of a reinforced-concrete shell. The tanks have concave bottoms (i.e., the center of each tank is lower than the perimeter) and a curving intersection of the sides and bottom. The inlet and outlet lines are located near the top of the liners. The twelve 100-series tanks are grouped into four sets of three tanks. Each tank in the three-tank grouping is connected to the next tank via a buried pipeline. These lines are also referred to as 'cascade' lines because they allowed the transfer of fluids between tanks using gravity flow. The SSTs in WMA C were used to store waste primarily from the bismuth phosphate, plutonium-uranium extraction (PUREX), and uranium extraction processes as well as the semi-works pilot tests.

A waste transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, pump pits, sluice pits, heel pits, and other miscellaneous structures support the transfer and storage of waste within the WMA C SSTs. Collectively, these are referred to as ancillary equipment. Another major component of significance is the 244-CR vault, located south of the tanks. The vault is a two-level, multi-cell, reinforced-concrete structure constructed below grade (*PUREX Source Aggregate Area Management Study Report* [DOE/RL-92-04]) and containing four underground tanks along with overhead piping and equipment. Two of the tanks have a capacity of 170,300 L (45,000 gal) each. The other two tanks have capacities of 55,500 L (14,700 gal) each. This vault was constructed in 1951 to support uranium recovery from metal waste; it ceased operating in 1988. It was last used to transfer waste solutions from processing and decontamination operations (DOE/RL-92-04).

The routing of liquid waste from the operations buildings to the tank farms was accomplished using underground transfer lines, diversion boxes, and valve pits. The diversion boxes housed the switching facilities where waste could be routed from one transfer line to another. The diversion boxes are belowground, reinforced-concrete boxes that were designed to contain any waste that escaped the high-level waste transfer line connections. These losses typically occurred during the reconfiguration of waste routings when jumpers were disconnected. Diversion boxes generally were drained by gravity to nearby catch tanks where any spilled waste was stored and then pumped to the SSTs (DOE/RL-92-04).

Figure 1-3. Location Map of WMA C in the 200 East Area of the DOE Hanford Site.

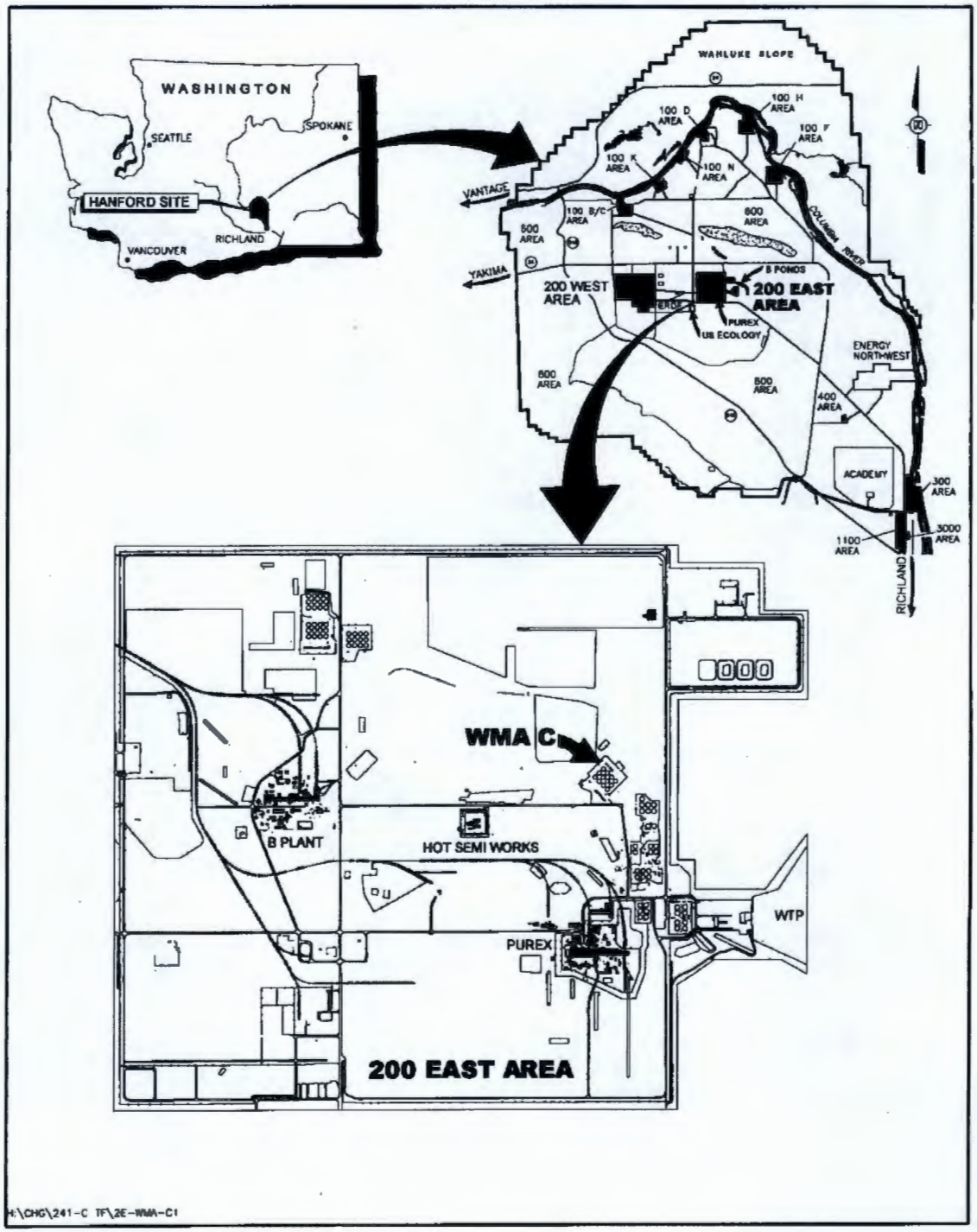
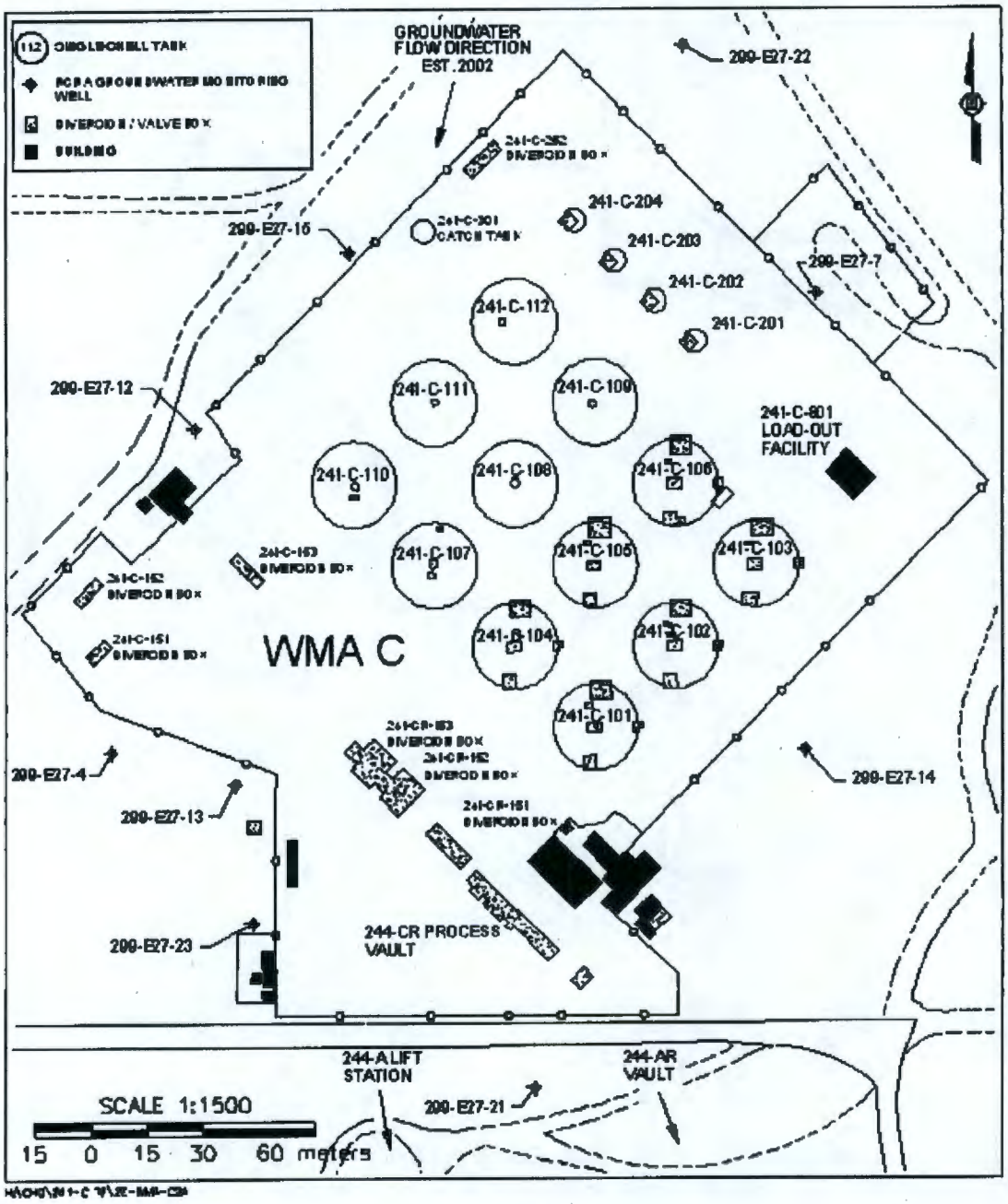


Figure 1-4. Location Map of WMA C and Surrounding Area.



Valve pits are belowground, reinforced-concrete structures that contain valve and jumper assemblies that were used for routing the liquid waste through the transfer lines. Liquid waste was routed to valve pits when several tanks were undergoing simultaneous pumping to a single receiver tank. Each valve pit has a flush line connected to a flush pit or drain line connected to an underground tank.

There are at least thirteen unplanned release site (UPRs) within or adjacent to WMA C. In additional, there are also planned release sites associated with some of the facilities at WMA C. There exists uncertainty in the volume and content of releases in and around WMA C. These release sites are the principal focus of the vadose zone characterization efforts of this DQO.

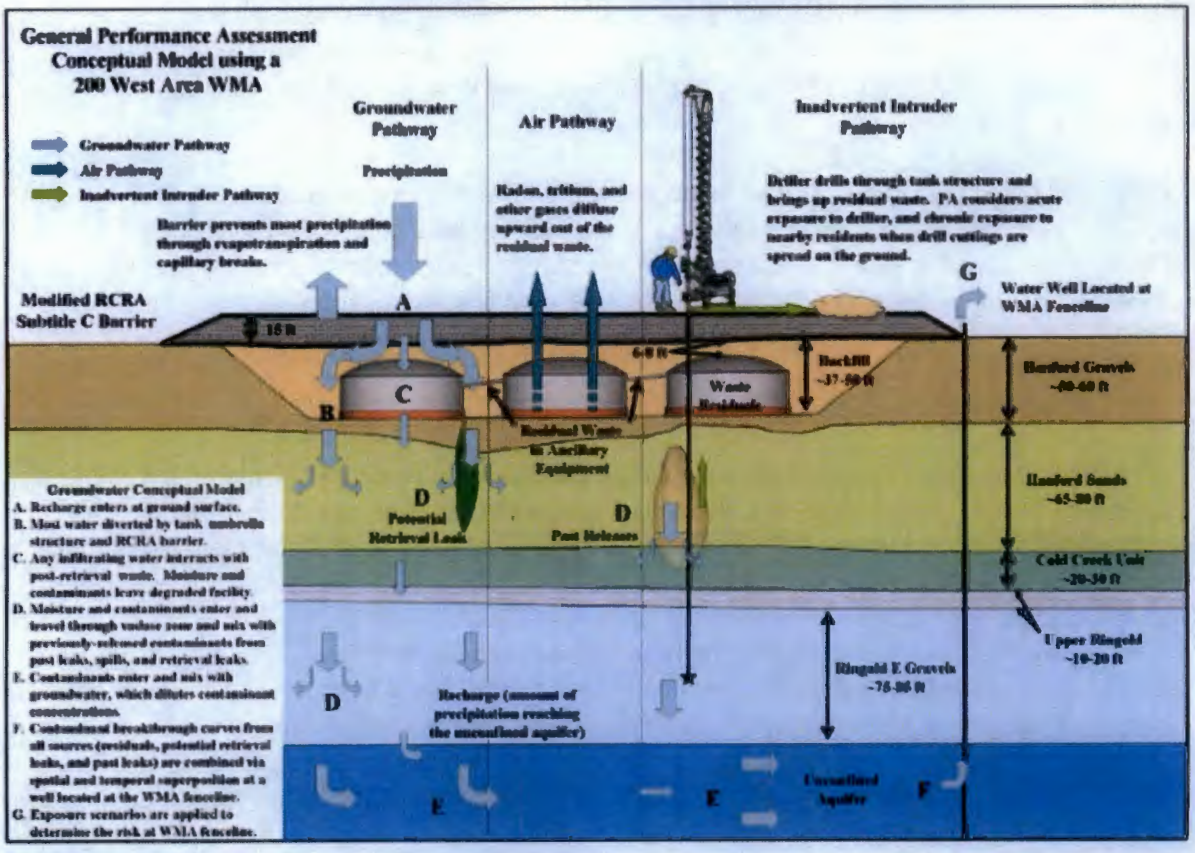
1.4 CONCEPTUALIZING AND MODELING CONTAMINATION

Models are developed to 1) help conceptualize the nature and extent of contaminants (visualizes and defines the location), the level of contamination and the extent of the spread of contamination; and 2) define analytical or numerical methods for predicting and quantifying constituent migration in the environment.

A conceptual model for each contaminant migration pathway was developed for each WMA, incorporating all available and relevant site-specific data. For groundwater pathways, much of the current data were collected under the Phase 1 RFI. Figure 1-5 presents a schematic of a typical conceptualization for a generalized WMA that was developed as part of the SST PA (DOE/ORP-2003-11, Rev.0). The scientific conceptualization includes the dominant processes controlling the mobilization and transport of contamination.
The conceptual model supports the following functions:

1. It provides an organized description of waste migration that can be evaluated as additional information is collected. Additional information can enhance confidence in the validity of the model, disprove aspects of the model, or result in refining the model.
2. It provides the framework for performance and risk assessments that support the analysis of corrective action and closure alternatives.
3. It identifies the processes and conditions that are believed to be common to all leak events.
4. It guides the application of a numerical flow and transport computer codes to project contaminant migration from the source. It guides formulation of input parameters needed to estimate contaminant migration through the vadose zone and groundwater.
5. In association with previous studies and historic process information, it aids in defining and prioritizing future data collection and analysis

Figure 1-5. General Performance Assessment Conceptual



The geology shown in the figure is specific to the 200 West Area.

This is the vertical and horizontal distribution of the levels of contaminants in the contaminated media. A conceptual model of the nature and extent of contamination is developed and validated through sampling and analysis of COPCs. This provides a 3-dimensional view of where contamination exists and what the contamination consists of. This information is an integral part of the fate and transport model.

A fate and transport model is an analytical description for predicting and quantifying constituent migration in the environment. For example, a fate and transport model may be used to predict vertical contaminant migration in the vadose zone to the groundwater table and migration from the vadose zone into groundwater. They can also be used to predict upward vertical migration of contaminants to the ground surface. Fate and transport models range from very simple equations requiring little data to very complex equations (or series of equations) requiring detailed site-specific information.

Fate and transport models are used by risk assessors to estimate the movement and chemical alteration of contaminants as they move through environmental media (e.g., air, soil, water and groundwater) to various receptors.

1.5 DQO TEAM

The development of this DQO has been based in part upon input from the DQO Team. The DQO team is identified in Table 1-4.

Table 1-2. DQO Team

Organization	Name	Function/Decision Authority
U. S. Department of Energy – Office of River Protection	Robert Lober	ORP Project Lead
U. S. Department of Energy – Richland Office	John Morse	RL Lead - Integration with Groundwater Operable Units
Washington Department of Ecology	Joe Caggiano	Co-lead Vadose Zone Project
	Les Fort	Co-lead Vadose Zone Project
CH2M HILL Hanford Group, Inc.	John Kristofzski	Vadose Zone Project Director
	Michael Galgoul	Project Lead
	Janet Badden	Regulatory Compliance
	Mike Connelly	Risk Assessment
	Fred Mann	Risk Assessment
	Dave Myer	Field Characterization
	Harold Sydnor	Field Characterization
	Jim Field	CMS
	David Banning	DQO Oversight
Cenibark International, Inc.	Paul Seeley	Principal Author

Interviews were conducted to help define the type of data the vadose zone characterization effort at WMA C will need to collect to help make decisions for closure. The interview process resulted in identifying data collection efforts needed to meet closure. These specific efforts are embodied in the previously described documents and include:

- **Characterize plumes from leaking or suspected leaking tanks**
- **Characterize Unplanned Release (UPR)-200-E-86, outside fence from C-152 pipeline.** (The single-shell tank (SST) performance assessment (PA) shows that this release has a high environmental impact at WMA C. Should be coordinated with IS-1 activities.)
- **Characterize vadose zone around facilities without logged boreholes or other vadose zone characterization** (such as C-200 tanks, C-301 catch tank, drains, tanks/vaults outside of farm, other facilities away from 100 series tanks and previous Vadose Zone Project investigations)
- **Demonstrate that all plumes have been found**. (Do systematic investigation around C-farm to establish contamination levels)

- **Place surface geophysical exploration (SGE) electrodes deep into vadose zone to support three dimensional SGE mapping.** (Two-dimensional SGE mapping has been performed. Additional electrodes are needed to develop three dimensional mapping)
- **Place SGE electrodes to support C Tank retrievals**
- **Obtain data to validate tank farm fate and transport computer models**
- **Confirm nature and extent of suspected releases**
- **Characterize nature and extent of surface and near surface releases**
- **Develop SGE network to support multiple functions.** (Establish network to support long-term monitoring requirements as well as any other applications to capitalize on technology and confirm capability at depth, including inactive miscellaneous underground storage tank [IMUST] monitoring for leaks. Network needs to extend beyond the tank farm fence line.)
- **Explore expanding the use of high resolution resistivity (HRR).** (Consider HRR technology cost effectiveness for emplacing vertical electrode arrays [VEA] for further resistivity tomography.)

1.6 PROJECT ISSUES

Project issues include both the global issues that transcend the specific DQO project and the technical issues that are unique to the project. Both global and project technical issues have the potential to impact the sampling design or the DQOs for the project.

1.6.1 Global Issues

This section is held in reserve.

1.6.2 Project Technical Issues

This section is held in reserve.

2.0 STEP 1 PROBLEM STATEMENT

The objective of a problem statement is to clearly define the problem (the reason analytical data are required) so the focus of the project (define the nature and extent of contamination and to support closure decisions including implementing interim measures) will be unambiguous. With the objective of the problem statement in mind, the scope of this DQO can be outlined in the following statements:

- This DQO will only address the data requirements related to the vadose zone in and adjacent to WMA C.
- The initial version of this DQO does not address the data requirements to support direct contact or ecological risk assessment in the Near-Surface strata at WMA C because these requirements have not yet been defined. Once ORP, Ecology and the Tank Farm contractor have defined these data requirements, this DQO will be revised to include the requirements.
- The DQO addresses data needed to characterize the vadose zone to support the RFI/CMS process. The DQO will not address characterization associated with the component closure activities for SSTs or any actions associated with ancillary equipment (pipes, pits, vaults, etc.) in the tank farm.
- The closure action criteria will be consistent with and support final closure of the tank farms. A separate DQO has been developed for the SSTs (RPP-23403, Rev.3). Ancillary equipment will be addressed in a separate component closure DQO or in DQOs for the closure of the tank farms.

Conduct soil remediation and corrective actions in a manner that is consistent with and contributes to final closure of WMA C.

Considering the purpose and scope of this DQO, a concise statement of the problem can be written as follows:

The principal study question (PSQ) identifies key unknown conditions that reveal the solution to the problem. The PSQ requires data to be resolved. Three PSQs have been developed that address the problem statement. The three PSQs are:

Principal Study Question #1 (Vadose Zone)
Are there concentrations of COCs and radionuclides in the vadose zone resulting from releases within WMA C that do not comply with preliminary corrective measure performance objectives for groundwater protection in the vicinity of the WMA boundaries?

Principal Study Question #2 (Closure)
Does the contaminated vadose zone in WMA C comply with Washington Administrative Code (WAC) 173-303-610 (2) preliminary closure performance objectives for protection of human health and the environment to allow closure activities in WMA C to continue?

Principal Study Question #3 (Closure)
Do the radiological contaminants in the vadose zone meet the closure requirements in DOE O 435.1?

3.0 STEP 2 DEFINE THE DECISION STATEMENTS

Decision statements link alternative actions with the PSQs and express a choice between alternative actions. Decision statements are created by combining the study questions with alternative actions. Using this formula, the decision statement can be expressed as:

Determine whether or not contaminated soil complies with WAC 173-303-610 (2) closure performance objectives for protection of human health and the environment and requires corrective actions in WMA C to proceed, or requires reassessment of the corrective actions.

Determine whether the soil at WMA C is compliant with DOE Manual 435.1 Chapter IV, P (1) requiring an appropriate corrective remedy or requires no action.

Figure 1-1 shows the general logic flowchart for the RFI/CMS process that supports closure actions of WMA C. The decisions are discussed and expanded in Section 6.0 while the sampling activities are discussed in Section 8.0. As indicated in the PSQs, they require decisions that must be addressed in order to proceed with closure.

4.0 STEP 3 IDENTIFY DATA INPUTS TO THE DECISION

This section describes the information required to address the problem statement and the decision statements. Data on the nature and extent of contamination as well as the fate and transport of the contaminants are required for completing the characterization, defining risks and selecting corrective measure alternatives. Nature and extent data includes determining the extent of contamination, chemical constituent concentrations, and radionuclide constituent concentrations. Fate and transport data includes determining the movement and changes that the contaminants may undergo over time through the vadose zone. The extent of contamination data is required to address one of the decision rules (see Section 6.0) and used with constituent concentrations to determine constituent inventories in the vadose zone. Concentration data are needed to determine direct contact and ecological risks and inventory data are needed for groundwater pathway modeling.

4.1 DATA NEEDS

Known or suspected release sites will require characterization before final decisions can be made on how these sites will be dispositioned for cleanup and closure. Several documents have defined data needs that require further characterization of known or suspected release sites in and around WMA C. The need for more data from additional characterization includes:

- RFI/CMS process – to define nature and extent so that baseline risks can be determined and alternatives evaluated for remedy selection; includes preparation of Field Investigation Reports (FIRs) which provide data assessments on the nature and extent of past contaminant releases from tanks and evaluate the potential reduction or elimination of human health and environmental risks from past releases through corrective actions.

- An Evaluation of Hanford Site Tank Farm Subsurface Contamination, FY2007 – data gaps are identified in the following general areas: existing subsurface inventory, contaminant release, recharge, and mobile contaminants

- SST Performance Assessment – to validate models and assumptions
- Additional Data Needs (See Section 4.1.4)

4.1.1 RFI/CMS Process

The RFI/CMS process requires that known or suspected releases be characterized through a combination of a review of existing information on the known process history, documentation concerning known or suspected releases and by conducting field investigations to collect samples for analysis to determine the nature and extent of any releases. This information is used to

determine the risk associated with confirmed releases to humans and the environment. In the case where a significant eminent risk exists, interim measures can be applied until a permanent remedy can be put in place. Otherwise an alternative analysis of corrective measures is conducted.

Phase 1 of the RFI began in 1998 and work to be conducted was described in the TWRS Vadose Zone Program Plan (DOE/RL-98-49). Phase 1 focused on vadose zone characterization and interim measure implementation. Characterization of the vadose zone focused on transport processes and how these might effect the movement of soil contamination and potential retrieval leaks. Interim measures included eliminating preferential pathways for water through the vadose zone by capping boreholes and eliminating driving forces for contamination movement by building infrastructure to prevent water from pooling on the tank farm surface and building barriers to prevent infiltration of water. This effort is complete and the Phase 1 RFI Report is due to be released in January 2008.

Field Investigation Reports (FIRs) provide data assessments on the nature and extent of past contaminant releases from tanks. These reports also evaluate the potential reduction or elimination of human health and environmental risks from past releases through corrective actions. FIRs also present computer simulations estimating future groundwater impacts from past releases, as well as a risk assessment. The FIRs for Waste Management Areas B/BX/BY, S/SX, and T&TX/TY have been issued. The FIRs for Waste Management Areas A/AX, C, and U are planned for release in the winter of FY-2008. Recommendations for further characterization in FIRs for further investigations and decisions include:

- Interim measures
- Accelerated corrective measures studies (CMSs)
- Future tank farm operations
- Collection of additional data and information
- Lessons learned

Efforts are now shifting to collect additional data to characterize contamination in the vadose zone to support risk analyses and provide additional data to evaluate alternatives to reduce or eliminate risks associated with releases. This DQO defines the data requirements to meet the needs of the RFI/CMS process.

4.1.2 An Evaluation of Hanford Site Tank Farm Subsurface Contamination, FY2007 (RPP-33441) (Gaps Report)

This document identifies data needs that are important to estimating future risks in performance assessments. These data gaps are also used as inputs to this data quality objectives process.

The Gaps Report is an update of *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination* (Jones et al. 1998). The document summarized knowledge of subsurface contamination beneath the tank farms at the time. It included a preliminary conceptual model for migration of tank wastes through the vadose zone and an assessment of

data and analysis gaps needed to update the conceptual model. The Gaps Report provides a status of the data, analysis of gaps outlined in Jones et al. (1998) and discussion of the gaps and needs that currently exist to support the mission of the Tank Farm Vadose Zone Project.

The data gaps and needs are arranged in groups that reflect components of the tank farm vadose zone conceptual model:

- Inventory
- Release
- Recharge
- Geohydrology
- Geochemistry
- Modeling

Within each group or component of the conceptual model, the new data gaps and needs are ordered by priority.

For the revised list of data gaps and needs, priorities were assigned based on the impact of the gap/need on groundwater impacts and the associated knowledge level. Impacts are defined as direct, indirect, low, and unclear. An impact is direct if the data or analytical result quantifies a condition or process that strongly influences eventual radionuclide contamination levels in the vadose zone or groundwater. An impact is indirect if it doesn't quantify a condition or process that influences radionuclide fate and transport in the vadose zone and groundwater. An impact is unclear if the effect of the process, condition, or analytical result on radionuclide migration is not known, but may be significant or provide a means to better understand the current and future distribution of radionuclides.

Knowledge levels are defined as low, medium, and acceptable. A knowledge level is low if no site-specific information is available and no general literature values can be used with confidence to represent the process or parameter in a radionuclide migration model. If the parameter or process is considered vital to the evaluation of radionuclide migration, additional data collection to develop usable values is recommended. Knowledge level is medium if some site-specific, quantifiable data or relevant literature values are available. A medium knowledge level is assumed to lead to a database that is sufficient to provide estimated values that can be used in radionuclide migration models to perform a reasonably conservative risk assessment. Use of these medium knowledge level estimates is expected to lead to conservatively high estimates of groundwater contamination. Additional data are expected to clearly improve both quantification of the condition or process and confidence in the values used in a radionuclide migration model. A knowledge level is acceptable if site-specific, quantifiable data are available to provide input into a radionuclide migration model and additional data are expected to only marginally improve understanding. Considering both the determination of impact and knowledge level, the data or analysis needs are ranked for prioritization.

Table 4-1 is a summary of key aspects of the data gaps that were identified. The existing subsurface inventories are relevant data gap needs for this DQO.

Table 4-1. Data Gap Summary.

Area	Description	Driver
Inventory	Retrieval tank leaks and residual waste concentrations will be measured during and after retrieval.	Key driver for intruder impacts; impacts groundwater analyses.
Existing subsurface inventory	Content and extent of contaminants; Major leaks have been characterized by borehole and direct push sediment samples as well as field gamma logging and high resistivity measurements.	Key driver for groundwater analyses.
Contaminant release	Release models (including effect of tank fill grout leachate).	Key driver for groundwater analyses for residual wastes in tanks.
Recharge	Gravel surface/surface barriers	Key driver for groundwater analyses
Mobile contaminants	What could cause contaminants not presently mobile to become mobile?	Such contaminants drive the groundwater analyses.

4.1.3 Single-Shell Tank Performance Assessment (SST PA)

As defined by DOE M 435.1-1, a performance assessment is "An analysis of a radioactive waste disposal facility conducted to demonstrate there is a reasonable expectation that performance objectives established for the long-term protection of the public and the environment will not be exceeded following closure of the facility."

The SST PA serves several different regulatory processes. The SST PA will support waste determinations for tank waste residuals remaining after completion of retrieval in accordance with the HFFACO (Ecology et al. 1989). Additionally, Appendix H to the HFFACO requires DOE to interface with the U.S. Nuclear Regulatory Commission (NRC) with respect to allowable waste residuals in tanks and the soil column (i.e., vadose zone). To meet these different purposes, the SST PA includes analysis of past releases within each SST WMA. The SST PA satisfies a requirement in the HFFACO for DOE to interface with the NRC with respect to allowable waste residuals in tanks and the soil column (i.e., vadose zone), and supports regulatory waivers to the HFFACO tank waste retrieval goals.

The HFFACO, Appendix I, Section 2.5 (Ecology et al. 1989) states that, "Ecology, as the lead agency for SST System closure, EPA, and DOE have elected to develop and maintain as part of the SST system closure plan one performance assessment for the purposes of evaluating whether SST system closure conditions are protective of human health for all contaminants of concern, both radiological and nonradiological. DOE intends that this performance assessment (PA) will document by reference relevant performance requirements defined by RCRA, HWMA, *Clean Water Act, Safe Drinking Water Act*, and the *Atomic Energy Act of 1954* (AEA), and any other performance requirements that might be ARARs [applicable or relevant and appropriate requirement] under CERCLA. The PA is of larger scope than a risk assessment required solely for nonradiological contaminants. The PA is expected to provide a single source of information that DOE can use to satisfy potentially duplicative functional and/or documentation requirements. A PA will be developed for each WMA and will incorporate the latest information

available. These PAs will be approved by Ecology and DOE pursuant to their respective authorities. Ecology approval means incorporation by reference, into the Site-Wide Permit through closure plans."

The SST PA was developed to evaluate three contaminant migration pathways (i.e., groundwater, air, and intruder) that can lead to human exposure through a variety of scenarios. Contaminant exposure scenarios are defined as sequences of human activities that establish levels of interaction with the waste found in air, water, and soil. Human interaction with the waste generally occurs through a variety of exposure pathways, such as direct human contact (e.g., contamination of skin), ingestion or inhalation (which enable contaminants to enter the body), or exposure to radiation (potentially important only for the first few hundred years until cesium-137 decays to inconsequential levels). Exposure scenarios were selected that represent plausible land use activities that could occur near a closed facility, and can be analyzed to provide exposure estimates that are comparable with regulatory criteria. Implicit in the assumptions of these scenarios is the idea that waste quantities should be sufficiently limited and isolated to permit safe land use with these activities. Exposure scenarios evaluated represent a range of possible exposure pathways. The scenarios include the residential farmer, site resident, and the industrial user.

The selection of scenarios discussed above implies knowledge of waste disposal in the area. Human exposure scenarios are also evaluated with the inadvertent intruder pathway in which knowledge of the location of the disposal site is assumed to be lost. These scenarios include a suburban resident with a garden, rural pasture, and commercial farming. The rural pasture scenario is considered part of the reference case, while the suburban resident and commercial farmer are considered in the sensitivity analysis. The intruder pathway is specific to the regulatory environment for the disposal of low-level radioactive waste (DOE O 435.1) and is not typically seen in environmental remediation investigations.

The evaluation of pertinent regulations also identified media-specific (i.e., air and groundwater) criteria or performance objectives that may be used for remediation goals. The SST PA uses these criteria as appropriate to the media and contaminant. If contamination is found, the characterization data along with the process history records will be used to refine inventory estimates for the WMA C specific performance assessment.

The SST PA documents the current baseline but it is recognized that as new data are collected the PA will require updating. Changes will be driven by insights from laboratory studies, field characterization efforts, numerical analyses, and maturation of closure design.

The methodology implemented in the SST PA results in the development of a path for future work that is directed to reduce uncertainty where possible, and to validate basic assumptions that support the SST PA. The data gaps and priorities are described in Section 7.5 of Preliminary Performance Assessment for Waste Management Area C at the Hanford Site (DOE/ORP-2003-11, Rev. 0). Data needs associated with WMA C vadose zone characterization include:

- **Improved Estimates of Past Release Inventories Lost to the Vadose Zone**
  Estimates of past release inventories that are consequential to the potential compliance status of a WMA will be improved. Large past releases are relatively well characterized; however, in some WMAs, risks are exceeded for relatively small release volumes (i.e., less than 6,000 gal). These releases have not been investigated in the field under the RCRA Corrective Action process. Information from soil sampling in the leak area or additional data from geophysical techniques may refine the associated inventory of these leak volumes. Past releases into the vadose zone are clearly indicated as the controlling factor for the estimates of early (i.e., less than 400 years after closure) groundwater impacts. Selected past release estimates will be refined for use in future analyses.

- **Use of Site-Specific Data to Model Each Waste Management Area**
  Site-specific data will be used to evaluate the information used for the WMA C template.

4.1.4 Additional Data Needs

Additional data are needed to resolve several questions concerning the volume and nature and extent of contamination in WMA C and to relate this information to closing Waste Management Area C. These questions include:

- WMA C tanks listed in *Tank Waste Monthly Summary Report* as leakers (or suspected leakers) are noted in Field and Jones (2005) as small leakers (~1,000 gallons or less). Is the soil contamination surrounding these tanks supportive of the projected tanks release quantities cited one document or the other?
- For WMA C and associated releases not previously characterized but thought to have reached at least 30 feet below surface, what was the waste stream release and have mobile constituents moved beyond the range of direct push technology ?
- For WMA C releases previously characterized, what is the extent and how does this relate to SGE results?
- What is nature of Co-60 in the region of continuing migration in the vadose zone observed in a few dry wells?
- Are there activities that would aid deep vadose zone sediment characterization of WMA C?

The *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* (DOE/ORP-2005-01) has shown that past unplanned releases from the tank system have the largest estimated impact on groundwater resources. The first key question in the characterization of such past releases is to determine which components of the tank system have released waste to the subsurface. Based on the observed drop in waste levels inside of some WMA C tanks (C-101, C-110, C-111, C-201, C-202, C-203, and C-204) these tanks are listed as leakers or suspected leakers in the *Tank Waste Monthly Summary Reports* for the cited tanks. However, Field and Jones (2005), using vadose zone and other data, suggest that there is little or no evidence for the C-101 leak size listed in the *Tank Waste Monthly Summary Reports*. Based on a new draft protocol, the Washington State Department of Ecology after reviewing existing data has agreed that the release from tank C-110 was likely less than 2,000 gallons and that prior leak estimates

from tank C-111 can be attributed to evaporation. The C-200 series have just been retrieved and it is unknown whether there were releases during the retrieval.

To aid in resolving this discrepancy, data is needed on the concentrations of key tank waste constituents (e.g., nitrates, Tc-99, Cs-137) and on vadose zone characteristics showing the effects of tank waste releases (e.g., pH, Na/Ca: Mg exchange). Expected sediment background levels would be similar to that found from borehole 200-E27-22 as reported in the *Characterization of Vadose Zone Sediments Below the C Tank Farm: Borehole C4297 and RCRA Borehole 299-E27-22* (PNNL-15617). The concentrations of mobile contaminants and the key waste steam indicators (pH, Na/Ca-Mg exchange) in sediment samples obtained in this WMA C campaign would be compared to the uncontaminated background levels to assess whether significant fluid leaks did occur at the sampled locations. Vadose zone sediment samples should be obtained at locations suspected of being near release points or where leak fluids may have cumulated as shown by moisture logs.

If Tc-99 or Cs-137 is found above three times the detection limit, then determination of the vadose zone sediment concentration of other tank waste constituents should occur with the realization that sample mass considerations may limit the analyses to gamma-emitting radionuclides and to inorganic chemicals. Similarly if the nitrate concentration is three times the background concentration, or if pH is greater than 8.5, or if there is evidence of sodium displacement of natural cations, then again extended characterization is needed (again, possibly limited by sample mass).

4.2 INTEGRATION OPPORTUNITIES CENTRAL PLATEAU OPERABLE UNITS

In addition to meeting the data needs to directly support the RFI/CMS /closure process within WMA C, it is important to understand the data needs involved in WMA C closure integration with the closure of the Central Plateau. The interfaces between the Central Plateau and WMA C must be clearly accounted for in closure planning. The interactions and interfaces between WMA C closure and other Central Plateau remediation and closure actions include waste sites, infrastructure, and groundwater. Proposed integration strategies for waste site remediation, infrastructure interface definition and remediation, and groundwater decision making and remediation are presented in the following sections. The intent of these strategies are to ensure that the WMA C closure is consistent with the actions taken on the Central Plateau, there is clarity in the responsibilities for these actions, and completeness in the coverage of all actions that must be taken. Fundamental to the integration between WMA C and the Central Plateau would be a strategy that allows DOE/ORP and DOE/RL to understand their respective processes to ensure that decisions and strategies will accommodate structures and facilities at the interface areas and be complementary.

The boundaries for WMAs have been defined for purposes of groundwater monitoring. Because there are waste sites and other tank farm system components that exist in both WMA C and the Central Plateau, there is a need to clarify the boundaries in the context of WMA/Central Plateau closure that go beyond the requirements for groundwater monitoring. The interface between WMA C and the C tank farm closure zone of the Central Plateau includes waste sites that require a determination of the program overseeing closure.

4.2.1 200-BP-5 DQO

Groundwater contamination in the 200-BP-5 OU is primarily related to waste disposal associated with B Plant past operations. A portion of this groundwater OU extends under WMA C. The OU 200-BP-5 DQO summary report identifies and evaluates existing data to better understand data gaps and uncertainties and to define additional data requirements to support the remedial investigation/feasibility study (RI/FS) process for the 200-BP-5 Groundwater Operable Unit (OU). The OU 200-BP-5 DQO summary report assembles and evaluates existing data to identify contaminants of potential concern (COPC) and contaminants of concern (COC), defines the preliminary conceptual site model (CSM) for both waste site sources and groundwater impact, and identifies data gaps and potentially applicable remedial technologies.

The OU 200-BP-5 DQO summary report identifies the population of interest, the spatial and temporal boundaries, defines the scale of decision making, and identifies any practical constraints (i.e., hindrances or obstacles) that must be taken into consideration. The OU 200-BP-5 DQO also defines the attributes that define the population of interest which then is used to establish spatial and temporal boundaries of the site under investigation. The vadose zone is considered a population of interest in the OU 200-BP-5 DQO. Vadose zone data are needed to identify COPC and to predict impacts of COPC on groundwater.

WMA C and the Hot Semi Works make up one of nine sub-geographic study area boundaries that comprise of the 200-BP-5 OU. The area borders the 200-PO-1 groundwater OU to the south and extends to the east 200-BP-5 OU boundary. Iodine-129, technetium-99 and nitrate plumes are known to exist in the groundwater below WMA C. Groundwater monitoring has not identified any contamination that is directly attributable to UPRs or other releases in WMA C. However, the presence of contaminants in the vadose zone requires characterization and a determination of the potential for resultant environmental impacts, which may provide a basis for remediation or closure.

4.2.1.1 Integration with OU 200-BP-5 DQO Scale of Decision Making

The OU 200-BP-5 DQO summary report defines the major strata that will be the primary focus of the RI characterization efforts. For the 200-BP-5 OU, the major strata are defined based on individual hydrogeologic units overlying and within the OU. These individual strata (vadose zone, unconfined aquifer, basalt aquitard, and confined aquifer units) are used in developing a CSM. For the CSM purposes, these designated strata are useful for evaluating contaminant plumes. For purposes of integration with the WMA C Vadose zone characterization efforts, the principal strata of interest is the vadose zone which the OU 200-BP-5 DQO summary report defines as the Hanford formation and overlying eolian deposits.

The OU 200-BP-5 DQO summary report identifies the temporal boundaries that may apply to each of its decision statements (DSs). The temporal boundary refers to the timeframe over which the data collected will apply to the DSs and when the optimum time is to collect the samples. The OU 200-BP-5 DQO summary report data collection timeframe for characterization extend through 2009. This timeframe provides a reasonable integration for the WMA C deep vadose zone characterization which should be completed in approximately the same timeframe.

The scale of decision making is defined by joining the population of interest and the geographic and temporal boundaries of the area under investigation. For the OU 200-BP-5 DQO summary report, the scale of decision making has been maintained in fairly global terms. The scale of decision making is a principal integration point between the WMA C Vadose zone characterization and the OU 200-BP-5 vadose zone characterization. This integration begins with data collection and characterization phases of the CERCLA RI and RCRA facility investigation process. Table 4-2 presents the basis for establishing the scale of decision making between the two characterization efforts. Table 4-2 focus is on the RI process of CERCLA because the vadose zone characterization efforts serve as supplemental input to that effort.

Table 4-2. Scale of Decision Making between RCRA Facility Investigation and CERCLA RI

Population of Interest	Geographic Boundaries	Temporal Boundary		Scale of Decision
		Time frame (years)	When to Collect Data	
Vadose zone data needed to identify COPC.	Vadose zone within the 200-BP-5 OU boundary	Oct 2005 to Oct 2006	During DQO process	Within the 200-BP-5 OU vadose zone geographic boundaries from October 2005 to October 2006 (Completed)
Vadose zone data needed to predict impact of COPC on groundwater.	Vadose zone within the 200-BP-5 OU boundary	Oct 2005 through Oct 2009	During DQO process and RI	Within the 200-BP-5 OU vadose zone geographic boundaries from October 2005 to October 2009
Concentration of COC in unconfined aquifer or expected to reach the groundwater over the next 1,000 years. This data will be used in models to develop risk estimates.	Vadose zone and groundwater within the 200-BP-5 OU boundary	Oct 2005 through Oct 2009	During DQO process and RI	Within the 200-BP-5 OU vadose zone and groundwater geographic boundaries from October 2005 to October 2009
Data required to develop and support a conceptual model for migration of uranium and technetium to groundwater.	Vadose zone within the 200-BP-5 OU boundary	Oct 2005 through Oct 2009	During DQO process and RI	Within the 200-BP-5 OU vadose zone and groundwater geographic boundaries from October 2005 to October 2009

4.2.2 200-IS-1 DQO

This 200-IS-1 DQO summary report supports site characterization decisions for remedial investigation (RI) of the 200-IS-1 Tanks/Lines/Pits/ Waste Group Operable Unit (OU) process waste pipelines. The 200-IS-1 OU consists of *Resource Conservation and Recovery Act of 1976* (RCRA) past-practice waste sites and treatment, storage, and disposal units that exist outside of the WMAs and includes an extensive network of pipelines, diversion boxes, catch tanks, valve pits, related infrastructure, and associated unplanned releases. The process waste pipeline systems were used to transport process waste from the separations facilities to the single- and double-shell tanks and to control or divert flow to disposal waste sites that received liquid waste

streams. The process-waste pipeline systems primarily are located within the industrial 200 Areas of Hanford's Central Plateau.

The primary objectives of the DQO process for the process-waste pipeline systems include the following.

- Determine of the environmental measurements necessary to support the remedial investigation/feasibility study process and remedial decision-making.
- Identify data needed for development of the remedial investigation/feasibility study work plan and sampling and analysis plan.
- Identify evaluation strategies that are inclusive of both RCRA and CERCLA requirements for the 200-IS-1 OU pipelines.
- Develop preliminary conceptual contaminant distribution model(s) that reflect the physical characteristics of the process-waste pipeline systems and surrounding soil and the anticipated distribution of contaminants. Data collection will support refinement of the model(s).

Data collected during the RI will be used to determine if the process-waste pipeline systems are contaminated above levels that will require remedial action, to support evaluation of remedial alternatives and/or closure strategies, and to verify or refine the preliminary conceptual contaminant distribution models.

During the DQO process, a binning strategy was developed that groups process-waste pipelines with similar process histories and contaminants for field investigations and sampling during RI activities. A two-phase sampling approach, with different data collection objectives and requirements for each phase, was identified for the process waste pipeline systems. Phase 1 will consist of acquisition of a data set that is smaller than that required for Phase 2. The purpose of the Phase 1 investigation will be to gather limited data in support of existing information that indicates that contamination likely is present at concentrations above preliminary cleanup levels. The data collected will be used to determine whether contaminant levels are consistently above action levels and to support remedial decision making (other than the no-action alternative).

Phase 2 sampling will be used for evaluation of those pipelines and associated structures where there is considerable uncertainty concerning whether contamination exceeding action levels is present. Proceeding directly to Phase 2 sampling would be appropriate for those pipelines where existing information indicates that contamination will not be present and/or where considerable variability is expected in potential results. Phase 2 sampling will be required if all remedial alternatives need to be assessed, including the no-action alternative. Phase 2 sampling requires a larger data set for decision-making.

The interiors of pipelines, associated appurtenances, and surrounding soils were identified as requiring data collection for remedial decision-making. Measured concentrations will be compared with the preliminary cleanup levels. The nature (for example, contaminant type and concentration) and extent of the contamination are the major RI data needs.

Targeted characterization sites include low points in the system, bends in the pipelines and known or suspected release sites. The tank farm pipeline characterization locations will be associated with transfer lines that conveyed waste into WMA C. Three candidate sampling locations have been identified on the cross site transfer pipeline going into WMA C and two candidate sites are on the transfer pipelines between WMA C and WMA A-AX. One candidate site is at the location of UPR-E-86, which is located outside of the WMA C fenceline. This UPR is also associated with WMA C and the vadose zone at this site will be characterized as part of this DQO effort. Pipeline characterization will be accomplished as part of the 200-IS-1 efforts.

4.3 ANALYTICAL PARAMETERS

An analytical strategy for the component closure action of an SST was developed during process meetings during the development of the SST DQO (RPP-23403, Rev. 3). This strategy is based on analyzing for major constituent categories (volatile organic compounds [VOC], semivolatile organic compounds [SVOC], inorganics, and radionuclides) by a set of specific analytical methods. The strategy identifies specific constituents (Single-Shell Tank Part A Permit [Part A] [CH2M HILL 2003], underlying hazardous constituents [UHC], and radionuclides from *Code of Federal Regulations,* 10 CFR 61.55) that will be analyzed with the quality control (QC) specified in the SST DQO (RPP-23403, Rev. 3). This strategy has been adopted in the 200-IS-1 DQO for tank farm pipelines and associated appurtenances and associated Unplanned Release Sites (UPRs). This strategy serves as the foundation for this DQO as well because tank waste was released into the vadose zone.

For the initial Near-Term characterization efforts chemical and radiological analyses will be performed on samples collected during the field program. Because sample volume is limited when direct push sampling techniques are used (see Section 8.2), it may not be possible to perform all analyses. To that end, a priority-of-analysis will be instituted. The approach taken parallels the tiered analysis approach used during the Phase 1 RFI field investigations.

Priority 1 Analysis

- Moisture content
- Gamma Energy Analysis
- 1:1 water extract
  - pH
  - technetium-99
  - nitrate
  - metals
  - anions
  - Total Organic Carbon

- Acid extracts
  - technetium-99
  - nitrate
  - metals
  - anions

Priority 2 Analysis

- mineralogy
- Identification of mobilizing agents
- Speciation of major contaminants

Priority 3 Analysis

- Associations of technetium-99 with minerals
- Semi-volatile organic compounds
- Volatile organic compounds

The following sections discuss the constituent categories: inorganic, organic, and radiological. Some constituents may be measured by more than one method. In these cases, the selection of the method may depend on the action levels required for a decision, method detection limits, or the expectation that the constituent is present.

Soil analyses will be performed utilizing the applicable methods outlined in SW-846. However, SW-846 methods may require modifications to address radiological concerns.

4.3.1 Inorganics

The analytical strategy for inorganics will utilize analytical methods that are capable of analyzing multiple constituents. This allows additional data to be obtained with minimum effort and costs. When these methods are utilized, all constituents will be reported.

The inorganic constituents are identified as Part A and UHC constituents. If the primary constituent does not meet the quantitation limits (see Section 4.4), it would be reanalyzed using either a smaller dilution (larger sample size) or a more sensitive existing method, such as inductively coupled plasma/mass spectrometry (ICP/MS). If neither of these options is possible, then a new method may need to be developed.

The inorganic constituents and analytical methods for these constituents are shown in Table 4-3. As shown in Table 4-3, with the exception of mercury, metals are determined by inductively coupled plasma/atomic emissions spectroscopy (ICP/AES). Mercury is determined by ICP-MS [SW-846 6020].

Table 4-3. Inorganic Constituents and Analytical Methods.

Constituent		Reason for Inclusion	Analytical Method	Alternate Method
Aluminum	Al	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Antimony	Sb	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-41 (ICP-MS)5
Arsenic	As	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Barium	Ba	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Beryllium	Be	U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Cadmium	Cd	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Chromium	Cr	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Cobalt	Co	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Copper	Cu	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Iron	Fe	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Lead	Pb	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Manganese	Mn	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Nickel	Ni	U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Selenium	Se	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Silver	Ag	A, U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Strontium	Sr	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Thallium	Tl	U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Uranium	U	R	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Vanadium	V	U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Zinc	Zn	U	6010B (ICP/AES) or PNNL-AGG-ICP-AES (ICP-OES)	6020 (ICP/MS) or PNNL-AGG-415 (ICP-MS)
Mercury	Hg	A, U	PNNL-AGG-415 (ICP-MS)	7470A, 7471A (CVAA)
Fluoride	F^-	U	9056 (IC)	AGG-IC-001 (IC)
Nitrite	NO_2^-	R	9056 (IC)	AGG-IC-001 (IC)

Table 4-3. Inorganic Constituents and Analytical Methods.

Constituent		Reason for Inclusion	Analytical Method	Alternate Method
Nitrate	NO_3^-	R	9056 (IC)	AGG-IC-001 (IC)
Acetate	$C_2H_3O_2^-$	R	9056 (IC)	AGG-IC-001 (IC)
Formate	CHO_2^-	R	9056 (IC)	AGG-IC-001 (IC)
Glycolate	$C_2H_3O_3^-$	R	9056 (IC)	AGG-IC-001 (IC)
Oxalate	$C_2O_4^{2-}$	R	9056 (IC)	AGG-IC-001 (IC)
Cyanide	CN^-	A, U	9014 (Spectrophotometric)	
Ferrocyanide	$Fe(CN)^{3-}$	A, U	Considered total cyanide.	AGG-IC-001 (IC)
Sulfide	S^{2-}	U	9215 (Ion Selective Electrode)	9034 (Titration)
Ammonium	NH_4^{+} [a]	W	EPA 300.7 (IC)	AGG-IC-001 (IC)
Hydroxide	OH^- [a]	W	Titration or pH (see text)	AGG-PH-001 (pH)

Notes:

A	Part A constituent.
R	Risk assessment constituent.
U	UHC constituent.
CVAA	Cold vapor atomic absorption
IC	Ion chromatograpy.
ICP/AES	Inductively coupled plasma/atomic emissions spectroscopy.
ICP/MS	Inductively coupled plasma/mass spectrometry

[a] Constituents added during DQO process meetings.

If the ICP/AES sensitivity is inadequate for some of the metals, they will be determined by alternative methods such as ICP/MS.

Four anions (nitrate, nitrite, fluoride, and cyanide) are identified as applicable constituents. Fluoride, nitrate, and nitrite are measured by ion chromatography (IC). The IC analyses are normally performed on a water digestion of solids; however, this will not provide information on insoluble fluorides or chlorides.

The cyanide procedure uses a microdistillation and spectrophotometric measurement of the distilled cyanide. Solid samples are dissolved in ethylenediaminetetraacetic acid (EDTA) before distillation. This distillation has been demonstrated to be effective for the insoluble nickel ferrocyanides generated in some Hanford Site processes. There are no specific methods for ferrocyanide but the total cyanide measurement provides a conservative estimate.

Ammonia will be determined by the IC method. Ammonia is normally measured using a microdistillation of the solids. Because of the volatile nature of ammonia in alkaline solutions, it is important to stabilize by acidifying as soon as possible.

The pH of solids is determined according to SW-846 method 9045C. This method uses a 1:1 mix of solids with water and then the pH is measured. The titration method for hydroxide is not applied to solids.

4.3.2 Organics

There is a large amount of uncertainty in the amount and composition of organics that may have been released into the vadose zone. Therefore, a strategy for effectively evaluating organic constituents was developed as well as a way that effectively evaluates the tentatively identified compounds (TICs). Detected organic constituents that are not part of the calibration mix are TICs.

The strategy for organic components is that they will be analyzed with the specified level of QC (see Section 4.4. This means they would be included in the calibration of the gas chromatographs and method detection limits (MDLs) would be determined for each constituent for the appropriate sample preparation required.

Because the volatile organic analysis (VOA) calibration standards are normally prepared in methanol, this constituent cannot be included as an analyte.

Table 4-4 shows constituents analyzed by SW-846 method 8260B VOC which are considered applicable for this DQO. In addition, the table shows the reason for inclusion as a constituent (found in the Part A or underlying hazardous constituent [UHC]). Constituents identified with asterisks may be determined by more than one method. All method numbers discussed in this section are SW-846 methods.

Table 4-5 shows method 8270C SVOC applicable for this DQO. In addition, the table shows the reason for inclusion as an applicable constituent (found in the Part A or UHC).

In addition to the organic constituents shown in Table 4-4 and Table 4-5, polychlorinated biphenyls (PCBs) will be analyzed. In addition, percent water is required for solids so the PCB concentration can be reported on a dry weight basis. The PCB concentration is determined using SW-846 method 8082.

4.3.3 Radionuclides

The strategy for analyzing radionuclides is similar to the inorganic analytical strategy but the radionuclides have more single constituent analytical methods. The applicable radionuclides are those identified in 10 CFR 61.55, constituents (e.g., ^{79}Se) added for risk assessment needs, and those that could be major activity contributors. Table 4-6 shows the constituents required by this DQO, the reason the constituent is included, and the methods used for analysis.

The development of analytical methods to lower the quantitation limits will take place after risk evaluations indicate method development is necessary.

Table 4-4. Method 8260B VOC Analyses For Constituents.

Constituent	CAS	Reason for Inclusion	Comments
1,1,1-Trichloroethane	71-55-6	A, U	
1,1,2,2-Tetrachloroethene	127-18-4	A	
1,1,2,2-Tetrachloroethane	79-34-5	A, U	
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	A	
1,1,2-Trichloroethane	79-00-5	A	
1,1,2-Trichloroethylene	79-01-6	A, U	
1,1-Dichloroethene	75-35-4	A, U	
1,2-Dichloroethane	107-06-2	A	
Chloroethene(vinyl chloride)	75-01-4	A	
2-Butanone(MEK)	78-93-3	A, U	
2-Nitropropane	79-46-9	A	
2-Propanone (Acetone)	67-64-1	A, U	
4-Methyl-2-pentanone (MIBK)	108-10-1	A, U	
Benzene	71-43-2	U	
Carbon disulfide	75-15-0	A	
Carbon tetrachloride	56-23-5	A, U	
Chlorobenzene	108-90-7	A, U	
Chloroform	67-66-3	A	
Dichloromethane (methylene chloride)	75-09-2	A, U	
Ethyl Acetate	141-78-6	A	
Ethylbenzene	100-41-4	A	
Diethyl ether	60-29-7	A	
Isobutanol*	78-83-1	A	
Methanol	67-56-1	A	Will not be analyzed. See explanation in text.
n-Butyl alcohol (1-butanol)*	71-36-3	A, U	
Toluene	108-88-3	A, U	
trans-1,3-dichloropropene	10061-02-6	U	
Trichlorofluoromethane	75-69-4	A	
Xylenes	1330-20-7	A	
o-Xylene	95-47-6	A	
m-Xylene	108-38-3	A	
p-Xylene	106-42-3	A	

Notes:

CAS Chemical Abstracts Service

* Constituent may be analyzed by the VOC (8260B) method or the SVOC (8270C) method.

A Part A constituent.

U UHC constituent.

Table 4-5. Method 8270C SVOC Analyses For Constituents.

Constituent	CAS	Reason for Inclusion	Comments
1,2,4-Trichlorobenzene*	120-82-1	U	
2,4-Dinitrotoluene	121-14-2	A	
2,4,5-Trichlorophenol	95-95-4	A, U	
2,4,6-Trichlorophenol	88-06-2	U	
2,6-Bis (tert-butyl)-4-methylphenol	128-37-0	A	
2-Chlorophenol	95-57-8	U	
2-Ethoxyethanol	110-80-5	A	
2-Methylphenol (o-cresol)	95-48-7	A	
4-Methylphenol (p-cresol)	106-44-5	A	
Acenaphthene	83-32-9	U	
Butylbenzylphthalate	85-68-7	U	
Cresylic acid (cresol, mixed isomers)	1319-77-3	A	
Cyclohexanone	108-94-1	A	
Di-n-butylphthalate	84-74-2	U	
Di-n-octylphthalate	117-84-0	U	
N-nitroso-di-n-propylamine	621-64-7	U	
Fluoranthene	206-44-0	U	
Hexachlorobutadiene*	87-68-3	A	
Hexachloroethane*	67-72-1	A	
m-Cresol (3-Methylphenol)	108-39-4	A	
Naphthalene	91-20-3	U	
Nitrobenzene*	98-95-3	A	
n-Nitrosomorpholine	59-89-2	U	
o-Dichlorobenzene*	95-50-1	A	
o-Nitrophenol	88-75-5	U	
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	59-50-7	U	
Pyrene	129-00-0	U	
Pyridine*	110-86-1	A	
Tributyl phosphate	126-73-8	R	

Notes:

CAS Chemical Abstracts Service.

* Constituent may be analyzed by the SVOC (8270C) method or the VOC (8260B) method.

A Part A constituent.

R Risk assessment constituent.

U UHC constituent.

Table 4-6. Radiochemistry Constituents.

Constituent	Reason for Inclusion	Analytical Method	Alternate Method
^{137}Cs	10 CFR 61.55	GEA	AGG-RRL-001 (GEA)
^{60}Co	10 CFR 61.55	GEA	AGG-RRL-001 (GEA)
^{152}Eu	Potential major activity contributor	GEA	AGG-RRL-001 (GEA)
^{154}Eu	Potential major activity contributor	GEA	AGG-RRL-001 (GEA)
^{155}Eu	Potential major activity contributor	GEA	AGG-RRL-001 (GEA)
^{14}C	10 CFR 61.55	Liquid Scintillation Counting	AGG-RRL-002 (LSC)
^{3}H	10 CFR 61.55	Liquid Scintillation Counting	AGG-RRL-002 (LSC)
^{129}I	10 CFR 61.55	PNNL-AGG-415 (ICP-MS)	
^{63}Ni	10 CFR 61.55	Liquid Scintillation Counting	AGG-RRL-002 (LSC)
^{90}Sr	10 CFR 61.55	AGG-RRL-003 (Separation/LSC)	
^{99}Tc	10 CFR 61.55	ICP/MS or PNNL-AGG-415 (ICP-MS)	Liquid Scintillation Counting
^{125}Sb	Risk assessment	GEA	AGG-RRL-001 (GEA)
^{79}Se	Risk assessment	Liquid Scintillation Counting	AGG-RRL-002 (LSC)
^{126}Sn	Risk assessment	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{233}U	Potential major activity contributor	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{234}U	Potential major activity contributor	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{235}U	Potential major activity contributor	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{236}U	Potential major activity contributor	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{238}U	Potential major activity contributor	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{237}Np	10 CFR 61.55	ICP/MS or PNNL-AGG-415 (ICP-MS)	Alpha Counting
^{238}Pu	10 CFR 61.55	Alpha Counting or AGG-RRL-005 (AEA)	ICP/MS or PNNL-AGG-415 (ICP-MS)
$^{239/240}Pu$	10 CFR 61.55	Alpha Counting or AGG-RRL-005 (AEA)	ICP/MS as ^{239}Pu and ^{240}Pu or PNNL-AGG-415 (ICP-MS)
^{241}Pu	10 CFR 61.55	Calculate from ^{238}Pu & $^{239/240}Pu$	Liquid Scintillation Counting or PNNL-AGG-415 (ICP-MS)
^{241}Am	10 CFR 61.55	Alpha Counting or AGG-RRL-005 (AEA)	ICP/MS or PNNL-AGG-415 (ICP-MS)
^{242}Cm	10 CFR 61.55	Alpha Counting or AGG-RRL-005 (AEA)	
^{243}Cm	10 CFR 61.55	Alpha Counting or AGG-RRL-005 (AEA)	
^{244}Cm	10 CFR 61.55	Alpha Counting or AGG-RRL-005 (AEA)	
^{228}Th	Possibly significant in some released tank waste.	Calculation	GEA or AGG-RRL-001 (GEA)
^{230}Th	Possibly significant in some released tank waste.	ICP/MS or PNNL-AGG-415 (ICP-MS)	
^{232}Th	Possibly significant in some released tank waste.	ICP/MS or PNNL-AGG-415 (ICP-MS)	

Notes:

GEA Gamma energy analysis

ICP/MS Inductively coupled plasma/mass spectrometry

Additional isotopes other than those requested are not normally reported for ICP/MS because measurements are made by peak hopping rather than scanning. ICP/MS may identify other isotopes but is limited to the mass range scanned.

Only two gamma emitting isotopes, ^{137}Cs and ^{60}Co, are identified in 10 CFR 61.55. The other gamma emitting isotopes are added for other reasons (see Table 4-4). In most Hanford Site tank waste, ^{137}Cs is the dominant gamma-emitting isotope. Other isotopes may not be detected or will be reported at a high less than level by GEA because of the ^{137}Cs background.

^{79}Se is determined by liquid scintillation counting. There are no standards or tracers for ^{79}Se because these isotopes are not commercially available. Nonradioactive selenium is used to correct for chemical yields in the procedures.

The ^{230}Th and ^{232}Th can be determined by alpha analysis but are normally measured by ICP/MS because of their long half-life. ^{228}Th must be determined by calculation from ^{232}Th and ^{232}U estimates or from alpha counting. Determination of ^{228}Th by GEA may be impacted by high ^{137}Cs levels.

In addition to the constituents discussed above, a bulk density or solids specific gravity depending on the solids consistency is required. Bulk density is needed to determine waste inventories.

4.4 QUALITY CONTROL

Laboratories performing analyses specified in this DQO shall maintain a quality assurance (QA) plan. The plan shall meet the *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL-96-68) baseline requirements for laboratory quality systems. For analysis of vadose zone samples to meet HASQARD, the PNNL QA document for compliance is, "Conducting Analytical Work in Support of Regulatory Programs". For analysis of vadose zone samples for research analysis, the PNNL QA document is "Environmental Sciences Laboratory QAP". All attempts will be made to meet the data quality requirements. These documents are part of the PNNL Standards-Based Management System. Available online at http://sbms.pnl.gov/standard/1a/1a00t010.htm

All sampling events will be conducted using controlled procedures. The sample specific QA requirements such as for trip blank/ splits/duplicates, etc. will be in the FSAP. For requirements recommended in the DQO that are not able to be implemented in the field due to ALARA/Safety/Heath restrictions, the Field investigation report will document the decisions/ justifications for not following the requirements and provide technical justification for the usability of the data for decision making by ORP and Ecology.

Evaluation criteria for QC analyses are shown in Table 4-7.

The QC criteria in Table 4-7 are goals for demonstrating reliable method performance. The laboratory's internal QA system will be used to evaluate the analytical data and processes whenever a criterion is exceeded. Primary constituent data not meeting the QC requirements will be noted accordingly and discussed in the narrative of the laboratory data report.

Table 4-7. Quality Control Parameters for Constituents. (2 Sheets)

Constituents	Method	QC Acceptance Criteria		
		LCS % Recovery[a]	Spike % Recovery[b]	Solid % RPD[c]
Al, Ag, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, Sb, Se, Sr, Tl, U, V, Zn	ICP/AES	80 – 120%	75 – 125%	≤30%
Hg	ICP-MS	80 – 120%	75 – 125%	≤30%
F^-, NH_4^+, NO_2^-, NO_3^-, $C_2H_3O_2^-$, CHO_2^-, $C_2H_3O_3^-$, $C_2O_4^{2-}$	IC	80 – 120%	75 – 125%	≤30%
CN^-	9014 (Spectrophotometric)	80 – 120%	75 – 125%	≤30%
S^{2-}	9215	80 – 120%	75 – 125%	≤30%
OH^-	Titration [g]	80 – 120%	N/A	≤30%
	pH (see text)	± 0.1 pH Units	N/A	N/A
PCB	GC/ECD	70 – 130%	70 – 130%	≤30%
VOC	GC/MS	70 – 130%	70 – 130%	≤30%
SVOC	GC/MS	70 – 130%	70 – 130%	≤30%
% H_2O	Gravimetric	80 – 120%	N/A	≤30%
Bulk Density	Gravimetric	N/A	N/A	≤30%
^{235}U, ^{238}U, ^{237}Np, ^{232}Th, ^{126}Sn	ICP/MS	80 – 120%	75 – 125%	≤30%
^{233}U, ^{234}U, ^{236}U, ^{230}Th,	ICP/MS	N/A[f]	N/A[f]	≤30%
^{228}Th	Calculation	N/A	N/A	N/A
^{60}Co, ^{137}Cs, ^{125}Sb	GEA	80 – 120%	N/A[e]	≤30%
^{152}Eu, ^{154}Eu, ^{155}Eu	GEA	N/A	N/A[e]	≤30%
^{129}I	GEA	80 – 120%	N/A[d]	≤30%
^{14}C, ^{3}H	Liquid scintillation counting	80 – 120%	75 – 125%	≤30%
^{63}Ni	Liquid scintillation counting	80 – 120%	N/A[d]	≤30%
^{90}Sr	Beta counting	80 – 120%	N/A[d]	≤30%
^{99}Tc	ICP/MS	80 – 120%	75 – 125%	≤30%
^{79}Se	Liquid scintillation counting	NP	N/A[d]	≤30%
^{238}Pu	Alpha counting	N/A[f]	N/A[d]	≤30%
$^{239/240}Pu$	Alpha counting	80 – 120%	N/A[d]	≤30%
^{241}Pu	Calculation from ^{238}Pu and $^{239/240}Pu$	N/A	N/A	N/A
^{241}Am	Alpha counting	80 – 120%	N/A[d]	≤30%
^{242}Cm, $^{243/244}Cm$	Calculation from ^{241}Am	N/A	N/A	N/A

Table 4-7. Quality Control Parameters for Constituents. (2 Sheets)

Constituents	Method	QC Acceptance Criteria		
		LCS % Recovery[a]	Spike % Recovery[b]	Solid % RPD[c]

Notes:

CVAA	Cold Vapor Atomic Absorption
GEA	Gamma Energy Analysis
GC/ECD	Gas Chromatography/Electron Capture Detector
GC/MS	Gas Chromatography/Mass Spectrometry
IC	Ion Chromatography
ICP/AES	Inductively Coupled Plasma / Atomic Emission Spectroscopy
ICP/MS	Inductively Coupled Plasma / Mass Spectroscopy
QC	Quality Control
TGA	Thermogravimetric Analysis
N/A	Not applicable
NP	Not performed

(a) LCS = Laboratory Control Sample. This sample is carried through the entire analytical method. The accuracy of a method is usually expressed as the percent recovery of the LCS. The LCS is a matrix with known concentration of constituents processed with each preparation and analyses batch. It is expressed as percent recovery; i.e., the amount measured, divided by the known concentration, times 100.

(b) For some methods, the sample accuracy is expressed as the percent recovery of a matrix spike sample. It is expressed as percent recovery; i.e., the amount measured, less the amount in the sample, divided by the spike added, times 100. One matrix spike is performed per analytical batch. Samples are batched with similar matrices. For other constituents, the accuracy is determined based on use of serial dilutions.

(c) RPD = Relative Percent Difference between the samples. Sample precision is estimated by analyzing duplicates taken separately through preparation and analysis. Acceptable sample precision is usually ≤20% RPD for liquids or ≤ 30% for solids if the sample result is at least 10 times the instrument detection limit.

RPD = ((absolute difference between primary and duplicate)/mean) x 100

(d) Matrix spike analyses are not required for this method because a carrier or tracer is used to correct for constituent loss during sample preparation and analysis. The result generated using the carrier or tracer accounts for any inaccuracy of the method on the matrix. The reported results reflect this correction.

(e) The measurement is a direct reading of the energy and the analysis is not affected by the sample matrix; therefore, a matrix spike is not required.

(f)No standards are run for these constituents.

(g)OH^- titration not conducted for solids. pH is determined for solids as described in the text.

Recommendations for ensuring sample integrity prior to analysis are provided in SW-846. The recommendations include type of sample container, holding time, preservation, and zero headspace in samples (for volatile components).

4.5 DETECTION LIMITS

Detection limits are commonly set an order of magnitude below the action limits required by the DQO. However, definite action limits are not available. Therefore, Tables 4-8 through 4-10 are provided for information and comparison only. Tables 4-8 and 4-9 compare the WAC 173-340 limits to calculated MDLs. Table 4-8 only presents the calculated MDLs.

Table 4-8. Comparison of WAC 173-340 Limits to MDLs for Organic Constituents. (2 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260B[a] (VOC) Estimated MDLs mg/kg	Method 8260B[a] (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270C[b] (SVOC) Estimated MDLs mg/kg	Method 8270C[b] (SVOC) Estimated MDLs mg/L
67-64-1	Acetone (2-Propanone)	3.21E+00	4.38E-02	1.72E-03	83-32-9	Acenaphthene	9.79E+01	1.54E+00	6.6E-01
71-43-2	Benzene	4.48E-03	**6.26E-03**	2.7E-04	117-84-0	Bis-2-ethylhexyl phthalate (Dioctylphthalate)	5.32E+05	1.52E+00	8.4E-01
75-15-0	Carbon disulfide	5.65E+00	9.25E-03	4.8E-04	71-36-3	Butanol; n- (n-butyl alcohol)	6.62E+00	1.38E+00	2.31E+00
56-23-5	Carbon tetrachloride	3.10E-03	**1.19E-02**	4.4E-04	85-68-7	Butylbenzylphthalate	8.93E+02	1.63E+00	3.2E-01
108-90-7	Chlorobenzene	8.74E-01	7.73E-03	2.7E-04	95-57-8	Chlorophenol; 2-	9.43E-01	**1.36E+00**	**1.08E+00**
67-66-3	Chloroform	3.81E-02	9.46E-03	3.3E-04	108-39-4	Cresol; m- (3-Methylphenol)	3.20E+00	**5.95E+00**	2.46E+00
107-06-2	Dichloroethane; 1,2-	2.32E-03	**6.43E-03**	3.5E-04	95-48-7	Cresol; o- (2-Methylphenol)	4.66E+00	2.61E+00	1.14E+00
75-35-4	Dichloroethylene; 1,1- (Dichloroethene)	5.22E-04	**1.03E-02**	3.9E-04	106-44-5	Cresol; p- (4-Methylphenol)	3.20E-01	**5.95E+00**	unknown
75-09-2	Dichloromethane (methylene chloride)	2.54E-02	7.66E-03	4.5E-04	1319-77-3	Cresylic acid (cresol, mixed isomers)	Note (e)	3.73E+00	3.67E+00
10061-02-6	Dichloropropene; 1,3,- (trans-)	1.41E-03[d]	**6.38E-03**	3.2E-04	108-94-1	Cyclohexanone	3.20E+02	2.24E+00	3.1E-01
141-78-6	Ethyl acetate	1.61E+02	9.72E-03	2.9E-04	84-74-2	Dibutylphthalate (Di-n-butylphthalate)	1.14E+01	2.02E+00	5.4E-01
60-29-7	Ethyl ether (Diethyl ether)	9.09E+00	8.85E-03	3.9E-04	95-50-1	Dichlorobenzene; 1,2- (ortho-)	7.03E+00	1.38E+00	5.0E-01
100-41-4	Ethylbenzene	6.05E+00	1.55E-02	8.1E-04	121-14-2	Dinitrotoluene; 2,4-	1.89E-01	**9.7E-01**	**5.1E-01**
67-72-1	Hexachloroethane	2.49E-01	5.9E-03	5.3E-04	110-80-5	Ethoxyethanol; 2-	2.56E+01	7.3E-01	5.1E-01
78-93-3	Methyl ethyl ketone (2-Butanone)	2.18E+01	2.42E-02	7.9E-04	206-44-0	Fluoranthene	6.31E+02	9.2E-01	8.5E-01
108-10-1	Methyl isobutyl ketone (4-methyl-2-pentanone)	1.28E+01	1.33E-02	3.4E-04	87-68-3	Hexachlorobutadiene	6.05E+00	3.4E-01	4.6E-01
79-46-9	Nitropropane; 2-	1.84E-05	1.58E-02	1.03E-03	78-83-1	Isobutyl alcohol (Isobutanol)	5.47E+01	1.84E+00	2.63E+00
79-34-5	Tetrachloroethane; 1,1,2,2-	1.23E-03	**6.53E-03**	4.3E-04	128-37-0	methylphenol; 2,6-Bis(tert-butyl)-4-	None	9.4E-01	6.8E-01
127-18-4	Tetrachloroethene; 1,1,2,2-	9.10E-03	8.19E-03	3.1E-04	59-50-7	methylphenol; 4-Chloro-3- (p-Chloro-m-cresol)	None	4.9E-01	1.28E+00
108-88-3	Toluene	7.27E+00	7.32E-03	4.3E-04	91-20-3	Naphthalene	4.46E+00	6.2E-01	4.7E-01
76-13-1	trichloro-1,2,2-trifluoroethane; 1,1,2-	1.92E+03	1.01E-02	8.4E-04	98-95-3	Nitrobenzene	5.11E-02	**6.5E-01**	**3.9E-01**
71-55-6	Trichloroethane; 1,1,1-	1.58E+00	8.94E-03	3.0E-04	88-75-5	Nitrophenol; o-	None	1.58E+00	1.03E+00
79-00-5	Trichloroethane; 1,1,2-	4.27E-03	**6.53E-03**	2.7E-04	621-64-7	N-nitroso-di-n-propylamine;	5.60E-05	**8.7E-01**	**1.03E+00**

Table 4-8. Comparison of WAC 173-340 Limits to MDLs for Organic Constituents. (2 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260B[a] (VOC) Estimated MDLs mg/kg	Method 8260B[a] (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270C[b] (SVOC) Estimated MDLs mg/kg	Method 8270C[b] (SVOC) Estimated MDLs mg/L
79-01-6	Trichloroethylene; 1,1,2-	2.60E-02	1.18E-03	4.3E-04	59-89-2	Nitrosomorpholine; N-	None	7.7E-01	1.01E+00
75-69-4	Trichlorofluoromethane	7.23E+01	9.33E-04	3.8E-04	129-00-0	Pyrene	6.55E+02	1.50E+00	6.4E-01
75-01-4	Vinyl chloride (1-Chloroethene)	1.84E-04	**4.45E-03**	**4.4E-04**	110-86-1	Pyridine	3.87E-01	**9.3E-01**	**5.5E-01**
1330-20-7	Xylenes	9.14E+01	1.43E-02	1.28E-03	95-95-4	Trichlorophenol; 2,4,5-	5.75E+01	7.1E-01	1.21E+00
108-38-3	Xylene; m-	8.44E+01	8.81E-03	1.02E-03	88-06-2	Trichlorophenol; 2,4,6-	9.24E-02	**7.5E-01**	**1.18E+00**
95-47-6	Xylene; o-	9.19E+01	5.53E-03	4.4E-04	126-73-8	Tributyl phosphate	7.0E-01	0.4	**5**
106-42-3	Xylene; p-	1.72E+02	8.81E-03	1.02E-03					
120-82-1	1,2,4 - Trichlorobenzene	3.0E+00	1.02E-03	6.7E-04					
		Constituent Limits 0.05[c] mg/kg	**Method 8082[d] PCBs MDL mg/kg**	**Method 8082[a] PCBs MDL mg/L**					
11104-26-2	Aroclor 1221	Note c	0.026	7.1E-03					
11141-16-5	Aroclor 1232	Note c	0.46	4.6E-02					
2674-11-2	Aroclor 1016	Note c	0.081	3.78E-02					
53969-21-9	Aroclor 1242	Note c	0.084	2.6E-02					
126572-29-6	Aroclor 1248	Note c	0.027	1.3E-02					
11097-6999-1	Aroclor 1254	Note c	0.016	4.03E-3					
11096-82-5	Aroclor 1260	Note c	0.113	2.86E-02					

Notes:

CAS Chemical Abstracts Service
VOC Volatile Organic Compound
SVOC Semivolatile Organic Compound
MDL Method Detection Limits
Shaded MDLs Constituents where the MDLs are above WAC 173-340 limits.
unknown MDL estimate is unknown.
None Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating limits.

(a) For solids, 8260B MDL assumes a 0.5-g sample size. If the sample has a high dose rate, a smaller samples size and larger MDL may result. For liquid, 8260B and 8082 MDL basis for liquids – assumes a 10-mL sample size. If the liquid is too radioactive, the sample size may be reduced to 1 mL, and the MDLs would be 10 times higher.

(b) For solids, 8270C MDL assumes a 2-g sample size. If the liquid is too radioactive or foams, the sample size may be reduced by a factor of 10 or more resulting in corresponding higher MDLs.

(c) 0.05 mg/kg is for total PCBs.

(d) For solids, 8082 MDL assumes a 1-g sample size.

(e) Constituent limits are presented for the individual isomers, m-Cresol (CAS 108-39-4), p-Cresol (CAS 106-44-4), o-Cresol (CAS No. 95-48-7) instead of for the mixed isomers of cresol (also called cresylic acid (CAS 1319-77-3)

(f) Constituent limit is for 1,3-Dichloropropene (CAS 542-75-6) instead of the isomer trans-1,3-Dichloropropene.

Table 4-9. Comparison of WAC 173-340 Limits to MDLs for Inorganic Constituents. (2 Sheets)

Metals	WAC 173-340 Limits mg/kg	Primary Method 6010B (ICP/AES)[a] MDLs mg/kg	Alternate Method 6020 (ICP/MS)[b] MDLs mg/kg		Primary Method 6010B (ICP/AES)[a] MDLs mg/L	Alternate Method 6020 (ICP/MS)[b] MDLs mg/L
Antimony (Sb)	5.42E+00	10.6			10.6	
Aluminum (Al)	4.52E+01	2.75			26.6	
Arsenic (As)	3.40E-02	**25.7**	**0.2**		**25.7**	**5.0E-01**
Barium (Ba)	9.23E+02	10.5	2.00E-03		10.5	5.0E-03
Beryllium (Be)	6.32E+01	0.65	2.00E-03		0.7	5.0E-03
Cadmium (Cd)	5.00E+00	1.05	2.02E-02		1.1	5.0E-02
Cobalt (Co)	None	2.55			2.6	
Copper (Cu)	2.63E+02	6.1			6.1	
Iron (Fe)	1.32E+03	10.05			10.1	
Lead (Pb)	2.50E+02	11.75	2.00E-01		11.8	5.0E-01
Manganese (Mn)	5.02E+01	0.55			0.6	
Nickel (Ni)	1.30E+02	5.5			5.5	
Selenium (Se)	5.20E+00	**25.9**	2.00E-01		**25.9**	5.0E-01
Silver (Ag)	1.36E+01	2.75	6.00E-04		2.8	1.5E-03
Strontium (Sr)	2.92E+03	0.55			0.6	
Thallium (Tl)	1.59E+00	**75.6**	4.00E-04		**75.6**	1.0E-03
Uranium (U)	1.32E+00	**25.75**			**25.8**	
Chromium (Cr)	2.00E+00 (Total Cr)	**2.6**	8.00E-02		**2.6**	2.0E-01
Vanadium (V)	5.60E+02	2.6	6.00E-03		2.6	1.5E-02
Zinc (Zn)	5.97E+03	1.05	6.00E-03		1.1	6.00E-02
	Constituent Limits mg/kg	**Primary Method 7470/71 (CVAA) MDLs mg/kg**			**Primary Method 7470/71 (CVAA) MDLs mg/L**	
Mercury (Hg)[d]	2.09E+00	0.05			0.005	
Anions	**Constituent Limits mg/kg**	**Primary Method 9056 (IC)[a] MDLs mg/kg**			**Primary Method 9056 (IC)[a] MDLs mg/L**	
Fluoride (F^-)	1.60E+01	20			100	
Nitrate (NO_3^-)	4.00E+01 (as nitrogen)	**280**			**1400**	
Nitrite (NO_2^-)	4.00E+00 (as nitrogen)	**200**			**1000**	
Acetate ($C_2H_3O_2^-$)	None	400			2000	

Table 4-9. Comparison of WAC 173-340 Limits to MDLs for Inorganic Constituents. (2 Sheets)

Metals	WAC 173-340 Limits mg/kg	Primary Method 6010B (ICP/AES)[a] MDLs mg/kg	Alternate Method 6020 (ICP/MS)[b] MDLs mg/kg		Primary Method 6010B (ICP/AES)[a] MDLs mg/L	Alternate Method 6020 (ICP/MS)[b] MDLs mg/L
Formate (CHO_2^-)	None	400			2000	
Glycolate ($C_2H_3O_3^-$)	None	400			2000	
Oxalate ($C_2O_4^{2-}$)	None	200			1000	
	Constituent Limits mg/kg	**Primary Method 9010B/9014 (Spec.) MDLs mg/kg**			**Primary Method 9010B/9014 (Spec.) MDLs mg/L**	
Cyanide (CN^-)[f]	8.00E-01	2.5			2.5	
Ferrocyanide $FE(CN)^{3-}$	Analyzed as cyanide					
	Constituent Limits mg/kg	**Primary Method 9030B/9215 (ISE) MDLs mg/kg**			**Primary Method 9030B/9215 (ISE) MDLs mg/L**	
Sulfide (S^{2-})[d]	None	50			50	
Cation	**Constituent Limits mg/kg**	**Primary Method EPA 300.7 MDLs mg/kg**			**Primary Method EPA 300.7 MDLs mg/L**	
NH_4^+	Not regulated	120			1.2	

Notes:

Shaded MDLs	Constituents where the MDLs are above the WAC 173-340 limits.
MDL	Method Detection Limits
CVAA	Cold Vapor Atomic Absorption.
GEA	Gamma Energy Analysis.
IC	Ion Chromatography.
ICP/AES	Inductively Coupled Plasma / Atomic Emission Spectroscopy.
ICP/MS	Inductively Coupled Plasma / Mass Spectroscopy
ISE	Ion Selective Electrode.
Spec.	Spectrophotometric
None	Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating limits.

(a) ICP/AES for solids assumes dilution factor (DF) = 500, 0.5g-50 mL-2mL-10. For liquid, it assumes high salt dilution factor and an acid digest, DF = 500, 1.0mL-50 mL-1mL-10mL. ICP MDLs based on 3050 digest.

(b) Solids ICP/MS based on dilution factor = 2000. Liquid ICP/MS assumes high salt dilution factor and an acid digest, DF = 5000, 1.0mL-50 mL-0.1mL-10mL. ICP/MS MDLs may be based on instrument detection limits (IDLs) and could be 10 times larger.

(c) Footnote (C) no longer used.

(d) Hg assumes a 0.005 µg detection limit and a 0.1g sample size.

(e) For solids, IC assumes a dilution factor = 2000 for water digest and a 50 µL loop. For liquid, IC assumes high salt dilution factor and an water digest DF= 10000, 0.1mL-10mL-0.1mL-10mL and a 50 µL loop.

(f) For solids, CN- assumes a 0.1g solid with EDTA solution. For liquid, CN^- high salt dilution factor assumes 0.1 mL sample is distilled.

Table 4-10. Comparison of Radiological Values to MDLs for Radionuclides.

Analyte	Analytical Method	Alternate Analytical Method	MDLs pCi/g	MDLs pCi/mL
^{241}Am	Alpha Counting		5.50E+03	1.10E+02
^{14}C	Liquid Scintillation Counting		4.00E+02	4.00E+01
^{242}Cm	Alpha Counting		5.50E+03	1.10E+02
^{243}Cm	Alpha Counting		5.50E+03 (as $^{243/244}Cm$)	1.10E+02 (as $^{243/244}Cm$)
^{244}Cm	Alpha Counting		5.50E+03 (as $^{243/244}Cm$)	1.10E+02 (as $^{243/244}Cm$)
^{60}Co	GEA		9.00E+03	2.50E+03
^{137}Cs	GEA		1.25E+04	2.50E+02
^{152}Eu	GEA		1.80E+04	6.50E+04
^{154}Eu	GEA		1.25E+04	4.60E+04
^{155}Eu	GEA		2.20E+04	8.10E+04
^{3}H	Liquid Scintillation Counting		4.60E+02	4.60E+01
^{129}I	Low Energy Gamma Counting		2.00+04	1.00E+03
^{63}Ni	Liquid Scintillation Counting		5.00E+3	1.00E+02
^{237}Np	ICP/MS	Alpha Counting	3.80E-02 1.05E+04[a]	9.52E-02 2.10E+02[a]
^{238}Pu	Alpha Counting	ICP/MS	1.70E+03 6.84E+02[a]	3.40E+01 1.71E+03[a]
^{239}Pu	Alpha Counting	ICP/MS	1.70E+03 (as $^{239/240}Pu$) 7.44E+00[a]	3.40E+01 (as $^{239/240}Pu$) 1.86E+01[a]
^{240}Pu	Alpha Counting	ICP/MS	1.70E+03 (as $^{239/240}Pu$) 2.27E-00[a]	3.40E+01 (as $^{239/240}Pu$) 5.86E+00[a]
^{241}Pu	Calculate from ^{238}Pu & $^{239/240}Pu$	ICP/MS	1.65E+04[a]	1.80E+04[a]
^{125}Sb	GEA		5.5E+06	2.0E+04
^{79}Se	Liquid Scintillation Counting		1.00E+03	1.00E+02
^{90}Sr	Beta Proportional Counting		1.65E+03	3.30E+01
^{99}Tc	Liquid Scintillation Counting	ICP/MS	5.00E+03 3.40E+01[a]	1.00E+02 2.55E+01[a]
^{126}Sn	ICP/MS		4.00E+02	2.0E+00
^{228}Th	Calculation	GEA	6.00E+05[a]	2.70E+06 (*)
^{230}Th	ICP/MS		2.88E-01	7.21E-01
^{232}Th	ICP/MS		4.40E-05	6.60E-05
^{233}U	ICP/MS		1.74E-01	4.34E-01
^{234}U	ICP/MS		3.75E-02	9.38E-02
^{235}U	ICP/MS		4.32E-05	1.19E-04
^{236}U	ICP/MS		5.18E-04	1.29E-03
^{238}U	ICP/MS		4.37E-04	9.24E-04

The MDLs in Tables 4-8 through 4-10 are based on the assumption that the radiation levels remaining in the soil will still be sufficiently high to require the use of sample sizes and analytical procedures that are routinely used for characterization of high level waste samples. If the radiation levels are significantly lower, the MDLs may be lowered by as much as a factor of 5 to 10 for many of the existing methods. This is accomplished by using larger sample sizes. Correspondingly, higher radiation levels could cause the MDLs to increase because a sample may require dilution to be analyzed. Dilution of a sample may also be required because of matrix effects. The MDLs will be reported with the analytical results and will be based on the actual sample size.

As indicated above, detection limits are dependent on such things as sample size (dictated by sample activity and sample availability), methods, and matrix effects. Therefore, when no action limit is established the laboratory will provide the lowest practical detection limit, which depends on the circumstances noted above.

The source of the WAC 173-340 limits is shown in Appendix A. Where physical-chemical parameter values (the distribution coefficient, Kd value, and Henry's Law Constant) are not available in the Cleanup levels and risk calculations (CLARC) 3.1 tables, parameter values were obtained from EPA Region 9 or default values of zero were used, as noted in Appendix A. The EPA Region 9 parameters are available at http://sbms.pnl.gov/standard/64/6414e010.htm.

Use of Model Toxics Control Act (MTCA) Method B and RESRAD values for comparison in Tables 4-8 through 4-10 does not imply that the associated vadose zone closure will be sufficient for tank farm closure performance standards. Analytical data generated according to this DQO will be used to quantify the risk contribution of vadose zone closure to the overall risk of the tank farm.

5.0 STEP 4 DEFINE STUDY BOUNDARIES

This step in the DQO process defines the spatial and temporal boundaries for the required sampling and analyses needed to make the necessary decisions. The spatial boundaries define the physical area to which the decisions will apply and where the samples should be taken. The temporal boundaries describe the timeframe that the data will represent and when the samples should be taken. In addition, this portion of the DQO addresses any sampling constraints.

5.1 SPATIAL AND TEMPORAL BOUNDARIES

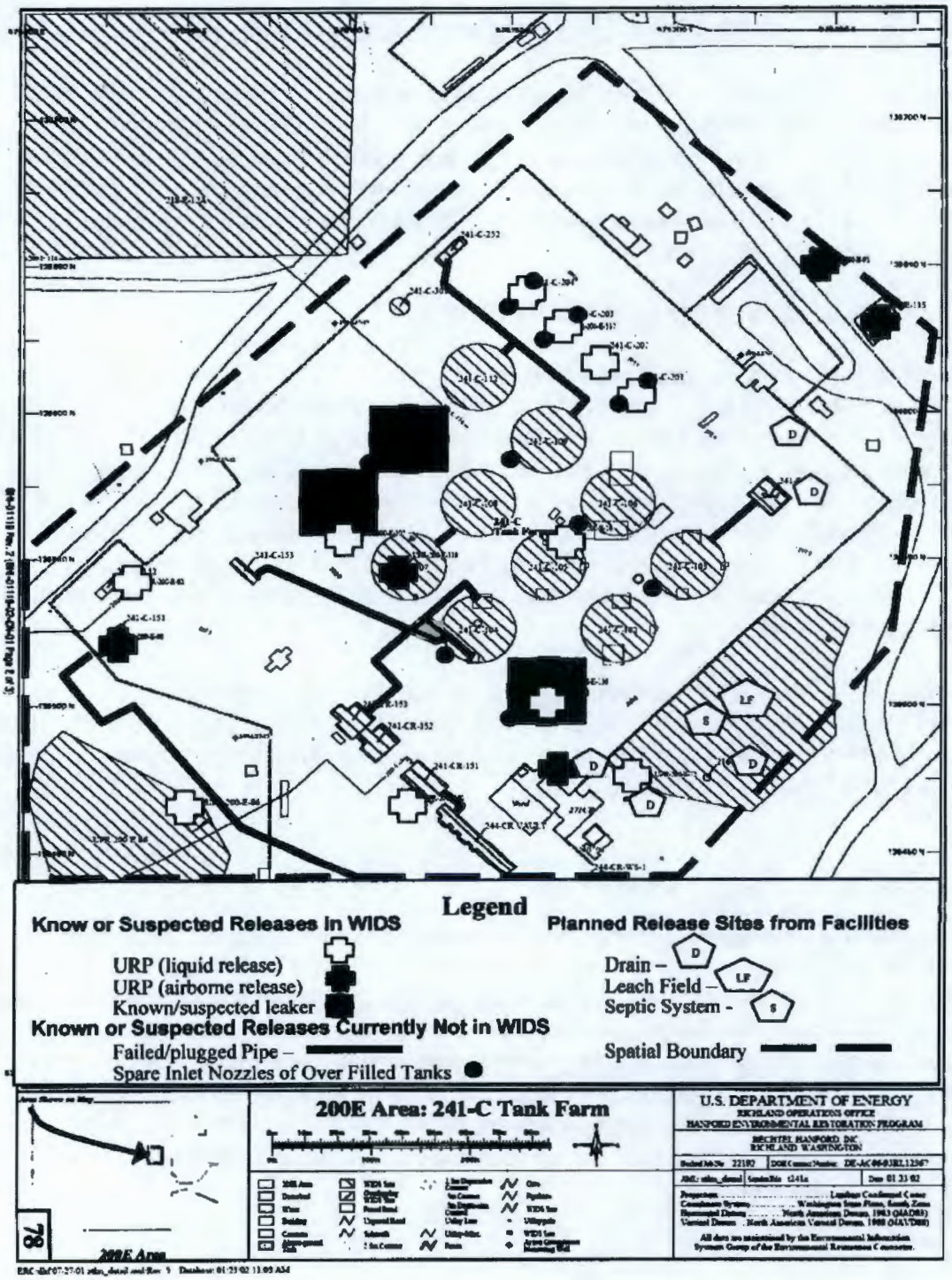
The spatial boundary for the sampling and analyses covered by this DQO are known or suspected release sites in and around WMA C. The area of interest outside of WMA C is inclusive of those waste sites and facilities that are close enough to be considered in the WMA C closure decision process, see Figure 5-1. The lateral boundary will be a perimeter outside of the WMA C fenceline that encompasses all areas of interest outside of WMA C. The vertical boundary will be from the ground surface to the top of the groundwater table. The initial Near-Term characterization efforts will be limited to the depth of the Direct Push technology (~100 feet bgs). To reach the vertical boundary at the top of the groundwater would require constructing a borehole.

The data collected will be used to support the RFI/CMS, the SST PA and closure. The temporal boundary for the data collected per this DQO will be the final closure of the SST farms. This DQO will be in effect until the sampling and analysis of soil in WMA C to support the CMS is complete and WMA C closure has occurred.

5.2 SAMPLING CONSTRAINTS

The spatial area that needs to be characterized is associated with a complex of underground facilities including tanks, piping networks, diversion boxes and other ancillary equipment. In addition, in WMA C tank waste retrieval is being conducted which requires a complex of above ground and near-surface facilities including skids, piping networks, support trailers and associated utilities. All of these facilities create access limitation on where samples can be collected. WMA C has topographic limitations that prohibit where equipment can be safely operated which pose additional limitation for sample collection in certain areas. Other considerations for sampling and analysis are resource limitations on the number of samples and sample handling considerations.

Figure 5-1. Known or Suspected Release Areas



6.0 STEP 5 DEVELOP DECISION RULES

The DQO process includes development of decision rules, which define the actions to be taken as a result of exceeding an action level. Decision rules require action levels and alternative actions that will be taken if the action levels are exceeded. Decision rules are expressed as "if then" statements that incorporates the parameter of interest, the scale of decision making, the action level, and the actions that would result from resolution of the decision rule. For this DQO, a decision rules were developed to address the decision statements in Section 3.0. The decision rule must be met before component closure actions can precede.

The decision rules for this DQO address the constituents of concern within the soil and address risk assessment. The decision rules are:

If performance evaluations indicate that contaminations in the soil meet performance objectives for human health and ecological risk and support compliance with WAC 173-303-610(2), and the corrective action(s) is approved by Ecology through incorporation into the *Resource Conservation and Recovery Act* (RCRA) Site-Wide Permit, then corrective actions for the soil can proceed; otherwise, the actions will be reassessed.

If radiological contaminates in the soil meet performance objectives of DOE Manual 435.1 Chapter IV, P(1) then closure can proceed consistent with the DOE approved closure plan as required by DOE Manual 435.1; otherwise, the actions will be reassessed.

7.0 STEP 6 SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

Analytical data only estimate the true condition of the site under investigation, therefore decisions that are made based on measured data potentially could have uncertainty which could lead to a decision error(that is, are subject to decision error). For this reason, the objective of DQO Step 6 is to determine which decision rules (if any) require a statistically based sample design. Step 6 defines the tolerable error limits on decisions specific to the WMA. The error limits established in this step are used to estimate the number of samples required to address the principal study questions (PSQs) and to establish performance goals for newly collected data.

During the initial scoping of the DQO it was recognized that it may be necessary to establish a priority in selecting sample locations. The purpose of prioritizing the selection of sample locations is to assist the Tank Farm Contractor in making decisions on where samples would be collected. Past experience has lead to an understanding that collection of soil samples in tank farms is difficult. The known or suspected release sites that need to be characterized are typically associated with a complex of underground facilities including tanks, piping networks, diversion boxes, other ancillary equipment as well as general utility infrastructure. In addition, in WMA, tank waste retrievals are being conducted which require a complex of above ground facilities including skids, piping networks, support trailers and associated utilities. All of these facilities possess access limitation on where samples can be collected. The following are suggested priorities which will be considered in the sample location selection process.

Data Needs of WMA C Vadose Zone Characterization	Priority In Selecting Sample Locations[1]
Confirm nature and extent of known and suspected releases. Characterize release from 241-C-152 pipeline (UPR-200-E-86).	A
Characterize vadose zone around facilities without logged boreholes or other vadose zone characterization.	B
Demonstrate that all plumes have been found.	C
Validate tank farm fate and transport computer models.	A
Characterize nature and extent of surface and near surface releases.	B
Develop SGE network to support multiple functions including tank retrievals and 3-D mapping.	B

1. Sample locations which are designated with an A have a higher priority in data collection than B designated goals which are a higher priority to C designated goals. Thus if there are interferences that limit or prevent sampling at certain locations the overall objective should be to collect data to meet the highest achievable data collection priority possible.

7.1 SAMPLE DESIGN

The PSQs address the nature and extent of contamination relative to a compliance requirement. A sampling design will be required that will collect data to ensure that the nature and extent of contamination has been adequately characterized to support closure decisions.

Access restrictions, SSTs and ancillary equipment within WMA C will limit potential sample locations. Limitations are expected in implementing all sample collection within WMA C, and adjustments to planned versus actual sample collection points are anticipated. Because of these restriction the final sampling design will be determined in the FSAP. Prior to finalizing the sample design the spatial boundary will be surveyed using ground penetrating radar (GPR). The results of this survey will aid in identification of below ground interferences and in selecting locations acceptable for ground penetrations.

8.0 STEP 7 OPTIMIZE SAMPLE DESIGN

Step 7 optimizes the sampling design to meet the needs specified in DQO Steps 1 through 6. The most resource effective design that satisfies the data quality objectives can then be selected. As stated above a GPR survey will be conducted across the entire spatial boundary to assist in finalizing sample locations in the FSAP.

8.1 KNOWN OR SUSPECTED RELEASE SITES

Know or suspected release site are characterized into the following groupings:

- Releases documented in the Waste Information Data System (WIDS)
- Documented known or suspected unplanned releases currently not in WIDS
- Planned release facilities such as cribs and drains.

8.1.1 Known and Suspected Release Sites at WMA C in WIDS

The WIDS is a database that provides a traceable source of information about sites of environmental interest at Hanford. The system is used to document historical information, and track investigation, remediation, and closure-action activities under the HFFACO. Known release sites are maintained in this data base and provide a description of the release event.

Thirteen unplanned releases (UPRs) are known or thought to have occurred within or adjacent to WMA C. There exists uncertainty in the nature and extent of UPRs from components within WMA C. Estimates of contaminant release volumes, inventories, and locations for some UPRs are included in the WIDS.

RCRA guidance (RCRA Facility Investigation Guidance (EPA 530/SW-89-031) states that if suspected releases are confirmed during initial investigations further characterization of such releases will be necessary. This characterization includes identification of the type and concentration of hazardous waste or hazardous constituents released, the rate and direction at which the releases are migrating, and the distance over which releases have migrated. Inter-media transfer of releases (e.g., volatilization of hazardous constituents from contaminated soils to the air medium) should also be addressed during the RFI, as appropriate. Therefore UPRs will be addressed as potentially contributing sources to the vadose zone in WMA C and the characterization efforts will support the risk assessment and subsequent alternatives evaluation to select a corrective action. In addition to the UPRs that exist within the WMA boundary, there are UPRs that are either adjacent to the boundary but outside the fenceline or are in close enough proximity to the WMA and therefore warrant integration in WMA Closure planning.

Consolidated UPRs (UPRs within the WMA C fenceline and collectively managed under WIDS site 200-E-133) include:

- **UPR-200-E-16** – A surface spill that resulted from a leak in an overground transfer pipeline between SSTs 241-C-105 and 241-C-108. The surface spill associated with this release is located approximately 18 m (60 ft) northeast of SST 241-C-105 and occurred in 1959. The spilled liquid was classified as coating waste from the PUREX process. The soil contaminated by the pipe waste buried in a trench inside WMA C.
- **UPR-200-E-27** – This wind-borne release is located just east of the 244-CR vault and extends east beyond the tank farm fenceline. The release originated either from the 244-CR vault or an adjacent diversion box and spread eastward, contaminating the inside of the tank farm and also several hundred feet beyond the tank farm perimeter fence. Contamination levels ranged between 50 and 100 millirads/hour and particle readings as high as 40,000 counts per minute were found outside the fence.
- **UPR-200-E-68** – Wind-borne surface contamination spread from diversion box 241-C-151. The release occurred in 1985 and was subsequently decontaminated to background radiation levels or covered with clean soil for later decontamination (the source document is inconclusive). Sometime after the release, diversion box 241-C-151 was opened, flushed, and sprayed with a fixative to physically fix contamination to the interior of the structure surface.
- **UPR-200-E-81** – Located northeast of the 244 CR vault, near diversion box 241-CR-151 and involves a release from a transfer line from 202-A Building to 241-C-102. This release occurred as a result of a leak in an underground transfer pipeline in October 1969. The waste that leaked from the pipeline consisted of PUREX coating waste and formed a puddle approximately 6 feet by 40 feet which seeped into the ground. The site is covered with 0.5 m (18 in.) of backfill and clean gravel.
- **UPR-200-E-82** – Occurred in December 1969, with the source determined to be the feed line running between SST 241-C-105 and the 221-B Building. The leak was discovered near diversion box 241-C-152. The liquid release flowed from transfer line V-122 in the vicinity of diversion box 241-C-152 to the northeast, downgrade, until it pooled into an area measuring approximately 0.46 m^2 (5 ft^2) outside the C tank farm fence. The leak volume is unknown. The contaminated site was covered with clean gravel in 1969. The depth of the clean gravel applied in 1969 was not provided in the WIDS report; however, it states that additional decontamination of the area occurred in 1985. There is a large mound of shotcrete over the area where the leak surfaced.
- **UPR-200-E-107** – The location of this release is unclear but is thought to be located at tank 241-C-110. Process waste was being directed to the first tank in the series. Waste failed to cascade to the second tank, indicating the overflow line was plugged. An overground transfer was attempted. During this transfer, the pump operation was checked under the assumption that it had not yet been submerged into the waste. Unfortunately this assumption was incorrect and, when tested, the pump discharged approximately 19 L (5 gal) of waste with enough velocity to propel it 6 m (20 ft).
- **UPR-200-E-118** – Located in the northeast portion of the tank farm and extends north up to about 300 m (1,000 ft) beyond the fenceline. It was the result of an airborne release from SST 241-C-107 that occurred in April 1957. The highest exposure rate was estimated to be 50 mrem/hr at the ground surface (DOE/RL-92-04).

- **UPR-200-E-136** – A release of 64,345 to 90,840 L (17,000 to 24,000 gal) of waste from SST 241-C-101. This tank was designated as a confirmed leaker in January 1970. This site includes the soil around and underneath tank 241-C-101. Between 1946 and 1970, 2,000 Ci were released (DOE/RL-92-04).
- **UPR-200-E-137** – Occurred when water entered SST 241-C-203, migrated through the saltcake, and either became entrained in the saltcake or leaked out of the tank. The leak was 1,500 L (400 gal) of PUREX high-level waste.

Associated UPRs (outside of the WMA C fenceline) include:

- **UPR-200-E-72** – Occurred in 1985 and is located south of WMA C near crib 216-C-8. The source of the contamination resulted from contaminated waste that was buried. The waste posed little release potential because the contamination was fixed in place with Turco Fabri-Film. The source of the contamination was determined to be from the burial of previously undocumented contamination material. The area was surrounded with a chain and posted as a surface contamination area; however, the site is no longer marked or posted. No information regarding the buried material is presented in the WIDS report; it is assumed that the contamination extends to the depth of the buried material, but the aerial extent and depth are unknown. The volume of the contamination is also unknown.
- **UPR-200-E-86** – A spill that resulted from a leak in a pipeline used to transfer waste from vault 244-AR to WMA C. The depth of the leaking pipeline (812) was approximately 2 m (8 ft) below ground surface. The release occurred in March 1971 near the southwest corner of WMA C, outside the fence. The spill consisted of 25,000 Ci of cesium-137. The soils surrounding the pipeline were sampled, and it was determined the contamination had not penetrated below 6 m (20 ft). The contamination plume volume was estimated at 37 m^3 (1,300 ft^3). The surface of the release site has been stabilized with shotcrete. The release site is demarcated with concrete AC-540 marker posts and signs indicating "Underground Radioactive Material."
- **UPR-200-E-91** – Located approximately 30 m (100 ft) from the northeast side of the tank farm. It resulted from surface contamination that migrated from WMA C. The date of the occurrence, its aereal extent, and the nature of the contamination are not known. DOE/RL-92-04 states that the contaminated soil was removed to UPR-200-E-56 (located on the north side of the 216-A-24 crib) and the area was released from radiological controls.
- **200-E-115** – Located east of C tank farm, south of 8th Street, across an unnamed gravel road. As a result of routine radiological surveys confirming radiological contamination in this area, the Dyncorp Integrated Soil, Vegetation and Animal Control group submitted a Waste Site Information Form to WIDS in 2000. The site was classified as Discovery until programmatic responsibility and ownership were determined in March 2001. No radiological surveys can be found to provide information about the radiological conditions inside the posted area. Very little is known about this posted area. During an interview with the Dyncorp Radiological Group in October 2000, an assumption was made that the area was posted by the CH2M HILL Hanford Group, Inc. East Tank Farm Radiological Control Group. A review of underground pipeline locations did not indicate a pipeline at this location. In 1980, a larger area of posted contamination (see UPR-200-

E-91) had been located in the same vicinity. The contaminated soil from UPR-200-E-91 was removed in 1981. Because so much time has passed, it is difficult to determine if the two sites are related. In June 2004, 200-E-115 was stabilized with gravel and posted as an Underground Radioactive Material Area.

8.1.2 Documented Known or Suspected Unplanned Releases Currently Not in WIDs

Supplemental Information on Hanford Tank Waste Leaks (RPP-RPT-29191) presents information on inadvertent discharges of waste from Hanford site tanks and ancillary equipment such as pipelines and diversion boxes from historical reports prepared by Hanford site operating contractors and the Atomic Energy Commission Richland Operations Office. RPP-RPT-29191 provides a review of these historical reports facilitates evaluations of single-shell tank leaks and updating the data on Near-Surface leaks, spills and plugged pipelines.

Based on the review in RPP-RPT-29191 of these historical reports, supplemental tank waste loss information was identified for twenty single-shell tanks. Eleven underground pipeline leaks and eight plugged pipelines were identified that were not previously documented in RPP-25113. Nine events not previously documented were identified that resulted in the inadvertent discharge of waste to the ground. These events are in addition to identified pipeline leaks. The waste loss information summarized in RPP-RPT-29191 will be further evaluated as part of the ongoing Resource Conservation and Recovery Act (RCRA) Field Investigation process being conducted for the waste management areas at the Hanford site.

Based on the review in RPP-RPT-29191 of these historical reports, supplemental tank waste loss information was identified for WMA C. Additional release events are defined as Tank Leak Information, Potentially Failed or Plugged Pipelines and Potentially New Unplanned Releases of Waste. Tables 8-1, 8-2 and 8-3 summaries this information for RPP-RPT-29191 for WMA C. These releases currently are not in WIDS but they are in the process of being added to that database.

Table 8-1. Tank 241-C-101 Leak Information

Date	Event as Described in Reference	Reference
3-18-1970	Miscellaneous: Started drilling the 4th well at 101-C on 3-17. Hit contamination at 38 foot level (10,000 c/m). Drilling terminated. Miscellaneous: 101-C: Resumed dry well drilling on the fourth well. Now at 82 foot level. Contamination encountered between 42 and 48 foot level (5,000 - 10,000 c/m) but after 48 foot, no contamination.	ARH-1526-1, page 130 and 132

Comment: See also Interoffice Memo "Evaluation of Tank C-101 Leak Data and Historical Records" (CH2M HILL 2003b) for additional information on tank 241-C-101.

Table 8-2. Potentially Failed and Plugged Pipelines (Not Identified in RPP-25113)

Potential Pipeline Leaks	
Date	Description of Event
6-1964	**Line V172** from diversion box 241-C-252 to tank 241-C-112
11-1964	Depleted cesium pipeline from 801-C Cs Load-Out facility to tank 241-C-103
2-1965	PUREX coating waste **line V8107** to diversion box 241-CR-151. This resulted in flooding of the 244-CR Vault up to the approximately level of the tank tops.
1-1975	**Line V113** from tank 241-AX-103 pump pit to diversion box 241-C-151 (PUREX sludge supernatant waste transfer line)
Potentially Plugged Cascade Lines	
5-1961	Cascade line from tank 241-C-107 to tank 241-C-108
Potentially Plugged Pipelines	
9-17-1957	PUREX coating waste pipeline from diversion box 241-CR-153 to tank 241-C-104
12-12-1968	PUREX supernatant pipeline from tank 241-C-105 to 221-B Plant (location unknown)
3-13-1970	PUREX supernatant pipeline from tank 241-A-102 to diversion box 241-C-151 (location unknown)

Table 8-3. Potentially New Unplanned Releases of Waste

Date	Location	Event as Described in Reference	Reference	Comments
11-20-1951	241-C-106 Spare inlet nozzle	On 11-20-51 water inadvertently seeped into the 106-C Metal Waste Storage Tank from a hose which had been left running to prevent freezing of the water line. After extensive checking it was determined that the liquid level in the tank had raised approximately 8½ inches and had reached the level of the stubbed inlet lines. All survey work showed no indications of tank overflow and the level of the tank has remained constant for the past four weeks. Corrective measures have been instituted to prevent a similar occurrence.	HW-23140, page 45	The stubbed inlet lines are only covered with a loose fitting cap, as shown on drawing W-72743. No record was located that indicated the liquid level in tank 106-C was purposefully reduced to below the elevation of the stubbed inlet lines. Tank liquid levels were not reported again until April 1952 (HW-27838). However, as of April 31, 1952, the liquid level in tank 106-C was reported as 519,000 gallons, which is well below the elevation of the stubbed inlet lines.
10-1967	Tank 241-C-105 Spare inlet nozzle	During excavation on the southwest side of 105-C, J. A. Jones personnel unearthed some contaminated soil. The spot is located directly beneath two blanked stubs. The extent of spreading or volume of the source contamination is unknown at this time. Analysis of a sample shows cesium to be the only gamma producing isotope present. 3.71 µCi/ml Cs-137 and 0.0039 µCi/ml Cs-134 were the results of analysis. This cesium ratio will allow determination of source and time of deposition of the activity. A sample of 105-C supernate is now being analyzed at Redox Laboratory.	ISO-651 RD, page 288	The absence of other gamma emitting radionuclides indicates this leak is old and did not occur in 1967. The curie ratio of ^{134}Cs to ^{137}Cs is 0.00105.

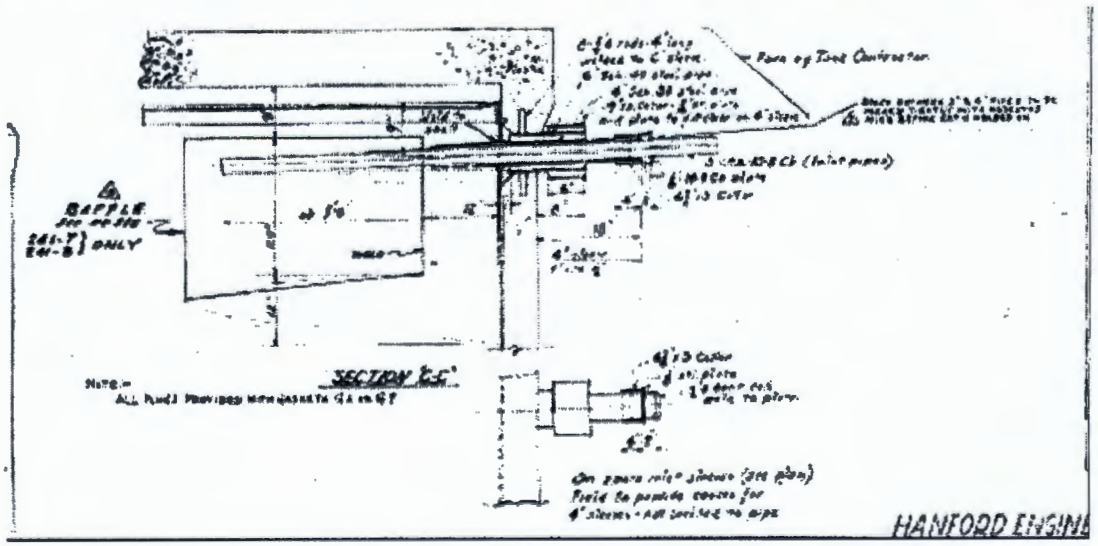
Table 8-3. Potentially New Unplanned Releases of Waste

Date	Location	Event as Described in Reference	Reference	Comments
11-1967	Tank 241-C-105 Spare inlet nozzle	Analysis of Soil Samples Near Tank 105-C Subject analyses showed that the solution that had leaked into the soil was not the same as that currently contained in the tank. This conclusion was made on the basis of the different Cs-137/Cs-134 ratios. See letter, HL Brandt – PW Smith to LW Roddy, November 9, 1967.	ISO-651 RD, page 298	Same event as above.

8.1.2.1 Potential Waste Losses from Spare Inlet Nozzles

The SSTs in the 241-C Tank Farm are each equipped with four, horizontal inlet nozzles, as shown in Figure 8-1 (W-72742 and W-72743). While Figure 8-1 depicts a typical inlet nozzle for the 200-series SSTs, the inlet nozzles were constructed the same in the 100-series SSTs. An inlet nozzle consists of an inner 4-inch diameter schedule 80 steel pipe with an outer 6-inch diameter schedule 40 steel pipe. The outer 6-inch diameter steel pipe is imbedded in the concrete sidewall of the SST, attached to the exterior of the carbon steel sidewall using mastic and protrudes ~8-inches from the exterior of the tank wall. The 4-inch diameter steel pipe is inserted through the 6-inch diameter steel pipe, protrudes ~12-inches inside the SST and ~18-inches beyond the exterior of the concrete sidewall of the SST. The 4-inch diameter steel pipe is welded to the sidewall of the carbon steel tank. An 8-inch diameter steel collar is tightly fitted around the 6-inch diameter steel pipe where the 4-inch diameter steel pipe exits this outer pipe. Process waste lines, which are 3-inch inner diameter, 11 gauge 18-8Cb (i.e. early form of stainless steel) tubing, are inserted through the 4-inch diameter steel pipe and extend ~4-ft inside the SST.

Figure 8-1. 20-ft Diameter SST Detail Showing Inlet Nozzles (Best Image Available)



The elevation of the four inlet nozzles for the 100-series SSTs is 17-ft 4-inches from the center of the tank bottom (H-2-1744). The elevation of the four inlet nozzles for the 200-series SSTs is 24-ft 7-inches from the center of the tank bottom (H-2-1744). All inlet nozzles on the 100-series SSTs in 241-C Farm are located at approximately the 8 o'clock position relative to north being 12 o'clock. For the 200-series SSTs, two spare inlets are located approximately at the 12:30 o'clock position and two spare inlets are located approximately at the 9:30 o'clock relative to north being 12 o'clock.

The process waste lines connecting to the inlet nozzles on SSTs C-101, C-104, C-107, C-108, C-110, and C-111 are supported by concrete troughs (W-74108, H-2-616, and H-2-2929). The concrete supports are 30-inches tall and 32-inches wide, except for C-101, which are only 26-inches wide. The concrete support beams have a 4-inch tall shoulder, resulting in a 24-inch (only 18-inches for C-101) wide trough running down the center of the beam.

Process waste lines from diversion box 241-C-252 connect to two inlet nozzles on each of the C-200 series SSTs and are supported by concrete troughs (W-74317). The other two inlet nozzles are spares on the C-200 series SSTs and are not supported. For the 200-series SSTs, the concrete support troughs are 37-inches tall and 20-inches wide with a 4-inch tall shoulder. The interior wide of the trough supporting the pipelines is 12-inches.

Some of the inlet nozzles on the SSTs are spares and do not have installed process waste lines. The design for the SSTs identified a 4.5-inch diameter cover was to be placed over the 4-inch diameter spare inlet nozzles (see Figure 8-1). It is known that some of the spare inlet nozzles are poorly sealed. SST BX-102 was overfilled in February 1951 and waste was lost to the ground through the spare inlet nozzles (HW-20742). As part of the investigation into the waste loss from SST BX-102, spare inlet nozzles on several SSTs) were examined (specific tanks were not identified. This investigation revealed "... that some [inlet nozzles] have blanks which are welded tight, some have wooden plugs driven into the spare nozzle covered by a cap and sealed with waterproofing, and some have caps covered with waterproofing membrane and then sealed in cement" (HW-20742, page 5).

Based on the SST BX-102 waste loss investigation, the potential exists that some waste may have been similarly released in the 241-C Farm if any of the SSTs were filled above the height of the spare inlet nozzles. If waste losses occurred through the spare inlets for SSTs C-101, C-104, C-107, C-108, C-110, and C-111 the waste may have been contained and channeled along the concrete troughs.

The waste volumes in all SSTs was reported monthly from January 1945 through December 1960 (except no data for August 1951 through March 1952), semi-annually from January 1961 through June 1965, quarterly from September 1965 through September 1976, and monthly thereafter. SSTs were removed from service in January 1981 and no waste additions were allowed after this date.

Based on a review of waste volume data for the WMA C tanks, SSTs C-101, C-103, C-104, C-106, C-109, C-111, C-201, C-202, and C-204 were filled with waste above the elevation of the spare inlet nozzles on several occasions. This over filling could have potentially resulted in waste leaking from these SSTs into the surrounding soil. The date and waste type present in each SST when the tank was filled with waste above the elevation of the spare inlet nozzles are summarized Table 8-4.

Table 8-4. Tank Filled Above Spare Inlet Nozzles

Tank	Date	Waste Type Present in Tank
C-101	June 1965 – December 1967	Received waste from CR Vault. Tank contains CR (28kgal), PUREX P1 (452kgal), and Coating Waste (CW) (94kgal).
C-103	October 1953 – March 1957	Tributyl Phosphate Plant (TBP) Waste
	June 1961 – December 1961	PUREX CW
C-104	August 1958	PUREX CW
	June 1965 – March 1966	After receiving 15,000 gallons of unknown waste type (likely PUREX CW based on RL-SEP-332, page B-2) from 244-CR Vault, the tank was filled above the spare inlets. Majority of waste in tank is PUREX CW
C-106	December 1965 – March 1966	PUREX P1 HLW supernate
C-109	June 1961 – December 1961	PUREX CW
	June 1965 – March 1968	Tank received 19,000 gallons from 201-C Sr Semiworks. Tank contains 112,000 gallons of evaporator bottoms (EB), 300,000 gallons of PUREX CW, and 142,000 gallons of Sr Semiworks waste.
C-111	May 1957	TBP Waste
	September 1957	Scavenged 242-B EB waste (i.e. concentrated 1C/CW and TBP wastes)
C-201	December 1955 – January 1956 June 1961 – June 1963	201-C Hot Semiworks waste from PUREX flowsheet tests
C-202	January 1957 – March 1957 June 1957 – October 1958 June 1961 – December 1963	201-C Hot Semiworks waste from PUREX flowsheet tests. Last waste transferred into tank was 201-C building flush solutions.
C-204	March 1968 – March 1970	201-C Hot Semiworks waste from PUREX flowsheet tests and 201-C building flush solutions.

8.1.3 Planned Release Facilities Such As Cribs and Drains

There are several facilities in and around WMA C which were designed to discharge into the vadose zone. No documentation that discharges occurred have been located. These facilities include:

- Cesium Loadout Facility Drain – The Process Engineering Cesium Loadout Facility at the 241 C Tank farm, (HW-71333) on drawing SK-2-19030, Rev 0 includes design specifications for a 4 foot diameter dry well drain which would receive releases from the valve pit and the loadout pad. This drain is located northeast of the Cesium Loadout building.
- 271-CR French Dry, Dry Well Drains and Tile Fields – The 271-CR Building had several drains associated with it. These occurred both inside and outside of the WMA C fenceline. Drains included a French drain, dry well drains and two tile fields. The two tile fields were associated with the septic tank system. An original tile field was replaced with a second expanded system along with a new septic tank. One of the drains appears to have been associated with a condensate line. The remainder of the drain systems do not have documentation of what, if any of releases consisted of.

The location of known or suspected release sites are shown on Figure 8-2.

8.2 OPTIMIZING THE NEAR-TERM SAMPLING LOCATIONS

The initial Near-Term characterization work will target specific areas of interest (AOI). A map of the AOI has been developed for WMA C and is based upon literature reviews and previous field investigations. Figure 8-3 shows the AOIs for WMA C. The AOI include UPRs that have been identified in WIDS, and areas that will require characterization to determine if a release has occurred. Areas the have been determined to need characterization to determine if Near-Term decisions are needed (i.e. is an interim corrective measure (ICM) required) will be the target of the initial efforts.

Optimizing sample locations in this initial Near-Term characterization effort will focus on the AOI in applying a sampling approach where areas of known or suspected releases have occurred. Five AOIs requiring characterization have been identified and one candidate AOI has been defined based upon known or suspected releases within WMA C.

Within the AOI specific sample locations will be selected based upon defined site limitations (slope of the ground surface), and infrastructure constrains. The actual sample locations within an AOI will be established following the field survey with GPR and other site preparation activities. The GPR survey will define where subsurface conflicts exist which will help define acceptable sample locations. During the survey above ground conflicts will also be defined.

As part of the initial Near-Term characterization the SGE electrodes network may be placed across the spatial boundary. Data from this network would be used to further define additional sampling locations as part of the initial Near-Term sampling and to identify sample locations to transition to the follow-on Phase 2 characterization.

Figure 8-2. Known or Suspected Release Areas

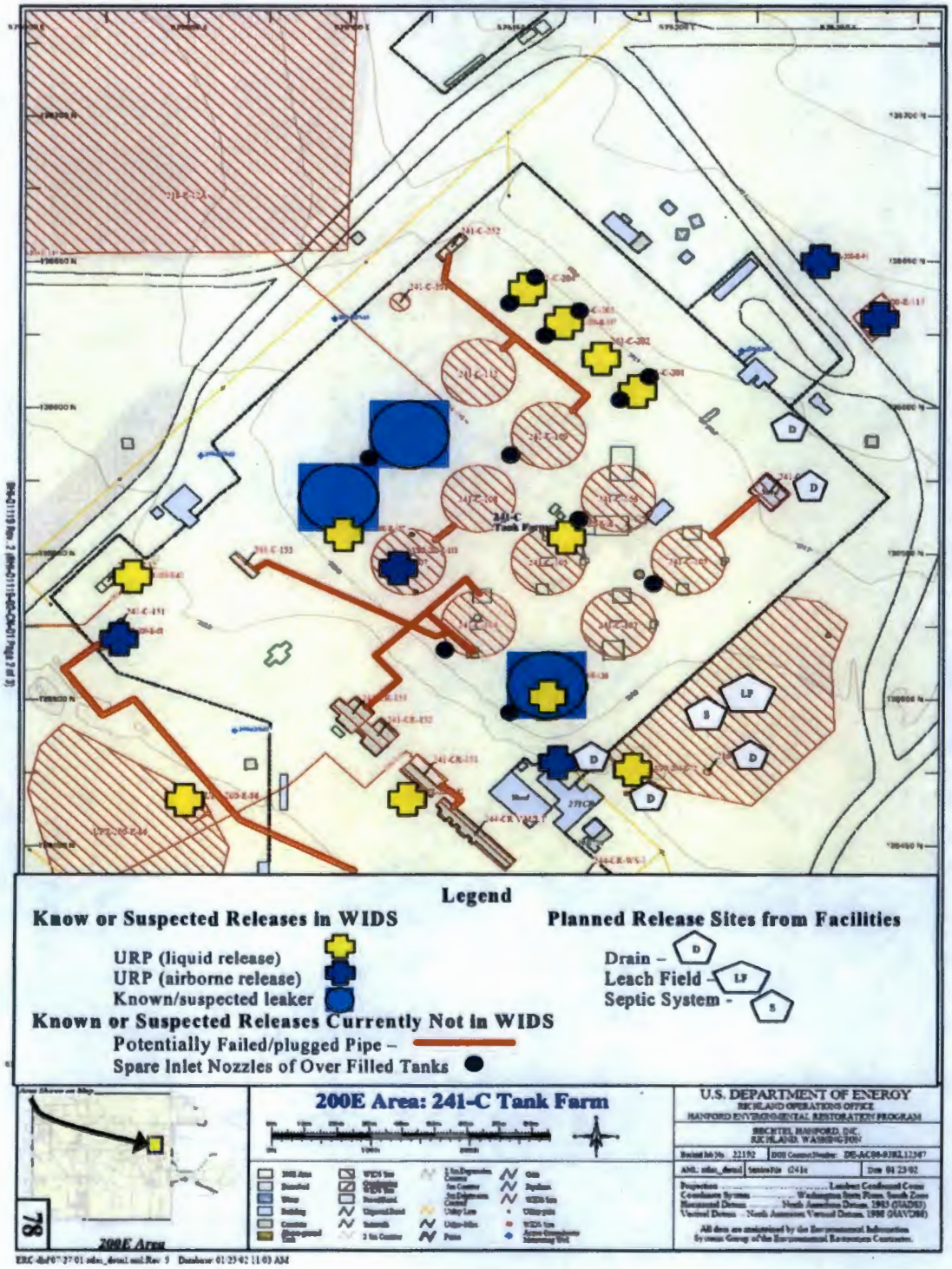
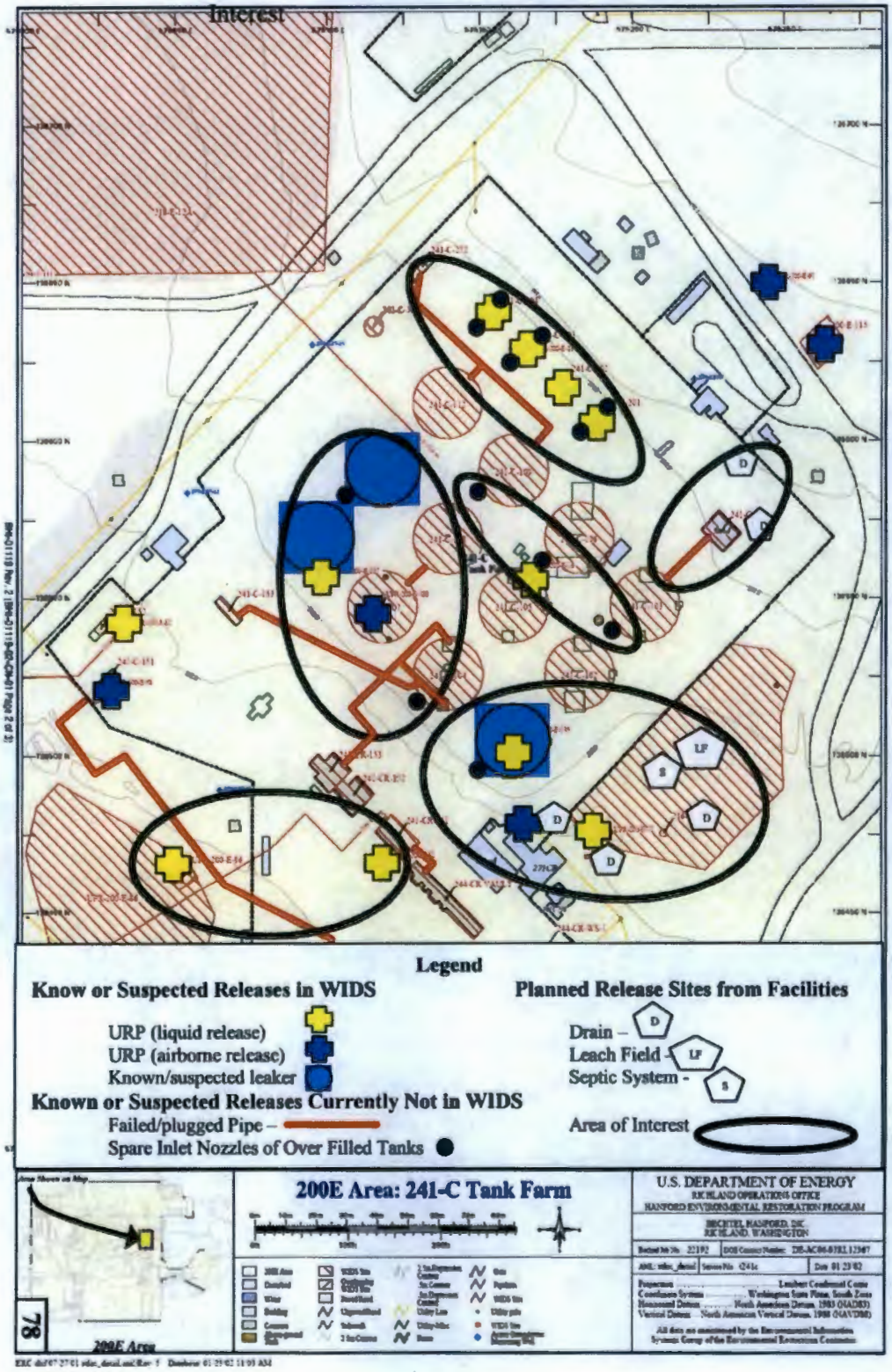


Figure 8-3. Known or Suspected Release Areas of Interest



8.3 OPTIMIZING THE NEAR-TERM SAMPLING TECHNOLOGY

The RFI Phase 1 Work Plan (RPP-16608) evaluated sampling and analysis options and alternative field sampling technologies. That evaluation and the experience gained during implementation of Phase 1 RFI field investigation has resulted in identifying the following sampling technologies for the initial Near-Term characterization efforts: Direct Push, SGE and borehole.

These technologies allow for investigations for the presence of contaminants in the vadose zone to be conducted using both indirect and direct evaluation techniques. Subsurface investigations will include geophysical logging and soil sampling. The deployment of any of these technologies will follow the FSAP which will document the selected field sampling locations within the AOI.

Direct push technology is planned for use to complete the initial Near-Term characterization of the vadose zone in WMA C. Two options are available for application: a single string approach where one sample can be collected; and a dual string approach where multiple samples can be collected. Both options are anticipated to be deployed in this effort. Option 1, the single string (2.5 inch O.D.) approach can collect a 1.5 inch by 24 inch sample. When the targeted depth is reached, the drive tip is loosened and the string is advanced to fill the sample device. Option 2, the dual string (2.625 inch OD) approach can collect a 1.08 inch by 24 inch sample at multiple depths.

The disadvantages of this technology are: 1) the limited depth (100 ft) to which it can be used to regularly collect samples; and 2) the quantity of sample material available for analysis. The ability to collect multiple samples in a given probe hole results in a 51% decrease in the volume of sample that can be collected. The depth limitations mean that the lateral extent of contamination may be determined, but not necessarily the vertical extent.

In the event that sampling via direct push technology is not able to provide the necessary information, subsequent revisions of the DQO will be used to address supplemental sampling approaches. The data gathered through application of direct push technology will be available to target those regions requiring deeper investigation through other established techniques (drill and sample, drive and sample, etc.).

9.0 QUALITY ASSURANCE PROJECT PLAN FOR THE VADOSE ZONE PROJECT

An evaluation of the requirements for quality assurance for activities undertaken by the Vadose Zone Program to characterize the vadose zone associated with tank farms in the Central Plateau of the Hanford Site has been developed (Hanford Tank Farm Vadose Zone Characterization Quality Assurance Requirements, (RPP-34161). The document provides an evaluation of quality assurance requirements for the following six areas:

- Planning
- Geophysical Measurements
- Vadose Zone Sampling
- Field Laboratory
- Laboratory and
- General Administrative requirements.

RPP-34161 provides an assessment of the quality assurance requirements for vadose zone characterization and defines how the quality assurance requirements will be applied. This document implements the requirements of the *Quality Assurance Program Description* (TFC-PLN-02) of the Tank Farm Contractor. The *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD, DOE/RL-96-68) is a key input to this evaluation.

The Vadose Zone Program recognizes that characterization data may support a variety of decisions. To ensure data can meet these data quality objectives the quality assurance requirements for the Program must span a broader application than laboratory analysis. The Quality Assurance report incorporates additional quality assurance requirements on the equations and parameters that describe how contaminants move through the vadose zone, the use of geophysical measurements (for example, the measurement of subsurface concentrations in three dimensions) for the interpretation of the location and extent of plumes and the integration of different types and quality of data. The document spans the full spectrum of characterization activities from planning to laboratory work as well as administration aspects of the program.

Presented in Appendix B are the quality assurance requirements for the six areas defined above from RPP-34161. The six tables present the activities under each of the six areas and associated quality assurance requirements. The endnotes for all six tables define how documentation of the requirements is to occur. These requirements will be implemented as the Quality Assurance Project Plan for all vadose zone work with tank farms in the Central Plateau of the Hanford Site.

10.0 REFERENCES

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APPENDIX A
WAC 173-340 METHOD B CLEANUP LEVELS FOR CHEMICALS IN ORDER BY CHEMICAL ABSTRACT NUMBER

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number [a].

		Soil Direct Contact		Groundwater Cleanup Levels			Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ug/L	Drinking Water MCL[b] ug/L	ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
50-32-8	benzo[a]pyrene	1.37E-01		1.20E-02		2.00E-01	1.20E-02	MTCA B	9.69E+02	CLARC 3.1	4.63E-05	CLARC 3.1	2.33E-01
53-70-3	dibenzo[a,h]anthracene	1.37E-01		1.20E-02			1.20E-02	MTCA B	1.79E+03	CLARC 3.1	6.03E-07	CLARC 3.1	4.29E-01
56-23-5	carbon tetrachloride	7.69E+00	5.60E+01	3.37E-01	5.60E+00	5.00E-03	3.37E-01	MTCA B	1.52E-01	CLARC 3.1	1.25E+00	CLARC 3.1	3.10E-03
57-12-5	cyanide		1.60E+03		3.20E+02	2.00E-01	2.00E+02	MCL	0.00E+00	Default	0.00E+00	Default	8.00E-01
57-14-7	dimethylhydrazine;1,1-	3.85E-01		3.37E-02			3.37E-02	MTCA B	0.00E+00	Default	0.00E+00	Default	1.35E-04
58-89-9	lindane [gamma-BHC]	7.69E-01	2.40E+01	6.73E-02	4.80E+00	2.00E-01	6.73E-02	MTCA B	1.35E+00	CLARC 3.1	5.74E-04	CLARC 3.1	2.09E-03
60-29-7	ethyl ether (diethyl ether)		1.60E+04		1.60E+03		1.60E+03	MTCA B	8.40E-02	Region 9	5.30E-04	Region 9	9.09E+00
60-34-4	methylhydrazine	9.09E-01		7.95E-02			7.95E-02	MTCA B	0.00E+00	Default	0.00E+00	Default	3.18E-04
60-57-1	dieldrin	6.25E-02	4.00E+00	5.47E-03	8.00E-01		5.47E-03	MTCA B	2.56E+01	CLARC 3.1	6.19E-04	CLARC 3.1	2.82E-03
62-75-9	nitrosodimethylamine;N-	1.96E-02		1.72E-03			1.72E-03	MTCA B	0.00E+00	Default	0.00E+00	Default	6.86E-06
67-64-1	acetone (2-Propanone)		8.00E+03		8.00E+02		8.00E+02	MTCA B	5.75E-04	CLARC 3.1	1.59E-03	CLARC 3.1	3.21E+00
67-66-3	chloroform (trichloromethane)	1.64E+02	8.00E+02	7.17E+00	8.00E+01		7.17E+00	MTCA B	5.30E-02	CLARC 3.1	1.50E-01	CLARC 3.1	3.81E-02
67-72-1	hexachloroethane	7.14E+01	8.00E+01	6.25E+00	1.60E+01		6.25E+00	MTCA B	1.78E+00	CLARC 3.1	1.59E-01	CLARC 3.1	2.49E-01
71-36-3	butanol;n- (n-butyl alcohol)		8.00E+03		1.60E+03		1.60E+03	MTCA B	6.92E-03	CLARC 3.1	3.61E-04	CLARC 3.1	6.62E+00
71-43-2	benzene	1.82E+02	2.40E+02	7.95E-01	2.40E+01	5.00E-03	7.95E-01	MTCA B	6.20E-02	CLARC 3.1	2.28E-01	CLARC 3.1	4.48E-03
71-55-6	trichloroethane;1,1,1-		7.20E+04		7.20E+03	2.00E+02	2.00E+02	MCL	1.35E-01	CLARC 3.1	7.05E-01	CLARC 3.1	1.58E+00
72-20-8	endrin		2.40E+01		4.80E+00	2.00E+00	2.00E+00	MCL	1.08E+01	CLARC 3.1	3.08E-04	CLARC 3.1	4.40E-01
74-83-9	bromomethane [methyl bromide]		1.12E+02		1.12E+01		1.12E+01	MTCA B	9.00E-03	CLARC 3.1	2.56E-01	CLARC 3.1	5.18E-03
74-87-3	chloromethane	7.69E+01		3.37E+00			3.37E+00	MTCA B	2.10E-01	Region 9	9.80E-01	Region 9	3.34E-02
75-00-3	ethyl chloride [chloroethane]					4.64E+00	4.64E+00	Region 9	8.80E-02	Region 9	4.50E-01	Region 9	3.03E-02
75-01-4	vinyl chloride [chloroethene; 1-]	6.67E-01	2.40E+02	2.92E-02	2.40E+01	2.00E+00	2.92E-02	MTCA B	1.86E-02	CLARC 3.1	1.11E+00	CLARC 3.1	1.84E-04
75-05-8	acetonitrile		4.80E+02		4.80E+01		4.80E+01	MTCA B	9.40E-02	Region 9	8.20E-04	Region 9	2.82E-01
75-09-2	dichloromethane (methylene chloride)	1.33E+02	4.80E+03	5.83E+00	4.80E+02	5.00E+00	5.00E+00	MCL	1.00E-02	CLARC 3.1	8.98E-02	CLARC 3.1	2.54E-02
75-15-0	carbon disulfide		8.00E+03		8.00E+02		8.00E+02	MTCA B	4.57E-02	CLARC 3.1	1.24E+00	CLARC 3.1	5.65E+00

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number [a].

		Soil Direct Contact		Groundwater Cleanup Levels			Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ug/L	Drinking Water MCL[b] ug/L	ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
75-21-8	ethylene oxide	9.80E-01		4.29E-02			4.29E-02	MTCA B	1.30E-02	Region 9	3.10E-03	Region 9	1.83E-04
75-35-4	dichloroethylene;1,1-	1.67E+00	7.20E+02	7.29E-02	7.20E+01	7.00E+00	7.29E-02	MTCA B	6.50E-02	CLARC 3.1	1.07E+00	CLARC 3.1	5.22E-04
75-69-4	trichlorofluoromethane		2.40E+04		2.40E+03		2.40E+03	MTCA B	9.60E-01	Region 9	4.00E+00	Region 9	7.23E+01
75-71-8	dichlorodifluoromethane		1.60E+04		1.60E+03		1.60E+03	MTCA B	3.50E-01	Region 9	4.10E+00	Region 9	2.90E+01
76-13-1	trichloro-1,2,2-trifluoroethane;1,1,2-		2.40E+06		4.80E+05		4.80E+05	MTCA B	0.00E+00	Default	0.00E+00	Default	1.92E+03
76-44-8	heptachlor	2.22E-01	4.00E+01	1.94E-02	8.00E+00	4.00E-01	1.94E-02	MTCA B	9.53E+00	CLARC 3.1	4.47E-02	CLARC 3.1	3.78E-03
78-87-5	dichloropropane;1,2-	1.47E+01		6.43E-01		5.00E+00	6.43E-01	MTCA B	4.70E-02	CLARC 3.1	1.15E-01	CLARC 3.1	3.30E-03
79-00-5	trichloroethane;1,1,2-	1.75E+01	3.20E+02	7.68E-01	3.20E+01	5.00E+00	7.68E-01	MTCA B	7.50E-02	CLARC 3.1	3.74E-02	CLARC 3.1	4.27E-03
79-01-6	trichloroethylene (TCE; trichloroethene)	9.09E+01		3.98E+00		5.00E+00	3.98E+00	MTCA B	9.40E-02	CLARC 3.1	4.22E-01	CLARC 3.1	2.63E-02
79-34-5	tetrachloroethane;1,1,2,2-	5.00E+00		2.19E-01			2.19E-01	MTCA B	7.90E-02	CLARC 3.1	1.41E-02	CLARC 3.1	1.23E-03
79-46-9	nitropropane; 2-	1.05E-01		4.61E-03			4.61E-03	MTCA B	0.00E+00	Default	0.00E+00	Default	1.84E-05
82-68-8	pentachloronitrobenzene	3.85E+00	2.40E+02	3.37E-01	4.80E+01		3.37E-01	MTCA B	0.00E+00	Default	0.00E+00	Default	1.35E-03
83-32-9	acenaphthene		4.80E+03		9.60E+02		9.60E+02	MTCA B	4.90E+00	CLARC 3.1	6.36E-03	CLARC 3.1	9.79E+01
84-74-2	di-butyl phthalate		8.00E+03		1.60E+03		1.60E+03	MTCA B	1.57E-01	CLARC 3.1	3.85E-08	CLARC 3.1	1.14E+01
85-68-7	butyl benzyl phthalate		1.60E+04		3.20E+03		3.20E+03	MTCA B	1.38E+01	CLARC 3.1	5.17E-05	CLARC 3.1	8.93E+02
87-68-3	hexachlorobutadiene	1.28E+01	1.60E+01	5.61E-01	1.60E+00		5.61E-01	MTCA B	5.37E+01	CLARC 3.1	3.34E-01	CLARC 3.1	6.05E-01
87-86-5	pentachlorophenol	8.33E+00	2.40E+03	7.29E-01	4.80E+02	1.00E+00	7.29E-01	MTCA B	5.92E-01	CLARC 3.1	1.00E-06	CLARC 3.1	1.15E-02
88-06-2	trichlorophenol;2,4,6-	9.09E+01		7.95E+00			7.95E+00	MTCA B	3.81E-01	CLARC 3.1	3.19E-04	CLARC 3.1	9.24E-02
88-85-1	dinoseb (2-sec-butyl-4,6-dinitophenol)		8.00E+01		1.60E+01	7.00E+00	7.00E+00	MCL	0.00E+00	Default	0.00E+00	Default	2.80E-02
91-20-3	naphthalene		1.60E+03		1.60E+02		1.60E+02	MTCA B	1.19E+00	CLARC 3.1	1.98E-02	CLARC 3.1	4.46E+00
92-52-4	biphenyl;1,1-		4.00E+03		8.00E+02		8.00E+02	MTCA B	4.70E+01	Region 9	2.10E-02	Region 9	7.55E+02
95-47-6	xylene;o-		1.60E+05		1.60E+04	1.00E+04	1.00E+04	MCL	2.41E-01	CLARC 3.1	2.13E-01	CLARC 3.1	9.19E+01
95-48-7	cresol; o- (2-methylphenol)		4.00E+03		8.00E+02		8.00E+02	MTCA B	9.12E-02	CLARC 3.1	4.92E-05	CLARC 3.1	4.66E+00
95-50-1	dichlorobenzene;1,2-[ortho]		7.20E+03		7.20E+02	6.00E+02	6.00E+02	MCL	3.79E-01	CLARC 3.1	7.79E-02	CLARC 3.1	7.03E+00
95-57-8	chlorophenol;2-		4.00E+02		8.00E+01		8.00E+01	MTCA B	3.88E-01	CLARC 3.1	1.60E-02	CLARC 3.1	9.43E-01

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number [a].

		Soil Direct Contact		Groundwater Cleanup Levels			Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ug/L	Drinking Water MCL[b] ug/L	ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
95-95-4	trichlorophenol;2,4,5-		8.00E+03		1.60E+03		1.60E+03	MTCA B	1.60E+00	CLARC 3.1	1.78E-04	CLARC 3.1	5.75E+01
98-86-2	acetophenone		8.00E+03		1.60E+03		1.60E+03	MTCA B	0.00E+00	Default	0.00E+00	Default	6.40E+00
98-95-3	nitrobenzene		4.00E+01		8.00E+00		8.00E+00	MTCA B	1.19E-01	CLARC 3.1	9.84E-04	CLARC 3.1	5.11E-02
100-00-5	chloronitrobenzene;p-	5.56E+01		4.86E+00			4.86E+00	MTCA B	3.90E-01	Region 9	9.80E-01	Region 9	6.56E-02
100-25-4	Dinitrobenzene; 1,4- (para-)		3.20E+01		6.40E+00		6.40E+00	MTCA B	0.00E+00	Default	0.00E+00	Default	
100-41-4	ethylbenzene		8.00E+03		8.00E+02	7.00E+02	7.00E+02	MCL	2.04E-01	CLARC 3.1	3.23E-01	CLARC 3.1	6.05E+00
100-42-5	styrene	3.33E+01	1.60E+04	1.46E+00	1.60E+03	1.00E+02	1.46E+00	MTCA B	9.12E-01	CLARC 3.1	1.13E-01	CLARC 3.1	3.28E-02
106-42-3	xylene;p-						1.60E+04	MTCA B	3.11E-01	CLARC 3.1	3.14E-01	CLARC 3.1	1.72E+02
106-44-5	cresol; p- (4-methylphenol)		4.00E+02		8.00E+01		8.00E+01	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E-01
106-46-7	dichlorobenzene;1,4- [para]	4.17E+01		1.82E+00		7.50E+01	1.82E+00	MTCA B	6.16E-01	CLARC 3.1	9.96E-02	CLARC 3.1	3.00E-02
106-93-4	ethylene dibromide (1,2-dibromoethane)	1.18E-02		5.15E-04		5.00E-02	5.15E-04	MTCA B	6.60E-02	CLARC 3.1	1.00E-01	Region 9	2.83E-06
106-99-0	butadiene;1,3-						1.14E-02	Region 9	7.20E-01	Region 9	7.30E+00	Region 9	3.55E-04
107-02-8	acrolein		1.60E+03		1.60E+02		1.60E+02	MTCA B	1.30E-01	Region 9	4.90E-03	Region 9	1.06E+00
107-05-1	allyl chloride [chloropropene; 3-]		4.00E+03		8.00E+02		8.00E+02	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E+00
107-13-1	acrylonitrile	1.85E+00	8.00E+01	8.10E-02	8.00E+00		8.10E-02	MTCA B	5.10E-03	Region 9	3.60E-03	Region 9	3.33E-04
107-87-2	methylcyclohexane						5.22E+03	Region 9	1.30E+01	Region 9	1.80E+01	Region 9	1.54E+03
108-38-3	xylene;m-		1.60E+05		1.60E+04	1.00E+04	1.00E+04	MCL	1.96E-01	CLARC 3.1	3.01E-01	CLARC 3.1	8.44E+01
108-39-4	cresol; m- (m-cresylic acid)		4.00E+03		8.00E+02		8.00E+02	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E+00
108-88-3	toluene		1.60E+04		1.60E+03	1.00E+03	1.00E+03	MCL	1.40E-01	CLARC 3.1	2.72E-01	CLARC 3.1	7.27E+00
108-90-7	chlorobenzene		1.60E+03		1.60E+02	1.00E+02	1.00E+02	MCL	2.24E-01	CLARC 3.1	1.52E-01	CLARC 3.1	8.74E-01
108-94-1	cyclohexanone		4.00E+05		8.00E+04		8.00E+04	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E+02
108-95-2	phenol		4.80E+04		9.60E+03		9.60E+03	MTCA B	2.88E-02	CLARC 3.1	1.63E-05	CLARC 3.1	4.39E+01
110-54-3	hexane;n-		4.80E+03		4.80E+02		4.80E+02	MTCA B	3.41E+00	CLARC 3.1	7.40E+01	CLARC 3.1	9.62E+01
110-80-5	ethoxyethanol; 2-		3.20E+04		6.40E+03		6.40E+03	MTCA B	0.00E+00	Default	0.00E+00	Default	2.56E+01

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

		Soil Direct Contact		Groundwater Cleanup Levels			Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ug/L	Drinking Water MCL[b] ug/L	ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
110-82-7	cyclohexane						3.47E+04	Region 9	9.60E-01	Region 9	8.20E+00	Region 9	1.30E+03
110-86-1	pyridine		8.00E+01		1.60E+01		1.60E+01	MTCA B	1.00E+00	Region 9	1.00E-01	Region 9	3.87E-01
118-74-1	hexachlorobenzene	6.25E-01	6.40E+01	5.47E-02	1.28E+01	1.00E+00	5.47E-02	MTCA B	8.00E+01	CLARC 3.1	5.41E-02	CLARC 3.1	1.50E-02
120-82-1	trichlorobenzene;1,2,4-		8.00E+02		8.00E+01	7.00E+01	7.00E+01	MCL	1.66E+00	CLARC 3.1	5.82E-02	CLARC 3.1	2.98E+00
121-14-2	dinitrotoluene;2,4-		1.60E+02		3.20E+01		3.20E+01	MTCA B	9.55E-02	CLARC 3.1	3.80E-06	CLARC 3.1	1.89E-01
121-44-8	triethylamine						1.22E+01	Region 9	1.30E-02	Region 9	3.70E-03	Region 9	5.19E-02
122-39-4	diphenylamine		2.00E+03		4.00E+02		4.00E+02	MTCA B	0.00E+00	Default	0.00E+00	Default	1.60E+00
123-91-1	dioxane;1,4-	9.09E+01		7.95E+00			7.95E+00	MTCA B	0.00E+00	Default	0.00E+00	Default	3.18E-02
126-73-8	tributyl phosphate	1.85E+02	1.60E+04	1.62E+01	3.20+03		1.62+01	Calc.	1.89+01	ORNL	6.13E-06	ORNL	6.18E+00
126-98-7	methacrylonitrile		8.00E+00		1.60E+00		1.60E+00	MTCA B	5.10E-03	Region 9	3.60E-03	Region 9	6.57E-03
127-18-4	tetrachloroethylene (PCE; tetrachlorethene)	1.96E+01	8.00E+02	8.58E-01	8.00E+01	5.00E+00	8.58E-01	MTCA B	2.65E-01	CLARC 3.1	7.54E-01	CLARC 3.1	9.10E-03
129-00-0	pyrene		2.40E+03		4.80E+02		4.80E+02	MTCA B	6.80E+01	CLARC 3.1	4.51E-04	CLARC 3.1	6.55E+02
141-78-6	ethyl acetate		7.20E+04		1.44E+04		1.44E+04	MTCA B	3.60E-01	Region 9	5.70E-03	Region 9	1.61E+02
206-44-0	fluoranthene		3.20E+03		6.40E+02		6.40E+02	MTCA B	4.91E+01	CLARC 3.1	6.60E-04	CLARC 3.1	6.31E+02
309-00-2	aldrin	5.88E-02	2.40E+00	5.15E-03	4.80E-01		5.15E-03	MTCA B	4.87E+01	CLARC 3.1	6.97E-03	CLARC 3.1	5.04E-03
319-84-6	hexachlorocyclohexane; alpha (alpha-BHC)	1.59E-01		1.39E-02			1.39E-02	MTCA B	1.76E+00	CLARC 3.1	4.35E-04	CLARC 3.1	5.45E-04
319-85-7	hexachlorocyclohexane; beta- (beta-BHC)	5.56E-01		4.86E-02			4.86E-02	MTCA B	2.14E+00	CLARC 3.1	3.05E-05	CLARC 3.1	2.27E-03
319-86-8	hexachlorocyclohexane;delta- (delta-BHC)							MTCA B					
542-75-6	dichloropropene;1,3-	5.56E+00	2.40E+03	2.43E-01	2.40E+02		2.43E-01	MTCA B	2.70E-02	CLARC 3.1	7.26E-01	CLARC 3.1	1.41E-03
621-64-7	nitroso-di-n-propylamine;N-	1.43E-01		1.25E-02			1.25E-02	MTCA B	2.40E-02	CLARC 3.1	9.23E-05	CLARC 3.1	5.60E-05
1330-20-7	xylene		1.60E+05		1.60E+04	1.00E+04	1.00E+04	MCL	2.33E-01	CLARC 3.1	2.79E-01	CLARC 3.1	9.14E+01
7439-92-1	lead		2.50E+02			1.50E+01	1.50E+01	MCL	1.00E+04	CLARC 3.1	0.00E+00	CLARC 3.1	3.00E+03
7439-97-6	mercury		2.40E+01		4.80E+00	2.00E+00	2.00E+00	MCL	5.20E+01	CLARC 3.1	4.70E-01	CLARC 3.1	2.09E+00
7440-02-0	nickel, soluble salts[c]		1.60E+03		3.20E+02	1.00E+02	1.00E+02	MCL (WAC)	6.50E+01	CLARC 3.1	0.00E+00	CLARC 3.1	1.30E+02
7440-22-4	silver[c]		4.00E+02		8.00E+01	1.00E+02	8.00E+01	MTCA B	8.30E+00	CLARC 3.1	0.00E+00	CLARC 3.1	1.36E+01

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number [a].

		Soil Direct Contact		Groundwater Cleanup Levels			Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ug/L	Drinking Water MCL[b] ug/L	ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
7440-28-0	thallium, soluble salts		5.60E+00		1.12E+00	2.00E+00	1.12E+00	MTCA B	7.10E+01	CLARC 3.1	0.00E+00	CLARC 3.1	1.59E+00
7440-38-2	arsenic, inorganic	6.67E-01	2.40E+01	5.83E-02	4.80E+00	5.00E+00	5.83E-02	MTCA B	2.90E+01	CLARC 3.1	0.00E+00	CLARC 3.1	3.40E-02
7440-39-3	barium		5.60E+03		1.12E+03	2.00E+03	1.12E+03	MTCA B	4.10E+01	CLARC 3.1	0.00E+00	CLARC 3.1	9.23E+02
7440-41-7	beryllium		1.60E+02		3.20E+01	4.00E+00	4.00E+00	MCL	7.90E+02	CLARC 3.1	0.00E+00	CLARC 3.1	6.32E+01
7440-47-3	chromium (total)					1.00E+02	1.00E+02	MCL	1.00E+03	CLARC 3.1	0.00E+00	CLARC 3.1	2.00E+03
7440-62-2	vanadium		5.60E+02		1.12E+02		1.12E+02	MTCA B	1.00E+03	CLARC 3.1	0.00E+00	CLARC 3.1	2.24E+03
7782-49-2	selenium and compounds		4.00E+02		8.00E+01	5.00E+01	5.00E+01	MCL	5.00E+00	CLARC 3.1	0.00E+00	CLARC 3.1	5.20E+00
8001-35-2	toxaphene	9.09E-01		7.95E-02		5.00E+00	7.95E-02	MTCA B	9.58E+01	CLARC 3.1	2.46E-04	CLARC 3.1	1.53E-01
16065-83-1	chromium (III)		1.20E+05		2.40E+04		2.40E+04	MTCA B	1.00E+03	CLARC 3.1	0.00E+00	CLARC 3.1	2.00E+03
16984-48-8	fluoride					4.00E+03	4.00E+03	MCL	0.00E+00	Default	0.00E+00	Default	1.60E+01
18540-29-9	chromium(VI)		2.40E+02		4.80E+01		4.80E+01	MTCA B	1.90E+01	CLARC 3.1	0.00E+00	CLARC 3.1	1.84E+01

Notes:

GW – Ground Water

CAS – Chemical Abstract Service

(a) The lowest value of columns 3 and 4 (Soil Direct Contact) and column 14 (Soil Conc. for GW Protection mg/kg) is used in Tables 4-8 through 4-11.

(b) MCL is the drinking water maximum contaminant level from 40 CFR 141, "National Primary Drinking Water Regulations"

(c) MCL for nickel, soluble salts, from WAC-173-201A "Water Quality Standards for Surface Waters of the State of Washington

APPENDIX B
HANFORD TANK FARM VADOSE ZONE CHARACTERIZATION QUALITY ASSURANCE REQUIREMENTS

B1.0 HANFORD TANK FARM VADOSE ZONE CHARACTERIZATION QUALITY ASSURANCE REQUIREMENTS (FROM RPP-34161)

General QA Controls	
Organization and Responsibility[1]	**2-1.** Management shall have documented policies that address and direct implementation of safety and quality standards. These policies shall address and assign such responsibilities as stop work authority and organizational independence for those persons assigned to safety and quality oversight. Each organization's QA plan and/or documentation shall define its policy regarding, and its commitment to, ethical standards, client confidentiality, and quality control. **2-1a.** "The organization's QA Plan shall describe or reference how periodic preventive and corrective maintenance of measurement or test equipment shall be performed to assure available and satisfactory performance of the systems.
Personnel Qualifications and Training[1]	**2-2.** Each organization shall have a documented training program which details the processes for identifying statutory, regulatory, or professional certifications which may be required to perform certain operations. In addition, the training program described in the QA Plan shall describe the processes for identifying, designing, performing, and documenting technical, quality, and project management training, as applicable.
Implementing Documents of QAPP	**2-3.** Field and Laboratory activities shall be directed and controlled by internally approved procedures/documents. .Adequate quality control shall be included to ensure that the precision, accuracy, sensitivity, and associated limitations of the methodology are well understood upon completion of the work. **2-3a.** EPA, DOE, and consensus methods (e.g., American Society for Testing Materials [ATSM] standards methods), such as those listed in Appendix B of Volume 4, shall be used where the technique is applicable to the sample matrix and the overall objective of the analysis. **2-3b.** Otherwise, a method based on proven technology and agreed upon between the laboratory and the client before the start of work shall be used. **2-3c.** Methods used for the first time, or modified, shall be qualified before routine use. Technical Procedures shall include or reference the acceptance and performance criteria for precision, accuracy, calibration, and detection limit (as appropriate) established during the qualification experiments. For subcontractors, the documentation shall be made available to the Vadose Zone Program.
Assessments, Corrective Actions and Improvements[1]	**2-4.** Each organization shall establish and implement a system to identify, document, correct, and prevent quality problems, and this system shall be subject to on-going documented review by management to assess its effectiveness. **2-4a.** Each organization shall establish and implement a formal mechanism for reporting to management the status of the QA program.
Documents and Quality records[1]	**2-5.** Each organization shall develop and implement a system for timely preparation, review, approval, issuance, use, control, revision, and maintenance of documents that prescribe work processes and specify requirements. Additionally, each organization shall establish and implement processes for identifying, preparing, approving, transmitting, correcting, distributing, retaining, retrieving, and disposal of quality records. This documentation shall form part of the Project File.

Data Reporting[1]	**2-6.** Each organization shall establish and implement document control that includes measures by which documentation can be controlled, tracked, and updated in a timely manner to ensure applicability and correctness are established.
Software Quality Assurance Systems[1, 2]	**2-7.** Each organization shall develop, document, and implement software control requirements applicable to both commercial and laboratory developed software. In addition, procedures for software control shall address the security systems for the protection of the software.
Procurement[1]	**2-8.** Each organization shall establish and implement a process to control purchased items and services; this process shall be subject to ongoing review by management to asses its effectiveness.
Changes and Deviations from Approved Plans[1, 3]	**2-9.** Each organization shall establish and implement a process to recognize deviations from approved actions and to control changes resulting from such deviations or from improved methods or different requirements. This process shall include requirements for reporting such events and corrective efforts to the Program. **2-9a.** Modifications that change the character of a regulatory-required action or omit a regulatory required action shall need the concurrence of the appropriate regulatory body. Alterations to the required regulatory methods shall be specially reported to the Program by providing a synopsis or direct quotation of the regulatory method requirement and a description of all changes made, the reason(s) why the requirement cannot be met and/or the technical health and safety, environmental, and/or waste management merits of the modification(s) shall be provided. The Program shall interface with the regulatory bodies. **2-9b.** Deviations that do not adversely impact the ability to meet the objectives or additional efforts shall be documented in the final formal report. When deviations are used routinely in a procedure, the procedure shall be incorporated into the procedure. **2-9c.** Substitutions that make adjustments which a reasonable, technically competent person would be expected to consider equivalent to the original shall be communicated to the client in writing.
Planning	
Integration Requirements[4]	**3-1.** The Vadose Zone Program shall establish and implement a process to integrate and the support the integration of all vadose zone data collection and analyses efforts in the Hanford Central Plateau.
Safety[1]	**3-2.** Each organization shall establish and implement a process to create and maintain safe working environments.
Lead Contractor Planning[5]	**3-3.** Each vadose zone characterization activity shall be planned and the plan documented (see also Requirement 13). The level of planning and documentation shall be determined based on regulatory requirements and the size of the activity. Each organization leading a vadose zone characterization effort shall document as a quality assurance record the completion of each planning process and how it meets the requirements of this section. **3-3a.** For regulatory decision rule data, supplemental data obtained during decision rule data collection, or rapid-turn around decision rule data, a formal planning process that uses the principles of EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4) shall be implemented. The appropriate regulators and DOE staff shall be included. **3-3b.** For other data collection forming the core of a primary document of the Hanford Federal Facility Agreement and Consent Order (Ecology, 1998, HFFACO), a formal planning process that uses the principles of EPA QA/G-4 shall be implemented.

	The appropriate regulators and DOE staff shall be included. **3-3c.** For other data collection covering multiple activities (e.g., geophysical measurements, sampling, and/or laboratory analyses) or involving multiple Hanford Prime Contractors, a formal planning process shall be implemented. **3-3d** For all other data collection, a structured planning process consistent with the size and complexity of the tasks shall be implanted.
Sampling and Analysis Plans[6]	**3-4.** The planning results for each vadose zone characterization activity shall be documented. **3-4a.** For those planning efforts using a process based on EPA QA/G-4 and which result in the gathering of samples and their subsequent analysis, a Sampling and Analysis Plan shall be issued. **3-4b.** For other planning efforts, the documentation shall be under configuration control.
Data Verification[6]	**3-5.** Each vadose zone characterization activity shall prepare and maintain documentation that describes how data obtained meets the objectives and goals of the planning documents. The document shall also describe actions to be taken if the data fail to fulfill the objectives and goals (See Section 3.9).
Communication of Requirements	**3-6.** Requirements, including those determined through the planning process, shall be formally communicated to appropriate subcontractors. Records of such communications shall be kept as part of the Project File.
Subcontractor Planning[7]	**3-7.** Each subcontractor performing a vadose zone characterization activity shall plan how that activity shall be performed and that plan shall be documented.
Waste Disposal Plans[8]	**3-8.** For those vadose zone characterization tasks that produce radioactive or chemically hazardous waste, the organization producing such waste shall prepare a waste disposal plan.
Geophysical Measurements	
General[9]	**4-1.** For each type of geophysical measurement, a set of documentation (such as QAPD, quality plans, procedures, or desk instruction) shall be created and maintained that control • the calibration and maintenance of equipment and instruments, • the collection of data • data reduction and analysis, and • data reporting. Software quality assurance requirements (see Section 2.8) shall also be included, as appropriate.
Calibration and Maintenance of Equipment and Instruments[10]	**4-2.** For each type of equipment used in a geophysical measurement, documentation shall be created and maintained that controls the calibration and maintenance of equipment and instruments. **4-2a.** This documentation shall set the requirements for initial calibration, continuing calibration, and special calibrations due to maintenance or unforeseen activities. The documentation shall describe acceptable standards for calibration sources. **4-2b.** This documentation shall set the requirements for maintaining the equipment, including the period of routine maintenance and the triggers for any special maintenance.

Collection of Data/Facility Entrance & Exit[11]	**4-3.** In the set of documentation describing data collection, there shall be the requirement that all safety, security, and access controls of the facility or site being investigated shall be honored. In particular, how contaminated equipment will be processed/released shall be described.
Collection of Data/Procedures for Measurements	**4-4.** The set of documentation describing geophysical measurement data collection shall require the maintenance of site/field logbooks. These logbooks document the activities (e.g., field calibrations, surveys, sample collection, sample transferred, contamination/decontamination events). While site logbooks normally summarize data, field logbooks provide details. Entries shall be made or initiated on a real-time basis, with summaries completed at the close of each work day. Entries shall be reviewed, with documentation of the review indicated by signature of the reviewer and the date. **4-5.** In the set of documentation describing data collection shall be the required steps to perform the field data measurements in a way expected to meet the accuracy and uncertainty requirements of the overall task as documented in the planning documents for the vadose zone characterization activity. Requirements for reporting deviations of this documentation (see Section 3.9) during actual field collection shall be documented.
Data Reduction and Analysis[10]	**4-6.** Document(s) describing the method(s) of translating raw data into interpreted data shall be created and maintained. The documentation shall describe decision points and the bases for appropriate decisions (for example, how interpreted data fall into various classes: e.g., acceptable data, unacceptable data and how outliers are treated).
Data Reporting[10]	**4-7.** Document(s) describing how data will be reported shall be created and maintained. The contract with the generating organization shall specify how raw data is maintained (usually, raw data shall be maintained by the generating organization through the life of the contract). Interpreted data shall be documented in formal reports consistent with the requirements of the organization having overall lead in the particular vadose zone characterization. Whenever technically feasible, the interpreted data shall be transferred into the official Hanford Site electronic data base for environmental data. **4-7a.** The Vadose Zone Program shall approve all publicly released documentation (including the verbal presentation).
Vadose Zone Sampling	
General[12]	**5-1.** For each type of sampling activity, the appropriate field sampling organization shall establish and maintain a set of documentation (such as QAPD, quality plans, procedures, or desk instruction) that control • the calibration and maintenance of equipment and instruments, • the collection of samples • the chain of custody, • the transportation of samples, • data and process reporting, and • waste disposal. Software quality assurance requirements (see Section 2.8) shall also be included, as appropriate.

Calibration and Maintenance of Equipment[10]	**5-2.** For each type of equipment used in a vadose zone sampling, documentation shall be created and maintained that control the calibration and maintenance of equipment and instruments. **5-2a.** This documentation shall set the requirements for initial calibration, continuing calibration, and special calibrations due to maintenance or unforeseen activities. The documentation shall describe acceptable standards for calibration sources. **5-2b.** This documentation shall set the requirements for maintaining the equipment, including the period of routine maintenance and the triggers for any special maintenance. The requirements shall include the inspection of maintenance records.
Collection of Samples/Entrance & Exit13	**5-3.** In the set of documentation describing sample collection shall be the requirement that all safety, security, and access controls of the facility or site being investigated shall be honored. In particular, how contaminated equipment will be processed/released shall be described.
Collection of Samples/Procedures for Sampling	**5-4.** The Tank Farm Vadose Zone Program shall be responsible for assuring that all necessary permits (e.g., Notice of Construction from the Washington State Department of Health) and Site/Company approvals (e.g., radiation worker qualification) to perform the task have been granted **5-5.** The set of documentation describing sample collection shall require the maintenance of site/field logbooks. These logbooks document all field activities performed (e.g., field calibrations, surveys, sample collection, sample transfer, contamination/decontamination events). While site logbooks normally summarize data, field logbooks provide details. Entries shall be made or initiated on a real-time basis (with the signature of the person making the entry along with the data and time).. Entries shall be reviewed weekly, with documentation of the review indicated by signature of the reviewer and the date. **5-6.** The set of documentation describing sample collection shall include the necessary steps to perform the actual collection of samples in a way expected to meet the accuracy and uncertainty requirements of the overall task. Requirements for sample preservation (if necessary) shall be included. Requirements for reporting deviations of this documentation (see Section 2.9) during actual field collection shall be documented. Such requirements shall include reporting the deviation to the task lead. **5-7.** In the set of documentation describing sample collection shall be the requirement that each vadose zone sample be in its own container with labeling that clearly and legibly notes the position from which the sample was obtained (including orientation and length), when the sample was obtained, and who was the responsible person for obtaining the sample.
Generation of Control Samples	**5-8.** The field sampling organization shall establish and maintain documentation (including procedures) that sets requirements for the generation of control samples based on the requirements of the planning documentation (see Sections 3.4 and 3.5). This documentation shall be approved consistent with the organization's requirements. Requirements for the generation of control blanks shall also be approved by the Vadose Zone Program. Procedures and desk instructions shall be available to the Vadose Zone Program

Chain of Custody	**5-9.** The field sampling organization shall establish and maintain documentation (including procedures) that sets requirements for the interface and custody responsibilities for sample collection, temporary storage, custody transfer, and shipping to the initial laboratory. The documentation shall specify the minimum information required on the chain of custody form. This documentation shall be approved consistent with the organization's requirements. Procedures shall also be approved by the Vadose Zone Program. Desk instructions shall be available to the Vadose Zone Program **5-10.** Once the sample has been placed in its unique container and labeled, the chain of custody form for that sample shall be completed.
Storage and Transportation of Samples[14]	**5-11.** The field sampling organization shall establish and maintain documentation that sets requirements for the storage and transportation of the samples to the initial laboratory. These requirements must recognize any preservation requirements set in the planning documents (see Section 3.4 and 3.5).
Data and Process Reporting	**5-12.** The Vadose Zone Program shall issue all reports required by permits and/or Site/Company requirements (e.g. borehole summary reports). The Vadose Zone Program shall be responsible that the surface is restored, that unneeded boreholes are decommissioned, that all waste is disposed of, and that all contaminated equipment has been decontaminated (when practical).
Waste Disposal	**5-13.** For those vadose zone sampling tasks that produce radioactive or chemically hazardous waste, the organization producing such waste shall dispose of the waste in accordance with their waste disposal plan (see Section 3.9).
Laboratory	
Basic Concepts[15]	**7-1.** For each type of laboratory measurement, a set of documentation (such as QAPD, quality plans, procedures, or desk instructions) shall be created and maintained that control • the traceability of samples, • the selection of methods • the calibration and maintenance of equipment and instruments, • the selection of subsamples, • the preparation of data, • the collection of data, • data reduction and analysis, • waste disposal, and • data reporting Software quality assurance requirements (see Section 2.8) shall also be included, as appropriate. **7-1a.** The laboratory shall notify the client when situations, such as anomalies and nonconformance's occur. **7-1b.** Laboratories shall document and apply procedures for estimating uncertainty.

Chain of Custody[16]	**7-2.** Each laboratory shall establish and maintain documentation (including procedures) that set requirements for the interface and custody responsibilities for custody transfer, temporary storage, and shipping. The documentation shall specify the additional minimum information required on the chain of custody form used in internal operations. The documentation shall also specify the minimum information required on the chain of custody form on samples shipped out of the laboratory. **7-2a.** The laboratory shall have a procedure, or series of procedures which address sample receipt. **7-2b.** Each sample or subsample shall be given a unique identifier regardless of its resample status. Every sample, sample replicate, subsample, and sample extract shall be labeled in a manner that allows traceability to the parent sample number.
Selection of Methods[17]	**7-3.** In those cases where an analysis method has not been selected by the client, the laboratory shall document the possible options, the selected option, and the reasons why the selected option was chosen. The type of documentation (email to formal report) will be determined by the quality level (See Section 1.2.3) that the analysis supports. Such changes shall be formally documented in the final report documenting the analyses.
Equipment[10]	**7-4.** For each type of equipment used in a laboratory measurement, documentation shall be created and maintained that control the calibration and maintenance of equipment and instruments. **7-4a.** This documentation shall set the requirements for initial calibration, continuing calibration, and special calibrations due to maintenance or unforeseen activities. The documentation shall describe acceptable standards for calibration sources. **7-4b.** This documentation shall set the requirements for maintaining the equipment, including the period of routine maintenance and the triggers for any special maintenance. **7-4c.** For equipment maintained by a DOE User Facility (such as the Environmental and Molecular Science Center or the Advanced Photon Source), maintenance requirements will be set by the DOE User Facility.
Selection of Samples[18]	**7-5.** In those cases where the client has not determined which subsection of the sample will be analyzed, the laboratory shall document the possible options, the selected option, and the reasons why the selected option was chosen. The type of documentation (email to formal report) will be determined by the quality level (See Section 1.2.3) that the analysis supports. Such changes shall be formally documented in the final report documenting the analyses.
Preparation of Samples[19]	**7-6.** Each laboratory shall establish and maintain documentation (including procedures) that sets requirements for the preparation of samples for each analytical technique to be used. Such requirements shall reflect the accuracy and uncertainty requirements from the planning documents (See Section 3.4 and 3.5). Where required by such planning documents, control samples shall be specified.

Analysis of Samples	**7-7.** The set of documentation describing laboratory data collection shall require the maintenance of logbooks or controlled electronic media. This system need only to document the activities undertaken. Entries shall be made or initiated on a real-time basis, with summaries completed at the close of each work day. Entries shall be reviewed, with documentation of the review indicated by signature of the reviewer and **7-8.** In the set of documentation describing data collection shall be the required steps to perform the laboratory data measurements in a way expected to meet the accuracy and uncertainty requirements of the overall task as documented in the planning documents for the vadose zone characterization activity. Requirements for reporting deviations of this documentation (see Section 3.9) during actual data collection shall be documented.
Data Reduction and Analysis[10]	**7-9.** For laboratory tasks that reduce or analyze raw data, document(s) describing the method(s) of translating raw data into interpreted data shall be created and maintained. The documentation shall describe decision points and the bases for appropriate decisions (for example, how interpreted data fall into various classes: e.g., acceptable data, unacceptable data). The document shall describe how outliers are treated.
Data Reporting[10]	**7-10.** Document(s) describing how data will be reported shall be created and maintained. The contract with the generating organization shall specify how raw data is maintained (usually, raw data shall be maintained by the generating organization through the life of the contract). Interpreted data shall be documented in formal reports consistent with the requirements of the organization having overall lead in the particular vadose zone characterization. Whenever technically feasible, the interpreted data shall be transferred into the official Hanford Site electronic data base for environmental data. **7-10a.** The lead organization shall approve all documentation (including verbal presentations) prior to release to the public.
Waste Disposal	**7-11.** For those laboratory tasks that produce radioactive or chemically hazardous waste, the organization producing such waste shall dispose of the waste in accordance with the appropriate waste disposal plan (see Section 3.9).
Special Requirements – Aqueous Chemical Analysis[13]	**7-12.** For each type of analytical measurements, the laboratory shall establish and maintain documentation that mandates the maximum number of samples analyzed before control samples are analyzed. Control samples introduced in the field or in preparation steps are counted as part of the samples. The documentation shall mandate techniques to determine the trending of such controls and the levels at which corrective actions are to take place.

1 For all organizations, this documentation shall be approved consistent with that organization's requirements. For subcontractors, the documentation shall be made available to the Vadose Zone Program.

2 Software systems quality assurance at the Tank Farm Contractor is implemented through "Software Development, Implementation, and Management" (TFC-BSM-IRM-HS-C-01), "Acquired Software Implementation and Management" (TFC-BSM-IRM-HS-C-02), "Custom Software Development Implementation and Management" (TFC-BSM-IRM-HS-C-03), "Utility Calculation Software Implementation and Management" (TFC-BSM-IRM-HS-C-04), "Software Retirement and Data Preservation" (TFC-BSM-IRM-HS-C-05), and "Software Accountability" (TFC-BSM-IRM-HS-C-07) as well as **"Spreadsheet Development and Verification" (TFC-ENG-DESIGN-C-32).**

3 HASQARD (Sections 4.4 and 4.5 of Volume 1) recognizes three types of deviations for laboratory activities. These have been generalized for vadose zone characterization activities to

- Substitution: Adjustment in a plan or other document (e.g., procedure) which a reasonable, technically competent person would be expected to consider equivalent to the original. Two examples might be substitution of equivalent columns yielding equivalent performance characteristics or using different glassware in a laboratory that results in the same overall digestion, extraction, or separation efficiency.

- Deviation: Divergence from the original plan or other document (e.g., procedure) that does not adversely impact the ability to meet the objectives (especially the precision, accuracy, sensitivity, and selectivity specifications) of the original. Examples might be taking a sample at a slightly difference position than was prescribed, but still meets the requirements of the Sampling and Analysis Plan, and using an additional reaction resulting in analyte purification.
- Modification: Changes in a plan or other document (e.g., procedure) that changes the character of the original and thereby, potentially limits the ability to meet the original specifications. Examples might be to limit the number of lines in the analysis of high resolution resistivity and using different methods of purification.
- Omission: Deletions to a plan or other document (e.g. procedure) that results in a loss of data. Examples may be not gathering/analyzing samples because of safety or other issues.
- Addition: Supplements to a plan or other document (e.g. procedure) that provides additional data. Examples are analyses of additional samples that were unexpectedly obtained or the performance of additional tests to better understand required results.

4 This documentation shall be approved consistent with Tank Farm Contractor requirements.

5 The Vadose Zone Program shall document the completion of each planning process. This documentation shall be approved consistent with the Tank Farm Contractor's requirements.

6 This documentation shall be approved consistent with that organization's requirements.

7 This documentation shall be approved consistent with that organization's requirements. In addition, that document shall be approved by the Vadose Zone Program for the work before characterization tasks are begun.

8 This documentation shall be approved consistent with that organization's requirements. In addition, if a subcontractor prepare the plan, the waste disposal plan shall be approved by the Vadose Zone Program for the work before characterization tasks are begun.

9 This documentation shall be approved consistent with the organization's requirements. In addition, if a subcontractor prepares a QAPD or quality plan, those documents shall be approved by the Vadose Zone Program for the work before characterization tasks are begun. Procedures and desk instructions shall be made available to the Vadose Zone Program

10 This documentation shall be approved consistent with the organization's requirements. The documentation shall be made available to the Vadose Zone Program.

11 This documentation shall be approved consistent with the organization's requirements.

12 This documentation shall be approved consistent with the organization's requirements. In addition, if a subcontractor prepares a QAPD or quality plan, those documents shall be approved by the Vadose Zone Program for the work before characterization tasks are begun. Procedures and desk instructions shall be made available to the Vadose Zone Program

13 This documentation shall be approved consistent with the organization's requirements. <u>The documentation shall be approved by the Vadose Zone Program</u>.

14 This documentation shall be approved consistent with the organization's requirements. Procedures and desk instructions shall be available to the Vadose Zone Program

15 This documentation shall be approved consistent with the organization's requirements. <u>In addition, if a subcontractor prepares a QAPD or quality plan, those documents shall be approved by the lead organization for the work before characterization tasks are begun.</u>

16 This documentation shall be approved consistent with the organization's requirements. Procedures shall also be approved by the Vadose Zone Program. Desk instructions shall be made available to the Vadose Zone Program

17 The documentation on method selection shall be approved by the lead organization before the analysis process begins.

18 The documentation on method selection shall be approved by the Vadose Zone Program before the subselection process begins.

19 This documentation shall be approved consistent with the organization's requirements. Procedures shall also be approved by the Vadose Zone Program. Desk instructions shall be available to the lead organization.