0056169

ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 662650

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental ○ Direct Revision ● Change ECN ○ Temporary ○ Standby ○ Supersedure ○ Cancel/Void ○	D. Crumpler, Tank Farm Vadose Zone, HO-22, 372-9234 HFCH0871	○ Yes ● No	6/6/01
	6. Project Title/No./Work Order No.: Site-Specific SST RFI/CMS Work Plan Addendum for WMAs T and TX-TY	7. Bldg./Sys./Fac. No.: RPP Vadose Zone	8. Approval Designator: N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.): RPP-7578, Rev. 0	10. Related ECN No(s).: N/A	11. Related PO No.: N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Completed	12d. Restored to Original Condition (Temp. or Standby ECNs only)
○ Yes (fill out Blk. 12b) ● No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change — 13b. Design Baseline Document? ○ Yes ● No

Document revised based on review and resolution of comments from Washington State Department of Ecology.

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14a. Justification (mark one)	14b. Justification Details
Criteria Change ● Design Improvement ○ Environmental ○ Facility Deactivation ○ As-Found ○ Facilitate Const. ○ Const. Error/Omission ○ Design Error/Omission ○	Changes required to incorporate comments on Rev. 0 received from Washington State Department of Ecology.

15. Distribution (include name, MSIN, and no. of copies)

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17. Cost Impact

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Additional	( ) $	( ) $
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18. Schedule Impact (days): Improvement ( ) ____ Delay ( ) ____

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	☐	Seismic/Stress Analysis	☐	Tank Calibration Manual	☐
Functional Design Criteria	☐	Stress/Design Report	☐	Health Physics Procedure	☐
Operating Specification	☐	Interface Control Drawing	☐	Spares Multiple Unit Listing	☐
Criticality Specification	☐	Calibration Procedure	☐	Test Procedures/Specification	☐
Conceptual Design Report	☐	Installation Procedure	☐	Component Index	☐
Equipment Spec.	☐	Maintenance Procedure	☐	ASME Coded Item	☐
Const. Spec.	☐	Engineering Procedure	☐	Human Factor Consideration	☐
Procurement Spec.	☐	Operating Instruction	☐	Computer Software	☐
Vendor Information	☐	Operating Procedure	☐	Electric Circuit Schedule	☐
OM Manual	☐	Operational Safety Requirement	☐	ICRS Procedure	☐
FSAR/SAR	☐	IEFD Drawing	☐	Process Control Manual/Plan	☐
Safety Equipment List	☐	Cell Arrangement Drawing	☐	Process Flow Chart	☐
Radiation Work Permit	☐	Essential Material Specification	☐	Purchase Requisition	☐
Environmental Impact Statement	☐	Fac. Proc. Samp. Schedule	☐	Tickler File	☐
Environmental Report	☐	Inspection Plan	☐	____	☐
Environmental Permit	☐	Inventory Adjustment Request	☐	____	☐

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number/Revision
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng.	J.D. Crumpler [signature]	6/7/01	PE		
Cog. Mgr.	A.J. Knepp [signature]	6/7/01	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other			Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

SITE-SPECIFIC SST PHASE 1 RFI/CMS WORK PLAN ADDENDUM FOR WMAs T AND TX-TY

May 25, 2001

Prepared for
U.S. Department of Energy
Office of River Protection

Prepared by
CH2M HILL Hanford Group, Inc.

Chris Willingham — Release Approval

6/7/01 — Date

RPP-7578
Revision 1

Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs T and TX-TY

D. Crumpler
CH2M HILL Hanford Group, Inc.

Date Published:
June 2001

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

Approved for Public Release; Further Dissemination Unlimited

Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs T and TX-TY

J. Dwayne Crumpler
Jacobs Engineering Group, Inc
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

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Key Words: RFI/CMS, vadose zone characterization, single shell tanks, waste management area, T tank farm, TX-TY tank farm

Abstract: This site-specific work plan addendum for WMAs T and TX-TY addresses vadose zone characterization plans for collecting and analyzing sediment samples.

Chris Willingham 6/7/01
Release Approval Date

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RECORD OF REVISION

RECORD OF REVISION	(1) Document Number RPP-7578 Rev. 1	Page 1

(2) Title
SITE-SPECIFIC SST PHASE 1 RFI/CMS WORK PLAN ADDENDUM FOR WMAs T and TX-TY

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initially released 3/9/01 on EDT 628947	D. Crumpler	A.J. Knepp 3/9/01
1 RS	Complete revision with incorporation of Ecology Comments per ENC-662650	J.D. Crumpler	A.J. Knepp 6/6/01

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LIST OF TERMS

bgs	below ground surface
CMS	corrective measures study
CoC	contaminant of concern
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
H/PP?	Hanford formation(?)/Plio-Pleistocene unit(?) (interval)
ICM	interim corrective measure
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA facility investigation
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WMA	waste management area

1.0 INTRODUCTION

This Site-Specific Single-Shell Tank (SST) Phase 1 *Resource Conservation and Recovery Act of 1976* (RCRA) Facility Investigation/Corrective Measures Study (RFI/CMS) Work Plan Addendum for Waste Management Areas (WMAs) T and TX-TY has been prepared to outline the investigation efforts for collection of field characterization data in and near WMAs T and TX-TY to support RFI/CMS decision making. This WMAs T and TX-TY addendum is necessary to identify and plan characterization efforts as part of an RFI. An RFI is covered under the categorical exclusion for the *National Environmental Policy Act of 1976* and categorical exemption under the "Washington State Environmental Policy Act (SEPA)" (10 CFR 1021 Subpart D and WAC 197-11.

Documented in this WMAs T and TX-TY addendum are the agreements made through a data quality objective (DQO) process. These agreements include the tasks, project responsibilities, and schedule for the next characterization effort to fulfill proposed Milestone M-45-54 (Ecology et al. 1999) of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). The Consent Order is commonly referred to as the Tri-Party Agreement. The field characterization efforts include the collection of vadose zone data from installation and sampling of three vertical boreholes (south of tank TX-105 and south-southeast of tank TX-107) to the top of Ringold Unit E. An additional borehole may be conducted either at tank TX-105 or tank TX-104 based on the preliminary results of the other borehole sampling, if available funding and schedule constraints allow.

1.1 REGULATORY BACKGROUND

The Tri-Party Agreement, which is signed by the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency, and the U.S. Department of Energy (DOE), addresses cleanup at more than 2,000 waste disposal and unplanned release sites on the Hanford Site. Some of these sites are treatment, storage, and/or disposal units that included 149 SSTs regulated under the Washington State "Hazardous Waste Management Act" and its implementing requirements in "Dangerous Waste Regulations" (WAC 173-303).

The SSTs are treatment, storage, and/or disposal units operating under interim status pending closure that must be operated, permitted, and maintained in compliance with the following:

- RCRA
- Washington State dangerous waste program regulations (WAC 173-303)
- Tri-Party Agreement Milestones M-45-00 and M-24-00
- Proposed Tri-Party Agreement Milestones M-45-51 and M-45-54 (Ecology et al. 1999).

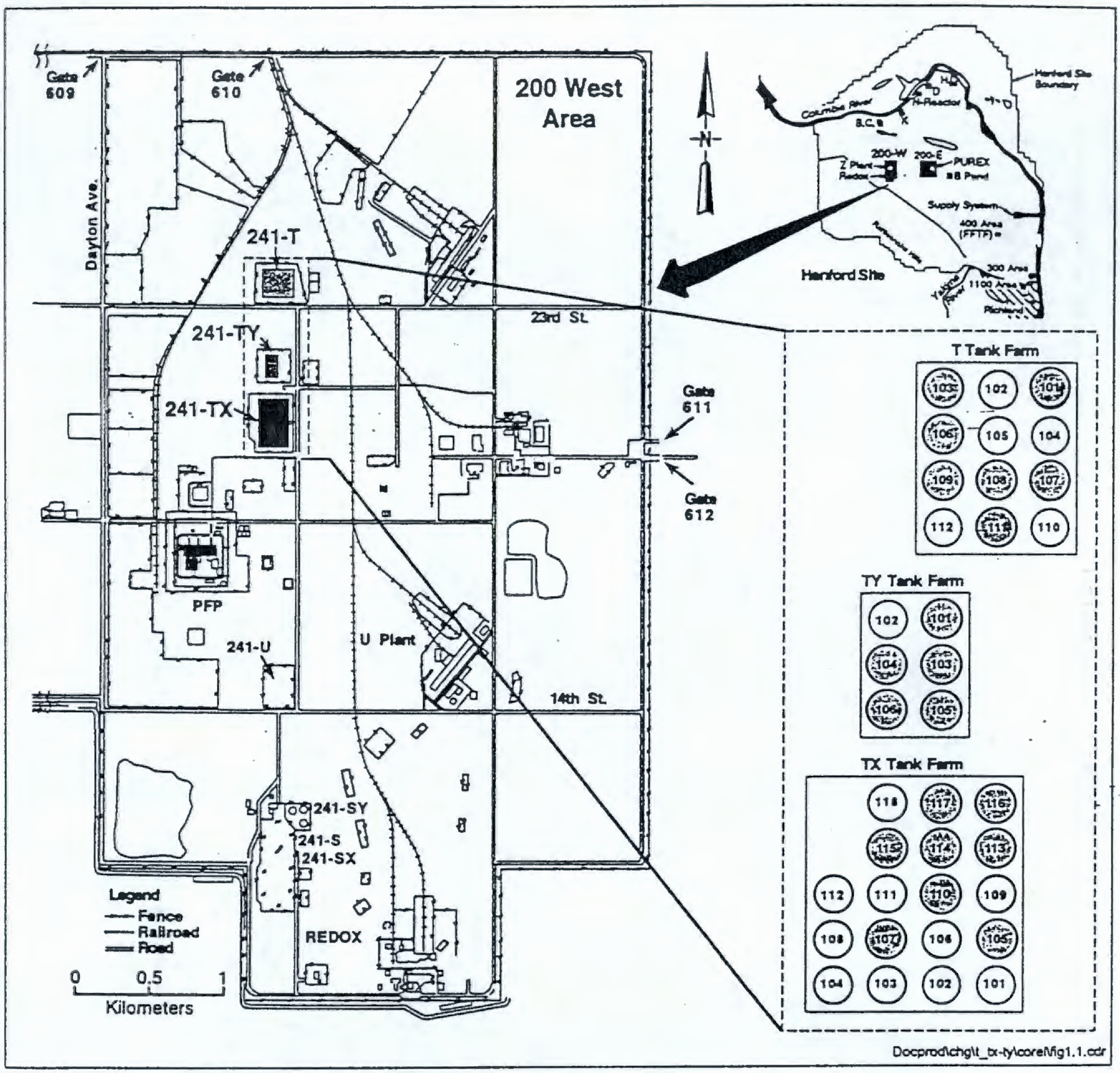
The tank farms will be closed under the Hazardous Waste Management Act and Major Milestone series M-45-00 of the Tri-Party Agreement. The 149 SSTs are grouped into 12 SST farms, which are in turn grouped into 7 WMAs for purposes of Hazardous Waste Management Act groundwater assessment and monitoring. To date, tank leaks and past-practice releases of tank waste including dangerous waste and dangerous waste constituents have resulted in groundwater contamination documented at five of the seven SST WMAs (i.e., WMA B-BX-BY, WMA S-SX, WMA U, WMA TX-TY, and WMA T). DOE has initiated a corrective action program to address the impacts of past and potential future tank waste releases to the environment. *Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas* (DOE/RL-99-36) has been issued and establishes the overall framework and requirements for the program. This addendum presents details specific to WMAs T and TX-TY.

The investigation activities outlined in this WMAs T and TX-TY addendum will be managed by the Tank Farm Vadose Zone Project as an integrated function of the Hanford Site Groundwater/Vadose Zone Integration Project. This WMAs T and TX-TY addendum is a Tri-Party Agreement primary document submitted to Ecology for review and approval pursuant to proposed Milestone M-45-54 (Ecology et al. 1999).

The T, TX, and TY tank farms comprise WMAs T and TX-TY, which were placed in assessment groundwater monitoring in 1993 because of elevated specific conductance in downgradient monitoring wells (WHC-SD-EN-AP-132). Figure 1.1 shows the location of the T, TX, and TY tank farms on the Hanford Site. Figure 1.2 shows the WMAs T and TX-TY and their associated surroundings. Technetium-99, chromium, iodine-129, tritium, fluoride, and nitrate are the only constituents to have exceeded drinking water standards (EPA-822-B-96-002) in WMAs T and TX-TY. The drinking water exceedances in the RCRA-compliant monitoring wells are currently limited to three wells (299-W10-24, 299-W11-23, and 299-W11-27) located along the northeast side of T tank farm and five wells (299-W14-12, 299-W14-13, 299-W14-2, 299-W15-4, 299-W15-22) located along the east and south of TX tank farm (PNNL-13404) (see Section 3.1.4).

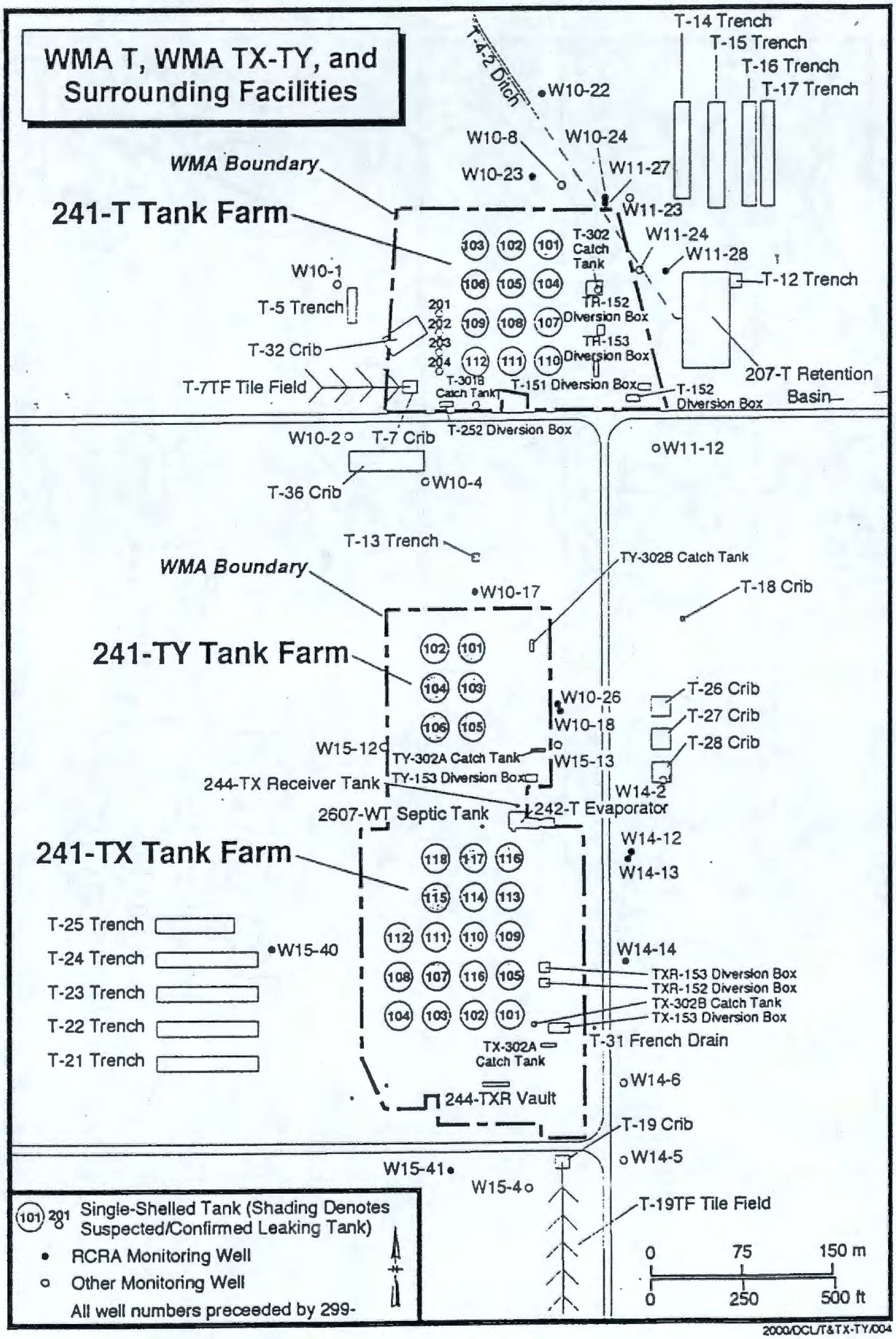
In fiscal year 1996, spectral gamma logging (i.e., collection of baseline gamma-specific radioisotope information in the upper vadose zone) was completed at the TX tank farm. Spectral gamma logging was completed at the TY tank farm in fiscal year 1996, and at the T tank farm in fiscal year 1999. The spectral gamma logging program builds on a previous program in which gross gamma data were collected as a secondary means of leak detection from the SSTs. Both programs used the network of drywells installed around each tank in each SST farm. The September 1997 final report on spectral gamma logging at the TX tank farm, *Vadose Zone Characterization Project at the Hanford Tank Farms: TX Tank Farm Report* (GJO-HAN-11), indicates that gamma-emitting contaminants cesium-137, cobalt-60, uranium-235, uranium-238, antimony-125, europium-152 and europium-154 were detected in the TX tank farm with cesium-137 being present at a maximum depth of 30.5 m (100 ft) below ground surface (bgs) (total depth of borehole) near tank TX-107. In addition, uranium-238 indicated horizontal movement of greater than 30.5 m (100 ft) associated with tanks TX-105 (boreholes 51-05-01, 51-05-03, 51-05-05, and 51-05-07) and TX-104 (boreholes 51-04-05, 51-04-06, and 51-00-07) (RPP-7123). Several other high cesium-137 concentrations were detected in the boreholes; however, these concentrations were associated with near-surface contamination resulting from surface spills, pipe leaks, or the proximity of the boreholes to pipes containing contamination. The January 1998 final report on spectral gamma logging at the TY tank farm, *Vadose Zone Characterization Project at the Hanford Tank Farms: TY Tank Farm Report* (GJO-HAN-16), indicates that gamma-emitting contaminants cesium-137, and cobalt-60 were detected throughout the 30.5 m (100 ft) depths of several of the boreholes in the southern portion of the tank farm.

Figure 1.1. Locations of WMA T and WMA TX-TY in the 200 West Area



Note: Shaded tanks are assumed or confirmed leaking tanks.

Figure 1.2. WMAs T and TX-TY and Surrounding Facilities



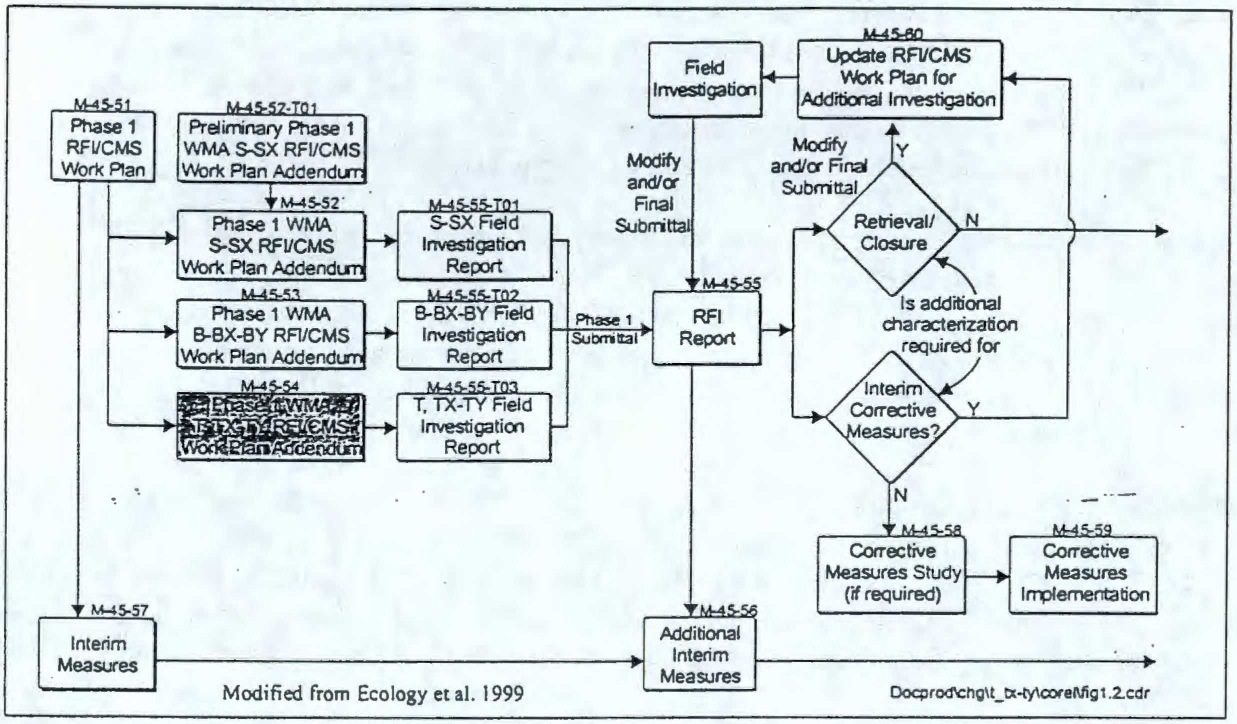
The September 1999 final report on spectral gamma logging at the T tank farm, *Vadose Zone Characterization Project at the Hanford Tank Farms: T Tank Farm Report* (GJO-HAN-27), indicates that gamma-emitting contaminants cesium-137, cobalt-60, and europium-154 were detected in the boreholes. The network of drywells installed around each tank was intended for leak detection and was generally installed between depths of 22.8 m and 45.7 m (75 to 150 ft) bgs, thus the maximum detection depth is limited by the drywell depth.

A groundwater assessment monitoring report that focuses on contaminants in the underlying unconfined aquifer, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas T and TX-TY at the Hanford Site* (PNNL-11809), has been completed. The findings indicate that WMA T is a source of groundwater contamination with a high degree of certainty. Based on the lack of direct evidence for a source upgradient to WMA TX-TY, it must be assumed that WMA TX-TY is the source of groundwater contamination.

Based on the results of the groundwater assessment, on July 10, 1998 Ecology requested that DOE develop and submit a corrective action plan for WMAs with documented leaks (i.e., S-SX, B-BX-BY, T, and TX-TY). Pursuant to the proposed Tri-Party Agreement Milestone M-45-54 (Ecology et al. 1999) and DOE/RL-99-36, the RCRA Corrective Action process is used to establish the framework within which vadose zone investigations are planned and carried out at WMAs T and TX-TY.

The initial sequence of investigations included initiation of characterization efforts in fiscal year 1999 in WMA S-SX as prescribed in *Preliminary Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA S-SX* (HNF-4380) and characterization of the remainder of WMA S-SX as prescribed in *Site-Specific SST Phase 1 RFI-CMS Work Plan Addendum for WMA S-SX* (HNF-5085) followed by characterization of WMA B-BX-BY as prescribed in *Site-Specific SST Phase 1 RCI/CMS Work Plan Addendum for WMA B-BX-BY* (RPP-6072). This addendum prescribes characterization of WMAs T, and TX-TY. Figure 1.3 shows the logical connections between these documents that become part of the RCRA corrective actions characterization process. All of these characterization efforts will be based on DOE/RL-99-36 and site-specific SST Phase 1 RFI/CMS work plan addenda for all four WMAs (proposed Milestones M-45-52, M-45-53, and M-45-54). Figure 1.3 shows how these milestones are addressed in the corrective action program.

Figure 1.3. RCRA Corrective Actions Characterization Activities and Documents



1.2 PURPOSE AND OBJECTIVE

DOE/RL-99-36 establishes the objectives of the characterization effort for the WMAs that are a part of the RCRA corrective action process. The objectives of the investigative efforts identified in this WMAs T and TX-TY addendum are as follows:

- Collect data to support an improved understanding of the nature and extent of contaminants in the vadose zone from surface to 45.7 m (150 ft) bgs or maximum depth of contamination, whichever is deeper unless refusal is encountered
- Collect data to support an improved understanding of vadose zone parameters affecting contaminant fate and transport required to perform risk assessments
- Provide WMA-specific information on source, nature, and extent of contamination for the planned activities listed in Section 1.3
- Provide WMA-specific characterization programs to address information gaps identified through a DQO process
- Support the Phase 1 RFI/CMS work plan objectives.

The DQO process was conducted from November 2000 through January 2001 (RPP-7455). The DQO process included participation by Ecology and DOE, the Hanford Site Vadose Zone/Groundwater Integration Project, stakeholders, Tribal Nations, Oregon Department of

Energy, and Hanford Site contractors. Meetings held as part of the DQO process involved varying levels of involvement by all participants.

The DQO process resulted in identification of activities (RPP-7455) to collect vadose zone data to support the objectives outlined in Section 1.3 and in this section. The process included meetings to complete a review of existing data, define the problem, identify and prioritize decisions, identify the input required to make decisions, and boundaries for the decisions. The meetings also addressed decision rules and uncertainty and sampling and analysis alternatives. The focus of the DQO process for the WMAs T and TX-TY addendum was on sampling and analysis alternatives. These alternatives and the decisions made by DOE based on the alternatives are documented in Section 4.0 and *Data Quality Objectives Report for Waste Management Areas T and TX-TY* (RPP-7455). Ecology reviewed RPP-7455 and provided comments and suggestions.

1.3 SCOPE OF ACTIVITIES

The characterization effort at WMAs T and TX-TY identified in this addendum will address installation of three new boreholes. Three locations for vertical boreholes were identified with the DQO process (RPP-7455). Based on Ecology comments on RPP-7455, another borehole to investigate the T-106 tank leak was ill advised considering the number of tanks for which no information was known and considering budgetary limitations. Therefore, the Tank Farm Vadose Zone Project and ORP propose three boreholes to be installed at two of these candidate sites, which are near tanks TX-105 and TX-107. An additional borehole may be conducted either near tanks TX-105 or TX-107 and TX-104, providing funding is available and their installation is consistent with other schedule priorities.

These activities support the following objectives:

- Development of a best-estimate of the concentration and distribution of contaminants of concern (CoCs) in WMAs T and TX-TY through soil sampling and analysis from three boreholes that represent known releases to the environment
- Refinement of a conceptual model for concentration, distribution, and mobility of contaminants in WMAs T and TX-TY
- Quantification of the risks posed by migration of past tank waste releases to the groundwater if no interim corrective measures (ICMs) are implemented
- Determination of whether interim measures or ICMs would effectively contribute to the mitigation of contaminant migration to groundwater to levels that would not pose unacceptable risk to human health and the environment before tank farm closure.

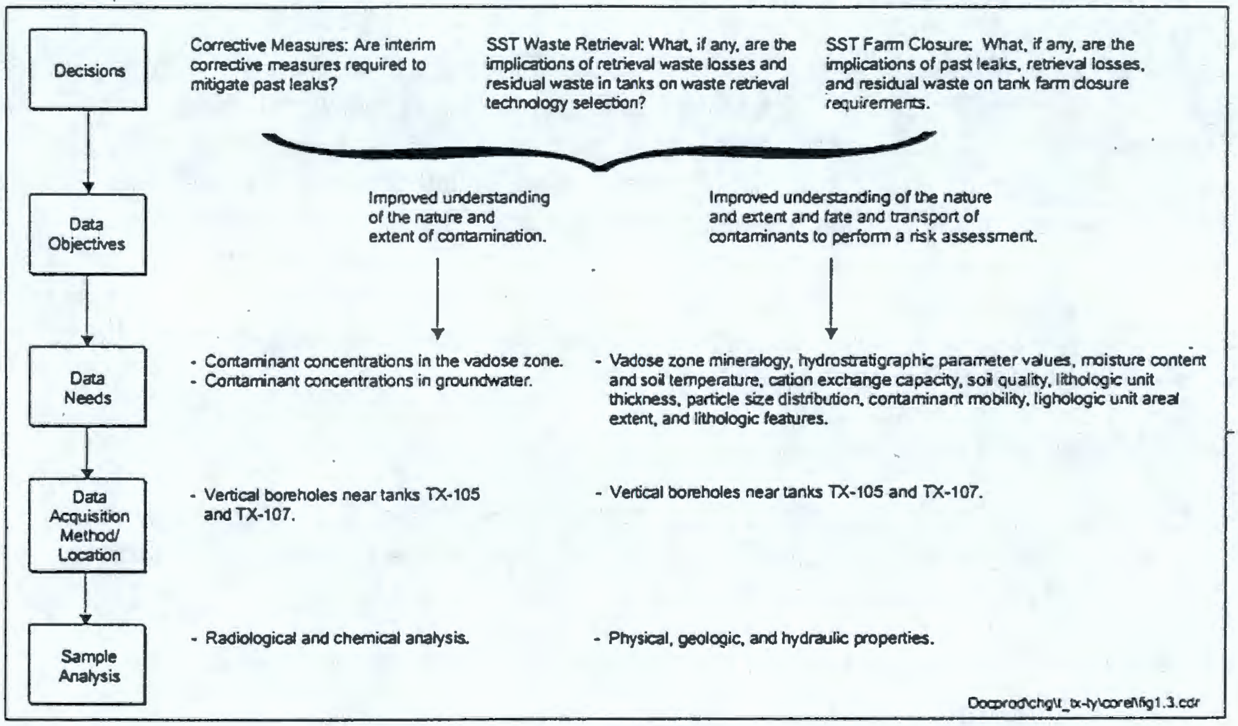
Risk assessments conducted in support of retrieval and closure decisions will be performed and will include the potential contribution or reduction in risk as a result of ICMs.

In addition to the characterization activities, a separate implementation plan is included as an appendix to DOE/RL-99-36. This implementation plan bridges the gap between the generalities in DOE/RL-99-36 and the specifics of this addendum. The implementation plan provides the approach to ensuring the availability of data required to complete the analyses and evaluations that would be included in the field investigation report for proposed target Milestone M-45-55-T03 as shown in Figure 1.3. Ecology approval of the implementation plan is not necessary before fieldwork begins.

1.4 SELECTION OF FIELD ACTIVITIES

Based on input from Ecology, DOE, and other DQO process participants, the characterization activities in support of the objectives and data needs for this addendum are illustrated in Figure 1.4. The DQO process resulted in a decision to characterize WMAs T and TX-TY with vertical boreholes as summarized in Figure 1.4.

Figure 1.4. Characterization Activities that Address DQO Process and Data Needs



Identification of locations for new exploratory boreholes – The DQO report (RPP-7455) resulted in the identification of several potential locations for the proposed new boreholes. A location south of tanks TX-105 and TX-107 was selected as the highest priority location based on spectral gamma data, groundwater quality data, and historical process knowledge. An additional candidate borehole will be installed depending on funding and schedule constraints either east of tank TX-105 and southwest of tanks TX-107 and TX-104. These locations are near past leak events either from the nearby tank or from a transfer line. The new boreholes will be installed using a similar drilling approach as previous investigations to reduce the likelihood of cross-contamination resulting from penetration through highly contaminated zones. Collection of sediment samples will be attempted from about 4.6 m (15 ft) bgs to just above the top of the Ringold Wooded Island member Unit E gravels approximately 45.7 m (150 ft) bgs or to maximum depth of contamination, whichever is deeper unless refusal is encountered at a maximum of 3-m (10-ft) intervals. Selected portions of the samples will be analyzed for chemical, radiological, and physical characteristics. A suite of geophysical surveys (i.e., spectral gamma, gross gamma, and neutron to total depth) will be performed. The boreholes will be decommissioned in accordance with "Minimum Standards for the Construction and Maintenance of Wells" (WAC 173-160). Previous investigations in this area have proven to be very costly, potentially dangerous due to the high levels of contamination that exist, and generally difficult because of subsurface conditions. Thus, as a result of these subsurface conditions no borehole will extend below 45.7 m (150 ft) bgs to ensure the drilling program stays on schedule. Three locations for vertical boreholes were identified in the DQO report (RPP-7455). Three boreholes will be installed at two of these candidate sites, which are near tanks TX-105 and TX-107. An additional borehole may be conducted either near tanks TX-105 or TX-107 and TX-104, providing funding is available and their installation is consistent with other schedule priorities. This work plan is written to accommodate the installation of one additional borehole pending adequate funding and schedule.

The rationale and approach to these decisions are addressed in Section 4.0 and RPP-7455. At this time, no vadose zone characterization is planned for the TY tank farm because of a lack of supporting data from process history knowledge and spectral gamma data; however, future vadose zone characterization planning activities will address the need for data from the TY tank farm. Although contamination zones exist in TY tank farm, the only large volume estimates are associated with tanks TY-105 and TY-106. Despite the large volume estimate associated with those tanks, no evidence supports the assumption of a potentially large contaminant inventory in the vadose zone. First, the contamination in the surrounding drywells consists of small zones of low-concentration cesium-137 and cobalt-60 in three drywells. Second, the historical record provides no corroborating information to justify the leak volume estimates. Finally, the inventory estimate for mobile radionuclides shows little total inventory from either leak (e.g., less than 1 Ci of technetium-99), even when the large leaks are assumed (RPP-7123). Therefore, leaked waste from these tanks would have been a rather dilute waste and no additional characterization efforts are recommended for these areas at this time. No vadose zone characterization is planned for the T tank farm because of the well characterized plume at tank T-106 and the lack of supporting data from process history knowledge and spectral gamma data and commingling of other plumes with tank T-106 plume.

1.5 ORGANIZATION OF THIS WMAS T AND TX-TY ADDENDUM

Nine sections and one appendix are included in this WMAs T and TX-TY addendum. The addendum is structured to provide information necessary to initiate the field investigations at WMAs T and TX-TY in fiscal year 2002. The sections and appendix are as follows:

- **Section 1.0** – Introduction to the WMAs T and TX-TY addendum that provides an overview of the issues and technical approach detailed in the remainder of the addendum
- **Section 2.0** – Overview of the physical and environmental setting of WMAs T and TX-TY

- **Section 3.0** – Summary of the available data on potential contaminant exposure pathways that will be used to develop a conceptual exposure pathway model for WMAs T and TX-TY needed to assess compliance with Federal and state environmental standards, requirements, criteria, or limitations that may be considered potential corrective action requirements and potential impacts to human health and the environment
- **Section 4.0** – Presentation of the rationale and approach for the field investigations
- **Section 5.0** – Presentation of the tasks and activities necessary to conduct field investigations
- **Section 6.0** – Presentation of the schedule for the site-specific investigations focused on vadose zone-related aspects of WMAs T and TX-TY in accordance with the tasks and activities discussed in Section 5.0
- **Section 7.0** – Description of the project management tasks necessary to implement the field investigation activities including responsibilities, organizational structure, and project tracking and reporting procedures; interfaces with tank farm operations activities and other DOE or contractor activities planned in or surrounding the tank farm addressed in this addendum
- **Section 8.0** – References used to develop this addendum
- **Section 9.0** – Glossary of terms that are used in this addendum
- **Appendix** – Sampling and Analysis Plan.

2.0 HISTORY AND SETTING

The history of operations in relationship to the tank farm layout and physical setting provides the background for the vadose zone and groundwater characterization investigation. Information and data relevant to the RFI/CMS investigations at the T, TX, and TY tank farm facilities were largely obtained from Historical Tank Content Estimate for the Northeast Quadrant of the Hanford Site 200 West Area (WHC-SD-WM-ER-351). This addendum updates and augments information from *Subsurface Conditions for T and TX-TY Waste Management Areas* (RPP-7123). Relevant details related to site history and physical settings are provided in Sections 2.1 and 2.2, respectively.

2.1 HISTORY

The SSTs in tank farms T, TX, and TY historically received high-level radioactive waste as well as hazardous or dangerous waste. They have been out of service since 1980, or earlier, but continue to store radioactive and dangerous waste. Waste in the SSTs consists of liquid, sludges, and salt cake (i.e., crystallized salts). Over the years, much of the liquid stored in the SSTs has been evaporated or pumped to double-shell tanks. The tank farm configurations, history of operations, leak detection systems, and interaction of WMAs T and TX-TY with surrounding facilities are discussed in the following subsections.

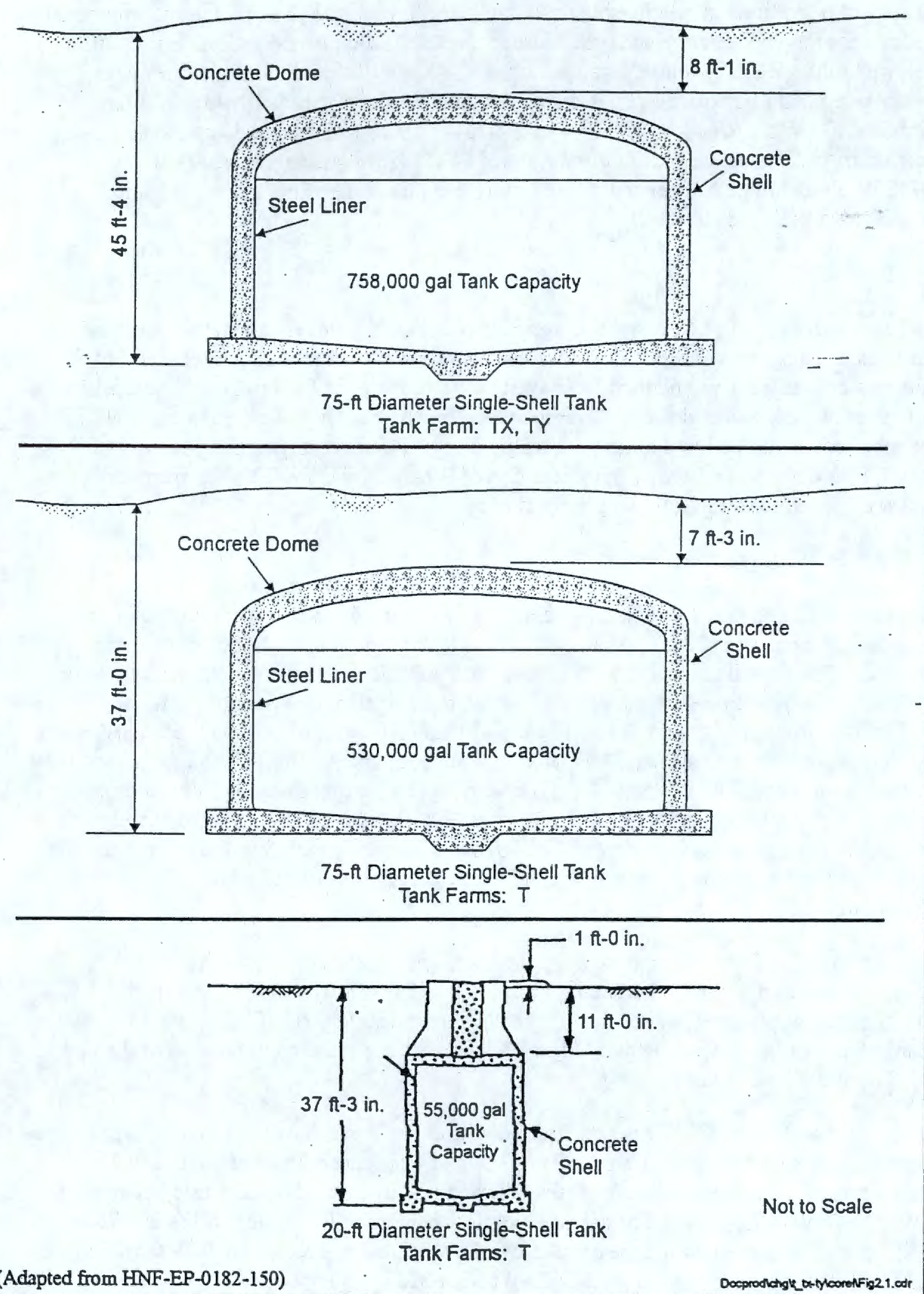
2.1.1 Tank Farm Layout

The SSTs in the T, TX, and TY tank farms are 23 m (75 ft) in diameter, except for 4 SSTs in T tank farm that are 6.1 m (20 ft) in diameter. The T tank farm contains 12 SSTs each with 2,006,050-L (535,000-gal) capacity, 4 SSTs each with 208,175-L (55,000-gal) capacity, waste transfer lines, leak detection systems, and tank ancillary equipment (see Sections 2.1.3 and 2.1.4). The TX tank farm contains 18 SSTs each with 2,869,030-L (758,000-gal) capacity, waste transfer lines, leak detection systems, and tank ancillary equipment. The TY tank farm contains 6 SSTs each with 2,869,030-L (758,000-gal) capacity, waste transfer lines, leak detection systems, and tank ancillary equipment. The 12 larger T tank farm SSTs are approximately 9.07-m (29.75-ft) tall from base to dome. The SSTs in TX and TY tank farms and the 4 smaller SSTs in T tank farm are approximately 11.4-m (37.25-ft) tall from base to dome (HNF-EP-0182-150).

The sediment cover from the apex of the tank domes to ground surface is 2.5 m (8.1 ft) at the TX and TY tank farms and 2.2 m (7.3 ft) at the T tank farm (HNF-EP-0182-150). The smaller SSTs in T tank farm are approximately 3.4 m (11 ft) below ground surface (HNF-EP-0182-150). All of the tanks have a dish-shaped bottom. Figure 2.1 shows the general configuration of the tanks in the T, TX, and TY tank farms.

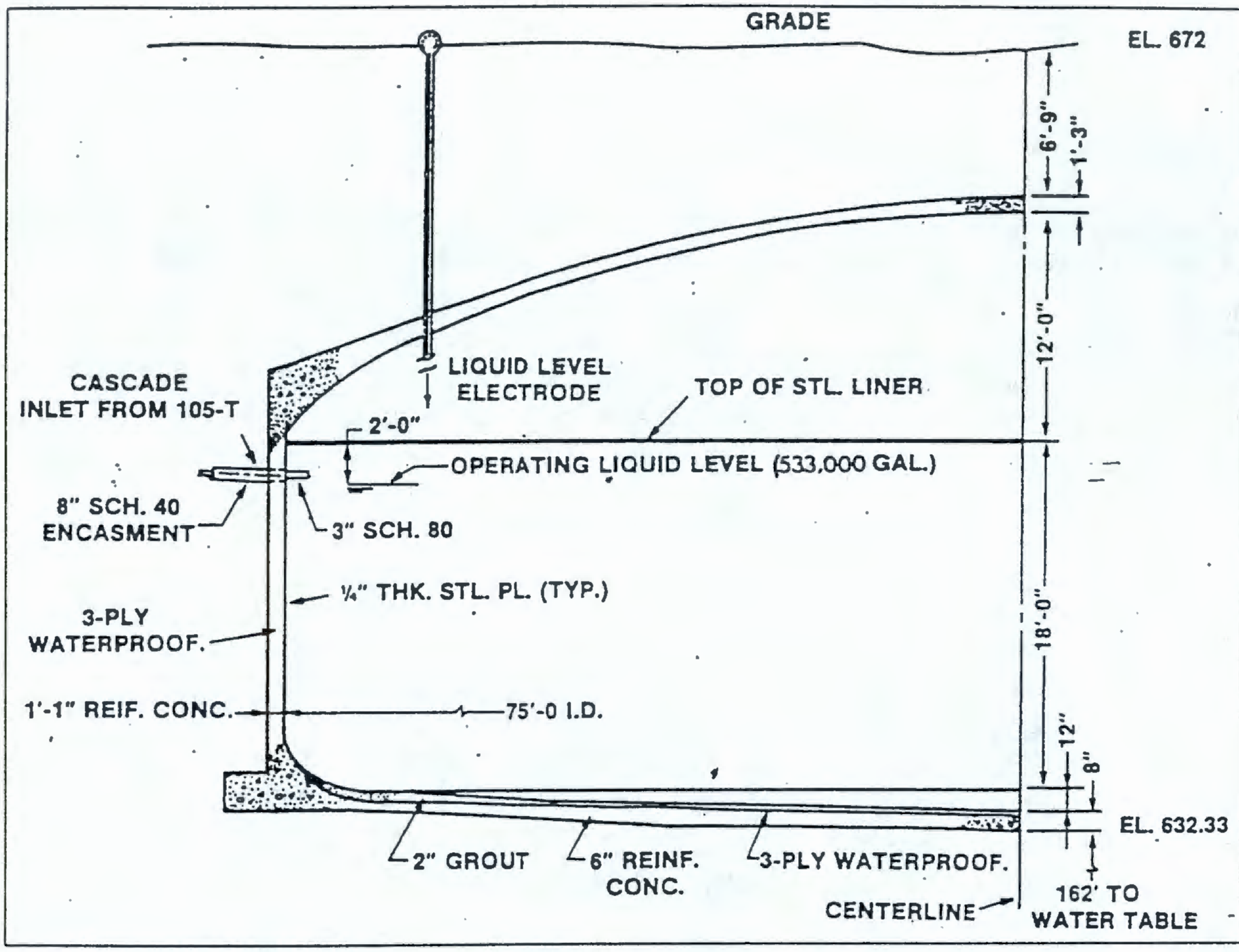
The 23-m- (75-ft-) diameter SSTs are constructed with cascade overflow lines in a 2-, 3-, or 4-tank series (3 sets of 2 tanks in TY tank farm, 3 sets of 4 tanks and 2 sets of 3 tanks in TX tank farm, and 4 sets of 3 tanks in T tank farm) that allowed gravity flow of liquid waste between the tanks (WHC-SD-WM-ER-351). The cascade overflow height for T tank farm SSTs is 4.78 m (15.67 ft) from tank bottom, while the cascade overflow height for TX and TY tank farm SSTs is 6.91 m (22.67 ft) from tank bottom (WHC-SD-WM-ER-351) (Figure 2.2).

Figure 2.1. General Configuration of Tanks in WMAs T and TX-TY



(Adapted from HNF-EP-0182-150)

Figure 2.2. Cross Section and Schematic for Tank 241-T-106 (RHO-ST-14)



2.1.2 History of Operations

The T tank farm was built from 1943 to 1944, the TX tank farm was built from 1947 to 1948, and the TY tank farm was constructed during 1952 (WHC-SD-WM-ER-351). From 1949 through 1952, T and TX tank farms and other cribs (notably crib 216-T-32) were constructed to handle the large volumes of generated waste. TY tank farm began operations in 1953 to support the reduction of tank waste volume. The T, TX, and TY tank farms received waste generated by a variety of major chemical processing operations.

In 1944, the T farm tanks began receiving bismuth phosphate wastes from T Plant. Because of limited tank space, intentional discharge of bismuth phosphate wastes to the soil column began in 216-T-32 crib and T-7 and T-5 trenches. The initial processing operation was bismuth phosphate plutonium extraction, which generated large amounts of waste requiring storage and, frequently, disposal.

From 1946 through 1952, the 216-T-32 crib was the primary discharge facility, receiving approximately 2.9×10^7 L (7.66×10^6 gal) of waste. To improve liquid reduction, the 242-T Evaporator was built in 1951 and began shipping condensate to T-19 crib and tile field.

Eventually, more disposal facilities became necessary to dispose of first-cycle waste, particularly with the advent of the uranium recovery program, which monopolized the resources of the evaporator in 1953. In 1954, first-cycle waste was intentionally discharged to the T trenches (northeast of WMA T) (2.9×10^6 L [7.66×10^5 gal]) via an overland pipe from tank T-106 and the TX farm trenches (west of TX tank farm) (5.0×10^6 L [1.32×10^6 gal]) via overland pipe from tank TX-110.

Substantial amounts of uranium were present in the T and TX farm tanks from the initial waste, produced by the bismuth phosphate process. This waste was called metal waste. The metal waste consisted of all the uranium from the bismuth phosphate process, approximately 90% of the original fission products activity, and approximately 1% of the original product from the process. The metal waste was brought just to the neutral point with 50% caustic and then treated with an excess of sodium carbonate as part of the bismuth phosphate process at the tank farms. The procedure yielded almost completely soluble waste at a minimum volume. The exact composition of the carbonate complex is unknown but was assumed to be a uranium phosphate-carbonate mixture.

A need arose for uranium, and the most readily available source was the metal waste in the tanks. Beginning in 1952, metal waste was sluiced from the tanks and sent to U Plant where uranium was extracted. Tributyl phosphate waste generated from the uranium removal process was returned to the tank farms. As part of the tributyl phosphate process, waste was processed through the 242-T Evaporator and condensate was discharged into the T-19 crib and tile field. A ferrocyanide treatment also was used to remove excess cesium-137 and strontium-90 from the liquid waste by precipitation beginning in October 1953. From this process, one batch of liquid waste 9.7×10^5 L (2.5×10^6 gal) was discharged to the T-18 test crib in December 1953.

T Plant was converted into a central decontamination facility in 1958 and the derived liquid waste was sent to tank T-112. Supernate liquid was discharged to cribs T-27 and T-28 beginning in 1960. Waste from the 340 Laboratory also was discharged to these facilities beginning in 1963. From 1960 through 1966, 4.9×10^7 L (1.3×10^7 gal) of waste were discharged to trenches T-27 and T-28 (east of TY tank farm) (RPP-7123).

The discovery or assumption of leaking tanks in the T, TX, and TY tank farms between 1959 and 1977 prompted a decision to put the tanks out of service and remove the remaining liquid from these tanks. The first efforts of liquid removal from the T, TX, and TY tank farms were the transfer of liquids to the 242-T Evaporator (RPP-7123), and tank TX-118 was the feed tank for this evaporator (WHC-SD-WM-ER-351). Some condensate from this source was discharged to the T-19 tile field (RPP-7123).

The salt well pumping program began in 1975 to accelerate removal of all excess liquid in the tanks as the first step in achieving interim stabilization. The salt well pumping performed on the T, TX, and TY farm tanks began in 1976.

All of the T, TX, and TY tanks were removed from service (i.e., no new additions of waste) in the late 1970s through 1980 (WHC-SD-WM-ER-351) and have been interim isolated or partially interim isolated. All T, TX, and TY tanks have been interim stabilized (HNF-EP-0182-150). Table 2.1 lists the volume of waste currently stored in the T, TX, and TY tanks. Previous evaluations have screened the universe of radiological and chemical constituents in the tanks and identified those constituents potentially associated with the SST system. The results of those screenings are provided in Section 3.0 of DOE/RL-99-36. DOE/RL-99-36 includes tables listing the radiological and chemical constituents that are contaminants of potential concern for the SST system. Those tables served as the starting point for defining contaminants of potential concern specific to WMAs T and TX-TY and are discussed in greater detail in Section 3.0 of this addendum and in RPP-7455.

2.1.3 Vadose Zone Leak Detection Systems

The T tank farm has 68 leak detection drywells available for leak detection monitoring. These drywells were drilled from 1944 to 1974. The depth ranges for these drywells are between 24.4 m (80 ft) and 45.7 m (150 ft) bgs, except for drywell 50-06-18, which is 54.8 m (180 ft) bgs. Gamma logging data from the drywells were used from 1944 through 1993 to ascertain the integrity of the associated tanks.

The TX tank farm has 96 leak detection drywells available for leak detection monitoring and provide access for limited vadose zone characterization (e.g., geophysical logging). These drywells were drilled from 1947 to 1977. The depth ranges for these drywells are between 22.9 m (75 ft) and 45.7 m (150 ft) bgs.

The TY tank farm has 70 leak detection wells available for leak detection monitoring and provide access for limited vadose zone characterization (e.g., geophysical logging). These drywells were drilled from 1951 to 1977. The depth ranges for these drywells are between 30.5 m (100 ft) and 45.7 m (150 ft) bgs.

2.1.4 Associated Facilities

Table 2.2 shows the facilities used during T, TX, and TY tank farm operations that are associated with WMAs T and TX-TY.

These associated facilities are located both inside and outside the WMAs T and TX-TY boundaries (Figure 2.3). Waste discharged to or stored at these facilities may have had an effect on the groundwater contamination at WMAs T and TX-TY.

A number of raw and potable water lines are also present in and around WMAs T and TX-TY (RPP-5002). Leaks from these lines could have contributed to tank waste migration in the vadose zone. Historical records about leaking water lines are incomplete.

Summaries of the operation, vadose zone contamination, and groundwater contamination history for each of these associated facilities are provided in *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination* (HNF-2603), *Historical Vadose Zone Contamination from T, TX, and TY Tank Farm Operations* (RPP-5957), and *Subsurface Conditions for T and TX-TY Waste Management Areas* (RPP-7123).

Figure 2.3. WMAs T and TX-TY and Surrounding Facilities

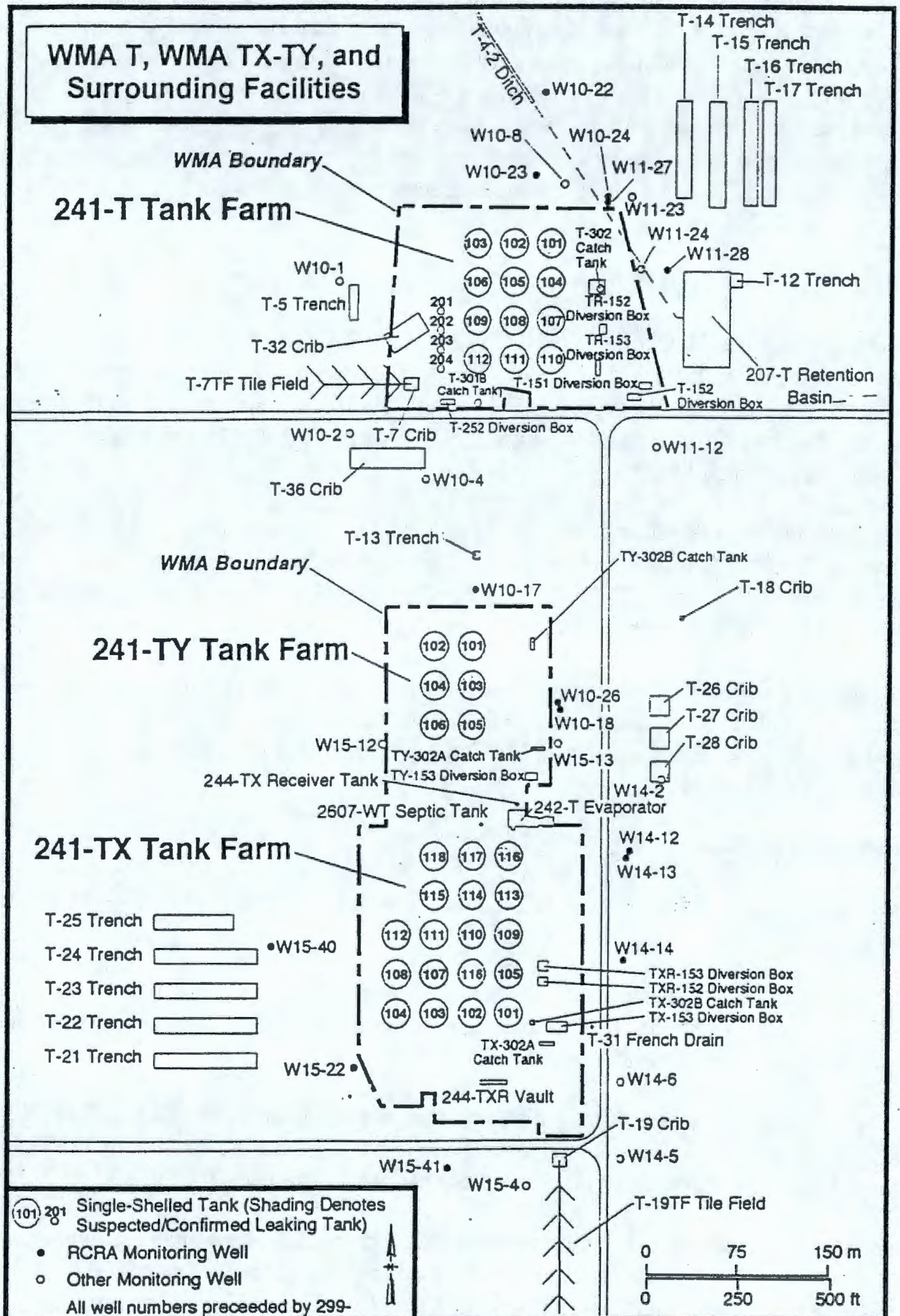


Table 2.1. Current Waste Volume in T, TX, and TY Farm Tanks (2 Sheets)

Tank	Total Waste Volume KL (Kgal)	Supernate KL (Kgal)	Salt Cake KL (Kgal)	Sludge KL (Kgal)
241-T-101	386 (102)	4 (1)	242 (64)	140 (37)
241-T-102	121 (32)	49 (13)	0 (0)	72 (19)
241-T-103	102 (27)	15 (4)	0 (0)	87 (23)
241-T-104	1,200 (317)	0 (0)	0 (0)	1200 (317)
241-T-105	371 (98)	0 (0)	0 (0)	371 (98)
241-T-106	80 (21)	8 (2)	0 (0)	72 (19)
241-T-107	655 (173)	0 (0)	0 (0)	655 (173)
241-T-108	167 (44)	0 (0)	87 (23)	80 (21)
241-T-109	220 (58)	0 (0)	220 (58)	0 (0)
241-T-110	1,397 (369)	4 (1)	0 (0)	1393 (368)
241-T-111	1,688 (446)	0 (0)	0 (0)	1688 (446)
241-T-112	254 (67)	27 (7)	0 (0)	227 (60)
241-T-201	110 (29)	4 (1)	0 (0)	106 (28)
241-T-202	80 (21)	0 (0)	0 (0)	80 (21)
241-T-203	132 (35)	0 (0)	0 (0)	132 (35)
241-T-204	144 (38)	0 (0)	0 (0)	144 (38)
241-TX-101	329 (87)	11 (3)	38 (10)	280 (74)
241-TX-102	821 (217)	0 (0)	821 (217)	0 (0)
241-TX-103	594 (157)	0 (0)	594 (157)	0 (0)
241-TX-104	246 (65)	19 (5)	140 (37)	87 (23)
241-TX-105	2,305 (609)	0 (0)	2305 (609)	0 (0)
241-TX-106	1,291 (341)	0 (0)	1291 (341)	0 (0)
241-TX-107	136 (36)	4 (1)	102 (27)	30 (8)
241-TX-108	507 (134)	0 (0)	484 (128)	23 (6)
241-TX-109	1,453 (384)	0 (0)	0 (0)	1453 (384)
241-TX-110	1,749 (462)	0 (0)	1609 (425)	140 (37)
241-TX-111	1,401 (370)	0 (0)	1238 (327)	163 (43)
241-TX-112	2,456 (649)	0 (0)	2456 (649)	0 (0)
241-TX-113	2,298 (607)	0 (0)	1605 (424)	693 (183)
241-TX-114	2,025 (535)	0 (0)	2010 (531)	15 (4)
241-TX-115	2,150 (568)	0 (0)	2150 (568)	0 (0)

Table 2.1. Current Waste Volume in T, TX, and TY Farm Tanks (2 Sheets)

Tank	Total Waste Volume KL (Kgal)	Supernate KL (Kgal)	Salt Cake KL (Kgal)	Sludge KL (Kgal)
241-TX-116	2,388 (631)	0 (0)	2131 (563)	257 (68)
241-TX-117	2,370 (626)	0 (0)	2260 (597)	110 (29)
241-TX-118	1,083 (286)	0 (0)	1003 (265)	80 (21)
241-TY-101	447 (118)	0 (0)	174 (46)	273 (72)
241-TY-102	242 (64)	0 (0)	242 (64)	0 (0)
241-TY-103	613 (162)	0 (0)	0 (0)	613 (162)
241-TY-104	163 (43)	0 (0)	0 (0)	163 (43)
241-TY-105	874 (231)	0 (0)	0 (0)	874 (231)
241-TY-106	80 (21)	0 (0)	0 (0)	80 (21)

Source: HNF-EP-0182-150.

Table 2.2. Treatment, Storage and/or Disposal Units and Associated Environmental Restoration Facilities at WMAs T and TX-TY (2 Sheets)

Facility	Description	TSD or ER facility	Operable Unit	WMA
241-TX Tank Farm (18 units)	Single-shell tanks	TSD	200-TP-5	TX-TY
241-TX-153	Diversion box	TSD	200-TP-5	TX-TY
241- TXR-152	Diversion box	TSD	200-TP-5	TX-TY
241-TXR-153	Diversion box	TSD	200-TP-5	TX-TY
241-TY-153	Diversion box	TSD	200-TP-5	TX-TY
242-T-151	Diversion box	TSD	200-TP-5	TX-TY
241-TX-302A	Catch Tank	TSD	200-TP-5	TX-TY
241-TX-302-XB	Catch Tank	TSD	200-TP-5	TX-TY
241-TY-302A	Catch Tank	TSD	200-TP-5	TX-TY
241-TY-302B	Catch Tank	TSD	200-TP-5	TX-TY
241-TXR	Vault	TSD	200-TP-5	TX-TY
244-TXR	Vault	TSD	200-TP-5	TX-TY
241-TY Tank Farm (6 units)	Single Shell Tanks	TSD	200-TP-5	TX-TY
2607-WT	Septic Tank	TSD	200-TP-5	TX-TY
2607-WTX	Septic Tank	TSD	200-TP-5	TX-TY
241-T Tank Farm (16 units)	Single Shell Tanks	TSD	200-TP-6	T
241-T-151	Diversion box	TSD	200-TP-6	T
241-T--152	Diversion box	TSD	200-TP-6	T
241-T-153	Diversion box	TSD	200-TP-6	T
241-T-252	Diversion box	TSD	200-TP-6	T
241-T-301	Catch Tank	TSD	200-TP-6	T
241-T -302	Catch Tank	TSD	200-TP-6	T
241- TR-152	Diversion box	TSD	200-TP-6	T
241-TR-153	Diversion box	TSD	200-TP-6	T
216-T-6	Crib	ER	200-TP-3	NA
216-T-7TF	Crib	ER	200-TP-1	NA
216-T -18	Crib	ER	200-TP-2	NA
216-T -19TF	Crib	ER	200-TP-2	NA
216-T -26	Crib	ER	200-TP-2	NA

Table 2.2. Treatment, Storage and/or Disposal Units and Associated Environmental Restoration Facilities at WMAs T and TX-TY (2 Sheets)

Facility	Description	TSD or ER facility	Operable Unit	WMA
216-T -27	Crib	ER	200-TP-2	NA
216-T -28	Crib	ER	200-TP-2	NA
216-T -32	Crib	ER	200-TP-1	NA
216-T -36	Crib	ER	200-TP-1	NA
207-T	Retention Basin	ER	200-TP-3	NA
2607-WT	Septic Tank	ER	200-TP-2	NA
216-T-5	Trench	ER	200-TP-1	NA
216-T -12	Trench	ER	200-TP-3	NA
216-T -13	Trench	ER	200-TP-2	NA
216-T -14	Trench	ER	200-TP-3	NA
216-T -15	Trench	ER	200-TP-3	NA
216-T -16	Trench	ER	200-TP-3	NA
216-T -17	Trench	ER	200-TP-3	NA
216-T-20	Trench	ER	200-TP-2	NA
216-T -21	Trench	ER	200-TP-1	NA
216-T -22	Trench	ER	200-TP-1	NA
216-T -23	Trench	ER	200-TP-1	NA
216-T -24	Trench	ER	200-TP-1	NA
216-T -25	Trench	ER	200-TP-1	NA
216-T-31	French drain	ER	200-TP-2	NA
216-T-4-1D	Ditch	ER	200-TP-3	NA
216-T-4-2	Ditch	ER	200-TP-3	NA
216-T-4A	Pond	ER	200-TP-3	NA
216-T-4B	Pond	ER	200-TP-3	NA

ER – environmental restoration.
NA – not applicable.
TSD – treatment, storage and/or disposal.
WMA – waste management area.

2.2 PHYSICAL SETTING

The following subsections summarize the topography, geology, hydrogeology, and surface water hydrology of WMAs T and TX-TY. More detail is provided in the geology and hydrogeology summaries because of their more direct relationship to the WMAs T and TX-TY field investigation. Because the meteorology, environmental resources, cultural resources, and human resources associated with WMAs T and TX-TY are the same as the 200 Areas at the Hanford Site, the reader is referred to Section 3.0 of DOE/RL-99-36 for related information. Sections 2.2.2 and 2.2.3 are taken directly from RPP-7123.

2.2.1 Topography

WMAs T and TX-TY lie within the west-central portion of the Hanford Site at an elevation between 200 and 210 m (660 and 690 ft) above mean sea level. The site lies in a low-relief area atop Cold Creek bar, a large compound flood bar formed during Pleistocene ice-age floods (Figure 2.4). WMAs T and TX-TY lie along the east flank of a north-south trending secondary cataclysmic flood channel that bisects Cold Creek Bar. The semi-arid climate, combined with the relatively young age and high permeability of the near-surface sediments, has resulted in no natural surface drainage channels being developed in the immediate vicinity of WMAs T and TX-TY. RPP-7123 provides more topographical information about WMAs T and TX-TY.

2.2.2 Geology

The T, TX, and TY tank farms were constructed in excavations into the near-surface sediments that overlie the Columbia River Basalt Group (i.e., bedrock) on the northern limb of the Cold Creek syncline. The stratigraphy beneath WMAs T and TX-TY is represented in Figure 2.5. Columbia River basalt forms the basement bedrock. Up to approximately 150 m (500 ft) of continental sediments overlie basalt in the Pasco Basin. From oldest to youngest, these deposits include the following:

- Several facies of the Miocene-to-Pliocene age, fluvial-lacustrine Ringold Formation
- Variably cemented and pedogenically altered deposits of the Plio-Pleistocene unit, which developed on the eroded and weathered surface of the Ringold Formation
- A relatively loose, fine-grained silty to sandy unit, designated the Hanford formation(?)/Plio-Pleistocene unit(?) (H/PP?) interval
- Deposits from Pleistocene-age cataclysmic floods (i.e., Hanford formation) that blanket the study area with mostly sand- and silt-dominated facies, capped by a sequence of gravel-dominated facies.

The vadose zone stratigraphy of the T, TX, and TY tank farms is discussed in RPP-7123.

Figure 2.4. Geomorphic Map

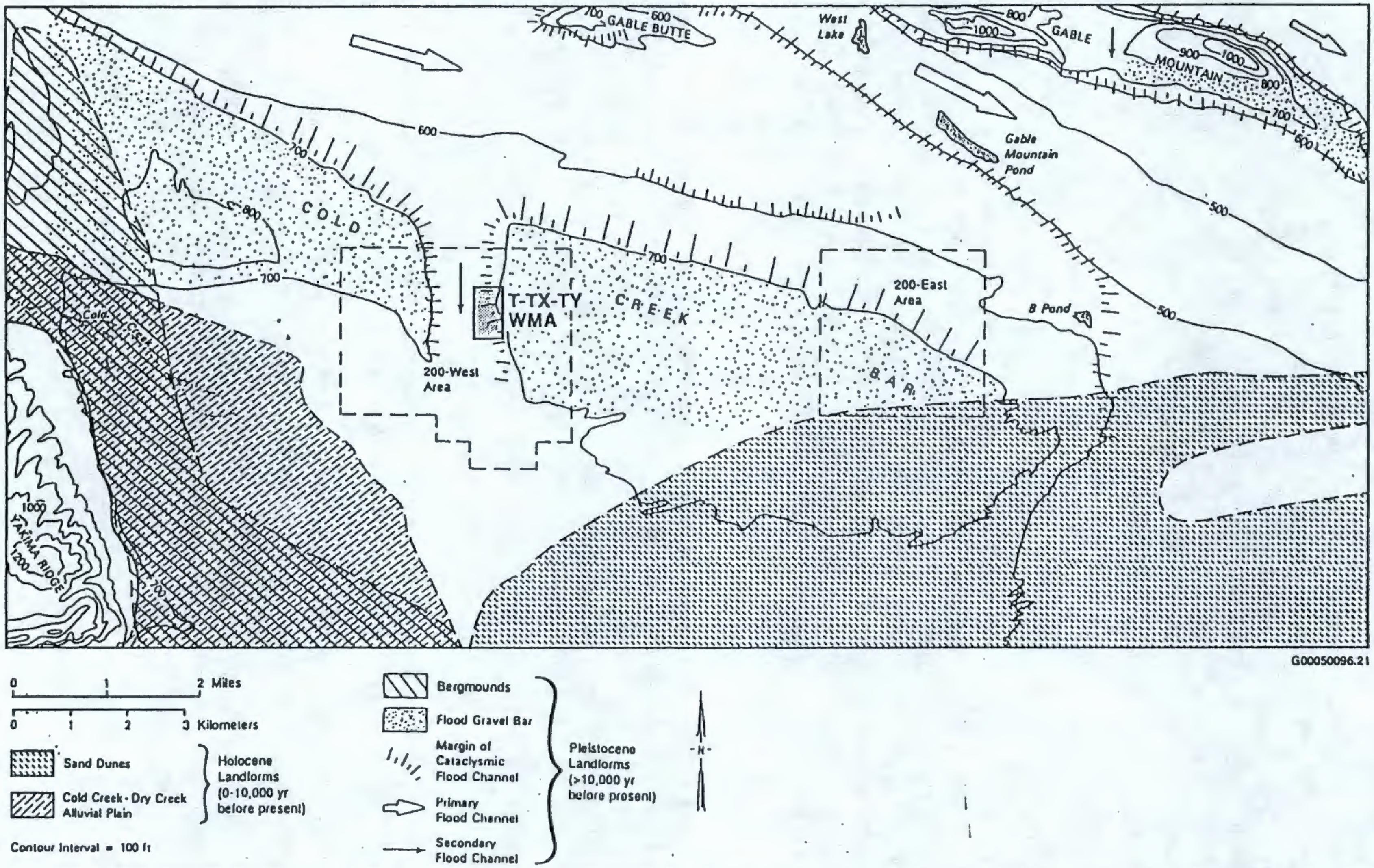
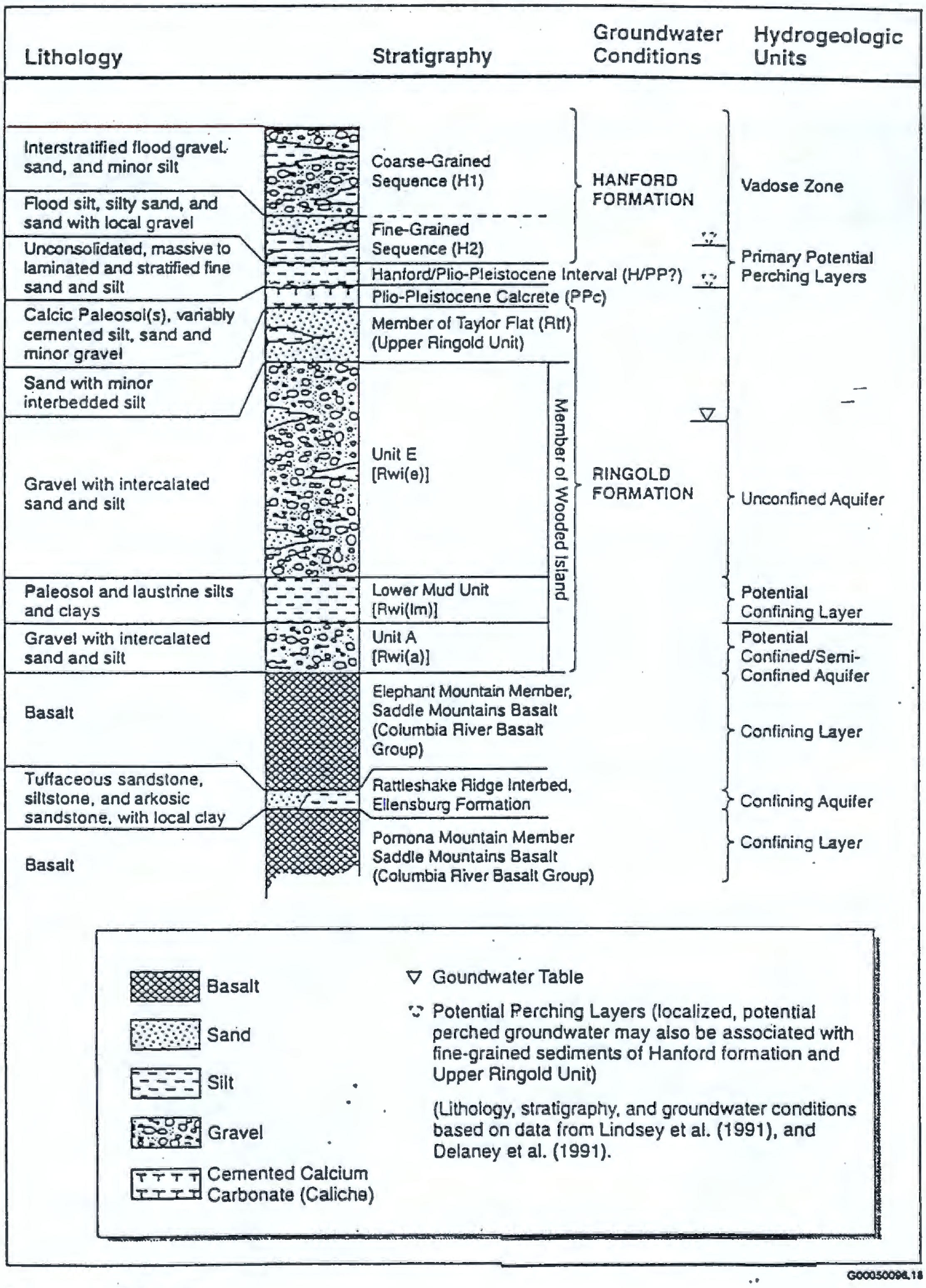


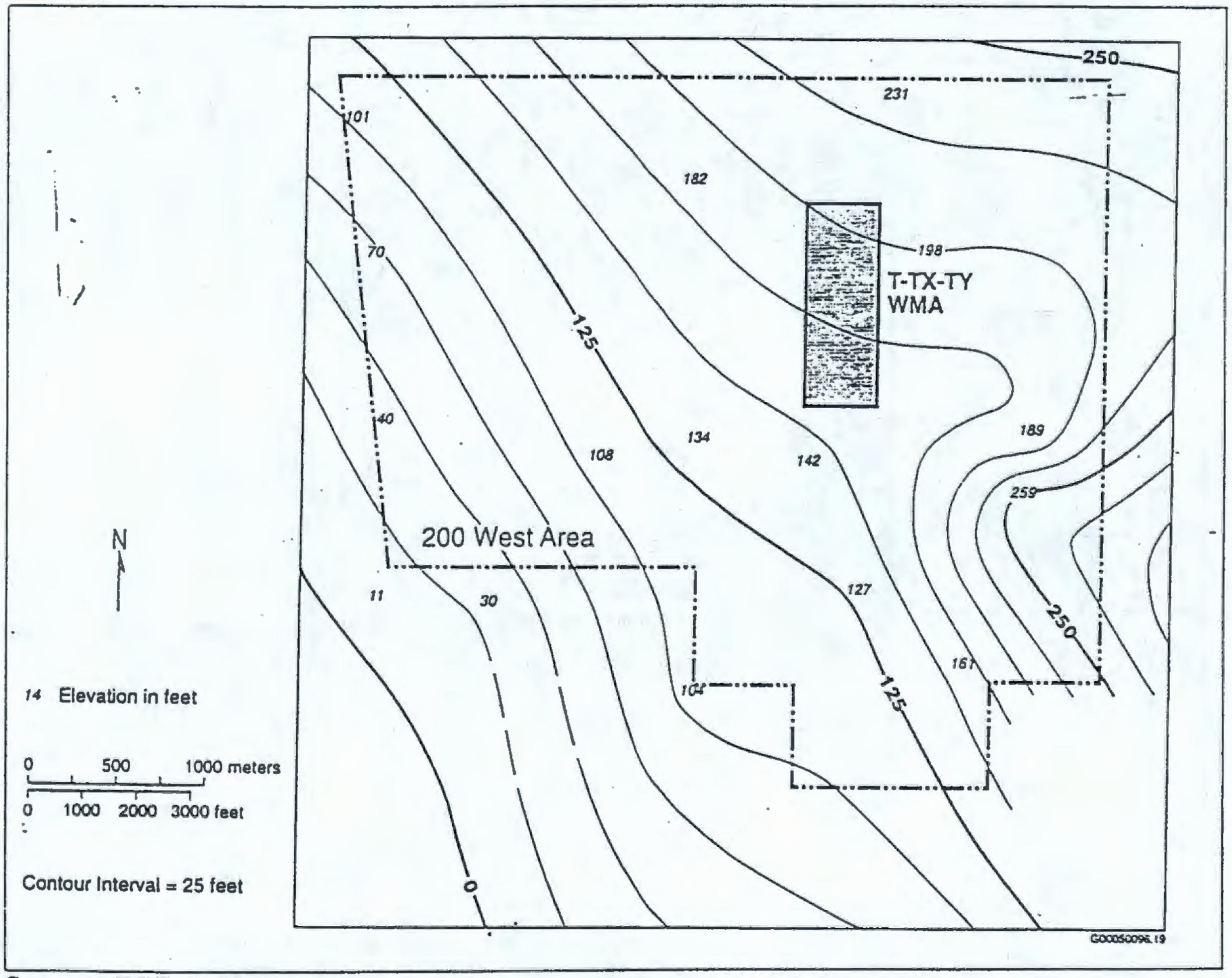
Figure 2.5. General Stratigraphy of WMAs T and TX-TY



Source: RPP-7123.

2.2.2.1 Columbia River Basalt Group. The surface of the Columbia River Basalt Group forms the bedrock base of the unconfined aquifer under WMAs T and TX-TY. The Elephant Mountain Member of the Saddle Mountains Basalt is the youngest flow and lies about 150 m (500 ft) bgs. The Elephant Mountain Member ranges from 25- to 27-m (80- to 90-ft) thick in the 200 West Area (RHO-BWI-ST-14). The top of the basalt dips gently southwest about 0.7 degree toward the axis of the Cold Creek syncline (Figure 2.6). In general, lavas of the Saddle Mountains Basalt and the overlying suprabasalt sediments thicken to the south toward the axis of the Cold Creek syncline. Only one borehole (299-W11-26, also referred to as DH-6) within 300 m (1,000 ft) of these WMAs extends to the basalt bedrock.

Figure 2.6. Top of Basalt Surface



Source: RPP-7123.

2.2.2.2 Ringold Formation. The Ringold Formation is up to 185-m (600-ft) thick in the center of the Pasco Basin and pinches out against the basin-bounding basalt ridges of the Yakima folds. The Ringold Formation at one time may have filled the basin to 275 m (900 ft) as indicated by erosional remnants of the Ringold Formation found at this elevation around the margins of the Pasco Basin. The top of the Ringold Formation beneath WMAs T and TX-TY is presently about 175 m (575 ft), suggesting that up to 100 m (325 ft) of the Ringold Formation was removed in this area during a post-Ringold regional incision and downcutting event that abruptly terminated Ringold deposition about 3.4 million years ago (Fecht et al. 1987).

The Ringold Formation consists of semi-indurated clay, silt, fine- to coarse-grained sand, and variably cemented granule to cobble gravel. Ringold Formation sediments have been classified into the following five sediment facies associations (Lindsey 1996).

- **Fluvial gravel** – Clast-supported granule to cobble gravel with a sandy matrix dominates this facies. Intercalated sand and mud also are found. The most common clasts are composed of basalt, quartzite, porphyritic volcanics, and greenstone. Silicic plutonic rocks, gneisses, and volcanic breccias also are found. Sand in the associated generally is quartzo-feldspathic, with basalt content usually ranging between 5% and 25%.

- **Fluvial sand** – Quartzo-feldspathic sand displaying cross-bedded and cross-laminated facies in outcrop dominates this facies association. The sand usually contains less than 15% basalt lithic fragments, although as much as 50% basalt may be present locally (Goodwin 1993). Intercalated strata consist of lenticular silty sand and clay up to 3-m (10-ft) thick and thin (less than 0.5 m [1.6 ft]) gravel. Fining upward sequences ranging from less than one meter to several meters thick are common.

- **Overbank deposits** – This facies association consists of laminated to massive silt, silty fine-grained sand, and paleosols containing varying degrees of pedogenic alteration, including both secondary clay and calcium-carbonate horizons. Overbank deposits occur as thin (less than 0.5- to 2-m [1.6- to 6.6-ft]) lenticular interbeds in the fluvial gravel and fluvial sand associations and as thick (up to 10 m [33ft]), laterally continuous sequences.

- **Lacustrine deposits** – Finely laminated, stratified to massive clay to silt facies with thin intercalated silty sand facies displaying occasional soft-sediment deformation characterize this facies association. Coarsening upward sequences less than 1-m (3-ft) thick to 10-m (33-ft) thick are common.

- **Alluvial fan** – Massive to crudely stratified, weathered to unweathered basaltic detritus dominates this facies association. These basaltic deposits generally are found around the periphery of the basin. This facies association is not represented beneath WMAs T and TX-TY.

The stratigraphic distribution of these facies associations provides the basis for subdividing the Ringold Formation into three mappable, informal members (i.e., Wooded Island, Taylor Flat, and Savage Island) exposed along the White Bluffs, located 25 km (15 mi) east of WMAs T and TX-TY along the eastern boundary of the Hanford Site (Lindsey 1996). The Wooded Island member consists predominantly of fluvial gravel with lesser occurrences of the other facies associations. Fluvial sand and overbank deposits characterize the Taylor Flat member. The Savage Island member consists predominantly of lacustrine deposits. Ringold Formation strata beneath WMAs T and TX-TY are assigned to the Wooded Island member locally overlain by an erosional remnant of the Taylor Flat member (Lindsey 1996). During the period of post-Ringold incision, the Savage Island member was completely eroded away from the center of the basin, including beneath WMAs T and TX-TY.

Fluvial gravels belonging to the Wooded Island member are the predominant facies association beneath WMAs T and TX-TY (Lindsey 1996, WHC-SD-EN-TI-290). These are further subdivided into the unit A and E gravels, which are separated by a lacustrine and/or overbank deposit facies interval designated the lower mud unit. More information on the Ringold Formation is provided in RPP-7123.

2.2.2.2.1 Wooded Island Member

Unit A. Unit A consists predominantly of the fluvial gravel facies association. Only boreholes W10-24, W14-14, and W-11-26 extend into unit A within WMAs T and TX-TY. Unit A is about 20-m (65-ft) thick. A less-than 2-m (5-ft) sequence of massive, fine-grained sand and silt belonging to the overbank facies association is found, at least locally, near the center of unit A.

Lower Mud Unit. As with unit A, only three boreholes (W10-24, W14-14, and W-11-26) near WMAs T and TX-TY penetrate into the overbank/lacustrine deposits of the lower mud unit. Based on a regional evaluation, the lower mud unit appears to be continuous beneath these WMAs, where it is between 6- and 11-m (20- and 36-ft) thick (DOE/RL-92-16, Lindsey 1996, WHC-SD-EN-TI-290). The lower mud unit pinches out a few thousand feet to the east, apparently removed during post-Ringold erosion. The top of the lower mud unit generally conforms to the top of basalt, dipping gently (0.6 degree) to the southwest. The dip of this unit probably is structural as a result of post-depositional tectonic folding; in this case, beds dip toward the axis of the Cold Creek syncline located south of the study area.

Unit E. Unit E consists predominantly of the fluvial-gravel facies association with occasional thin beds of the fluvial-sand and/or the overbank facies associations. Within WMAs T and TX-TY, unit E averages about 85-m (275-ft) thick and the top of the unit dips gently to the southwest, consistent with the top of basalt and underlying Ringold units. There exists 23 ft (7 m) of relief on top of the Ringold unit E beneath these WMAs. The water table lies within unit E gravels at about 70-m (230-ft) deep, about halfway between basalt bedrock and the ground surface.

2.2.2.2.2 Taylor Flat Member. The Ringold Formation informal member of Taylor Flat within WMAs T and TX-TY (previously referred to as the upper Ringold unit) consists of interstratified, well-bedded fine to coarse sand to silt belonging to a mixture of fluvial-sand and overbank facies associations. The member is discontinuous across the study area because of post-Ringold erosion and pedogenesis. In some areas erosion has stripped away the member entirely, while in others up to 10 m (30 ft) are sandwiched between the Plio-Pleistocene unit and the Ringold member of Wooded Island gravels.

The distribution and thickness of the Taylor Flat member is highly variable beneath these WMAs. Thickness ranges from 0 to 10 m (0 to 33 ft). Generally, the Taylor Flat member is absent to the south and becomes thicker to the north. It is locally absent beneath the TX tank farm. The top of the unit dips to the southwest and, where the unit is present, up to 9.4 m (31 ft) of relief exists on top of it.

2.2.2.3 Plio-Pleistocene Unit. The Plio-Pleistocene unit lies unconformably on the tilted and truncated Ringold Formation that formed following incision and downcutting of the Ringold Formation by the ancestral Columbia River system, which began about 3.4 million years ago. Several different facies make up the Plio-Pleistocene unit at the Hanford Site (DOE/RW-0164, HNF-5507, Lindsey et al. 1994, SD-BWI-DP-039):

- Pedogenic calcrete (i.e., calcic paleosols)
- Sidestream-alluvial
- Coarse-grained mainstream alluvium
- Silt-rich alluvial and/or eolian.

Neither the mainstream alluvial facies of the Plio-Pleistocene unit (also referred to as the pre-Missoula gravels) nor the sidestream alluvial facies are present beneath WMAs T and TX-TY. The calcrete facies of the Plio-Pleistocene unit (also referred to as the caliche layer) and the silt-rich alluvial and/or eolian facies are well represented and ubiquitous beneath WMAs T and TX-TY. The following discussion focuses on the Plio-Pleistocene calcrete facies. The silt-rich alluvial and/or eolian facies (formerly called the early Palouse soil) is discussed in Section 2.2.2.4.

Diagnostic features of the pedogenic calcrete facies of the Plio-Pleistocene unit include induration associated with a high concentration of calcium-carbonate cement, presence of root traces and animal burrows in cores, and white color (PNL-7336). As a result of a long period of surficial weathering in a semi-arid environment similar to current conditions, calcic-soils developed atop the Ringold Formation. While some aggradation of new material may be associated with the calcrete, much of the material is the result of in situ weathering of the uppermost Ringold Formation (either unit E gravels or fine-grained deposits of the Taylor Flat member). The calcium-carbonate overprint may occur on a variety of lithologies, including silt, felsic sand and gravel, and basaltic sand and gravel (RPP-6149). The amount of calcium-carbonate within the Plio-Pleistocene calcrete averages 10 to 20 wt%, but has been measured as high as 70 wt%. The top of the Plio-Pleistocene calcrete is well defined by a coincident significant increase in calcium-carbonate content and a decrease in mud content and sorting, accompanied by a sudden drop in total gamma activity (i.e., potassium-40) on borehole geophysical logs (GJO-HAN-11, GJO-HAN-16, PNL-7336). In this addendum the top of the Plio-Pleistocene calcrete is defined as the top of the first pedogenically altered, carbonate-rich, cemented zone accompanied by a sudden drop in gross gamma activity.

The top of the Plio-Pleistocene calcrete dips to the southwest at about 1 degree. Some of the dip probably reflects the paleotopography that existed following post-Ringold incision and during the subaerial weathering of the eroded Ringold surface. Because the relief, 12.2 m (40 ft) on top of the Plio-Pleistocene calcrete, is almost double that of the top of the Ringold lower mud unit (0.6 degree), at least some of the relief must be nontectonic (i.e., sloping floodplain dipping toward valley axis). The Plio-Pleistocene calcrete interval is generally between 3- and 7-m

(10- to 20-ft) thick beneath the T, TX and TY tank farms and somewhat thicker to the north and east. More information about the Plio-Pleistocene unit is provided in RPP-7123.

2.2.2.4 Hanford Formation(?)/Plio-Pleistocene Unit(?) Interval. A distinctive silt-rich interval, referred to here as the H/PP? interval, overlies the Plio-Pleistocene calcrete facies over most of the 200 West Area (DOE/RW-0164, RHO-ST-23, SD-BWI-DP-039) (Figure 2.5). Recent investigators have included the H/PP? interval as a subunit of the Plio-Pleistocene unit (Lindsey et al. 1994). Unlike the lower boundary of these strata, which easily is differentiated from the underlying Plio-Pleistocene calcrete, the upper contact with the overlying Hanford formation in the vicinity of WMAs T and TX-TY can be difficult to identify. Because the upper portion of these deposits may appear similar to or grade upward into the Hanford formation, these deposits are referred to as the H/PP? interval. Historically, deposits of the H/PP? interval have been described as a massive, unconsolidated, micaceous, brown to yellow, loess-like silt and minor fine-grained sand (ARH-LD-137, DOE/RL-92-16, DOE/RW-0164, PNL-6820, PNL-7336, RHO-BWI-ST-14, SD-BWI-DP-039, WHC-SD-EN-TI-008). Subsurface Geology of the Hanford Separations Areas (HW-61780) reports this well-sorted, buff-colored, eolian unit to be up to 21-m (70-ft) thick in the southern portion of 200 West Area. The H/PP? interval deposits generally were thought to be derived from the eolian reworking of the underlying Ringold member of Taylor Flat (upper Ringold unit) and/or the Plio-Pleistocene calcrete facies (DOE/RW-0164).

More recent investigations indicate the H/PP? interval may contain facies other than eolian silt and fine sand (Lindsey et al. 1994, RPP-6149, Slate 1996). For example, a study in the WMA S-SX, located approximately 1.8 km (1 mi) south of WMAs T and TX-TY, indicates the H/PP? interval is composed of mostly intercalated layers of fine sand and silt, more characteristic of alluvial deposits (RPP-6149), at least at this location. It appears then that the H/PP? interval may consist of a mixture of fine-grained deposits from both eolian and alluvial depositional environments. Regardless of its exact stratigraphic relationship and origin, the H/PP? interval is a distinctive lithostratigraphic unit that significantly influences the moisture and contaminant distribution within the vadose zone.

The top of the H/PP? interval is identified based on an increase in background gamma activity on geophysical logs (GJO-HAN-11) and an increase in mud content (up to 75 wt%). Calcium-carbonate content often is a few weight percent more than the overlying fine-grained Hanford formation (H2 unit) and usually is significantly less than that for the underlying pedogenic calcrete facies of the Plio-Pleistocene unit. The basal contact is distinct, indicated by a sharp drop in total gamma activity and percent mud content (PNL-7336). Also, compared to the pedogenically altered and cemented Plio-Pleistocene calcrete, the H/PP? interval deposits are relatively loose and friable. While the H/PP? interval often contains moderate to high concentration of calcium-carbonate, it appears to be evenly disseminated and therefore probably is of detrital origin. This is in sharp contrast to the underlying Plio-Pleistocene calcrete, where the calcium-carbonate is concentrated within discrete calcic horizons.

Similar to the other stratigraphic units, the top of the H/PP? interval dips gently to the southwest (RPP-7123). As much as 13.4 m (44 ft) of relief exists on top of the H/PP? interval across

WMAs T and TX-TY (RPP-7123). The H/PP? interval is generally 2- to 5-m (5- to 15-ft) thick beneath the T, TX, and TY tank farms (RPP-7123). The maximum thickness within the study area is 7 m (20 ft) in borehole 299-W14-4 (RPP-7123). More information about the H/PP? interval is provided in RPP-7123.

2.2.2.5 Hanford Formation. The Hanford formation is the informal name given to all glaciofluvial deposits from cataclysmic ice-age floods (DOE/RW-0164). Sources for floodwaters included glacial Lake Missoula, pluvial Lake Bonneville, and ice-margin lakes that formed around the margins of the Columbia Plateau (Baker et al. 1991). Cataclysmic floods were released during at least four major glacial events that occurred between about 1 million and 13 thousand years ago (early- to late-Pleistocene time). The Hanford formation consists of mostly unconsolidated sediments that cover grain sizes from pebble to boulder gravel, fine- to coarse-grained sand, silty sand, and silt. The formation is further subdivided into gravel-, sand-, and silt-dominated facies, which transition into one another laterally with distance from the main, high-energy, flood currents. Gravel-, sand-, and silt-dominated facies are also referred to as the coarse-grained, transitional, and rhythmite facies of the Hanford formation, respectively (Baker et al. 1991). Facies of the Hanford formation are commonly described as laterally interfingering. The relative proportion of each facies at any given location is related to distance from main, high-energy flood flows at the time of deposition. The following provide descriptions of the Hanford formation facies.

- **Gravel-dominated facies** – This facies generally consists of coarse-grained basaltic sand and granule to boulder gravel. These deposits display an open framework texture, massive bedding, plane to low-angle bedding, and large-scale planar cross-bedding in outcrop. Gravel-dominated beds sometimes grade upward into sand- and silt-dominated facies. Gravel clasts are predominantly basalt, with lesser amounts of Ringold Formation clasts, granite, quartzite, and gneiss (WHC-SD-EN-TI-012). The gravel-dominated facies was deposited by high-energy floodwaters in or immediately adjacent to the main cataclysmic flood channelways.

- **Sand-dominated facies** – This facies consists of fine- to coarse-grained sand and granule gravel. The sands typically have a high-basalt content and are commonly referred to as black, gray, or "salt-and-pepper" sands. They may contain small pebbles, rip-up clasts, and pebble-gravel interbeds and often grade upward into thin (less than 1 m [less than 3 ft]) zones of silt-dominated facies. This facies commonly displays plane lamination and bedding and less commonly channel cut-and-fill sequences. The sand-dominated facies was deposited adjacent to main flood channelways during the waning stages of flooding. The facies is transitional between the gravel-dominated facies and the silt-dominated facies.

- **Silt-dominated facies** – This facies consists of thin-bedded, plane-laminated, and ripple cross-laminated silt and fine- to coarse-grained sand. Beds are typically a few to several tens of centimeters thick and commonly display normally graded bedding (WHC-SD-EN-TI-012). Sediments of this facies were deposited under slackwater conditions and in back-flooded areas (Baker et al. 1991, DOE/RW-0164).

The sand and gravel fractions of the Hanford formation generally consist of about 50% basalt and 50% felsic material (RHO-ST-23). This mineral assemblage gives the Hanford formation the characteristic "salt and pepper" appearance often noted in drillers' and geologists' logs. The felsic material is composed of primarily quartz and feldspar, with some samples containing more than 10% pyroxene, amphibole, mica, chlorite, ilmenite, and magnetite. The silt- and clay-sized fractions consist of quartz, feldspar, mica, and smectite.

Based on lithologies observed at WMAs T and TX-TY, the Hanford formation is divided into two informal units designated H1 and H2. These units are equivalent to the upper coarse (Hc) and lower fine (Hf) units of the Hanford formation, respectively, as reported in *200 West Groundwater Aggregate Area Management Study Report* (DOE/RL-92-16).

2.2.2.5.1 H2 Unit. The H2 unit consists predominantly of the sand-dominated facies of the Hanford formation. Internally, this sequence probably contains multiple graded beds of plane- to foreset-bedded sand or gravelly sand several meters or more thick, which sometimes grade upward into silty sand or silt. Cementation is very minor or absent, and total calcium carbonate content is generally only a few weight percent or less.

The H2 unit is continuous beneath WMAs T and TX-TY. The base of the H2 unit sometimes is difficult to distinguish from the underlying H/PP? interval with which it may share a similar grain-size distribution. However, the gross gamma geophysical log is useful for differentiating the two units. The base of the H2 unit is picked based on the point where the gross gamma log begins to increase significantly. The H2 unit also has been identified on the basis of an abrupt transition from well-stratified sand to highly interstratified sand and silt in some continuous, recently cored boreholes at the S and SX tank farms (RPP-6149).

The top of the H2 unit is chosen based on the first appearance of flood gravels more than or equal to 1.5-m (5-ft) thick in an upward direction. The top of the H2 unit dips to the west. Approximately 20 m (65 ft) of relief occurs on the surface of the H2 unit beneath WMAs T and TX-TY. The top of this unit is sometimes complicated where the sand sequence is interbedded with gravels; when this occurs picking the contact between the fine-grained sequence (H2 unit) and the overlying flood gravels (H1 unit) is difficult. Interbedding of flood sands and gravels probably represents lateral facies changes as a result of transitional depositional environment or gravel-starved areas during deposition. The H2 unit generally thickens to the southeast beneath WMAs T and TX-TY because of the greater distance to the nearest high-energy flood flows in this direction. More information about the H2 unit is provided in RPP-7123.

2.2.2.5.2 H1 Unit. The H1 unit overlies the H2 unit, except where the H1 unit has been removed by excavation. The H1 unit is equivalent to the upper gravel sequence of the Hanford formation discussed in *Hydrogeology of the 200 Areas Low-Level Burial Grounds – An Interim Report* (PNL-6820), and to the Quaternary fine gravel documented in *Geologic Map of the Priest Rapids 1:100,000 Quadrangle, Washington* (Reidel and Fecht 1994).

Based on observations of outcrop and intact core samples, the H1 unit is interpreted to consist of the high-energy, gravel-dominated facies interbedded with lenticular and discontinuous layers of the sand-dominated facies. Silt-dominated facies may also be present, although they probably constitute a relatively small percentage of the total.

The H1 unit is thicker in the western portion of WMAs T and TX-TY because of a north-south-trending paleochannel. The H1 unit is locally thinner beneath the tank farms as a result of excavation and backfilling near the tanks. In a few places, all the H1 unit appears to have been removed during excavation for the tanks beneath the T, TX, and TY tank farms (GJO-HAN-11, GJO-HAN-16, GJO-HAN-27). More information on the H1 unit is provided in RPP-7123.

2.2.2.6 Holocene Deposits. Holocene deposits emplaced over WMAs T and TX-TY since the last floods are limited to recent windblown silt and sand and construction backfill. Eolian sheet sands occur sporadically at the surface and generally are less than 1- to 2-m (3- to 7-ft) thick. Eolian sand does not overlie the tank farms themselves (having been removed during excavation) but does occur around the periphery of the tank farms. Backfill material occurs to depths of 15 m (55 ft) and consists of Hanford formation sediments (H1 unit) excavated from depths from 14 to 17 m (45 to 55 ft) bgs.

2.2.2.7 Clastic Dikes. Clastic dikes are vertical to subvertical sedimentary structures that cross-cut normal sedimentary layering. Clastic dikes are a common geologic feature of the Hanford formation in the 200 Areas, especially in the sand- and silt-dominated facies. Clastic dikes are much less common in the gravel-dominated facies of the Hanford formation. Clastic dikes were noted during excavation of the T, TX, and TY tank farms (ARH-LD-135, ARH-LD-136, ARH-LD -137). Clastic dikes were intersected by boreholes 299-W15-134 and 299-W15-180 in the TX tank farm (RPP-7123).

Clastic dikes occur in swarms and form four types of networks (BHI-01103):

- Regular-shaped polygonal patterns
- Irregular-shaped, polygonal patterns
- Preexisting fissure fillings
- Random occurrences.

Clastic dikes near WMAs T and TX-TY probably occur randomly in the gravel-dominated facies (the Hanford formation H1 and H2 units) and as regular-shaped polygons in the sand facies (the Hanford formation H2 unit). Regular-shaped polygonal networks resemble 4- to 8-sided polygons and typically range from 3-cm to 1-m (1-in. to 3-ft) wide, from 2-m to more than 20-m (6-ft to more than 65-ft) deep, and from 1.5 to 100 m (5 to 325 ft) along their strike. Smaller dikelets, sills, and small-scale faults and shears are commonly associated with master dikes that form the polygons.

In general, a clastic dike has an outer layer of clay with coarser infilling material. Clay linings are commonly 0.03- to 1.0-mm (0.001- to 0.04-in.) thick, but linings up to about 10-mm (0.4-in.) thick are known. The width of individual in-filling layers ranges from as little as 0.01 cm to more than 30 cm (0.0004 in. to more than 12 in.) and their length can vary from about 0.2 m to more than 20 m (8 in. to more than 65 ft). In-filling sediments are typically poorly sorted to well-sorted sand but may contain clay, silt, and gravel (HNF-4936).

2.2.3 Hydrogeology

General groundwater flow directions under WMAs T and TX-TY have changed substantially because of Hanford Site operations. The flow direction in the local unconfined aquifer was from west to east before Hanford Site operations began. The water table changed significantly after waste disposal operations began in the early 1950s. In particular, during the time of most active waste disposal in the late 1940s and the 1950s in this area, groundwater flowed toward the south or southeast primarily because of large volumes disposed of in 216-T-4 T pond, located 330 m (1,100 ft) north-northwest of T tank farm. The shift in discharge of large volumes of wastewater in the early 1950s to U pond raised the water table in the vicinity of WMAs T and TX-TY as much as 19 m (62 ft) above the pre-Hanford Site-operations level (PNNL-12086). Starting in the early 1950s, effluent discharges to U pond, located approximately 450 m (1,475 ft) southwest of WMA U, created a broad, flat, 26-m (85-ft) mound on the existing water table that quickly shifted to a dominant northeasterly flow through WMAs T, TX-TY, and U (RHO-ST-82). This northeasterly flow continued to dominate during the 1960s through 1980s and most of the 1990s. As a result of U pond being decommissioned in 1984, water table elevations across the 200 West Area have been declining since 1985. See Figure 2.3 for locations of wells monitored to track recent water level changes and contamination events. Water level declines have become even more pronounced since other effluent discharges throughout the 200 Areas ceased in 1995. Water levels have declined approximately 7 m (23 ft) in the last 10 years around WMAs T and TX-TY (RPP-7123). Water levels are expected to continue to decline but at a decreasing rate (excluding pump-and-treat activity areas).

The unconfined aquifer beneath WMAs T and TX-TY is within unit E of the Ringold formation (BHI-00184). Gravels within the Ringold Formation unit E vary greatly in degree of cementation, and therefore, exhibit a wide range of hydraulic properties. In the vicinity of WMAs T and TX-TY, reported hydraulic conductivity values range from 1.2 m to 19 m per day (3.9 to 62 ft per day) and transmissivity values range from 47 to 1,130 m^2 per day (500 to 12,159 ft^2 per day) (DOE/RL-92-16, WHC-SD-EN-TI-014). A fluorescent dye tracer test conducted near the northwest corner of WMA T in 1974 as part of the tank T-106 leak study indicated groundwater flow velocity on the order of 0.4 m per day (1.3 ft per day) (RHO-ST-14). On the basis of the water table map presented in *High Level Waste Leakage from the 241-T-106 Tank at Hanford* (RHO-ST-14), at present the hydraulic gradient is approximately half the value it was in 1974 (PNNL-11809). Therefore, the current groundwater flow velocity is estimated at approximately 0.2 m (0.7 ft) per day.

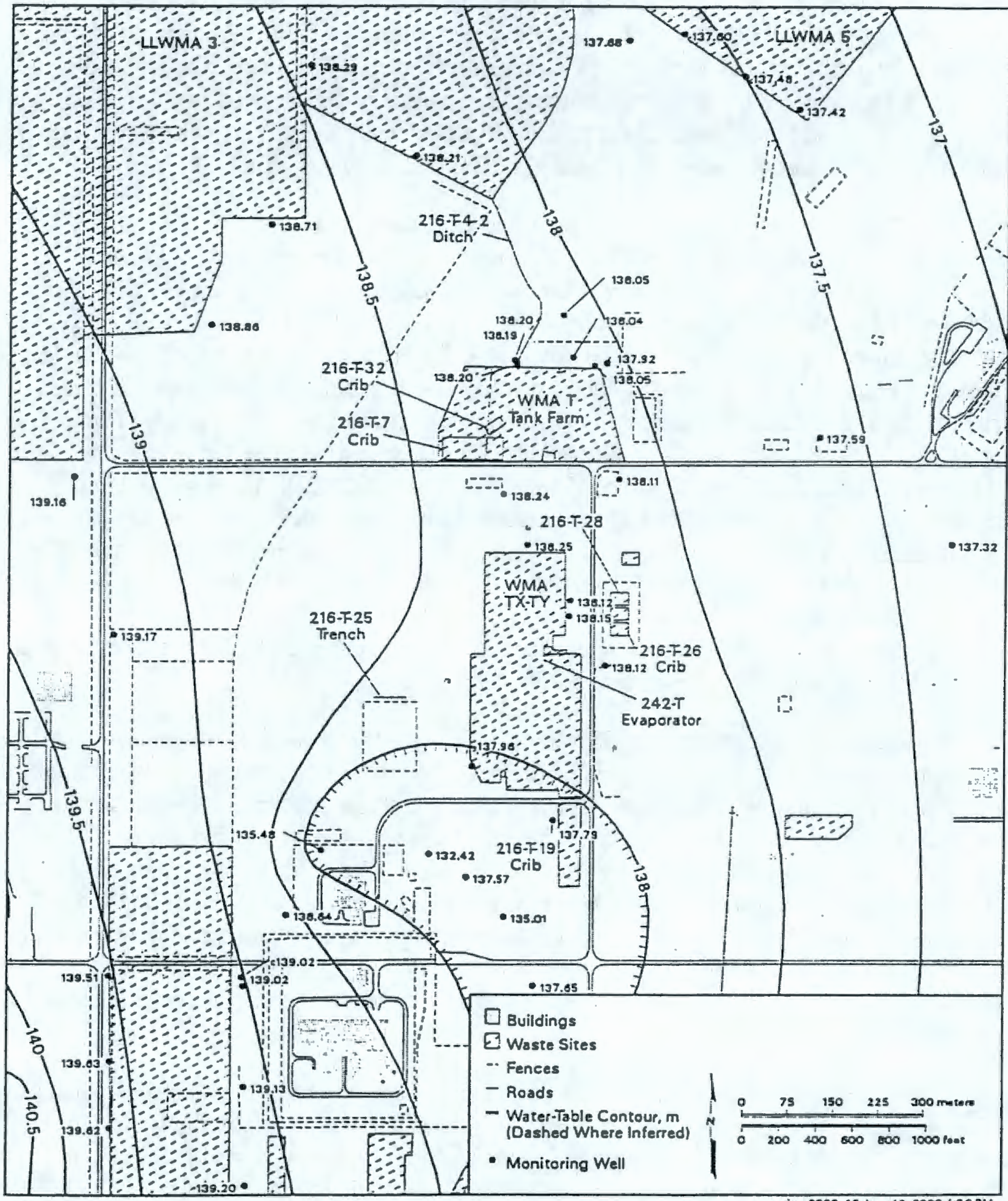
The hydraulic gradient is sufficiently steep across the 200 West Area to be measurable. With about 100 cm (32.8 in.) of change or more across each WMA, the use of discrete water elevations to determine flow direction is easily accomplished. Even steeper gradients occur south of WMA TX-TY because of pump-and-treat activities at groundwater operable unit 200-ZP-1. In WMAs T and TX-TY, new wells with longer screened intervals have replaced older wells that have gone dry. For example, well 299-W10-23 replaced well 299-W10-15 and well 299-W10-24 replaced well 299-W11-27. Along with the water level decline in this area has been a decrease in the hydraulic gradient and, in the last few years, changes in the flow direction in some portions of WMAs T and TX-TY (Figure 2.7). The mound caused by discharges to the U pond, though relatively flat, continues to influence groundwater flow. Groundwater flow direction is becoming more easterly (i.e., the original pre-Hanford Site operations flow direction) as shown in Figure 2.7. However, remediation pumping that began at groundwater operable unit 200-ZP-1 in 1994 and the resulting cone of depression gradually created a south-to-southeasterly flow component at the southern end of the TX and TY tank farms (Figure 2.7).

Hydraulic response of the aquifer to pump-and-treat operations at groundwater operable unit 200-ZP-1 is reported in *Fiscal Year 1997 Annual Summary Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump and Treat Operations and Operable Units (DOE/RL-99-02) and Fiscal Year 1998 Annual Summary Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump and Treat Operations and Operable Units* (DOE/RL-99-79). The most recent impact on water levels is shown in Figure 2.7. Pumping at groundwater operable unit 200-ZP-1 developed in three phases. Phase 1 consisted of 1 pilot well extracting water at 150 L/min (45 gal/min) from August 29, 1994 to July 19, 1996. In Phase 2, three wells were used to extract water at 570 L/min (150 gal/min) from August 5, 1996 to August 7, 1997 (DOE/RL-99-02). Phase 3 began on August 29, 1997 using 5 wells to extract contaminated water at a rate of 720 L/min (190 gal/min). Phase 3 pump-and-treat of the water from the carbon tetrachloride plume continues at approximately this rate (DOE/RL-99-79). Water levels have declined rapidly, but the future rate of long-term changes in water levels at WMAs T and TX-TY is uncertain, partly because of pump-and-treat activities. Screen lengths in new wells are 11 m (35 ft) in anticipation of significant continuing water level decline over the next several years.

2.2.3.1 Recharge. Recharge through the vadose zone is primarily controlled by the surface sediment type, vegetation type, topography, human-made, and spatial and temporal variations in seasonal precipitation at WMAs T and TX-TY. As used in this addendum, the recharge rate is the amount of precipitation that enters the sediment, is not removed by evaporation or transpiration, and eventually reaches the groundwater table. The recharge to the unconfined aquifer beneath the T, TX, and TY tank farms from infiltrating precipitation is an important parameter for calculating groundwater impacts from past tank leaks, future tank waste retrieval losses, and residual tank waste currently in the SSTs (Jacobs 1998). The tank farm surface characteristics and infrastructure create an environment conducive to enhanced general recharge and transient, high-intensity events.

Most of the precipitation at the Hanford Site occurs from September through February when little to no evaporation or transpiration occurs. Recharge varies temporally and spatially. The temporal variation occurs with changes in temperature, plant activity, and precipitation. Both seasonal and long-term variations, as a result of climatic change, are important. The spatial variation occurs with changes in vegetation type, surficial sediment type, and human-made structures (e.g., paved parking lots). A lag time exists between a change in recharge rate from infiltration at the surface and a change in the flow field in the vadose zone as the water infiltrates through the ground.

Figure 2.7. Water Table Map of the Northern 200 West Area in 1999



Source: RPP-7123.

2.2.3.2 Natural Infiltration. No direct measurements of the natural infiltration rate under WMAs T and TX-TY have been made. However, observations from similar, disturbed, gravel-covered areas at the Hanford Site indicate that as much as 10 cm (3.9 in.) can infiltrate a vegetation-free coarse gravel surface per year (Fayer et al. 1996, Gee et al. 1992, PNL-10285). That rate represents about 60% of the average annual meteoric precipitation (rainfall plus snowmelt). *Estimated Recharge Rates at the Hanford Site* (PNL-10285) indicates that WMAs T and TX-TY is estimated to have about 2 to 5 cm (0.8 to 1.97 in.) of infiltration per year based on soil type, vegetation, and land use and infiltration rates of 5 to 10 cm (1.97 to 3.9 in.) immediately south of the tanks per year. Actual recharge is significantly different and not uniform because of the presence of the tanks, the disturbed soil surrounding the tanks, and no vegetative cover. Recharge is intercepted and "shed" by the tank domes and flows into the disturbed soil near the tanks. Thus, infiltration rates near tank edges and between rows of tanks are likely manyfold higher than average areal infiltration rates.

Lysimeter data from the Field Lysimeter Test Facility located between the 200 West and 200 East Areas show that the recharge rate ranges from 24% to 66% of the annual precipitation for years 1990 to 1994 for lysimeters with gravel over sand and bare vegetation conditions, which are typical of current tank farm ground conditions (PNL-10508). This is equivalent to approximately 4 to 11.1 cm (1.57 to 4.37 in.) of recharge per year based on the long-term annual precipitation rate of 16.8 cm (6.61 in.) per year (PNNL-11107). However, more recent lysimeter field measurements acquired August 1995 to August 1996 from the Field Lysimeter Test Facility resulted in 16.06 cm (6.32 in.) drainage per year, which is 66% of the actual precipitation over that period. These lysimeters were designed to simulate tank farm conditions in the 200 Areas.

2.2.3.3 Artificial Recharge. Artificial recharge in the 200 West Area is associated with trenches, cribs, ditches, and drains that were used to dispose of approximately 1.7×10^{11} L (4.4×10^{10} gal) of waste water (DOE/RL-92-16). Leaking water lines are another source of artificial recharge in the tank farms. Higher infiltration rates are observed around the tank farms, which are covered with gravel and kept clear of vegetation.

Waterline ruptures, such as the one in September 1996 at the S tank farm, demonstrate that surface water could enter and collect in low spots (PNNL-11810). Transient saturation from runoff collecting in low spots could be a more significant driving force than average annual infiltration. For example, rapidly melting snow is one natural event that can lead to surface flooding. This type of occurrence has been documented at the T tank farm (PNNL-11809), but no similar record is available for WMA TX-TY. WMA T is a topographical low. Slopes adjacent to WMA T, especially along the east side, tend to funnel surface runoff directly into the T tank farm. This occurrence was documented in photographs following rapid snow melt in February 1979 (PNNL-11809). This ponded water over and around the tanks definitely infiltrated the vadose zone and drove any existing vadose zone contamination deeper into the soil column. WMA TX-TY also is likely to have significant runoff recharging areas near and in the tank farms.

Discharges within WMAs T and TX-TY were unplanned releases. Quantities are not known for many of the identified releases. Reported releases are primarily leaks from transfer pipelines, diversion boxes, and tanks. The most significant release, in terms of quantity and degree of contamination is the release of approximately 435,321 L (115,000 gal) of waste from tank T-106 in 1973. RPP-7123 provides more information on artificial recharge related to WMAs T and TX-TY.

2.2.4 Surface Water Hydrology

No flood plains exist in or between the 200 Areas. Floods in Cold Creek and Dry Creek have occurred historically; however, there have been no observed flood events. Based on a probable maximum flood evaluation, no impact would occur at WMAs T and TX-TY (PNNL-6415). Surface flooding has occurred on the T tank farm in 1979 due to rapid snowmelt (PNNL-11809).

3.0 INITIAL CONDITIONS AND CORRECTIVE ACTION REQUIREMENTS AND OBJECTIVES

The purpose of this section is to describe what is known about confirmed or suspected contamination in the vadose zone and groundwater and identify the potential corrective action requirements and objectives. The information on known and suspected contamination is presented in Section 3.1 and RPP-7123. A summary of this information is also provided in Section 3.0 of DOE/RL-99-36. Potential corrective action requirements are provided in Section 3.2. The confirmed or suspected contamination information was used to develop the Section 3.3 discussion on the potential impacts to the public health and the environment based on potential corrective action requirements and objectives. Section 3.4 addresses preliminary corrective action objectives and alternatives with respect to Section 5.0 of DOE/RL-99-36. Additional data to support improved understanding of the nature and extent of contamination at WMAs T and TX-TY will be collected during the field investigation described in this addendum.

3.1 KNOWN AND SUSPECTED CONTAMINATION

A summary of available data and conditions is needed to effectively develop a characterization plan designed to collect data to support a determination of the presence and extent of contamination at a site caused by a given event or activity. A summary of available WMAs T and TX-TY data regarding source, sediments, and groundwater contamination is presented in the following subsections and in RPP-7123.

When interpreting the data in the following subsections, it is important to note the amount of radioactive decay that has taken place since the data were gathered. For example, the half-life of cesium-137 is 30.2 years, approximately the time between 1968 and 1998. Thus, cesium-137 levels would, in 1998, have been approximately half of their 1968 values. Where possible, the dates for radionuclide inventories have been given, but calculations of the decayed inventories through the present time have not been made.

3.1.1 Sources

The source terms for WMAs T and TX-TY are dependent upon nuclear and chemical aspects of the processes that generated the waste. The inventory of chemicals and radionuclides lost to the vadose zone in WMAs T and TX-TY is a function of the waste types stored in the tanks over their decades of use. Because of their long operational history, the tank farms received waste generated by all of the major processes. The T and TX tank farms initially received waste streams discharged from the bismuth phosphate process operating in T Plant (DOE/RL-91-61). By the end of 1952, the T, TX, and TY tank farms were being used to support the uranium recovery program being conducted in the U Plant, as well as the bismuth phosphate process. Once the REDOX, PUREX, and isotope recovery processes in B Plant came on line, tanks within these WMAs received multiple waste types. A number of tanks within WMAs T and TX-TY served as feeder tanks for the 242-T Evaporator. Thus, because tanks and associated infrastructure failed at different times, various waste types were lost to the vadose zone in these WMAs. Estimates of leak chemistry and radionuclide constituents for WMAs T and TX-TY tank leaks are provided in *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX,* *and TY Tank Farms* (RPP-7218). Best estimates of specific sources for each leak event are provided in RPP-7123.

The volume of waste lost from many of the T, TX, and TY tanks is highly uncertain. Except for losses from tank T-106 (RHO-ST-14), no detailed analyses of known or suspected leaks have been done in these WMAs. Available information on specific leak events is provided in RPP-7123 and RPP-7218.

Sources of releases include fluid discharges; tank waste through tank leaks; ancillary equipment leaks and failures (i.e., diversion boxes, transfer and cascade pipelines); and trenches and cribs (see Section 2.1.4). These releases impacted the sediments. These releases are discussed in detail in RPP-7123. Estimated releases or leaks from the tanks in WMAs T and TX-TY are indicated in Table 3.1. The uncertainty associated with the leak durations is even greater than that for the estimated tank leak volumes.

Throughout the operational history of the T, TX, and TY tank farms, fluids have been discharged both deliberately and inadvertently. A summary of discharge events is provided in RPP-7123. Three types of fluid discharges associated with T, TX, and TY tank farm operations have occurred numerous times in and around WMAs T and TX-TY. These discharges included the following:

- Periodic failure of ancillary equipment used to transfer liquids between tanks
- Deliberate collection and routing of cooling water and tank condensate to cribs
- Mechanical failure of tanks and leakage into the underlying soil column
- Overfilling of a tank.

Leaks from ancillary equipment were observed and recorded when sufficient fluid reached the surface from the buried, but near-surface, sources. The primary parts of the ancillary equipment system responsible for the surface spills appear to be the collection points for fluids being transferred around the tank farm (e.g., diversion boxes, valve pits, and catch tanks). Numerous pipes feed into these collection points. The pipes were frequently attached, detached, and reattached as part of normal operations, because the permanent pipelines would become clogged or unusable. Plugging of underground pipelines resulted in waste escaping containment, especially transfer and cascade lines.

Most of the trenches and cribs associated with the T, TX, and TY tank farms operated from the beginning of tank farm operations in 1944 until the early 1970s. RPP-7123 supplies a history of waste and its volume released to these cribs and trenches. RPP-7123 provides more information on surface and near-surface spills.

A detailed discussion of the 20 tanks (7 SSTs in T tank farm, 8 SSTs in TX tank farm, and 5 SSTs in TY tank farm) that are assumed or confirmed leakers is provided in Section 3.3 of RPP-7123. The estimated volume of the leaks is provided in Table 3.1 of this addendum. Based on *Waste Summary Report for Month Ending September 31, 2000* (HNF-EP-0182-150) and RPP-7218, the three highest-volume releases ranked in descending order are as follows:

Table 3.1. Estimated Past Leak Losses from T, TX, and TY SSTs

Tank	HNF-EP-0182-150 Estimated Leak Volume (gal)	RPP-7218 Estimated Leak Volume (gal)	Estimated Leak Date[c]	Assumed Waste Type[d]
241-T-101	7,500	10,000	1992/1969	REDOX Cladding
241-T-103	<1,000	3,000	1974/1973	B Plant
241-T-106	115,000	115,000	1973	B Plant Isotope Recovery
241-T-107	--[a]	--	1984	Uncertain
241-T-108	<1,000	--	1974	Uncertain
241-T-109	<1,000	--	1974	Uncertain
241-T-111	<1,000	--	1974	Uncertain
241-TX-105	--[a]	--	1977	MW
241-TX-107	2,500	8,000[b]	1984/1977	Uncertain
241-TX-110	--[a]	--	--	Uncertain
241-TX-113	--[a]	--	--	Uncertain
241-TX-114	--[a]	--	--	Uncertain
241-TX-115	--[a]	--	--	Uncertain
241-TX-116	--[a]	--	--	Uncertain
241-TX-117	--[a]	--	--	Uncertain
241-TY-101	<1,000	--	1973	TBP
241-TY-103	3,000	3,000	1971	TBP
241-TY-104	1,400	--	1981	Uncertain
241-TY-105	35,000	35,000	1960	TBP
241-TY-106	20,000	20,000	1957	TBP
Totals	189,400	194,000	NA	NA

Note: Based on RCRA corrective action program, all single-shell tank leak volume estimates in HNF-EP-0182-150 are currently under review and significant revisions are anticipated. There will be revision to Appendix F in HNF-EP-0182-150 as a better understanding of tank leak events are developed.

To convert gallons to liters, multiply by 3.785.

[a]Based on 19 tanks with cumulative leak volume of 150,000 gallons for an average of 8,000 gallons for each of the 19 tanks.
[b]The leak volume of 8,000 gal is assigned, the actual leak volume is highly uncertain (RPP-7218).
[c]The first date corresponds to HNF-EP-0182-150, while the second corresponds to RPP-7218.
[d]All waste types from RPP-7218, see Section 9.0 for definition.

NA = not applicable.
RCRA = *Resource Conservation and Recovery Act of 1976.*

- Tank T-106 with an estimated 435,275 L (115,000 gal) leaked
- Tank TY-105 with an estimated 132,475 L (35,000 gal) leaked
- Tank TY-106 with an estimated 75,700 L (20,000 gal) leaked.

3.1.2 Releases to Sediment

Releases of historical fluid discharges to trenches, T Retention Pond, and cribs to the sediment; tank waste through tank leaks; ancillary equipment leaks; and surface spills, along with evaluation of spectral and gross gamma surveys, are of direct interest to the WMAs T and TX-TY field investigation.

Detailed information about the spectral gamma surveying and historical gross gamma surveying conducted at T, TX, and TY tank farms is provided in RPP-7123. Spectral gamma logging data are available in separate reports for the T, TX, and TY tank farms (GJO-HAN-11, GJO-HAN-16, GJO-HAN-27).

Because SSTs T-106, TY-105, and TY-106 are associated with the largest release volumes, they are discussed in more detail in the following subsections. Tanks TX-105 and TX-107 are also discussed because spectral gamma data indicates leaks may have occurred at these tanks of higher volume than that indicated in HNF-EP-0182-150. Information for other tank leaks that affect WMAs T and TX-TY are presented in RPP-7123 and *Single-Shell Tank Leak History Compilation* (HNF-4872). The following sections are taken directly from RPP-7123.

3.1.2.1 Tanks T-103 and T-106. Tanks T-103 and T-106 are considered together because they leaked roughly at the same time and the gamma data suggest a partial mixing of discharged fluids from each source. Because of proximity and timing, both tanks frequently have been evaluated together. Given the time of the leaks and the tank waste histories (RPP-7218), waste lost from these tanks was B Plant waste, generated by cesium-137 recovery from PUREX supernate liquid.

The apparent driving force for leakage from tank T-103 was a 98,420 L (26,000 gal) tank overfill in 1973 (WHC-SD-WM-ER-351), causing an estimated 4,921 L (1,300 gal) discharge (ARH-2874) through a spare fill line. The uncertainty of this estimate is large. An additional estimate of about 3,785 L (1,000 gal) (HNF-EP-0182-150) was based on an observed liquid level drop of 0.8 cm (0.3 in.) in late 1973 and early 1974. Because this change is so small, the reliability of this hypothesis is highly uncertain. Regardless of the uncertainty surrounding the number of leak events and total leak volume, spectral gamma data from several nearby drywells indicate leakage has occurred (GJ-HAN-120). Only drywell 50-03-04 contains a small zone of cesium-137 (1-10 pCi/g) at 6 m (20 ft). Presumably, this is the well closest to the source. The other gamma-producing contaminants in this well include cobalt-60, europium isotopes, antimony-125, niobium-94, and tin-126 (GJO-HAN-27). Drywells 50-03-05, 50-02-08, and 50-02-09 also appear to contain contamination from this leak. Interpreted historical gamma data from drywell 50-02-09 indicate migration of ruthenium-106, antimony-125, and europium isotopes from 1976 through 1985 at 8 m to 15 m (32 to 48 ft).

The tank T-106 leak is the largest, most thoroughly documented SST leak. In addition to the most recent spectral gamma logging of surrounding drywells, several earlier studies have been completed. The first extensive study of these two leaks was done shortly after they occurred (ARH-2874) and a follow-up study was completed in 1978 (RHO-ST-14). More recently, an extensive sampling and analysis program was completed on soil samples taken from a borehole near the center of the tank T-106 leak to improve understanding of its nature and the extent of contamination in the vadose zone produced by this event (BHI-00061). Supporting data from these sources are provided in Appendix F of RPP-7123.

The liquid level drops from tank T-106 are unambiguous because they were significantly larger than background fluctuations and permit an unusually reliable estimate of leakage (435,321 L [115,000 gal]) and leak rate. A large number of drywells contain contamination from this leak because of the large extent of the leak and the high density of drywells constructed to quantify the soil column contamination caused by this leak. For many of these wells, historical and spectral gamma data were collected in 1973, 1978, and in the mid 1990s, providing the most complete characterization data set of any tank farm leak on the Hanford Site. Appendix F in RPP-7123 contains a summary table including ranges and peaks from the 1973, 1978, and 1990s spectral gamma data from these drywells.

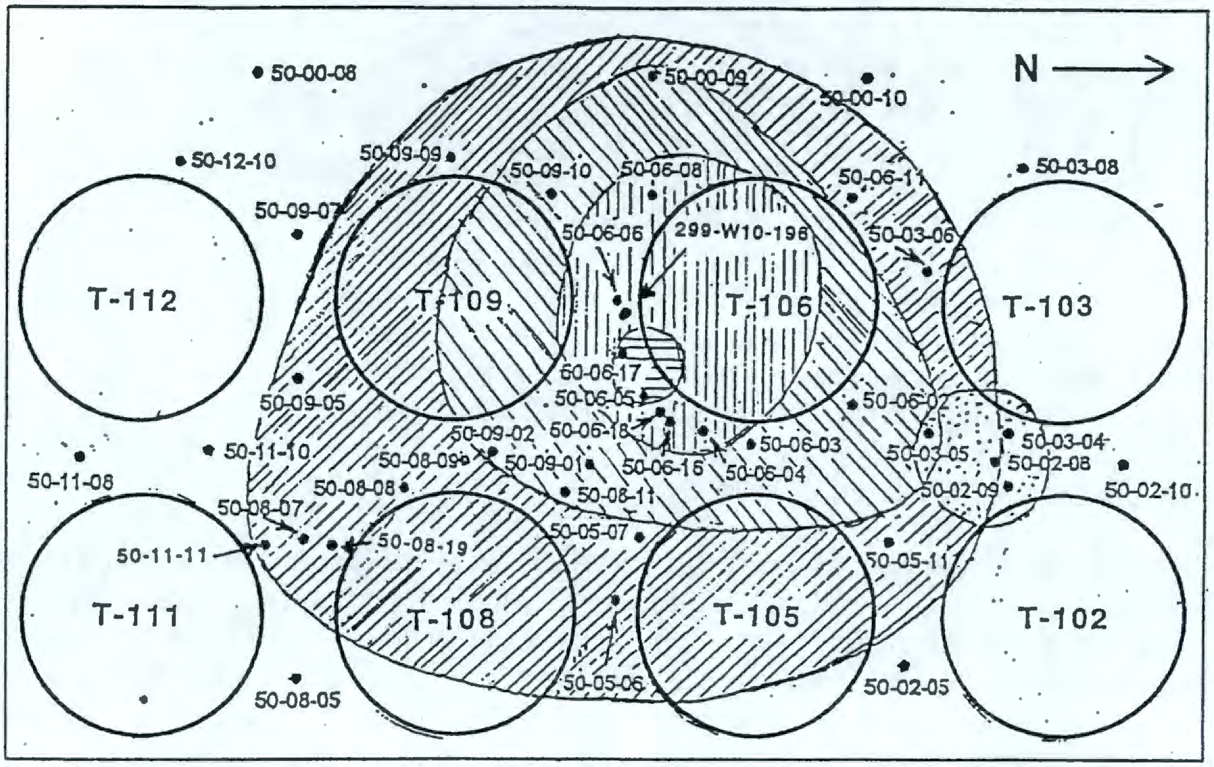
The spectral gamma data from the tank T-106 drywells reveals what appear to be four zones of different gamma signatures with increasing distance from the leak source. These zones are shown in Figure 3.1. All the zones are estimated to extend beneath tank T-106. Zone 1 is closest to the leak source and Zone 4 is farthest away. The two wells in Zone 1 nearest the leak source at the southern section of tank T-106 are characterized by thick zones of very high cesium-137 concentrations (about 10^8 pCi/g) beginning near tank bottom depth (about 11 m [35 ft]). Zone 2 drywells typically show thin zones of high cesium-137 concentration at 11 m to 14 m (35 to 45 ft) and cobalt-60 plus europium isotopes that frequently extend to the drywell bottoms. Occasionally, other isotopes are present, including uranium, tin-126, and antimony-125. Zone 3 drywells show no cesium-137, sporadic occurrences of europium isotopes, and cobalt-60 from 11 m (35 ft) to the bottom of the drywells. Zone 4 drywells show only cobalt-60 from 20 m (65 ft) to the bottom of the drywells. The map view distribution of the different zones is quite similar to the 1 µCi/l ruthenium isopleth (Figure 3.2) estimated in RHO-ST-14.

Interpretation of the historical gamma data collected from 1975 through 1994 indicates ruthenium-106 and cobalt-60 migration in almost all the wells in Zones 1 through 4. Downward migration of ruthenium-106 and cobalt-60 at Zone 3 drywells 50-00-09 and 50-09-10 appears to have occurred near the tank bottom around 1980 and again at greater depths (about 18 m to 30 m [60 to 100 ft]) in the late 1980s. Cesium-137 migration is indicated in Zone 1 in the late 1970s.

3.1.2.2 Tanks TY-105 and TY-106. Tanks TY-101, TY-103, TY-104, TY-105, and TY-106 are listed in HNF-EP-0182-150 as suspected leakers. Except for tank TY-106, small drops in liquid level in each tank are used as evidence of leakage. However, the small leaks (less than 2.5 cm [1 in.]) could be spurious or could be explained by numerous nonleak processes such as evaporation.

Elevated gamma readings in monitoring drywells around tanks TY-101, TY-103, and TY-105 also were used as evidence of leaking from these tanks (GJO-HAN-16).

Figure 3.1. Spectral Gamma Characteristics in Vadose Zone Soils Contaminated by Tank Waste Leaked from Tanks T-103 and T-106



Drywell Spectral Gamma Characteristics Due to Tank 241-T-106 Leak

Zone 1: Thick regions of > 10^7 pCi/g C137 concentration from 35-100 ft

Zone 2: Small regions of > 10^7 pCi/g Cs from 35-45 ft; Co-60 and europium isotopes from 35-100 ft

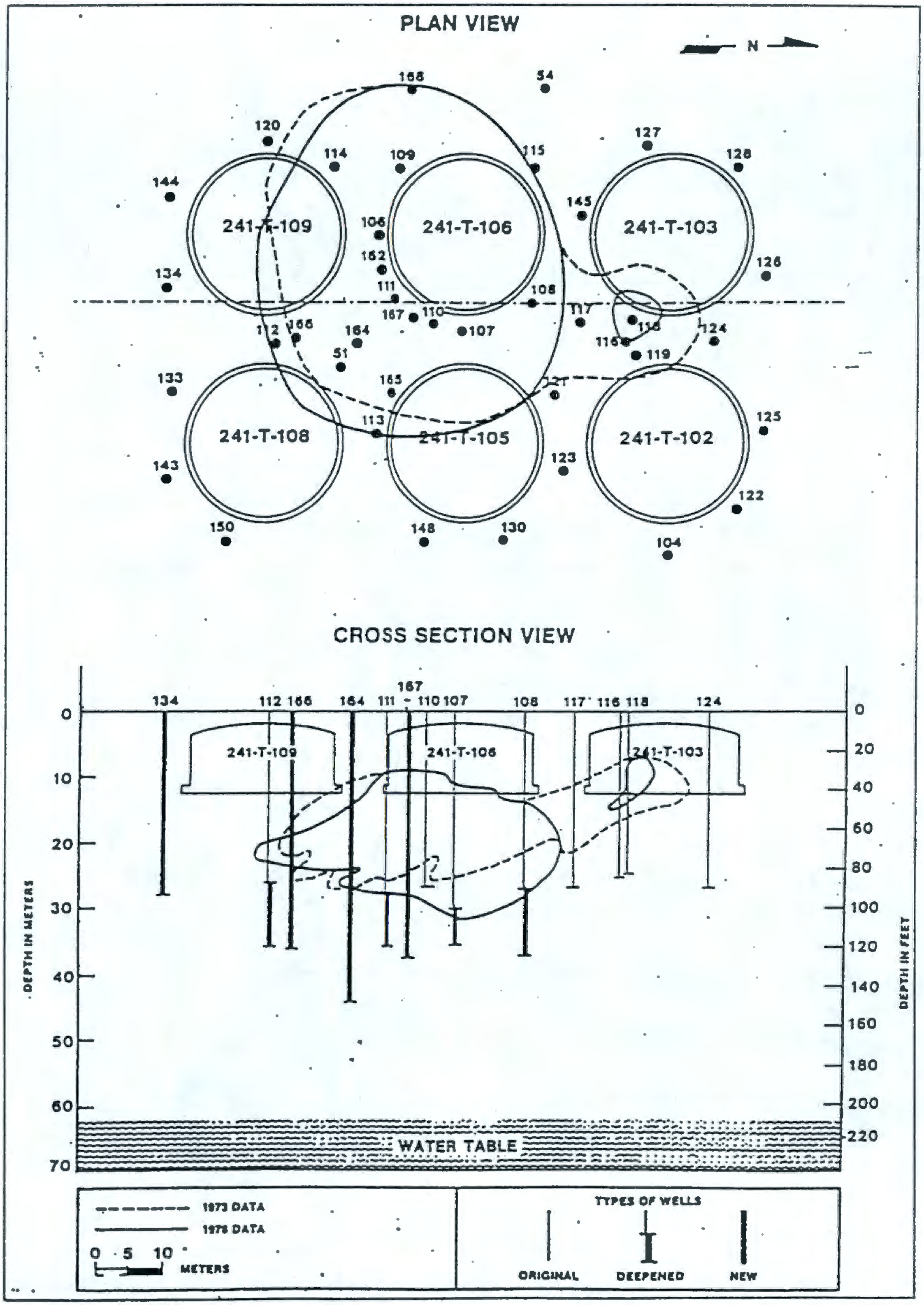
Zone 3: No Cs-137 present; Co-60 from 35-100 ft and sporadic europium isotopes from 35-100 ft

Zone 4: Co-60 65 ft and below, frequently to the bottom of the drywell(~100 ft)

Drywell Spectral Gamma Characteristics Due to Tank 241-T-103 Leak

Estimated zone of contamination from the tank T-103 leak primarily Co-60 and europium isotopes from 20-90 ft

Figure 3.2. Map View and Cross Section of 1 µCi/L ^{106}Ru Contours in 1973 and 1978 Created After Tank Waste Leaked from Tanks T-103 and T-106



Assumed leakage from tank TY-106 in 1959 is problematic because the estimated 75,708-L (20,000-gal) leak is not reflected in the drywell data nor is the liquid level decrease evidence recorded. Contaminants from a leak of this size should be observed even with the paucity of drywells located nearby and, given the estimated size of this leak, unambiguous liquid level drops also should have been observed.

Only the leak from tank 241-TY-105 appears to be sufficiently large to be a source of potentially significant groundwater contamination based on spectral and historical gamma data and liquid level observations (RPP-7123). The leak volume estimate is large (132,489 L [35,000 gal]), but not clearly substantiated in the record (RPP-7123). Drywells 52-03-06, 52-05-07 and 52-06-06, all located around tank 241-TY-105 contain elevated gamma readings, supporting the plausibility of a substantial leak. Elevated gross gamma readings from drywell 52-03-06 in 1974 were recorded. Current contamination in drywell 52-03-06 includes a small amount of cesium-137 (less than 1pCi/g) and cobalt-60 from 15 m (50 ft) to the drywell bottom (GJO-HAN-16). Drywell 52-05-07 contains cesium-137 approximately 1 to 30 pCi/g located from 15 m to 27 m [50 to 90 ft]) and cobalt-60 (approximately 1 to 10 pCi/g located from 15 m to 30 m [50 to 98 ft]) (GJO-HAN-16). Drywell 52-06-05 also contains cesium-137 and cobalt-60 located between 15 m and 46 m (50 and 150 ft), but because the casing is perforated, this contamination could be caused by the perforated casing forming a local artificial preferential pathway. Given the time of the leaks and the tank waste histories (RPP-7218), waste lost from these tanks was unscavenged tributyl phosphate (TBP) waste, generated by uranium recovery from metal waste in U Plant processing operations.

Conceptualization of the leak from tank 241-TY-105 is hampered by a minimal historical record of the event and sparsely distributed drywells near this tank (RPP-7123). The record indicates a leak occurrence in 1960. The drywells that appear to be associated with this event, 52-05-07, 52-03-06 and 52-06-05, and possibly 52-03-12, suggest that the leak occurred nearest drywell 52-05-07 because this drywell contains the most extensive cesium-137 contamination beginning near the tank-bottom depth. Thus, either the leak originated at the tank bottom or at a shallower depth some distance from the drywell and migrated downward. Once the leaking fluid got below the tank bottom, it flowed horizontally to the north and southwest, contaminating the areas around drywell 52-03-06, possibly drywells 52-03-12 and 52-06-05. Flow also could have occurred to the south, east, and southeast, but there are no drywells in these directions to measure migration. Cobalt-60 contamination remains near these existing drywells and also suggests vertical migration, particularly at drywell 52-03-06 where cobalt-60 exists at relatively high concentrations (>10 pCi/g) down to the drywell bottom at 30 m (100 ft) bgs (RPP-7123).

Therefore, the historical records, including liquid level drops in the tank, and the drywell gross gamma and spectral gamma data provide supporting evidence that a leak associated with tank TY-105 occurred, but not from tank TY-106 of the reported magnitude (75, 708 L [20,000 gal]) (RPP-7123).

3.1.2.3 Tanks TX-105 and TX-107. Several small drops in liquid level were noted in tank TX-107 in 1975 and later (GJO-HAN-11); these appear to be true indicators of leakage. Historical and spectral gamma data also suggest leakage from tank TX-107 in the same period.

Because large volumes of supernate liquid were transferred through tank TX-107 during the leak period, the liquid loss estimates are highly unreliable. The extent of the contamination attributed to this tank leak suggests that the leak volume estimate of 9,464 L (2,500 gal) is low, perhaps substantially low.

Elevated gamma readings in drywells monitoring tanks TX-105 and TX-107 also were used as evidence of leaking from these tanks (GJO-HAN-11). Connections between specific drywell data and individual tank leaks include the following.

- Interpreted historical gamma data in drywell 51-05-08 indicate migration of ruthenium-106 at 11 m to 16 m (36 to 54 ft) between 1975 and 1977. Given several recorded instances of unexplained liquid level drops in tank TX-105 starting in 1973, the ruthenium-106 movement may be a corroborating indicator of leakage from this tank or piping associated with this tank.

- Drywells 51-03-01, 51-03-11, 51-03-12, 51-07-18, 51-07-07, 51-03-09, and 51-04-05 show commonality in current spectral gamma characteristics and historical migration patterns suggesting leakage from tank TX-107 beginning about 1975. The primary gamma emitter is cobalt-60, which is present from 14 m to 21 m (45 to 70 ft). Europium-154 also is present at 15 m to 18 m (50 to 60 ft) in all but the two southernmost drywells, 51-03-09 and 51-04-05. Historical gamma data indicate migration of cobalt-60 from northeast to the southwest over time between 1977 and 1992. Interpreted historical gamma data (RPP-6353) suggest more than one migration event in drywells 51-03-11, 51-07-18, 51-07-07, and 51-04-05. Given the time of the leak and the tank waste history (RPP-7218), waste lost from this tank was B Plant waste, generated by cesium-137 recovery from PUREX supernate liquid.

The remaining assumed leaker, tank TX-107, has more substantial evidence of leakage and is considered a candidate for additional characterization.

In the remainder of the TX tank farm, two areas of uranium contamination occur that are not obviously connected to an assumed tank leak. First, uranium-238 and -235 are found in a set of drywells around tanks TX-105 and TX-101, including drywells 51-00-03, 51-05-01, 51-05-03, 51-01-05, 51-05-07, 51-01-09, and 51-01-08. A range of uranium-238 concentrations from 1 to more than 100 pCi/g exists in this set of drywells from 14 m to 23 m (45 to 75 ft) with the higher contamination levels occurring at shallower depths in the northeast drywells. The uranium-235 concentrations mirror the uranium-238 values at about an order of magnitude lower. Second, uranium-238 and uranium-235 are found at similar relative concentrations in a set of drywells around tank TX-104, including drywells 51-04-02, 51-03-09, 51-04-05, 51-04-06, and 51-00-07. A range of uranium-238 concentrations from 1 to about 100 pCi/g exists in this set of drywells wells from 14 m to 30 m (45 to 100 ft) with the higher contamination levels occurring at shallower depths in the northeast drywells, 51-04-02 and 51-04-05. In both cases, a line drawn around the listed drywells outlines a rough oval with the long axis running northeast to southwest. The presence of uranium contamination at these concentrations strongly indicates leakage of metal waste in the early 1950s. No other substantive information is available that describes the nature of this leak.

Additional information is presented in RPP-7123.

3.1.3 Intentional Liquid Waste Disposals to Surrounding Cribs and Trenches

Numerous cribs, trenches, tile fields, and T retention pond surround WMAs T and TX-TY (see Figure 2.2). Throughout the operational history of the T, TX, and TY tank farms, fluids were discharged to the ground, both deliberately and inadvertently. A list of intentional discharge sites and unplanned releases with descriptive information is provided in Appendix A of RPP-7123 and RPP-5957. These facilities received some of the largest quantities of liquid waste ever discharged on the Hanford Site.

At T tank farm, significant amounts of liquid were discharged into three facilities within WMA T and west of the T farm tanks. From 1946 through 1952, 224 waste (2.9×10^7 L [7.7×10^6 gal]) was disposed in the two 216-T-32 cribs (RPP-5957). From 1947 through 1955, second cycle, 5-6, and 224 waste (1.1×10^8 L [2.9×10^7 gal]) were discharged into the soil column through the 216-T-7 crib and tile field. In 1951, a discharge pipe was connected between the 216-T-7 crib and tank T-112, the last tank in the cascade series receiving second cycle and 5-6 waste; this allowed continuous flow into the crib. In 1955, second cycle waste (4.5×10^7 L [1.2×10^7 gal]) was discharged into the soil column through the 216-T-5 trench.

Several facilities received liquid waste adjacent to and outside of WMA T. Just south of the T tank farm, crib 216-T-36 received 5.2×10^5 L (1.4×10^5 gal) of decontamination and condensate waste liquids in 1967 and 1968. Finally, to the northeast of the T tank farm in trenches 216-T-14, -15, -16, and –17, a total estimated discharge of 3.8×10^6 L (1.0×10^6 gal) of first-cycle waste in 1954 is reported.

Near the TX tank farm, the 216-T-19 crib and tile field at the southeast corner of the tank farm received liquid waste from 1951 through 1980. In all, 4.3×10^8 L (1.1×10^8 gal) were discharged; the bulk of the material was condensate from the 242-T Evaporator operations with some bismuth phosphate waste (second cycle, 5-6, and 224 waste). To the west of the TX tank farm and outside WMA TX-TY, the 216-T-21, -22-, -23, -24, and -25 trenches received 8.0×10^6 L (2.1×10^6 gal) of first-cycle waste in 1954.

At the TY farm, no facilities inside the WMA boundary were used to intentionally discharge liquid waste. Primary liquid discharge facilities are located east of the TY farm. They include the 216-T-18 crib, which received 1×10^6 L (2.6×10^5 gal) of scavenged tributyl phosphate waste in 1953; the 216-T-26 crib, which received 1.2×10^7 L (3.2×10^6 gal) of scavenged first-cycle waste in 1955 and 1956; and the 216-T-27 and -28 cribs, which received 4.9×10^7 L (1.2×10^7 gal) of 340 Building laboratory waste from 1960 through 1966.

The total liquid amounts released to the ground within WMAs T and TX-TY from unplanned releases are not well quantified. However, the descriptions indicate that these releases were uniformly small (no more than a few gallons) within WMAs T and TX-TY, with the possible exception of UPR-200-W-100, the underground pipe leak between tanks TX-105 and TX-108. This unplanned release is unusual and may have been a relatively large leak. In 1954, an underground pipe leak of first-cycle waste between tanks TX-105 and TX-108 (UPR-200-W-100) was detected by the discovery of surface contamination. Clean soil was placed over the contaminated area.

3.1.4 Groundwater

RCRA groundwater monitoring at WMAs T and TX-TY moved from interim status detection level monitoring to assessment monitoring (40 CFR 265 Subpart F) in 1993 because specific conductance limits were exceeded in downgradient wells at the two WMAs, as set forth in WHC-SD-EN-AP-132. Specific conductance is a RCRA indicator parameter that measures the quantity of ionic species in solution. The increased specific conductance in well 299-W11-27, starting in late 1995, has pushed the specific conductance above the critical mean in WMA T. Even though this well was replaced in 1998 by deeper well 299-W10-24, which has a longer screened interval, concentrations of contaminants remain relatively high. The increased specific conductance in these two wells is a result of increased concentrations of calcium, magnesium, nitrate, and sulfate; associated with this trend are increasing activities of technetium-99 and tritium. High specific conductance also is present at downgradient wells 299-W10-17 and 299-W14-12 in WMA TX-TY.

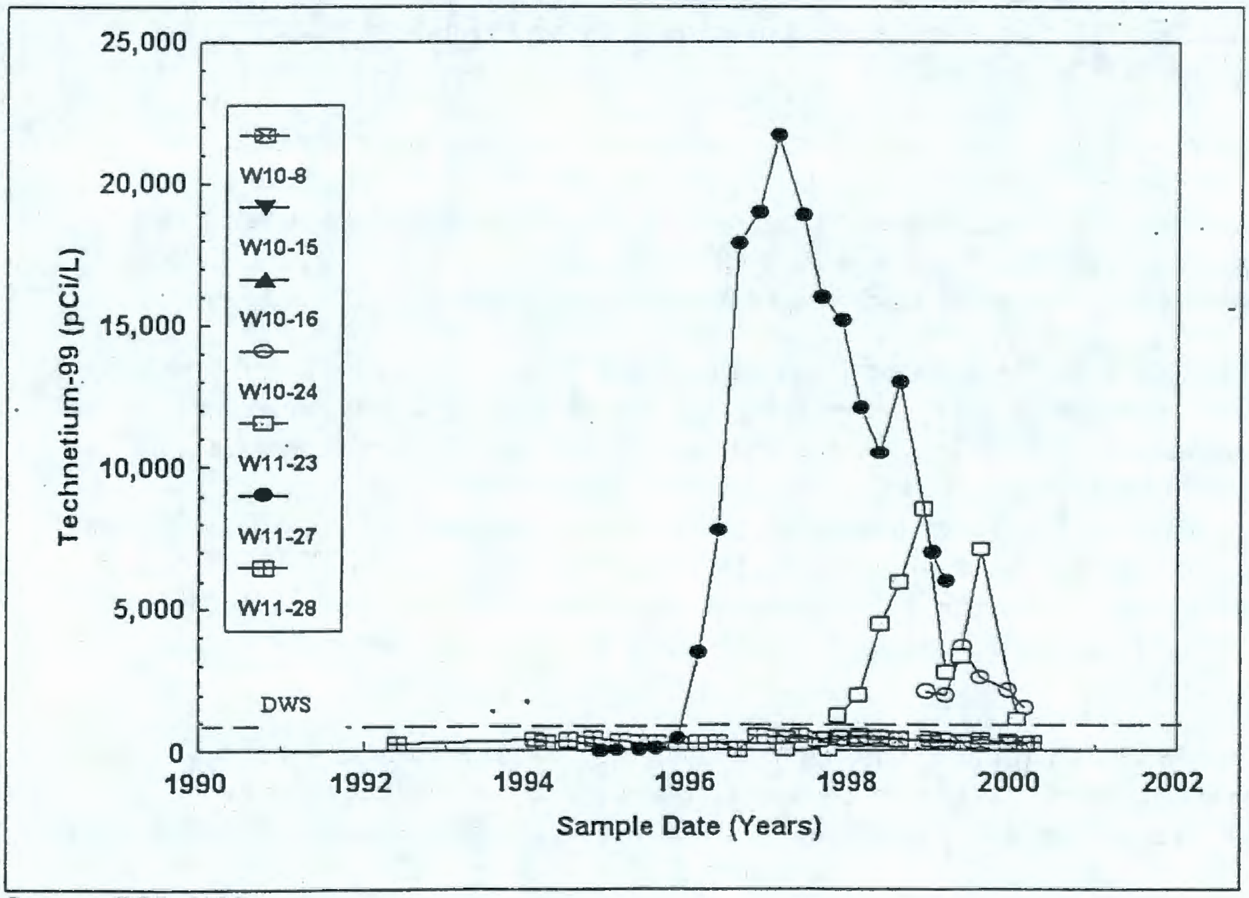
A groundwater investigation has indicated that contamination in downgradient RCRA monitoring wells is attributed to WMAs T and TX-TY (PNNL-11809). The findings confirmed contaminants have been released to the groundwater from these WMAs. Additional information is provided in *Hanford Site Groundwater Monitoring for Fiscal Year 1998* (PNNL-12086), *Hanford Site Groundwater Monitoring for Fiscal Year 1999* (PNNL-13116), and RPP-7123.

The main tank constituents known to be highly mobile and used for tracking tank-related waste are nitrate, chromium and technetium-99 (presumably present as TcO_4^-). Chromium and technetium-99 are found in discrete locations. Groundwater samples also are analyzed for cobalt-60, which generally is made mobile in the vadose zone under the influence of tank fluid chemistry, but rarely is seen in groundwater. Tritium and nitrate are widespread in the 200 West Area and are present everywhere in groundwater underlying WMAs T and TX-TY. Tritium is linked to 242-T Evaporator, tank leak sources, and crib and trench discharges (PNNL-13404). Nitrate is derived from numerous sources, including trench, crib, and tank leak sources (PNNL-13404).

3.1.4.1 WMA T Groundwater Contamination. Groundwater to the northeast of WMA T has been characterized by very low ionic strength, essentially contaminant-free groundwater, resulting from leaks from a transfer line taking T Plant effluent from retention basin 207-T to the T-4-2 ditch (see Figure 2.3). The line is made of 24-in.-diameter vitrified clay pipe, which is very brittle. The changes in water chemistry suggest that the line was damaged during drilling of well 299-W11-27. In late 1995, following termination of surface effluent discharges within the 200 West Area, well 299-W11-27 (located at the northeast corner of WMA T) exhibited a rapid increase in specific conductance; other constituents (calcium, chromium, nitrate, magnesium, sulfate); and technetium-99 reaching a maximum of 21,700 pCi/L (drinking water standard is 900 pCi/L) in February 1997 (PNNL-11809).

Two newer nearby wells, 299-W10-24 and 299-W11-23, show a continuing although less consistent pattern of reduced technetium-99 (see Figure 3.3) (PNNL-13116). In well 299-W10-24, the replacement well for 299-W11-27, technetium-99 has ranged between 1,960 and 3,660 pCi/L. The sampling pump in well 299-W10-24 is set at a depth of approximately 4.6 m (15 ft) below the water table. Technetium-99 concentrations in well 299-W11-23 started to increase in November 1997, reaching a high of 8,540 pCi/L in November 1998. Technetium-99 subsequently dropped to 2,755 pCi/L in March 1999 before rebounding to 7,110 pCi/L in August 1999. Finding technetium-99 in well 299-W11-23 is apparently a result of the change in groundwater flow direction from northeast to east. Apparently, the plume stretching northeast from well 299-W11-27 is moving eastward across well 299-W11-23. The location and concentrations of the plume inside the WMA that initially affected well 299-W11-27 are unknown at this time.

Figure 3.3. Historical Technetium-99 Concentrations Near WMA T

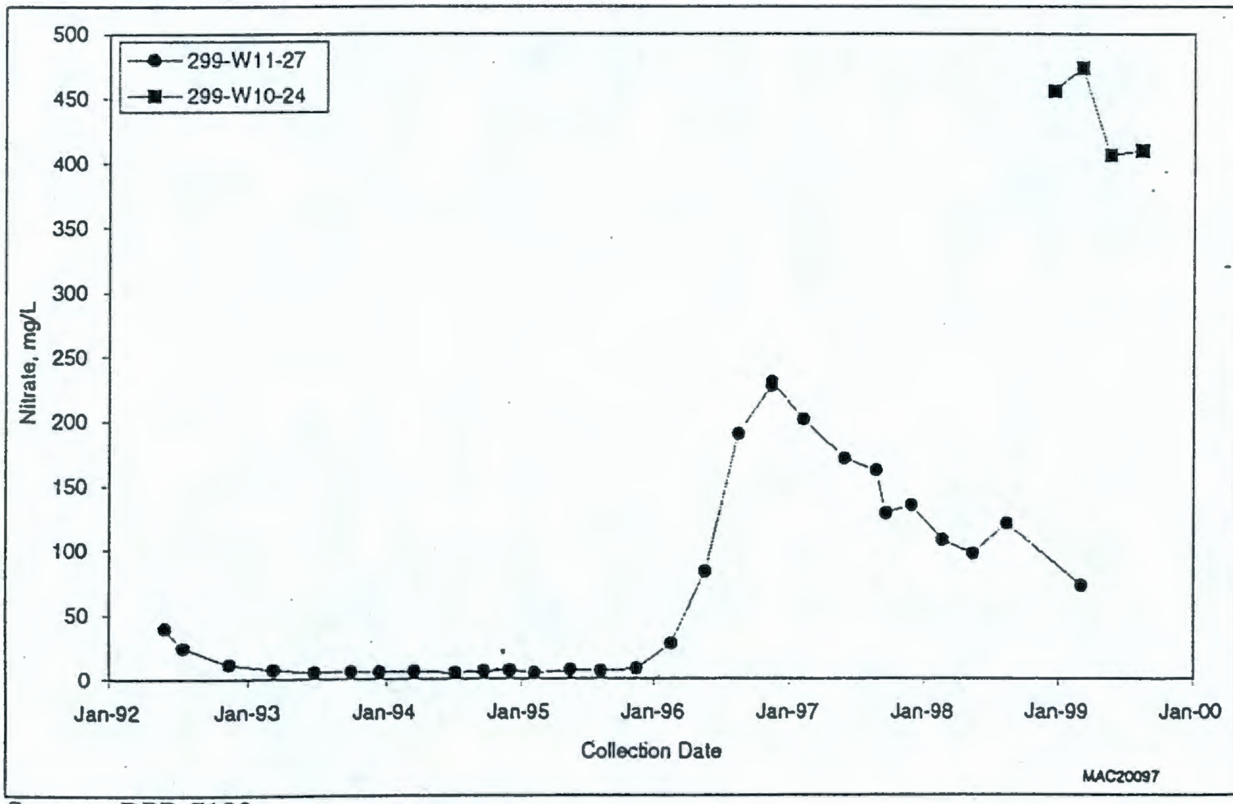


Source: RPP-7123.

Chromium concentrations in well 299-W11-27 exhibited a peak in fiscal year 1996 (PNNL-11809). The chromium in replacement well 299-W10-24 is higher than currently found in well 299-W11-27, unlike technetium-99, which currently is higher in well 299-W11-27. This may indicate different sources for chromium and technetium-99 or a common source and slightly different mobility in the soil column.

Nitrate concentration trends in well 299-W11-27 and its replacement, well 299-W10-24, are shown in Figure 3.4. The recent increase in nitrate concentration in well 299-W11-27 is strongly correlated with the technetium-99 trend (Figures 3.3 and 3.4), but this correlation does not carry through to replacement well 299-W10-24. The nitrate concentration in well 299-W10-24 is much higher than in well 299-W11-27, whereas the technetium-99 concentration is lower. This reversal in relative concentration suggests the presence of multiple nitrate sources that contribute contamination to groundwater intercepting well 299-W10-24. Thus, the nitrate and technetium-99 present in well 299-W11-27 plausibly could come largely from waste stored in the T tank farm and exist high in the aquifer, but in well 299-W10-24 nitrate also is supplied from a different and more distant source present deeper in the aquifer.

Figure 3.4. Historical Concentrations of Nitrate in Monitoring Wells at WMA T

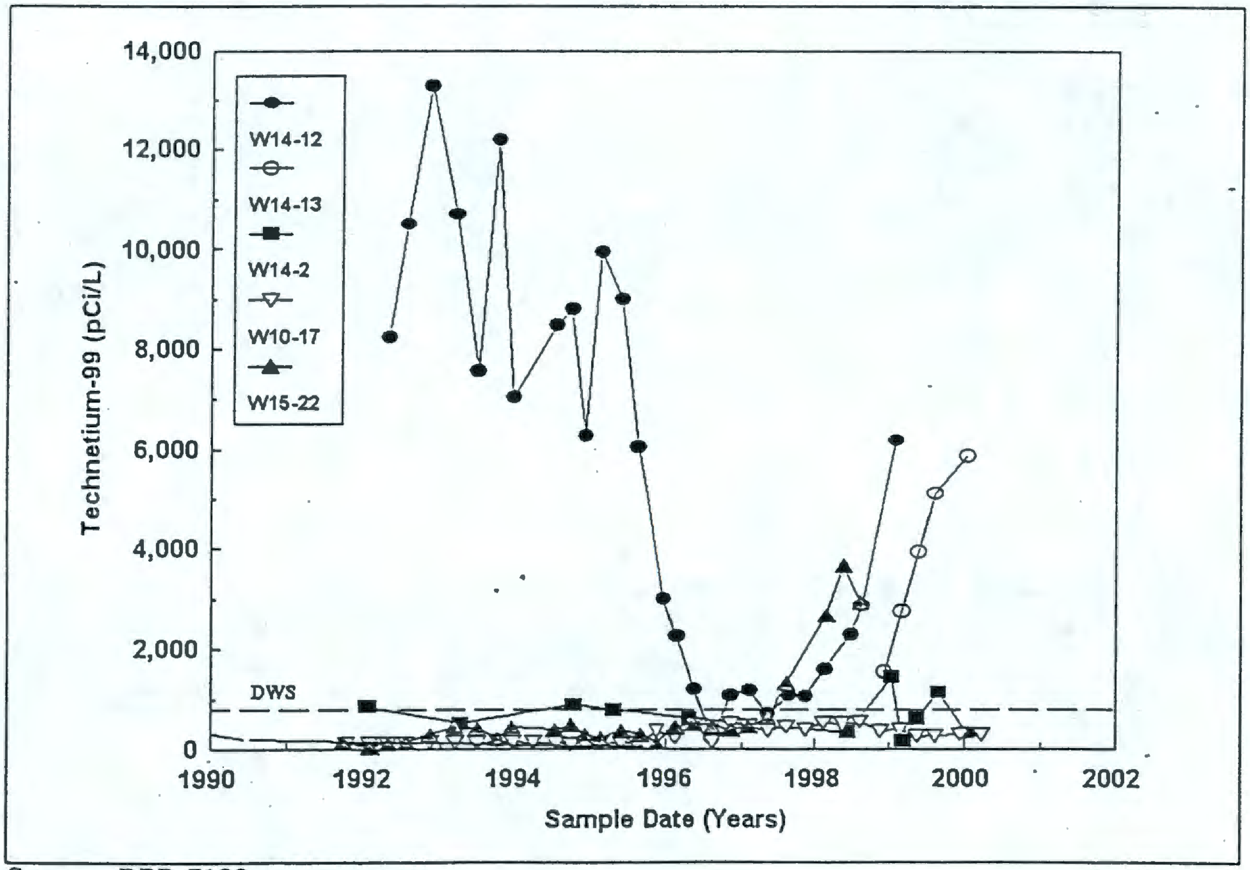


Source: RPP-7123.

3.1.4.2 WMA TX-TY Groundwater Contamination. Groundwater chemistry near WMA TX-TY has been dominated by groundwater containing high concentrations of sodium and nitrate and various concentrations of tritium, technetium-99, and other contaminants resulting from 50 years of waste management activities. This chemistry is a mixture of two primary sources, tank supernate liquid disposed of to the ground during tank cascading, and carbon tetrachloride and nitrate-rich water from waste disposal in the Plutonium Finishing Plant trenches (PNNL-13116). Another significant, tritium-rich component is apparently from the disposal of evaporator condensate in the 216-T-19 crib and tile field south of WMA TX-TY (PNNL-13116).

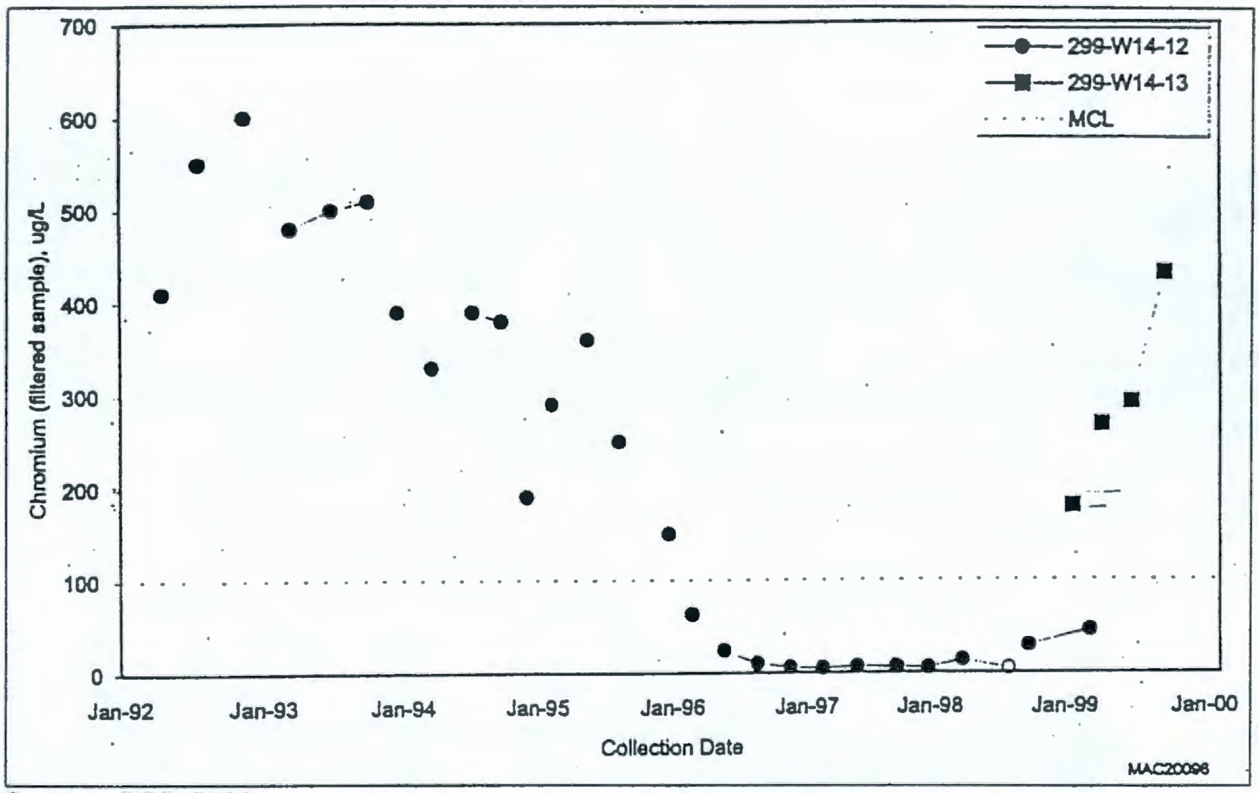
Wells 299-W14-12, 299-W14-13, 299-W15-22, and 299-W15-4 near WMA TX-TY contain contaminants considered to have originated from tank leaks (PNNL-13116). Contaminant levels of chromium, cobalt-60, iodine-129, nitrate, technetium-99, and tritium were elevated in well 299-W14-12 when it was first sampled in 1992 and remained high for several years before dropping to low levels in 1996. Technetium-99 had a high value of 13,300 pCi/L in November 1992 (Figure 3.5) (PNNL-13116). Similarly, chromium had its highest value of 600 µg/L in November 1992 (Figure 3.6). At about the same time, elevated levels of other constituents have also occurred in well 299-W14-12, including calcium and magnesium and, to a lesser extent, sodium (PNNL-13116).

Figure 3.5. Historical Technetium-99 Concentrations Near WMA TX-TY



Source: RPP-7123.

Figure 3.6. Chromium in Wells 299-14-12 and 299-W14-13



Source: RPP-7123.

Recently, both technetium-99 and chromium increased in well 299-W14-12 until it went dry and was replaced by well 299-W14-13 where technetium-99 and chromium continue to increase in concentration. Groundwater flow direction in the vicinity of well 299-W14-12 was toward the northeast when monitoring was initiated, but gradually changed to a southeasterly flow, probably in response to the 200 ZP-1 operable unit pump-and-treat operations south of WMA TX-TY. It seems plausible that recent increases in contaminant concentrations in well 299-W14-13 are related to this groundwater flow direction. It is unclear whether the source of this contamination is the same or a different source than the one providing the contamination peaks in 1992. The present location and extent of the earlier pulse are uncertain because of the lack of monitoring wells to the east of WMA TX-TY.

Technetium-99 in well 299-W15-22 (located in the southwestern corner of WMA TX-TY) was increasing in fiscal year 1998 to an average activity of 3,100 pCi/L. Slight increases in chromium and nitrate were also observed. In the water samples that were collected, no clear increases in other constituents are observed as in well 299-14-12. The near-simultaneous increase of these three constituents suggests a tank leak source, not necessarily the same leak source that affects wells 299-W14-12 and 299-W14-13. Again, expecting that the 200-ZP-1 operable unit pump-and-treat operation has had some influence on these observations is reasonable. Because of declining water levels, this well cannot be sampled again and has not yet been replaced.

Finally, technetium-99 levels also have increased in well 299-W15-4 since the initiation of the 200-ZP-1 operable unit pump-and-treat operations south of WMA TX-TY. Concentrations exceeded the drinking water standard of 900 pCi/L (EPA-822-96-002) in July 1999, though the most recent sample in October 1999 was below the drinking water standard. Well 299-W15-4, originally constructed to monitor the 216-T-19 crib, is directly south of the WMA in a direct flow path between WMA TX-TY and the nearest extraction well. It is possible that a WMA TX-TY tank leak is the source of the technetium-99 observed in well 299-W15-4.

3.1.5 Surface Water and River Sediment

Based on contaminant plume maps in PNNL-13116, surface water and river sediment contamination has not occurred related to contamination releases associated with WMAs T and TX-TY.

3.2 POTENTIAL CORRECTIVE ACTION REQUIREMENTS

The purpose of this addendum is to propose field investigations in the vicinity of WMAs T and TX-TY to characterize these sites sufficient to reach a decision as to whether corrective action is needed. The RCRA corrective action process as specified in Section 7 of the Tri-Party Agreement is used to establish the framework within which vadose zone investigations at WMAs T and TX-TY are planned and conducted. Based on Section 7.5 of the Tri-Party Agreement, any required corrective action at WMAs T and TX-TY will be conducted to comply with federal and state environmental laws and promulgated standards, requirements, criteria, and limitations that are legally applicable or relevant and appropriate requirements under the circumstances presented by the release or threatened release of dangerous substances, pollutants, or contaminants. Site-specific and plateau-wide potential applicable or relevant and appropriate requirements are identified and discussed in Section 2.0 and Appendix F of DOE/RL-99-36 that was prepared pursuant to proposed Tri-Party Agreement Milestone M-45-51 (Ecology et al. 1999). DOE/RL-99-36 includes identification of potential corrective action standards for protection of human health and the environment.

Only two potentially applicable or relevant and appropriate requirements from the list in Appendix F of DOE/RL-99-36 are not applicable or relevant and appropriate requirements for this addendum. These requirements are related to emissions of asbestos-related material during disposal or demolition and renovation activities (40 CFR 61 Subpart M).

3.3 POTENTIAL IMPACTS TO PUBLIC HEALTH AND THE ENVIRONMENT

This section presents a preliminary conceptual model of the vadose zone portion of the groundwater exposure pathway because the vadose zone is the focus of this addendum. The vadose zone conceptual model is a set of working hypotheses made up of elements of tank waste characteristics, past leak characteristics, geology, hydrogeology, and driving forces that include infiltration from precipitation and human sources of water. The data, both existing and to be collected, will be used to test these hypotheses. If the hypotheses are consistent with the data, then that consistency would initially be deemed an endorsement. If the hypotheses are not consistent, then the hypotheses will be revised in an effort to refine and improve the conceptual model.

DOE/RL-99-36 focuses on all potential exposure pathways, including groundwater (Ecology et al. 1999). The conclusions in the following subsections are based on preliminary data and are tentative; they will be subject to refinement as data are gathered during the RFI/CMS process.

3.3.1 Conceptual Exposure Pathway Model

This section presents a preliminary vadose zone conceptual model for WMAs T and TX-TY. The conceptual model is based on information presented in Section 2.0 and Section 3.1 of this addendum and is, therefore, intended to be preliminary. The exposure pathway in this conceptual model is limited to near-surface releases associated with the waste tanks and transport in the vadose zone and is shown conceptually in Figure 3.7. Through the corrective action process, the concepts illustrated in Figure 3.7 must ultimately be confirmed, disproved, or shown to be inconsequential in the context of retrieval and closure, including the WMAs T and TX-TY endstate. A generalized conceptual model is provided in Section 4.0 of DOE/RL-99-36 and identifies the preliminary conceptual model of this addendum.

The data and evaluations previously discussed are integrated and summarized in this section in the form of a preliminary vadose zone conceptual model. The conceptual model is a preliminary working effort because the data are not complete, not all the data have been evaluated, and in many cases, the data are not validated. The purpose of the vadose zone conceptual model is to help focus the preliminary field data collection. The vadose zone conceptual model will be refined in the site-specific Phase 1 RFI/CMS field investigation report for WMAs T and TX-TY based on evaluation of the data collected under the guidelines in this addendum and the continued evaluation of existing data.

The contaminant sources, mechanisms for these contaminants to be released into other environmental media, potential types of movement through the vadose zone, and one type of potential receptor are shown conceptually in Figure 3.7. The schematic illustrated on Figure 3.7 — together with estimates of values for key parameters (e.g., contaminant concentrations) — are a part of the basis for assessing initial human health risks associated with the various contaminants and receptors.

The results of the human health risk assessment will be provided in the site-specific Phase 1 RFI/CMS field investigation report for WMAs T and TX-TY. The vadose zone conceptual model is used in this addendum to qualitatively express the current understanding of the following:

- Pathways that contaminants may follow to the groundwater based on the integration of contaminants, hydrochemical, hydrogeologic, and geologic data (inferences are made on relatively sparse and unevenly distributed data)

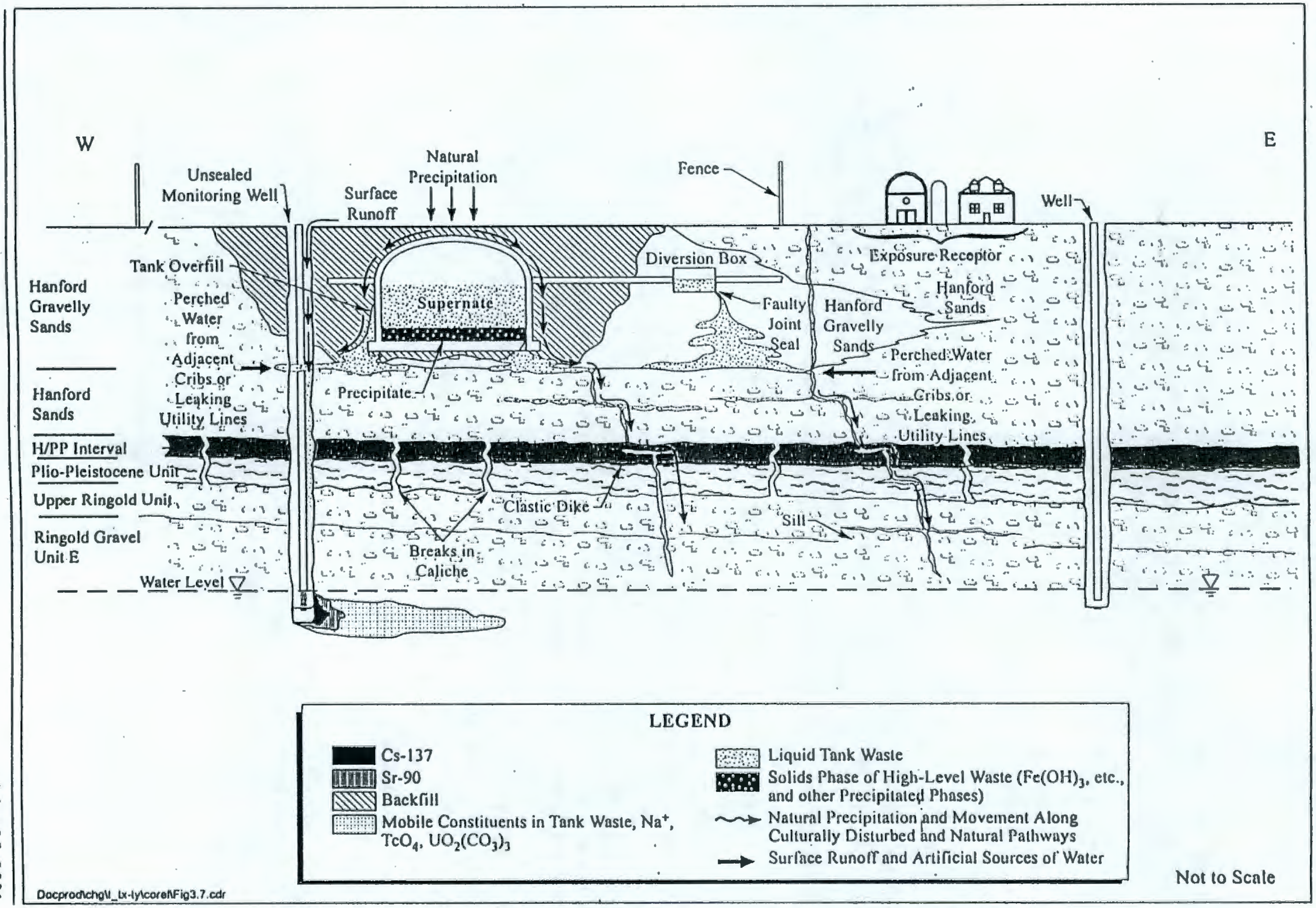


Figure 3.7. Preliminary Generalized WMAs T and TX-TY Vadose Zone Conceptual Model

- Contaminant sources with most of the available data for source locations for the upper 40 m (130 ft) of the vadose zone (inference is made to the presence of contaminants in the lower vadose zone based on groundwater contamination and historic records of water levels).

Key aspects of the WMAs T and TX-TY vadose zone conceptual model required to support this addendum are summarized in the following subsections.

3.3.1.1 Sources

3.3.1.1.1 Chemical Processing. Irradiated nuclear fuel from the Hanford Site plutonium production reactors contained fission products and lesser amounts of neutron activation products as well as the unreclaimed uranium and transuranic radionuclides. Plutonium was chemically extracted from the fuel matrix at T Plant and S Plant in the 200 West Area and B Plant and A Plant in the 200 East Area.

The T, TX, and TY tank farms received waste generated by a variety of major chemical processing operations, roughly in parallel with operations at the B, BX, and BY tank farms. The T, TX, and TY tank farms contain aqueous waste generated from five different operations: wartime bismuth phosphate plutonium separations (1943-1945), post-war bismuth phosphate operation (1946-1956), uranium recovery and scavenging (1952-1958), in-tank solidification (1960-1974), and interim stabilization and isolation (1975-present) (RPP-5957).

3.3.1.1.2 Tank-Related Considerations. The SSTs are constructed of a single layer of carbon steel surrounded by a layer of reinforced concrete, which forms the roof and sidewall support. The tanks declared leakers in the T, TX and TY tank farms (Section 3.1.1) apparently failed because of waste transfer leaks and/or accelerated corrosion of the steel liner and leaked through the reinforced concrete.

The vadose zone conceptual model for this addendum focuses on those contamination sources in the vicinity of the SSTs in WMAs T and TX-TY. As discussed in Section 3.1 and RPP-7123, one hypothesis for the observed contaminants in the RCRA groundwater monitoring wells is that contaminants from tank leaks have migrated downward through the vadose zone and then traveled in a direction consistent with the local groundwater flow. Releases from the SSTs in WMAs T and TX-TY could represent a significant present contamination source in the vadose zone. It is certain that the leaks from those tanks contained several radioisotopes and chemicals commonly found in tank waste (e.g., cesium-137, technetium-99, sodium, chromium, and nitrate). Thus, contaminants (i.e., technetium-99, chromium, and nitrate) that are remnants of these past leaks are likely present in the vadose zone, especially within the finer-grained sediments of the Hanford formation. RPP-7123 provides a discussion of the contaminated areas in WMAs T and TX-TY.

3.3.1.2 Geologic Conceptual Model. The geology of the T, TX and TY tank farms was documented after the drywell boreholes were completed in the early 1970s (ARH-LD-137, ARH-LD-135, and ARH-LD-136). The major stratigraphic units of the suprabasalt sediments present beneath WMAs T and TX-TY are the Ringold Formation, Plio-Pleistocene unit, H/PP?

interval, and the Hanford formation (in ascending order) (see Section 2.0). Several sources of data were included in evaluating valid conceptual model(s) for the T, TX, and TY tank farms geology (ARH-LD-135, ARH-LD-136, ARH-LD-137, HNF-2603, Lindsey 1996, PNNL-11809, Slate 1996, RPP-7123, WHC-SD-EN-TI-008, WHC-SD-EN-TI-014). Potential geologic control or influence on contaminant migration in the vadose zone is of particular interest. Elevation maps of the basalt are presented in Figure 2.4 and for the other stratigraphic units in RPP-7123 and will be used as a source for this information.

Clastic dikes, illustrated conceptually in Figure 3.7, are lenses or tabular bodies, relatively narrow at 18 to 38 cm (7 to 15 in.) (BHI-00230, BHI-01103), with textural characteristics typically comprised of clay and sand. The presence of clastic dikes has been observed in these WMAs. The localized effect of the dikes on contaminant movement may occur over the scale of a few meters, but no direct indication of this movement has been measured. The geologic cross-sections provided in RPP-7123 represent the preliminary working geologic conceptual model for this work plan.

3.3.1.3 Hydrologic Properties. Preliminary hydrologic property values will be provided in the site-specific Phase 1 RFI/CMS field investigation report for WMAs T and TX-TY that will be prepared pursuant to proposed Tri-Party Agreement Milestone M-45-55-T03 (Ecology et al. 1999).

3.3.1.4 Receptors. Receptors are organisms with the potential for exposure to the released contaminants and include both biota and humans. A likely point of exposure for terrestrial biota is in the plant root zone where flora could absorb buried contaminants. Terrestrial animals (especially burrowing animals) may be exposed by direct contact, inhalation, and ingestion of contaminated sediment, water, plants, and animals.

For the receptors, the site-specific Phase 1 RFI/CMS field investigation report for WMAs T and TX-TY will use "Model Toxics Control Act Cleanup Regulation" (WAC 173-340) Methods B and C exposure scenarios at these WMA boundaries to evaluate human health risks for the chemicals, the Hanford Site risk assessment methodology (DOE/RL-91-45) and the 15 mrem/yr dose above background standard (EPA OSWER Directive No. 9200.4-18) as stated in RPP-7455 to evaluate human health risks from radionuclides.

The Model Toxics Control Act Method B (defined in WAC 173-340-705) residential scenario is a combination of the risk equations specified in WAC 173-340-720 through 173-340-750 inclusive of sections 173-340-7490 through 173-340-7494. The Model Toxics Control Act Method C (defined in WAC 173-303-706) industrial scenario is a combination of the risk equations specified in WAC 173-340-720 through 173-340-750 inclusive of sections 173-340-7490 through 173-340-7494. WAC 173-340-730 is not applicable to either scenario as it is not expected that WMAs T and TX-TY or any remedial activity under consideration will impact surface water.

4.0 RATIONALE AND APPROACH

The RFI/CMS process is the RCRA-specified method by which risks from releases to the environment are characterized and corrective action alternatives are evaluated and implemented if required to minimize potential risks to human health and the environment. Objectives and data needs must be identified before designing a data collection program to support the RFI/CMS process. The data collected are used as a basis for making an informed risk management decision regarding the most appropriate corrective action(s) to implement. The data needs for field characterization efforts at WMAs T and TX-TY were identified through a DQO process that was executed based on the requirements established in the proposed Tri-Party Agreement commitments identified in Change Control Form Number M-45-98-03 (Ecology et al. 1999) and in Section 6.0 of DOE/RL-99-36. The data needs identified in the DQO planning process will be collected in accordance with DOE/RL-99-36 (proposed Milestone M-45-51) and this addendum (proposed Milestone M-45-54).

4.1 RATIONALE

An understanding of subsurface conditions and contaminant migration processes is required to support decision making on interim measures and ICMs, SST waste retrieval, and tank farm closure. A comprehensive list of data needs to support these decisions has been developed based on the current level of understanding. However, it is generally recognized on both a technical and regulatory basis that uncertainties regarding existing contaminant inventory, distribution of contaminants in the vadose zone from past leaks, and uncertainties associated with contaminant migration processes are of primary importance to future decision making. The need to reduce these uncertainties through field and laboratory investigations serves as the basis for initiating characterization activities through this addendum.

Characterization objectives and data needs for WMAs T and TX-TY were developed during the DQO planning process that was carried out for the Phase 1 RFI/CMS work plan (DOE/RL-99-36) and this addendum. A separate DQO process (RPP-7455) was conducted to support the development of this document.

The DQO process is a planning tool to aid in the determination of the type, quantity, and quality of data needed to take the next step in the iterative process of characterizing a contaminated site or area. There are a number of possible approaches to implementing the DQO process. The planning process used to identify data collection activities in this addendum is described in Section 6.0 of DOE/RL-99-36 and summarized in this section and RPP-7455.

Before initiating meetings to discuss characterization activities to be conducted in the fiscal year 2002 timeframe, the Tank Farm Vadose Zone Project technical team conducted a review of existing information that included published and unpublished reports, interpretations of historical and recent geophysical survey data, and information from previous DQO meetings. To prioritize data needs for inclusion in the fiscal year 2002 effort, a review of the available information on the current state of knowledge of WMAs T and TX-TY subsurface contamination was conducted by the Tank Farm Vadose Zone Project technical team. The review results were incorporated into RPP-7123 and summarized in RPP-7455 and Section 3.0 of this addendum.

A series of DQO meetings were held from November 2000 to January 2001 that focused specifically on the data needs for the field characterization efforts to be conducted at WMAs T and TX-TY. These meetings served to identify the following:

- Existing data and what is currently known about WMAs T and TX-TY
- Data needs that will likely be satisfied by fiscal year 2002 characterization activities
- Options for data collection from the additional characterization activities.

The DQO meetings included representatives from Ecology, DOE, Hanford Site contractors, stakeholders, Tribal Nations, Oregon Department of Energy, and Hanford Site Vadose Zone/Groundwater Integration Project as indicated in RPP-7455.

Meetings held as a part of the DQO process involved varying levels of involvement by all participants. The DQO meetings provided a foundation of existing information and identification of characterization options for consideration by the decision makers.

Through the DQO process, it was determined that the primary goal of the WMAs T and TX-TY field investigation is to implement vadose zone characterization activities that will support the iterative process of improving the understanding of inventory (i.e., nature and extent of past releases) and contaminant migration processes (fate and transport) necessary to support risk assessments. Additional characterization data are needed to support near-term corrective measures decisions and SST waste retrieval and tank farm closure decisions.
The characterization effort will provide data that, when combined with historical data, will improve the ability to make informed corrective measures, waste retrieval, and tank farm closure decisions.

4.2 DATA NEEDS

Current understanding of the nature and extent of contamination at WMAs T and TX-TY is based largely on order-of-magnitude estimates of past leak volumes and inventories and on historical information on the distribution of gamma-emitting radionuclides measured to a depth of 30.5 to 45.7 m (100 to 150 ft) in drywells located around the tanks. Historical drywell gross gamma data was collected from the early 1960s through 1994; however, detailed analysis of the gross gamma data has only recently been conducted. Three reports have been issued on this subject, one for the T tank farm (RPP-6088) one for the TX tank farm (RPP-6353) and one for the TY tank farm (HNF-3831).

Comprehensive spectral gamma logging of all drywells in WMAs T and TX-TY was completed in the 1996 through 1999 period. Spectral gamma logging reports have been issued for the T, TX, and TY tank farms (GJO-HAN-27, GJO-HAN-11, GJO-HAN-16). Spectral gamma logging data provide greater insight into the distribution and movement of specific gamma-emitting contaminants (e.g., cesium-137). However, limited data exist on the distribution of non-gamma-emitting mobile tank waste contaminants (e.g., technetium-99, hexavalant chromium, and nitrate). While there is emerging data on the distribution and movement of tank waste contamination in the groundwater, the data are not sufficient to support more than qualitative hypotheses on the specific sources of contaminant releases responsible for the observed groundwater contamination.

During the DQO process, the participants determined that the primary focus of the fiscal year 2002 data collection effort at WMAs T and TX-TY should be directed toward characterizing the contamination source in the vicinity of the probable largest releases. This effort should improve the understanding of tank leak inventory and distribution to support testing and refining a site-specific conceptual model for tank leaks and contaminant migration processes. A number of characterization technologies, including screening techniques, were considered. Because the current understanding of the distribution of radionuclides in the leak-contaminated vadose zone is still limited and is based primarily on indirect evidence, the focus of the fiscal year 2002 data collection program at WMAs T and TX-TY will be on sampling the vadose zone soils in areas of known tank leaks, spills, and overfill events within the tank farms and analyzing the samples for a range of contaminants of interest.

4.3 CHARACTERIZATION OPTIONS

The Tank Farm Vadose Zone Project technical team plans to use existing information and the characterization data collected during the Phase 1 characterization to develop a best basis or best estimate of the concentration and distribution of CoCs in WMAs T and TX-TY. This will involve the integration and synthesis of historical data, process knowledge, in-tank inventory models, and the characterization data collected during Phase 1. The integration and synthesis of these data will require interpolation and extrapolation due to the limitations of collecting samples within the tank farms. This effort will result in a conceptualization of CoC concentrations and distributions that would be used to evaluate human health and environmental risks.

Based on data needs identified in Section 5.0 of RPP-7455 and in the DQO meetings, a number of characterization options were considered for the fiscal year 2002 effort at WMAs T and TX-TY. These characterization options included installing new boreholes; decommissioning and/or extending existing boreholes; using direct-push technology; using auger drilling; and using nonintrusive geophysical techniques. These options are based on characterization techniques and innovative technologies identified in Section 6.3 of DOE/RL-99-36 for methods that have been successfully used on the Hanford Site. These options and potential deployment locations were evaluated in terms of the type of information that could be provided, as well as the technical risk associated with deployment during fiscal year 2002. Although all of the options considered could provide valuable data that would serve to improve the understanding of subsurface contamination, a number of the options were considered to be of lesser value or not feasible due to technical risk for the characterization effort to be implemented in fiscal year 2002. The list of characterization options considered during the DQO process, along with the rationale for including or omitting each option from the fiscal year 2002 effort, is provided in RPP-7455.

The characterization options selected for implementation at WMAs T and TX-TY during fiscal year 2002 are provided in Table 4.1 and consist of vertical borehole installation near selected tank waste releases. Table 4.1 includes the sampling method, implementation design, and rationale. The DQO process identified three sites for installation of vertical boreholes, (tanks T-106, TX-105, and TX-107). Based on comments received on RPP-7455 from Ecology, the vertical borehole at tank T-106 has been reprioritized and is not included in fiscal year 2002 vadose zone characterization efforts. This initial (Phase 1) site-specific investigation to be conducted in fiscal year 2002 is anticipated to entail the installation of three vertical boreholes near tanks TX-105 and TX-107. An additional vertical borehole may be installed in fiscal year 2002 provided funding is available and its installation is consistent with other schedule priorities.

4.3.1 Installation of Vertical Boreholes

Several options were considered for collection of deeper vadose zone data. The preferred option was installation of vertical borehole(s). Three locations, in the vicinity of tanks TX-105 and TX-107, will receive boreholes as part of the initial site-specific investigation in fiscal year 2002. An additional location inside WMA TX-TY boundaries (east of tank TX-105 or southwest of tank TX-107) associated with known past releases (Table 4.1) may receive a borehole provided adequate funding and sufficient schedule are available. If this additional borehole is not conducted in fiscal year 2002, attempts will be made to install this and an additional two other boreholes in fiscal year 2003 or during Phase 2 characterization activities, depending on decisions made by Ecology and DOE. The potential target areas around tanks TY-105 and TY-106 for future field investigations would be considered again at this time. Vadose zone samples would be collected as the borehole(s) are advanced down to the top of the Ringold unit E (47 m [150 ft] bgs)or maximum extent of contamination, whichever is deeper unless refusal is encountered. Determination of maximum extent of contamination will be through gamma screening of cuttings or soil samples with non detect gamma indication for 1.5 m (5 ft). This option was selected because a vertical borehole at these locations (i.e., in the vicinity of tanks TX-105 and TX-107) would provide source characterization along with distribution of contaminants at the locations of interest from within WMAs T and TX-TY. Source characterization would do the following:

- Provide a basis for estimating contaminant inventories and processes that would control the migration of contaminants

- Support evaluation of the correlations between concentrations of CoCs and existing gamma data, and potentially support evaluation of the relationship between the CoCs in the soil and the concentrations of CoCs present in the tanks at the time the leaks were believed to occur

- Support assessment of contaminant mobility; potential drivers (e.g., moisture content); and the effects of tank leaks on soil properties to support predictive numerical modeling efforts necessary to evaluate potential future groundwater impacts, the associated risks, interim corrective measures, and further characterization as warranted.

Source characterization efforts also would involve identifying what contaminants are present and, subsequently, identifying the potential CoCs for corrective action, retrieval, and closure decisions. If correlations between the CoCs and available gamma data can be established, there is a potential that the wealth of existing gross gamma and spectral gamma data can be used to better understand the location and distribution of CoCs in the vadose zone.

Table 4.1. Proposed WMAs T and TX-TY Phase 1 Characterization Design

Area of Interest	Screening Technology	Sampling Method	Implementation Design*	Rationale
Tank 241-TX-105	Gross alpha/beta; gamma spectrometry, soil moisture	Vertical borehole. Borehole advanced using cable tool drilling rig or pile driver with split-spoon or core barrel sampler for subsurface sample recovery.	Vertical borehole planned to top of Ringold unit E gravels or maximum extent of contamination, whichever is deeper. Collect soil samples by split-spoon techniques at 3-m (10-ft) intervals beginning 9 m (30 ft) bgs and continue to 45.7 m (150 ft) bgs or maximum extent of contamination, whichever is deeper. All samples would be conditionally analyzed for the CoCs.	The vertical borehole needed to determine CoC distribution, support risk assessment, and correlate to local groundwater observations. The largest and deepest migration of uranium isotopes in the WMA is associated with releases from this tank.
Tank 241-TX-107	Gross alpha/beta; gamma spectrometry, soil moisture	Vertical boreholes. Boreholes advanced using cable tool drilling rig or pile driver with split spoon or core barrel sampler for subsurface sample recovery.	Attempt to drill to top of Ringold unit E gravels or maximum extent of contamination, whichever is deeper. Collect soil samples by split-spoon techniques at 3-m (10-ft) intervals beginning 9 m (30 ft) bgs and continue to 45.7 m (150 ft) bgs or maximum extent of contamination, whichever is deeper. All samples would be conditionally analyzed for the CoCs.	The vertical boreholes needed to determine CoC distribution, support risk assessment, and correlate to local groundwater observations. Spectral gamma survey of this release indicates a substantial potential for downward and horizontal migration of contaminants. This investigation activity will support evaluation of potential contribution to observed groundwater contamination by technetium-99.

*Figure 4.1 indicates the proposed locations as discussed in the implementation design.

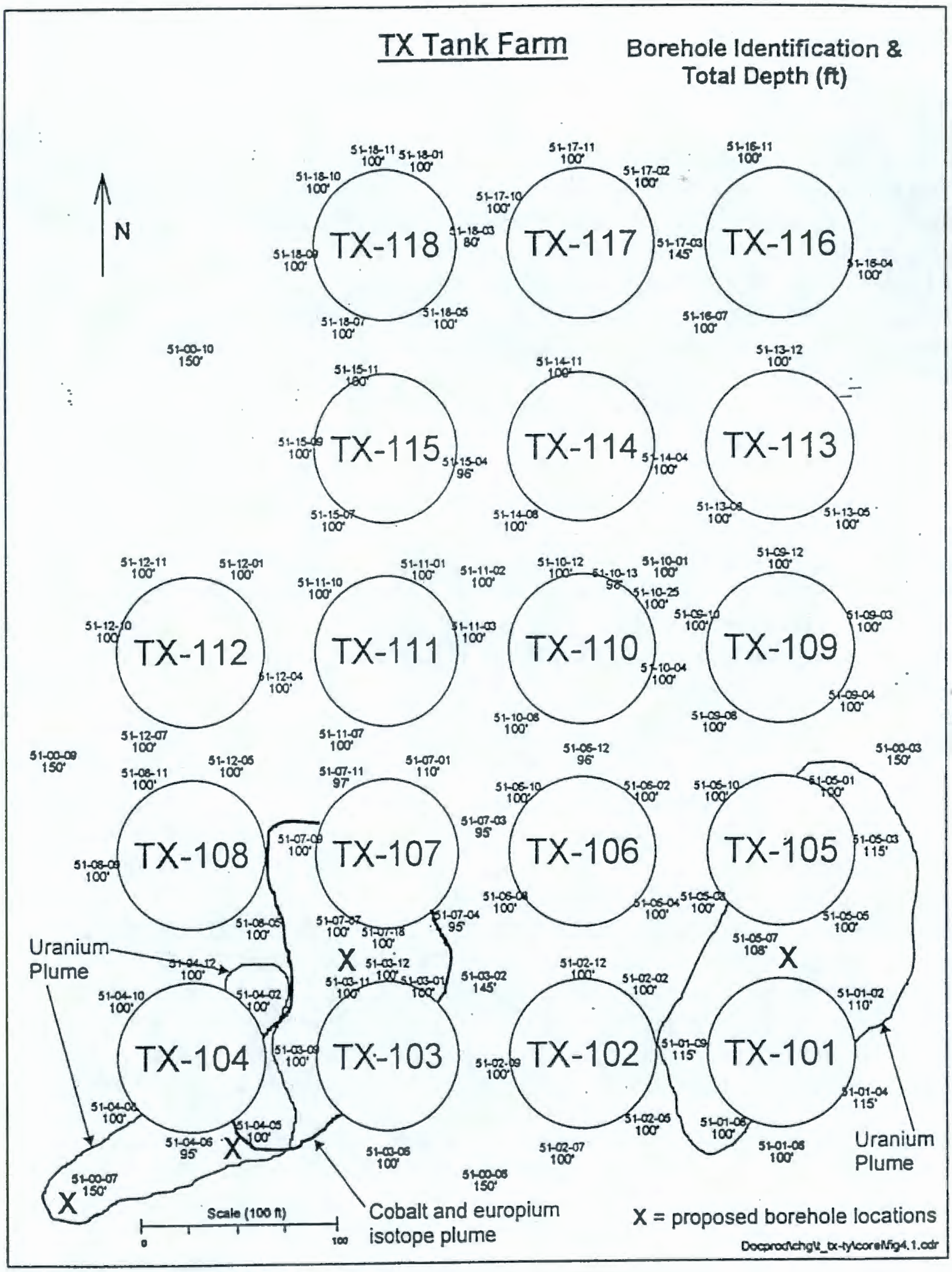
bgs = below ground surface.
CoC = contaminant of concern.
WMA = waste management area.

4.3.1.1 Borehole Locations. Candidate locations for vertical borehole installation considered in the DQO process are presented in RPP-7455. Each option evaluated was identified because samples from the identified locations could provide data to address source characterization (i.e., nature of contamination); location and distribution (i.e., extent of contamination); and transport pathways and processes (i.e., contaminant fate and transport). An additional consideration was potential programmatic risk (i.e., risk to the program if the characterization effort were unsuccessful) associated with a fiscal year 2002 deployment. Each option could provide data to address a number of different questions and data gaps. A location (i.e., vicinity of tanks TX-105 and TX-107) has been identified from these evaluations (Figure 4.1). The locations were selected based on historical knowledge of WMAs T and TX-TY (e.g., waste transfer records, leak history, previous vadose zone characterization efforts, historical gross gamma logging data, recent spectral gamma logging data, and RCRA groundwater assessment findings). Based on the information provided in RPP-7123 and as summarized in Section 3.0, the DQO participants decided that one of the areas of interest in the WMAs T and TX-TY was in the vicinity of tank TX-105. A vertical borehole is recommended to be placed south of tank TX-105, between tanks TX-105 and TX-101 (Figure 4.1). The spectral gamma database shows a potentially large metal waste contamination zone indicated by high uranium concentrations in several drywells around and between tanks TX-105 and TX-101. Contaminant information is not available for this zone except for the uranium isotopes but it is expected that technetium-99 will be present in this zone. The concentration and distribution of technetium-99 can be partially determined by completing a deep borehole in the middle of the plume. Because the waste source is metal waste, a relatively high inventory of technetium-99 may be present.

For the tank TX-107, a vertical borehole is recommended to be placed immediately south of the tank (Figure 4.1). Review of the spectral gamma database indicates an extensive and fairly well-defined contaminant zone from a past leak event. Similarly, the historical gross gamma record provides a relatively detailed tracking of the leak event. As indicated by the spectral gamma database, there are relatively high concentrations of cobalt-60 and europium isotopes in this area. There may also be approximately 4.57 curies of technetium-99 based on prediction from the Hanford defined waste model (RPP-7123) which may be associated with the recent occurrence of technetium-99 peaks in nearby groundwater monitoring wells. The technetium-99 inventory estimate of 4.57 curies is directly related to the leak volume estimate (i.e., 30,280 L [8,000 gal] for tank TX-107) and may be much larger if the volume estimate is low.

A third vertical borehole is recommended to be place southeast of tank TX-104. Review of spectral gamma data indicates that the leading edge of the contaminant zone attributed to tank TX-107 extends to the southwest and is last recorded in drywell 51-04-05. The additional information from this borehole would provide the horizontal extent of this contamination. The southern boundary of the tank farm is encountered in this direction and drywell coverage may not have intercepted the leading edge of the plume as it migrates downdip within the vadose zone. Additionally, the historical gross gamma database supports this borehole as being unstable. In addition, a metal waste leak based on uranium-238 identified in the spectral gamma logging begins from drywell 51-04-05 and extends southwest to drywell 51-00-07. This borehole would support the leading edge of migration from contaminates released from tank TX-107 tank or ancillary equipment as well as a release of metal waste from tank TX-104.

Figure 4.1. TX Tank Farm Borehole Locations



Modified from RPP-6353.

Based on adequate funding and sufficient schedule, a fourth borehole may be attempted either southwest of drywell 51-00-07 or east of tank TX-105 depending on the preliminary analytical data collected from the other boreholes. This borehole would assist in defining the horizontal extent of migration in the vadose zone or the source (i.e., pipe leak from diversion boxes to the east and feeding tank TX-105).

4.3.1.2 Borehole Construction and Sampling Methodology. The final borehole construction and sampling methodology for the vertical boreholes in WMAs T and TX-TY has not been completed. Installation of these boreholes is targeted to intercept tank waste plumes and could encounter highly contaminated sediments. The proposed sampling methodology to be used during construction of the WMAs T and TX-TY boreholes is to collect sediment samples ahead of the casing. There are a number of uncertainties associated with application of this sampling methodology. The primary uncertainty is associated with the potential worker doses resulting from handling highly radioactive samples. Additional uncertainties include sample handling in the laboratory and interfaces between the field and the laboratory. Limitations associated with collecting sediment samples include having to sample without the benefit of gamma ray logging to identify radiation levels. Because of this limitation, the details of the sampling plan will be developed assuming that each sample has the potential to be highly contaminated. The final borehole construction and sampling methodology for the vertical boreholes in WMAs T and TX-TY will be designed to maintain compliance with the requirements of the Notice of Construction (DOE/ORP-2000-05) for drilling operations inside the tank farms. The following subsections provide the history and rationale for installation of a borehole at the three locations and an additional borehole within the TX tank farm provided adequate funding and schedule constraints.

4.3.1.2.1 Tank TX-105 Borehole. Eight of the eighteen 23-m- (75-ft-) diameter tanks in the TX tank farm are listed as being confirmed or suspected leakers (HNF-EP-0182-150). Reliable leak estimates are not available for any of these tanks. Except for tank TX-107, the remaining 7 tanks all are estimated to have leaked about 30,283 L (8,000 gal). This is a non-tank-specific value averaged over 19 tanks located in several tank farms that are considered to have leaked a total of 567,810 L (150,000 gal). Tank TX-105 is listed in HNF-EP-0182-150 as a suspected leaker because of small drops in liquid level in the tank. Elevated gamma readings in drywells monitoring tank TX-105 also were used as evidence of leaking from this tank (GJO-HAN-11). Interpreted historical gamma data in drywell 51-05-08 indicate migration of ruthenium-106 at 11 m to 16 m (36 to 54 ft) between 1975 and 1977. Given several recorded instances of unexplained liquid level drops in tank TX-105 starting in 1973, the ruthenium-106 movement may be a corroborating indicator of leakage from this tank or piping associated with this tank.

Uranium-238 and uranium-235 are found in a set of drywells around tanks TX-105 and TX-101, including drywells 51-00-03, 51-05-01, 51-05-03, 51-01-05, 51-05-07, 51-01-09, and 51-01-08. Tank TX-101 is located south and adjacent to tank TX-105 (Figure 4.1). A range of uranium-238 concentrations from 1 pCi/g to more than 100 pCi/g exists in this set of drywells from 14 m to 23 m (45 to 75 ft) with the higher contamination levels occurring at shallower depths in the northeast drywells. The uranium-235 concentrations mirror the uranium-238 values at about an order of magnitude lower. A line drawn around the listed drywells outlines a rough oval with the long axis running northeast to southwest. The presence of uranium contamination at these concentrations strongly indicates leakage of metal waste in the early 1950s. No other substantive information is available that describes the nature of this leak (RPP-7123).

A vertical borehole located southwest of tank TX-105 and near the axis of the oval would provide confirmation and better understanding of the nature and extent of non-gamma-emitting contaminants in this zone where no information exists (Figure 4.1).

4.3.1.2.2 Tank TX-107 Borehole. Several small drops in liquid level were noted in tank TX-107 in 1975 and later (GJO-HAN-11); these appear to be true indicators of leakage. Historical and spectral gamma data also suggest leakage from tank TX-107 in the same period. Because large volumes of supernate liquid were transferred through tank TX-107 during the leak period, the liquid loss estimates are highly unreliable. The extent of the contamination attributed to this tank leak suggests that the leak volume estimate of 9,464 L (2,500 gal) is low, perhaps substantially low.

Elevated gamma readings in drywells monitoring tank TX- 107 also were used as evidence of leaking from these tanks (GJO-HAN-11). Drywells 51-03-01, 51-03-11, 51-03-12, 51-07-18, 51-07-07, 51-03-09, and 51-04-05 show commonality in current spectral gamma characteristics and historical migration patterns suggesting leakage from tank TX-107 beginning about 1975. The primary gamma emitter is cobalt-60, which is present from 14 m to 21 m (45 to 70 ft). Europium-154 also is present at 15 m to 18 m (50 to 60 ft) in all but the two southernmost drywells, 51-03-09 and 51-04-05. Historical gamma data indicate migration of cobalt-60 from northeast to the southwest over time between 1977 and 1992. Interpreted historical gamma data (RPP-6353) suggest more than one migration event in drywells 51-03-11, 51-07-18, 51-07-07, and 51-04-05. Given the time of the leak and the tank waste history (RPP-7218), waste lost from this tank was B Plant waste, generated by cesium-137 recovery from PUREX supernate liquid.

A vertical borehole located just south of tank TX-107 near the source of the plume would provide better understanding of the nature and extent of non-gamma-emitting contaminants in this zone where no information exists.

4.3.1.2.3 Tank TX-104 Borehole. An elongated uranium contamination region underlies tank TX-104. This region is similar to the contaminated region underlying tanks TX-105 and TX-101. This contamination zone occurs in the vadose zone at between 14 m and 30 m (45 and 100 ft) with the long axis of the footprint running northeast to southwest. The extent of the zone is well constrained on the north, west, and east sides by the absence of uranium in existing drywells. However, the extent of the zone on the south side where no drywells are present, is unknown. As with the tanks TX-105/TX-101 leak event, the historical record provides no indication of leak volume.

Given the similarities of the two contamination zones, the source of the leak could very well be related to the tanks TX-105/TX-101 leak. The contamination spreading scenario described for the tanks TX-105/TX-101 leak event is considered to be applicable to this leak event as well. Contaminants from this region may or may not have entered the groundwater. Technetium-99, which would be expected to be present in the metal waste fluid, has appeared in wells W15-22 and W15-4 showing peaks in 1998 and perhaps currently. A complicating factor is the pump-and-treat operation occurring just south of the TX tank farm. This operation may be pulling contamination from underneath the tank farm toward the south. If so, at least three sources are plausible for the contamination found in these two monitoring wells, including the two uranium contamination regions and contamination from the tank TX-107 leak event. The soluble uranium may have reached groundwater at about the same time as technetium-99, but it has not been measured in groundwater samples.

4.4 INVESTIGATIVE SAMPLING AND ANALYSIS AND DATA VALIDATION

Samples and data will be collected during the vertical borehole installation while driving the casing and by conducting geophysical surveying as described in Appendix A. Periodic sediment samples will be collected. Sample lengths will be reduced if necessary when penetrating known hot zones to reduce worker exposure. All samples will be field screened for radiation, sealed, refrigerated, and shipped for analysis. Laboratory analyses will be performed on the sediment samples for radiological and geochemical constituents, as described in the Sampling and Analysis Plan presented in Appendix A. Limited analysis for physical parameters (e.g., moisture retention and hydraulic conductivity) may also be performed on sediments that show visible evidence of being altered by the tank leak chemistry (e.g., cementation, discoloration).

Data from the vertical boreholes determined by project management to be relevant for the purpose of validation will be made available by the primary laboratory on request. Validation will be performed in accordance with the quality assurance project plan in DOE/RL-99-36.

5.0 RFI/CMS TASKS AND PROCESS

The primary purpose of this section is to provide a summary of the tasks that will be performed for the WMAs T and TX-TY field investigation. A detailed description of these tasks is provided in the Sampling and Analysis Plan (Appendix A). Tasks are designed to provide information needed to meet the DQOs identified in Section 4.0. Environmental monitoring requirements for protecting the health and safety of onsite investigators are described in DOE/RL-99-36.

Following approval, this addendum will not be modified without notification to Ecology and DOE. Any changes to the scope of work that may be needed will be documented through change requests in accordance with the procedures identified in Appendix A of DOE/RL-99-36.

To satisfy the data needs and DQOs specified in Section 4.0, the following tasks will be performed during the RFI:

- Task 1 – Project Management
- Task 2 – Geological and Vadose Zone Investigation
- Task 3 – Data Evaluation.

The tasks and their component subtasks and activities are outlined in the following subsections. Information about each task is provided to allow estimation of the project schedule (see Section 6.0) and costs.

A separate plan will be developed by the Hanford Groundwater Monitoring Program to cover groundwater investigations at WMAs T and TX-TY (PNNL-12057, PNNL-12072).

5.1 TASK 1 – PROJECT MANAGEMENT

The project management objectives throughout the course of the WMAs T and TX-TY RFI/CMS are to direct and document project activities so the data and evaluations generated meet the goals and objectives of the work plan and to ensure that the project is kept within budget and on schedule. General project management objectives are addressed in Section 7.0 of DOE/RL-99-36. The project management activity will be to assign individuals to the roles established in Section 7.0 of this addendum. Specific subtasks that will occur throughout the RFI and RFI/CMS are addressed in Section 7.0 of DOE/RL-99-36.

5.2 TASK 2 – GEOLOGIC AND VADOSE ZONE INVESTIGATION

The geologic and vadose zone investigation will further characterize the geology of WMAs T and TX-TY and provide additional information on the source, nature, and extent of contamination and the potential migration paths of the contamination.

The geologic and vadose zone information will be evaluated to determine the following:

- WMA conceptual vadose zone model
- Release and movement of contaminants

- Development of ICM alternatives
- Initiation of data collection for support of retrieval and closure activities.

The geologic and vadose zone investigation for WMAs T TX-TY will comprise compiling pertinent existing data and collecting data from drilling activities in the vadose zone. The types of data needed from the surface and vadose zone include the following:

- Thickness and areal extent of geologic units
- Lithology, bedding types, facies geometry, particle size, and sorting
- Presence, concentration, and nature of contaminants in sediments.

Subtasks 2a and 2b have been established to gather geologic and vadose zone data.

5.2.1 Subtask 2a – Field Activities

Field activities will include geologic and geophysical logging associated with deep vadose zone characterization in vertical boreholes south of tanks TX-105 and TX-107. Another borehole installation will be attempted south of tank TX-104. Depending on funding and schedule constraints, an additional borehole installation may be attempted further south or southwest of tank TX-104 or east of tank TX-105. The tentative locations of the planned vertical boreholes are provided in Figure 5.1.

The requirements for geologic and geophysical surveying and sediment sampling for physical and laboratory analytical parameters in the vadose zone borings are provided in Appendix A. Information and data will be collected from the surface downward to the top of Ringold unit E of the Wooded Island member approximately 45.7 m (150 ft) bgs or the maximum extent of contamination, whichever is deeper. Geologic logging will be performed with the drilling operations unless highly radioactive sediments require removal of samples at a separate sample extraction facility.

The following activities are planned for the vadose zone characterization in vertical boreholes.

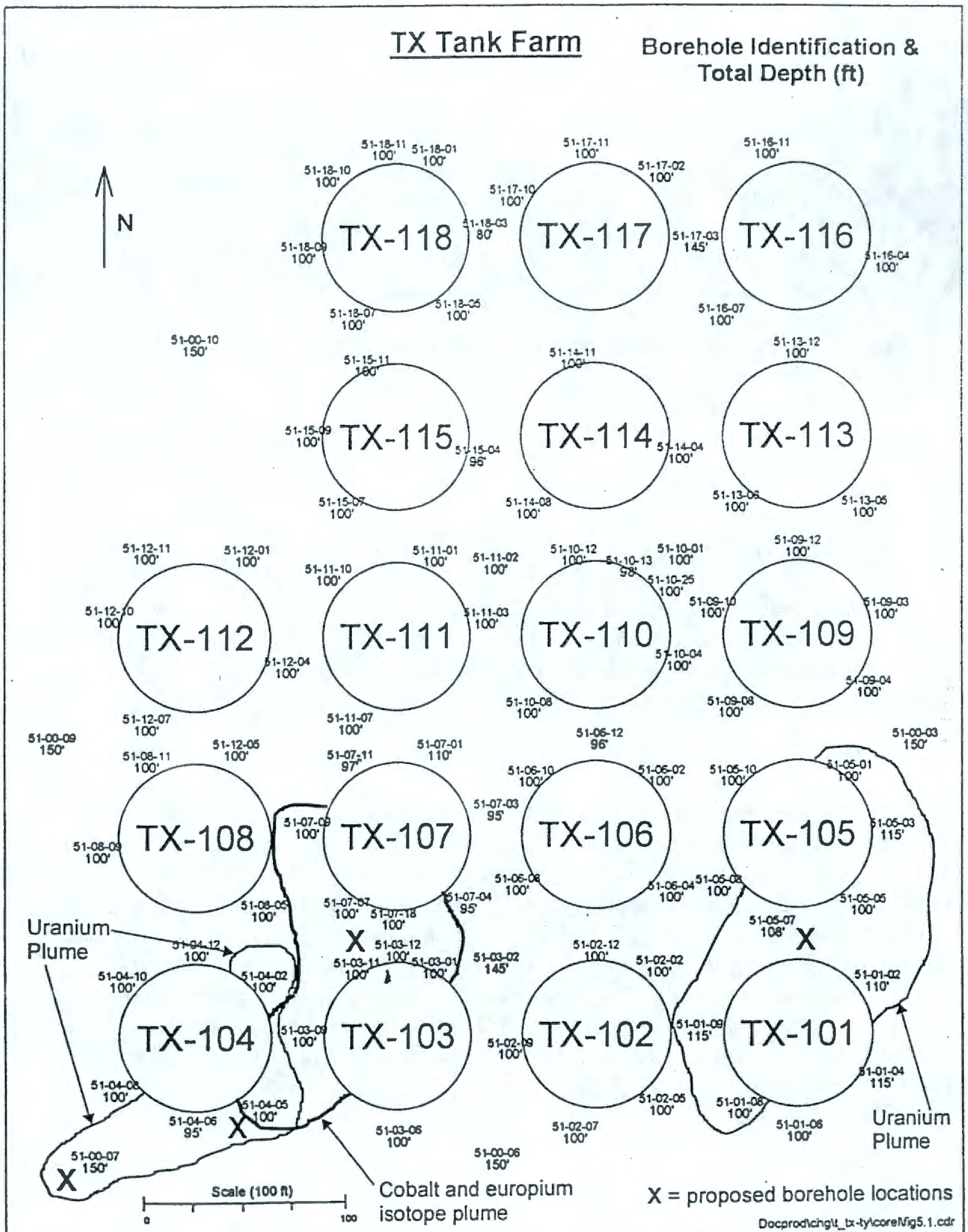
- Conduct borehole geophysical surveying and analysis (i.e., neutron, gross gamma, and spectral gamma.

- Obtain sediment samples to analyze for the presence and concentration of contaminants and to evaluate alterations of the sediments from waste chemistry effects.

- Obtain sediment samples to support preparation of the borehole geologic logs and stratigraphic and lithologic contact correlation with other boreholes and wells in the WMAs T and TX-TY vicinity.

The final design for the vertical boreholes has not been completed. One of the primary constraints on sample collection is the potential radiation level, which will limit the sample volumes that can be brought to the surface for the boreholes at tank locations TX-105 and TX-107.

Figure 5.1. WMAs T and TX-TY Proposed Sampling Locations for Vertical Boreholes



Modified from RPP-6353.

The current planning basis for the vertical boreholes south of tanks TX-105 and TX-107 includes driven samples that will be collected. The samples will be transported to the laboratory and analyzed for the CoCs identified in Appendix A. Nominally, 21 horizons will be sampled based on the geophysical surveys or the need to provide depth coverage as identified in Appendix A.

Subsurface conditions are variable and the process of installing the vertical boreholes must be flexible. Some or all of the work described in Appendix A may require modification. This addendum is intended to serve as a guideline and is designed to allow for changes depending on conditions encountered in the field. Any change will be recorded on the appropriated field documentation, memoranda, or letters. A complete documented record of activities will be maintained for preparation of a final summary report.

Appropriate permits and compliance with the Notice of Construction permit (DOE/ORP-2000-05) will be maintained during the drilling operations for inside the tank farm. The selected drilling method will comply with the requirements of the Washington State Department of Health for the Notice of Construction permit and other pertinent requirements and appropriate engineering systems to prevent the possible contaminated air from being released to the environment.

5.2.2 Subtask 2b – Laboratory Analysis

Laboratory analyses to be conducted for the WMAs T and TX-TY geologic and vadose zone investigation are described in Appendix A. These analyses will include radiological and chemical analysis of selected sediment samples. Physical and hydrologic analysis of selected sediment samples will also be performed.

5.3 TASK 3 – DATA EVALUATION

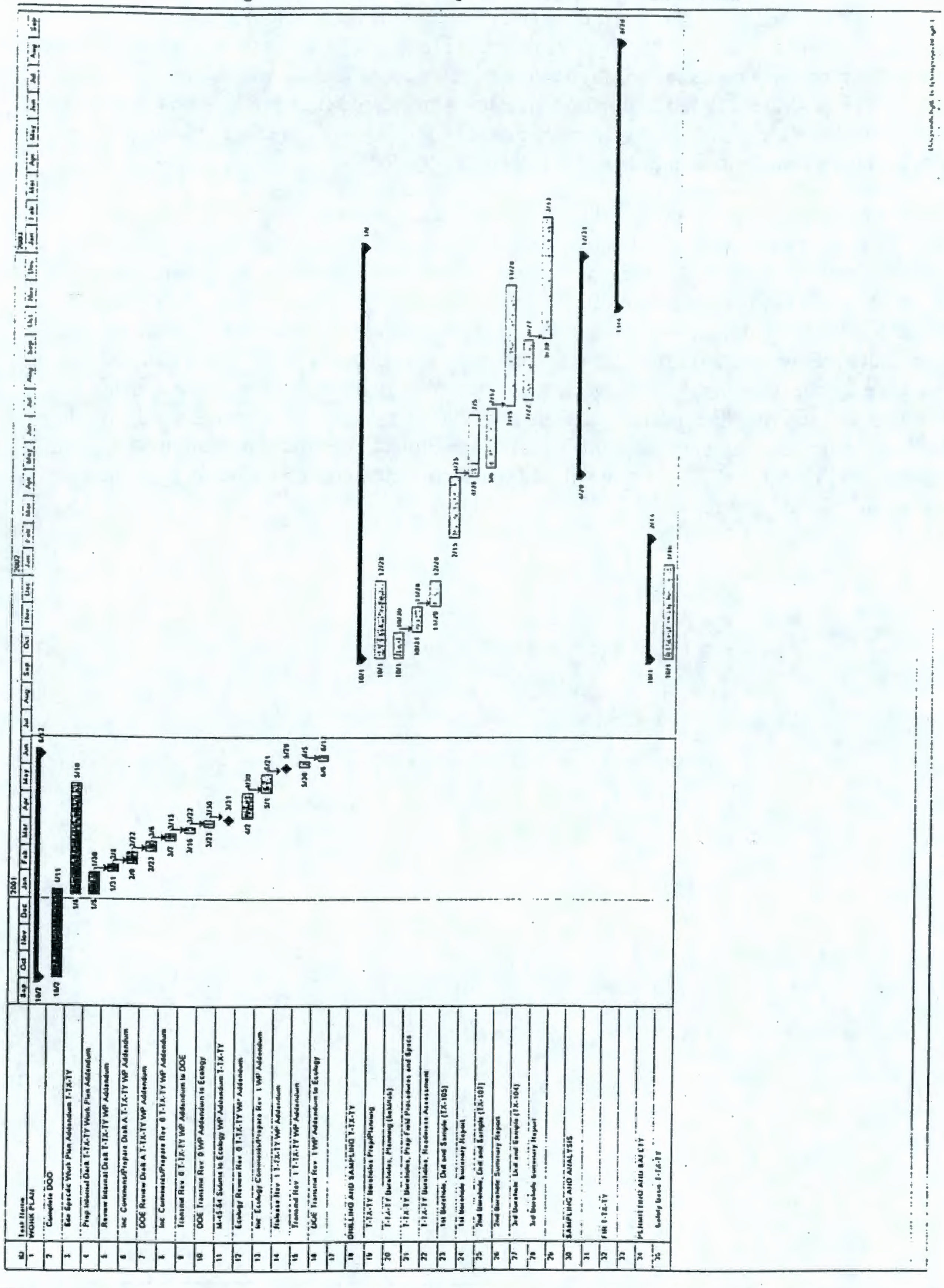
Data generated during the field investigation will be integrated and evaluated, coordinated with RFI activities, and presented in an ongoing manner to allow decisions regarding any necessary rescoping to be made during the course of the project. The assessment of data against the DQOs, use of the data by others, and to support future activities will be conducted and documented in a field investigation report for WMAs T and TX-TY (Ecology et al. 1999). The results of these evaluations will be made available to project management personnel to keep project staff informed of progress being made. The interpretations developed under this task will be used to refine the conceptual model and to determine whether interim measures or ICMs are warranted for WMAs T and TX-TY through a field investigation report for WMAs T and TX-TY to fulfill Tri-Party Agreement Milestone M-45-55-T03.

6.0 SCHEDULE

The work described in Section 5.0 is detailed in the schedule for developing plans and conducting field activities. The schedule, shown in Figure 6.1, is the baseline that will be used to measure progress. The characterization activities described in this addendum were identified during a DQO process to fulfill proposed Tri-Party Agreement Milestone M-45-54 to be completed by March 2001. Activities were planned using the work breakdown structure and project milestones defined in Section 7.0 of DOE/RL-99-36.

Based on DOE guidance for establishing a baseline scope, schedule, and budget document, the use of a multi-year work plan was adopted. The activities identified in Figure 6.1 were taken from the multi-year work plan, which is updated annually and describes the specific details associated with each proposed project. The multi-year work plan incorporates milestones defined in the Tri-Party Agreement and reflects the schedule and commitments made therein. The multi-year work plan defines the scope, schedule, and budget to a level of detail that will be adequate for the planning and management of that project. The work breakdown schedule numbers and activity identification numbers are included in Figure 6.1 to correspond with the schedule maintained by the Tank Farm Vadose Zone Project. The planned field investigation report for WMAs T and TX-TY that will address interim measures and ICMs is scheduled for submittal to Ecology on June 30, 2003 (Figure 6.1).

Figure 6.1. Preliminary Characterization Schedule



7.0 PROJECT MANAGEMENT

This section defines the administrative and institutional tasks necessary to support the RFI/CMS process for WMAs T and TX-TY and manage activities described in Section 5.0 of this addendum. This section also defines the responsibilities of the various participants, organizational structure, and project tracking and reporting procedures. This section is in accordance with the provisions of the Tri-Party Agreement action plan. Any revisions to the Tri-Party Agreement action plan that would result in changes to the project management requirements would supersede the provisions of this section.

7.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization and responsibilities are described in Section 7.2 of DOE/RL-99-36. Discussion of the roles of SST Program Manager and Tank Farm Vadose Zone Project Manager and of work control, cost control, schedule control, meetings, records management, progress and final reports, quality assurance, health and safety, and community relations are also addressed in Section 7.2 of DOE/RL-99-36. This addendum follows the structure outlined in that work plan except where more detail is required. Interfaces with tank farm operations is part of the work control, schedule control, and roles and responsibilities as defined in DOE/RL-99-36. Integration with other organizations, including the Groundwater and Vadose Zone Integration Project, are addressed in Section 7.3 of DOE/RL-99-36.

Detailed information in the form of a work package defining the site-specific activities and instructions needed to carry out the investigative tasks discussed in this section will be developed before initiating field work. Where appropriate, the work package will reference the appropriate procedure or standards rather than listing the entire procedure for a task and will be in accordance with *Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68). Any reference to the quality assurance project plan provided in Appendix A of DOE/RL-99-36 as a source of additional information will be referenced.

The work package shall be prepared in accordance with CH2M HILL Hanford Group, Inc. work control procedures and the procedures listed in Appendix A of DOE/RL-99-36. The work package must satisfy the following requirements.

- Include a scope of work introductory section.
- Identify any field screening activities not described in the work plan or in the relevant procedures. Identify any field screening equipment to be used that is not described in the relevant procedures.
- Include the frequency of measurement.
- Identify the applicable procedures needed to conduct the work. If a procedure includes several different ways to accomplish the work, the work package should specify the method of choice or reference the specific procedure.

7.2 DOCUMENTATION AND RECORDS

All RFI/CMS plans and reports will be categorized as primary or secondary documents, as described by Section 9.1 of the Tri-Party Agreement action plan. The process for document review and comment will be as described in Section 9.2 of the action plan. If necessary after finalization of any document, revisions will be in accordance with Section 9.3 of the Tri-Party Agreement action plan. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Section 12.0 of the Tri-Party Agreement action plan.

Administrative records, which must be maintained to support Hanford Site RCRA activities, will be in accordance with Section 9.4 of the Tri-Party Agreement action plan.

8.0 REFERENCES

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40 CFR 61 Subpart M, "National Emissions Standards for Asbestos," *Code of Federal Regulations*, as amended.

40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, Groundwater Monitoring," *Code of Federal Regulations*, as amended.

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9.0 GLOSSARY

Accuracy: The measure of the bias in a system. Analytical accuracy is normally assessed through the evaluation of matrix-spiked samples, reference samples, and split samples.

Audit: Systematic checks to verify the quality of operation of one or more elements of the total measurement system. In this sense, audits may be of two types: (1) performance audits, in which quantitative data are independently obtained for comparison with data routinely obtained in a measurement system or (2) system audits, which involve a qualitative onsite evaluation of laboratories or other organizational elements of the measurement system for compliance with established quality assurance program and procedure requirements. For environmental investigations at the Hanford Site, performance audit requirements are fulfilled by periodic submittal of blind samples to the primary laboratory or by the analysis of split samples by an independent laboratory. System audit requirements are implemented through the use of standard surveillance procedures.

B Plant High-Level Waste: B Plant reprocessed large quantities of the high-level waste streams produced by the PUREX and REDOX processes to recover cesium-137 and strontium-90. The waste streams from B Plant operations were very high in total activity and contained substantial concentrations of organic complexants.

Bias: A systematic error that contributes to the difference between a population mean of a set of measurements and an accepted reference or true value.

Blind Sample: Any type of sample routed to the primary laboratory for performance audit purposes, relative to a particular sample matrix and analytical method. Blind samples are not specifically identified as such to the laboratory. They may be made from traceable standards or may consist of sample material spiked with a known concentration of a known compound. (See Audit).

Borehole: A circular hole made by boring; esp. a deep vertical hole of small diameter, such as a shaft, a well (an exploratory oil well or a water well), or a hole made to ascertain the nature of the underlying formations, to obtain samples of the rocks penetrated, or to gather other kinds of geologic information.

Comparability: An expression of the relative confidence with which one data set may be compared with another.

Completeness: A measure of the amount of valid data obtained compared to the total data expected under correct normal conditions.

Conceptual Model: A tool designed to represent a simplified version of reality based on a set of working hypotheses. For instance, the vadose zone conceptual model includes the simplified elements of tank waste characteristics, past leak characteristics, geology, hydrogeology, and driving forces that include infiltration from precipitation and human sources of water.

Deviation: An approved departure from established criteria that may be required as a result of unforeseen field situations or that may be required to correct ambiguities in procedures that may arise in practical applications.

Dip: The angle that a structural surface makes with the horizontal, measured perpendicular to the strike of the structure.

Down Dip: A direction that is downwards and parallel to the dip of a structure or surface.

Drywell: A hollow cylinder of reinforced concrete, steel, timber, or masonry constructed in a pit or hole in the ground that does not reach the water table and is used principally for monitoring in the unsaturated zone.

Equipment Blanks: Pure deionized, distilled water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks are used to verify the adequacy of sampling equipment decontamination procedures.

Field Duplicate Sample: A sample retrieved from the same sampling location using the same equipment and sampling technique; placed in separate, identically prepared and preserved containers; and analyzed independently. Field duplicate samples are generally used to verify the repeatability or reproducibility of a dataset.

First- and Second-Cycle (1C and 2C) Waste: The 1C and 2C waste streams were generated by the successive purification steps in the bismuth phosphate process. The 1C waste stream was frequently mixed with the metal waste stream. Second-cycle waste contained significantly less total activity and mixed fission product content than the 1C and metal waste streams.

Interim-Isolation: Administrative designation reflecting the completion of the physical effort required for interim isolation (except for isolation of risers and piping) that is required for jet pumping or for other methods of stabilization.

Interim Stabilized: Status term for when a tank contains less than 189,250 L (50,000 gal) of drainable interstitial liquid and less than 18,925 L (5,000 gal) of supernate liquid. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow or saltwell screen inflow must also have been at or below 0.19 L (0.05 gal) per minute.

Intrusion Prevention: Administrative designation reflecting completion of the physical effort required to minimize the addition of liquids into an inactive storage tank, process vault, sump, catch tank, or diversion box. Under no circumstances are electrical or instrumental devices disconnected or disabled during the intrusion prevention process (with the exception of the electrical pump).

Laboratory Duplicate Samples: Two aliquots removed from the same sample container in the laboratory and analyzed independently.

Matrix-Spiked Sample: A type of laboratory quality control sample. The sample is prepared by splitting a sample received from the field into two homogenous aliquots (i.e., replicate samples) and adding a known quantity of a representative analyte of interest to one aliquot to calculate the percentage of recovery of that analyte.

Maximum Contaminant Level: The maximum permissible level of a contaminant in water that is delivered to any user of a public water system.

Metal Waste: Metal waste was the first waste stream generated by the bismuth phosphate process after fuel rod dissolution. The metal waste stream contained approximately 0.5 pounds of uranium/gallon. A high level of carbonate was added to the stream to maintain uranium solubility, resulting in carbonate concentration of approximately 2.5 molar. Metal waste is unique at the Hanford Site for being the only large volume waste stream containing high concentrations of uranium as well as high concentrations of mixed fission products.

Nonconformance: A deficiency in the characteristic, documentation, or procedure that renders the quality of material, equipment, services, or activities unacceptable or indeterminate. A deficiency is not categorized as a nonconformance when it is of a minor nature, does not effect a permanent or significant change in quality if it is not corrected, and can be brought into conformance with immediate corrective action. If the nature of the condition is such that it cannot be immediately and satisfactorily corrected, however, it shall be documented in compliance with approved procedures and brought to the attention of management for disposition and appropriate corrective action.

Operable Unit: A group of land disposal sites placed together for the purposes of doing a remedial investigation and feasibility study and subsequent cleanup actions. The primary criteria for placement of a site into an operable unit includes geographic proximity, similarity of waste characteristics and site type, and the possibility for economics of scale.

Out of Service: Designation of a tank that is no longer authorized to receive waste; a tank that does not meet the definition of an in-service tank. Before September 1998, such tanks were designated inactive.

Partially Interim Isolated: Administrative designation reflecting the completion of the physical effort required to minimize the addition of liquids into an inactive storage tank, process vault, sump, catch tank, or diversion box. In June 1993, the designation interim isolation was replaced by intrusion prevention.

Past-Practice Units: A waste management unit where waste or substances (intentionally or unintentionally) have been disposed of and that is not subject to regulation as a treatment, storage, and/or disposal unit.

Precision: A measure of the repeatability or reproducibility of specific measurements under a given set of conditions. The relative percent difference is used to assess the precision of the sampling and analytical method. Relative percent difference is a quantitative measure of the variability. Specifically, precision is a quantitative measure of the variability of a group of measurements compared to their average value. Precision is normally expressed in terms of standard deviation, but may also be expressed as the coefficient of variation (i.e., relative standard deviation) and range (i.e., maximum value minus minimum value). Precision is assessed by means of duplicate and replicate sample analysis.

Quality Assurance: The total integrated quality planning, quality control, quality assessment, and corrective action activities that collectively ensure that the data from monitoring and analysis meets all end user requirements and/or the intended end use of the data.

Quality Assurance Project Plan: An orderly assembly of management policies, project objectives, methods, and procedures that defines how data of known quality will be produced for a particular project or investigation.

Quality Control: The routine application of procedures and defined methods to the performance of sampling, measurement and analytical processes.

Range: The difference between the largest and smallest reported values in a sample and is a statistic for describing the spread in a set of data.

REDOX High-Level Waste: REDOX waste was the primary high-activity waste stream produced by the REDOX process. This waste stream contained substantial mixed fission products and displayed high total activity.

Reference Samples: A type of laboratory quality control sample (e.g., laboratory control standard, independent calibration verification standard) prepared from an independent, traceable standard at a concentration other than that used for analytical equipment calibration but within the calibration range.

Refusal: When 100 blows per foot nominally have been reached in attempting to collect a soil sample.

Removed from Service: Designation of a tank that is no longer authorized to receive waste or intended for reuse.

Representativeness: May be interpreted as the degree to which data accurately and precisely represent a characteristic of a population parameter, variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of a sampling program.

Split Sample: A sample produced through homogenizing a field sample and separating the sample material into two equal aliquots. Field split samples are usually routed to separate laboratories for independent analysis, generally for purposes of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method (See Audit). In the laboratory, samples are generally split to create matrix-spiked samples (see Matrix-Spiked Samples).

Strike: The direction or trend that a structural surface takes as it intersects the horizontal.

TSD Unit: A unit used for treatment, storage and/or disposal (TSD) of hazardous waste and is required to be permitted (for operation and/or post-closure care) and /or closed pursuant to *Resource Conservation and Recovery Act of 1976* requirements under the Washington State "Dangerous Waste Regulations" (WAC 173-303) and the applicable provisions of *Hazardous and Solid Waste Amendment of 1984*.

Up-Dip: A direction that is upwards and parallel to the dip of a structure or surface.

Uranium Recovery Waste (or Tributyl Phosphate Waste): The tributyl phosphate waste stream was generated during processing of metal waste at U Plant for uranium recovery. The tributyl phosphate waste stream is basically metal waste with the uranium largely removed, ferric oxide added, and diluted by approximately a factor of two. The waste stream also contains variable amounts of tributyl phosphate.

VOA Trip Blanks: Volatile organics analysis (VOA) trip blanks are a type of field quality control sample, consisting of pure deionized distilled water in a clean, sealed, sample container, accompanying each batch of containers shipped to the sampling site and returned unopened to the laboratory. Trip blanks are used to identify any possible contamination originating from container preparation methods, shipment, handling, storage, or site conditions.

Validation: A systematic process of reviewing data against a set of criteria to provide assurance that the data are acceptable for their intended use. Validation methods may include review of verification activities, editing, screening, cross-checking, or technical review.

Verification: The process of determining whether procedures, processes, data, or documentation conform to specified requirements. Verification activities may include inspections, audits, surveillance, or technical review.

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APPENDIX A

SAMPLING AND ANALYSIS PLAN

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CONTENTS

FIGURE

TABLES

LIST OF TERMS

bgs	below ground surface
CHG	CH2M HILL Hanford Group, Inc.
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
SAP	Sampling and Analysis Plan
WMA	waste management area

A.1.0 INTRODUCTION

The focus of this Sampling and Analysis Plan (SAP) is vadose zone investigation of waste management areas (WMAs) T and TX-TY, which contain the T, TX, and TY tank farms. Sampling and analysis of vadose zone sediments will occur in the vicinity of the T, TX, and TY tank farms to meet the objectives of this investigation.

This plan details the field and laboratory activities to be performed in support of the investigation of vadose zone contamination in WMAs T and TX-TY and is designed to be used in conjunction with the work plan and referenced procedures. The field investigations at WMAs T and TX-TY addressed in this SAP are for installation of vertical boreholes. The data quality objective (DQO) process (RPP-7455) resulted in the identification of several potential locations for proposed new boreholes. This initial (phase 1) site-specific investigation to be conducted in fiscal year 2002 is anticipated to entail the installation of three vertical boreholes.

The new boreholes will be installed using a variation of the drive-and-drill drilling technique. Staged (telescoping) casings may be used to reduce the likelihood of cross-contamination from penetrating through the highly contaminated zones. The final borehole construction and sampling methodology for the vertical boreholes in WMAs T and TX-TY will be designed to maintain compliance with the requirements of the Notice of Construction (DOE/ORP-2000-05) for drilling operations inside the tank farms.

Collection of spilt-spoon driven samples will be attempted from about 4.6 m (15 ft) below ground surface (bgs) to top of the Ringold Formation unit E gravels approximately 45.7 m (150 ft) bgs or the maximum extent of contamination, whichever is deeper on 3-m (10-ft) intervals. Continuous drill cutting samples will not be collected, because drill cuttings are not produced by the proposed drilling method unless for the purpose of sampling. This drilling method will reduce contaminated soils brought to the surface and requiring disposal for the waste management requirements in Appendix D of *Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas* (DOE/RL-99-36). Selected portions of the samples will be analyzed for chemical, radiological, and physical characteristics. A suite of geophysical surveys will be performed. The boreholes will be decommissioned in accordance with Washington State "Minimum Standards for the Construction and Maintenance of Wells" (WAC 173-160).

Technical procedures or specifications that apply to this work include Duratek Federal Services sampling and geophysical surveying procedures (SML-EP-001), sample and mobile laboratories procedures (SML-EP-001), and vadose zone characterization at the Hanford Site tank farms, high-resolution passive spectral gamma-ray logging procedures (P-GJPO-1783). All field and laboratory work prescribed by this SAP shall also be in conformance with *Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68). Field and laboratory personnel should be familiar with these documents, as appropriate, and maintain a copy for guidance during work activities.

The field activities related to this investigation comprise vadose zone sampling geophysical logging and sample analysis. This SAP addresses the requirements of the vadose zone sampling and analysis.

The quality assurance project plan, Appendix A of DOE/RL-99-36, is an integral part of the SAP and must be used jointly. RPP-7455 references the sampling analytical quality assurance and quality control requirements that must be used to obtain representative field samples and measurements. Knowledge of the health and safety plan (Appendix B of DOE/RL-99-36) is required by those involved in the field sampling because it specifies procedures for the occupational health and safety protection of project field personnel. The data management plan (Appendix C of DOE/RL-99-36) denotes the requirements for field and laboratory data storage. The waste management plan (Appendix D of DOE/RL-99-36) denotes the requirements for the management of waste and the appropriate collection, characterization, and designation of waste produced by the characterization activities.

A.2.0 INSTALLATION OF VERTICAL BOREHOLES (WELL NUMBER TBD)

The following is a discussion of the field tasks and associated subtasks required for the drilling, sampling, and sample analysis associated with the vertical boreholes.

A.2.1 PROJECT MANAGEMENT (TASK 1 OF SECTION 5.0)

Project management will be followed as described in DOE/RL-99-36.

A.2.2 GEOLOGIC AND VADOSE ZONE INVESTIGATION (TASK 2 OF SECTION 5.0)

The geologic and vadose zone investigation task has two subtasks relevant to the installation of the new boreholes: Subtask 2a, field activities, and Subtask 2b, laboratory analysis. The following subsections describe these subtasks.

A.2.2.1 Field Activities (Subtask 2A of Section 5.0)

The field activities addressed in this subtask required to support the geologic and vadose zone investigation are drilling, geophysical logging, sediment sampling, and reporting activities.

A.2.2.1.1 Drilling Activities. Drilling will be conducted using specifications and guidance in accordance with "Minimum Standards for the Construction and Maintenance of Wells" (WAC 173-160). Drilling operations will also conform to SP 4-1, "Soil and Sediment Sampling"; WP 2-2, "Field Cleaning and/or Decontamination of Equipment"; and the task-specific work package that will be generated for these field activities (ES-SSPM-001). The work package will contain such information as borehole construction, sampling technique, and radiation protection. All waste will be handled in accordance with the requirements of WAC 173-303 and/or the site-specific waste control plan. These techniques are based on minimizing the exposure of field personnel to both radiation and chemical pollutants to as low as reasonably achievable and in compliance with regulatory requirements.

Current plans for the initial site-specific investigations of WMAs T and TX-TY are to install three vertical boreholes in fiscal year 2002. *Data Quality Objectives Report for Waste Management Areas T and TX-TY* (RPP-7455) identified three sites for installation of vertical boreholes, (tanks T-106, TX-105, and TX-107). Based on comments received from the Washington State Department of Ecology (Ecology) on RPP-7455, the vertical borehole at tank T-106 has been reprioritized and is not included in fiscal year 2002 vadose zone characterization efforts. This initial (Phase 1) site-specific investigation to be conducted in fiscal year 2002 is anticipated to entail the installation of three vertical boreholes near tanks TX-105 and TX-107. An additional vertical borehole associated with known past releases may be installed in fiscal year 2002 provided adequate funding, sufficient schedule are available and is consistent with other schedule priorities. If this additional borehole is not conducted in fiscal year 2002, attempts will be made to install this and an additional two other boreholes in fiscal year 2003 or during Phase 2 characterization activities depending on decisions made by Ecology and the U.S. Department of Energy.

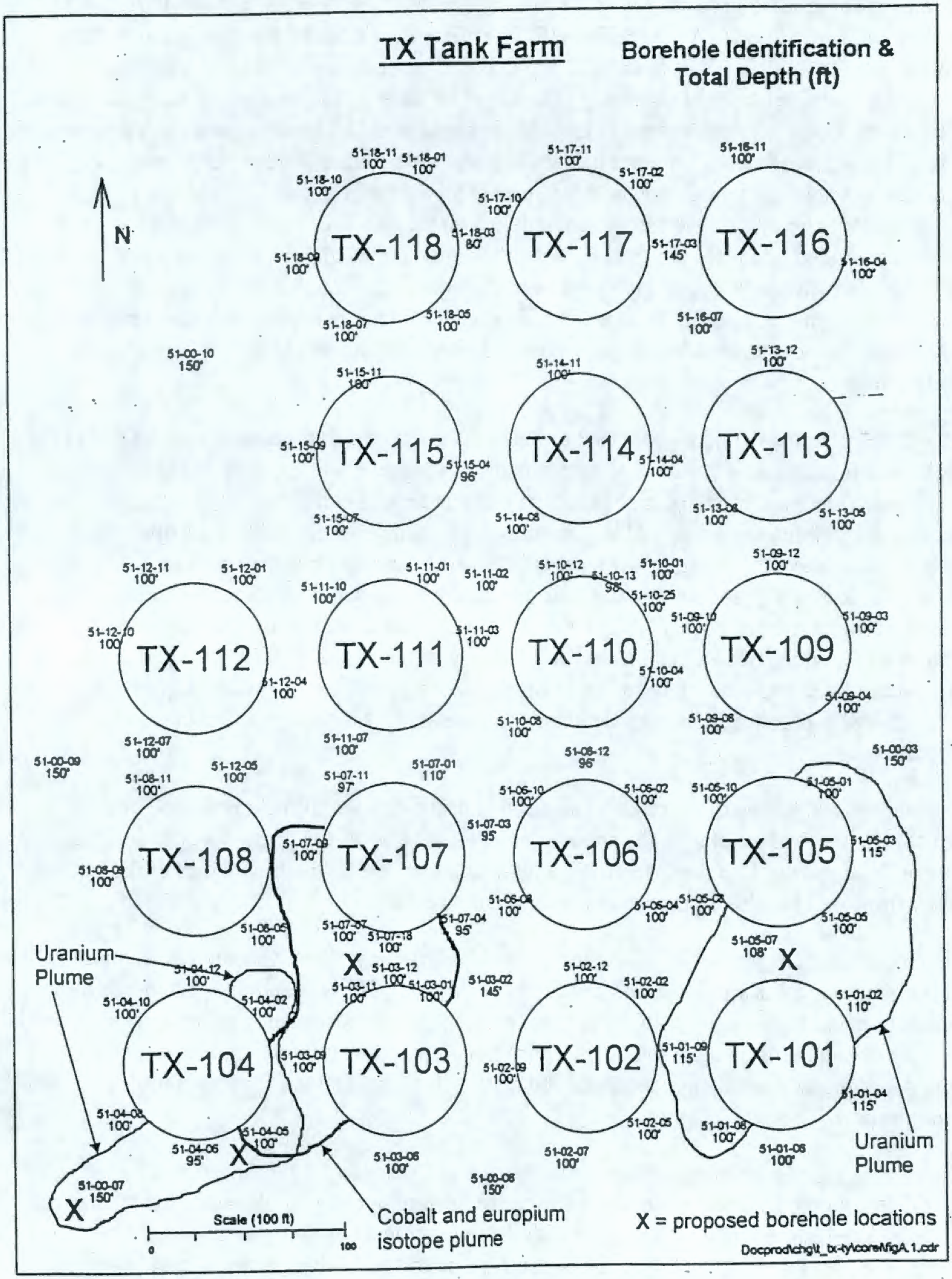
Vadose zone samples would be collected as the borehole(s) are advanced down to the top of the Ringold unit E or maximum extent of contamination, whichever is deeper unless refusal is encountered. The maximum extent of contamination is determined by 1.5 m (5 ft) of nondetectable gamma screening of the soil samples or cuttings in the field. This option was selected because vertical boreholes at these locations (i.e., in the vicinity of tanks TX-105 and TX-107) would provide source characterization along with distribution of contaminants at the locations of interest from within WMAs T and TX-TY. The approximate location of the boreholes in the vicinity of tanks TX-105 and TX-107 are shown in Figure A.1. The boreholes would extend from groundsurface to top of Ringold Formation unit E gravels at approximately 45.7 m (150 ft) bgs or the maximum depth of contamination, whichever is deeper unless refusal is encountered.

The boreholes would be advanced using a variation of the drive-and-drill method. The final design for the vertical boreholes has not been completed. One of the primary constraints on sample collection could be the potential of a high radiation level, which would limit the sample volumes from that borehole that can be brought to the surface.

Subsurface conditions are variable, and the process of installing the vertical boreholes must be flexible. Some or all of the work may require modification. This addendum is intended to serve as a guideline and is designed to allow for changes depending on conditions encountered in the field. Any change will be recorded on the appropriated field documentation, memoranda, or letters. A complete documented record of activities will be maintained for preparation of a final summary report.

Appropriate permits and compliance with the Notice of Construction permit (DOE/ORP-2000-05) will be maintained during the drilling operations for inside the tank farm. The selected drilling method will comply with the requirements of the Washington State Department of Health for the Notice of Construction permit and other pertinent requirements and appropriate engineering systems to prevent contaminated air from being released to the environment.

Figure A.1. WMAs T and TX-TY Proposed Sampling Locations for Vertical Boreholes



Modified from RPP-6353.

All split-spoon samples will be collected in advance of the casing being driven. Driven split-spoon samples will be attempted at a maximum of every 3-m (10-ft) intervals beginning at 9 m (30 ft) bgs. The casing is to be driven to total sample depth at the end of each day's drilling effort to prevent potential hole collapse. Split-spoon samplers will be new or decontaminated before reuse. Procedures for decontamination of sampling equipment are contained in WP 2-2, "Field Cleaning and/or Decontamination of Equipment" (ES-WSPM-001).

The depth of the vadose zone borings will be to the top of the Ringold Unit E member or maximum extent of contamination whichever is deeper, unless refusal or perched water is encountered. If the U.S. Department of Energy desires to continue the borehole through a perched water zone, then Ecology would be notified. The use of field screening instruments will be used for evaluating alpha-, beta-, and gamma-emitting radionuclides. Radiological screening is expected to be effective in determining the initial extent of contamination.

In addition to the borehole geologic logging, radiation measurements will be made using hand-held instruments on each segment of sample recovered during sampling and on the drill cuttings brought to the surface. Blow count measurements will be collected during all drive samples collected while advancing the split-spoon sampler. General observation will be noted as to drilling progress and problems. All of this information will be included in each borehole geologic log. Borehole geologic logs and well summary sheets will be prepared in accordance with approved Duratek procedures using American Society for Testing and Materials procedures (ASTM D2488).

A geologist will prepare a geological log for the vertical boreholes, based on the sediment samples. Borehole geologic logs will be prepared in accordance with approved procedures. The geologic log will include lithologic descriptions, sampling intervals, health physics technician hand-held instrument readings, screening results, evidence of any alteration of sediments, and general information and observations deemed relevant by the geologist to the characterization of subsurface conditions. Sediment samples will be screened with hand-held instruments for radiation, as appropriate, using techniques and procedures defined in the work package. Screening results and general observations as to drilling progress and problems will be included in each borehole log.

Waste containing unknown, low-level mixed radioactive waste and/or hazardous waste will be contained, stored, and disposed of in accordance with Appendix D of DOE/RL-99-36, or the most current procedures approved by Ecology, including waste utilizing the area of contaminant approach, and as specified in the quality assurance project plan (Appendix A of DOE/RL-99-36). These activities will be documented in the field activity reports. Waste will be disposed of at the Mixed Waste Burial Grounds in accordance with Appendix D of DOE/RL-99-36. All important information will be recorded on field activity report forms per approved procedures. The field activity report form includes borehole number, site location drawings, drawing of the downhole tool strings, site personnel, sampling types and intervals, zones noted by the health physics technician as elevated in radiological contaminants, instrument readings will be noted and the depth represented by those readings, and specific information concerning borehole completion.

The new boreholes will be decommissioned in accordance with WAC 173-160 following completion of geophysical surveys. All temporary steel casing removed from the boring will be surveyed and either decontaminated and released or transferred to an appropriate disposal facility. Specific procedures for borehole abandonment will be documented in the field work package. These procedures will comply with U.S. Environmental Protection Agency (EPA) requirements and WAC 173-160.

Should the contamination extend all the way to groundwater and drilling to groundwater is feasible (i.e., refusal does not occur), the new boreholes may be completed as a *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant groundwater monitoring wells. A groundwater sample will be collected and analyzed based on current groundwater analysis for WMAs T and TX-TY. Should technetium-99 concentrations exceed 10 times (9,000 pCi/L) the drinking water standard (900 pCi/L) a RCRA-compliant groundwater monitoring well will be installed. If so, the new wells will be included in the RCRA groundwater monitoring network for routine groundwater sampling and analysis. If not completed as RCRA-compliant groundwater wells, then the boreholes will be decommissioned in accordance with WAC 173-160.

Should the contamination extend deeper than 47 m (150 ft) bgs drilling will cease on that borehole and move to the next borehole. A discussion with Ecology on how to proceed with a different drilling method and schedule will be conducted to stay on the schedule of drilling and sampling three boreholes in fiscal year 2002.

If completed as a groundwater monitoring well, a 4-in. stainless steel casing and screen will be permanently installed, and a flush mount surface protection/well seal will be constructed. The well will be completed in accordance with WAC 173-160 requirements to meet groundwater protection goals. Specific work steps for well completion will be documented in the tank farm work package.

Contaminant dragdown during drilling and sampling activities is unavoidable and has been observed in recent sampling activities. Different drilling and sampling techniques will impact dragdown to varying degrees. Because the objective of the characterization activities identified in the DQO is to safely sample in and below regions of known leakage, the dragdown issue is a secondary concern. However, appropriate drilling procedures will be used to minimize the effect of contaminant dragdown.

A.2.2.1.2 Geophysical Surveying Activities. Based on sampling and construction methods, downhole spectral-gamma or gross gamma geophysical logging will be conducted to ascertain the gamma-emitting radionuclide concentrations. The spectral-gamma or gross gamma logging frequency will be directed by CH2M HILL Hanford Group, Inc. (CHG).

A suite of geophysical logs, as determined by the CHG Field Team Leader, will be run any time the casing size is changed and at the completion of the borehole. This will provide some flexibility with the planning of geophysical logging during the drilling process.

The following logging techniques could be used for the vertical boreholes:

- Gross-gamma logging to support correlation of confining layers and stratigraphy
- Spectral-gamma logging for measuring the distribution of selected radionuclides
- Neutron logging for measuring the relative moisture content.

The existing equipment and procedures for gross-gamma and spectral-gamma logging in use at the Hanford Site provide acceptable data (P-GJPO-1783).

All steel casing will be removed and transferred to an appropriate disposal facility or controlled decontamination facility and released for future use, and each boring will be in accordance to EPA requirements and WAC 173-160.

A.2.2.1.3 Sediment Sampling Activities. Borehole sampling will be performed to define the depth of contamination. The borehole will serve to establish the general lithology of the sediments lying below the site and to give indications of how radionuclides and other contaminants have migrated. It also will provide sediment samples for determination of sediment chemistry and vadose zone properties. This SAP is specific to the borehole sampling event and is not applicable to future borehole sampling events.

For the new boreholes, sampling will begin at 4.6 m (15 ft) bgs to allow for a limited-open borehole and placement of a sealed surface casing. Drilling and sampling will continue until the top of the Ringold Unit E member at approximately 45.7 m (150 ft) bgs or maximum extent of contamination, whichever is deeper unless refusal is encountered. Refusal is defined as 100 blows per foot. Maximum extent of contamination will be based on field measurements. Split-spoon samples will be attempted at a maximum of every 3 m (10 ft) beginning at 4.6 m (15 ft) bgs. Table A.1 shows the proposed sampling strategy for the new boreholes.

Table A.1. Sample Locations for Boreholes in TX Tank Farm

Sample Depths 4.6 meters to 24.4 meters (30 feet to 80 feet)	Sample Depths 24.4 meters to 36.9 meters (80 feet to 121 feet)	Sample Depths 36.9 meters (121 feet) to top of Ringold Formation unit E gravels (45.7 meters [150 feet])
4.6 meters (15 feet)	25.9 meters (85 feet)	39.6 meters (130 feet)
6.7 meters (22 feet)	27.4 meters (90 feet)	42.7 meters (140 feet)
9 meters (30 feet)	28.9 meters (95 feet)	45.7 meters (150 feet)
11.9 meters (39 feet)	29.9 meters (98 feet)	
13.7 meters (45 feet)	32.0 meters (105 feet)	
15.8 meters (52 feet)	33.5 meters (110 feet)	
17.9 meters (59 feet)	35.1 meters (115 feet)	
19.8 meters (65 feet)	36.8 meters (121 feet)	
22.9 meters (75 feet)		
24.4 meters (80 feet)		

Source: Amended from Table B-1 of RPP-7455.

After the sediment samples are screened, these samples will be transported to the Pacific Northwest National Laboratory Applied Geology and Geochemistry group for analysis. All material removed from the borehole will be sent to the laboratory for possible future analysis. Samples will be contained in airtight sample containers after their initial screening by the health physics technician and are to be kept under refrigeration. This process is used to retain sediment moisture in as close to field condition as possible. All samples will be transported to the laboratory under refrigeration to further limit alteration of sediment moisture.

Field quality control samples also will be submitted for the full spectrum of chemical and radionuclide analyses. These quality control samples will consist of the following.

- **Equipment rinseate blanks** – One equipment rinseate blank per borehole drilling activity or, if multiple types of samplers are used, once per type of sampler.

A.2.2.1.4 **Groundwater Sampling Activities.** No sampling of groundwater will be conducted for these characterization efforts unless contamination extends all the way to groundwater and drilling to groundwater is feasible (i.e., no refusal). If a groundwater sample is collected, analyses will be conducted in accordance with PNNL-12057 and PNNL-12072.

A.2.2.1.5 **Field Reporting Activities.** Field logs will be maintained to record all observations and activities conducted. A site representative will record the activities on a field activity report. Items for entry will include the following:

- Borehole number
- Site location drawings
- Drawings of the downhole tool strings
- Site personnel present
- Sampling types and intervals
- Zones noted by the health physics technician as elevated in radiological contaminants
- Instrument readings and the depth represented by those readings
- Specific information concerning borehole progress and completion.

All completed field records will be maintained and processed in accordance with approved CHG procedures.

A.2.2.2 Laboratory Analysis (Subtask 2B of Section 5.0)

The following sections describe the laboratory analyses required for the samples collected from the vertical boreholes. Laboratory analyses will be performed on sediment samples in accordance with this SAP. All analytical work prescribed by this SAP will be performed by qualified laboratories with approved quality assurance plans. If the primary contracting laboratory is unable to complete the analyses, it is the primary contracting laboratory's responsibility to subcontract the laboratory work to a qualified secondary laboratory. Samples for laboratory analysis will be placed in appropriate containers and properly preserved in accordance with SP 4-1, "Soil and Sediment Sampling" (ES-SSPM-001), and in accordance with the quality assurance project plan (Appendix A of DOE/RL-99-36). All samples for laboratory analysis will be transported under chain of custody in accordance with the quality assurance project plan.

Sediment cuttings containing low-level and mixed radioactive waste will be contained, stored, and disposed of according to procedures defined in Appendix D of DOE/RL-99-36. Sediment cuttings containing hazardous waste and those containing unknown waste will be contained and disposed of at the mixed waste burial grounds in accordance with Appendix D of DOE/RL-99-36. Storage of archive samples will be done until approval to dispose of the samples is provided by the CHG technical representative.

Geologic logging for the vertical boreholes will be conducted as it was for the borehole 41-09-39 extension in WMA S-SX. Specifically, once sample material from the vertical boreholes is received at the laboratory, and it will be geologically logged by an assigned geologist in general conformance with standard procedures. The assigned geologist will photograph the samples and describe the geologic structure, texture, and lithology of the recovered samples. Special attention is to be paid to the presence of contaminant alteration. If such a phenomenon is noted, that sample will be noted, preserved for more detailed physical, chemical, and mineralogic analyses, and recorded in the laboratory notebook.

Sediment subsamples for laboratory analysis will be defined by location in the sample after the field screening and geologic logging have been completed and indication of contamination locations have been identified. Approximately 21 sediment subsamples from each of the boreholes will be chosen for screening analysis. The following criteria will be used to identify subsamples for laboratory analysis based on concurrence with Ecology:

- One subsample will be taken at 4.6 m (15 ft) bgs.
- One background subsample will be taken at 9 m (30 ft) bgs.
- One subsample will be taken at 11.9 m (39 ft) bgs, at the level of the tank bottom.
- One subsample will be taken at the Hanford formation and Hanford formation(?)/ Plio-Pleistocene unit(?) interval contact at approximately 24.4 m (80 ft) bgs.
- One subsample will be taken at the Hanford formation(?)/Plio-Pleistocene unit(?) interval and Plio-Pleistocene unit contact at approximately 29.9 m (98 ft) bgs.
- One subsample will be taken at the Plio-Pleistocene unit and Upper Ringold Formation contact at approximately 32 m (105 ft) bgs.
- One subsample will be taken at the Upper Ringold Formation and Ringold unit E contact at approximately 36.8 m (121 feet) bgs.
- Subsamples will be taken of any paleosols seen in the split-spoon drive samples.
- Subsamples will be taken in locations where elevated or altered gamma surveying or moisture content was measured during the geological and geophysical borehole logging process.

- At least one subsample will be taken every 3 m (10 ft) if samples have not already been taken, based on the above criteria to ensure continuous distribution and lithologic completeness.

Table A.1 shows the subsamples identified for laboratory analyses. Worker safety considerations may limit the collection of samples at certain intervals. A 1:1 water extract of all subsamples shall undergo screening analyses. Screening analyses comprise the following:

- Nitrate analysis by the colorimetric method
- Electrical conductance
- Total organic carbon/total carbon
- gamma energy analysis
- pH.

These analyses, along with the gamma surveying and moisture content measurements performed during the field geophysical surveys and the laboratory geologic logging, will be used to determine the extent of further subsample analysis. Table A.2 identifies the full complement of potential analyses and their respective laboratory preparation and analytical methods.
This paragraph and the remainder of this appendix identify which analysis will be conducted on which sample. If more than one preparation or analytical method is listed, the expertise of the laboratory geochemistry staff will be used to determine which methods will produce the best results and will provide the best understanding of the chemistry involved. For those methods that produce multiple constituents (i.e., inductively coupled plasma), all constituents identified will be reported. Every effort is to be made to meet regulatory holding times where appropriate. The DQO process identified the need for volatile organic analysis and semivolatile organic analysis. An attempt will be made to perform these analyses; however, based on experience from WMA S-SX, it is unlikely that the holding time for volatile organic analysis can be met. If holding times cannot be met, analysis of these compounds will not be performed. Based on previous experience, it is anticipated that holding times for the semi-volatile organic analysis can be met.

Because the purpose of the new borehole analyses is to gain an understanding of the nature and extent of contamination, the fate and transport of the contaminants in the vadose zone and to produce *Resource Conservation and Recovery Act of 1976*-compliant data, the analysis of these subsamples comprises two levels. The baseline level involves analysis of organic, inorganic, and radiochemical constituents in full conformance with DOE/RL-96-68 and with no modifications to methods (as defined by DOE/RL-96-68) without concurrence from the CHG technical representative and from Ecology. Substitutions and deviations to methods as defined in DOE/RL-96-68 will require concurrence from Ecology. The second level involves a research-type approach to the analyses. In this level, procedures may be modified or developed to gain a more comprehensive understanding of the dynamics involved. Although specific quality control criteria do not apply to this level, compliance with the other quality assurance requirements in DOE/RL-96-68 must still be met and research analysis will be initiated only following review and approval of the activities by the CHG technical representative.

The background subsample, backfill – Hanford formation contact subsample, Hanford formation H1 unit and Hanford formation H2 unit contact sample, peak gamma concentration sample, the four subsamples obtained at the Hanford formation and Hanford formation(?)/Plio-Pleistocene unit(?) interval contact, the Hanford formation(?)/Plio-Pleistocene unit(?) interval and Plio-Pleistocene unit contact, Plio-Pleistocene unit and Upper Ringold contact, the Upper Ringold and Ringold unit E contact will be analyzed for the constituents and properties identified in Table A.2. It is recognized that conditions may occur when all of the analyses identified in Table A.2 are not warranted (e.g., limited potential for data) and these occurrences will be evaluated on a case-by-case basis.

At the request of Ecology, three samples at 4.6 m (15 ft), 6.7 m (22 ft), and 11.9 m (39 ft) at or near the base of the tank will be analyzed for volatile and semivolatile organics identified in Table A.2.

The remaining samples will be analyzed for specific constituents listed in Table A.2 depending on the results of the nitrate, electrical conductivity, total organic carbon/total carbon, and pH screening analyses. A review of the screening analyses results with technical representatives along with Ecology will be conducted prior to performing additional analyses. Screening analysis may be used to determine whether alternative analytical techniques with lower detection limits should be used for specific radionuclides of concern. The screening criteria and associated analytical requirements are identified as follows:

- Gamma-emitting radioisotopes by gamma energy analysis
- Metals and radioisotopes by inductively coupled plasma-mass spectrometry
- Tritium and strontium-90 by the liquid scintillation method
- Particle size distribution
- Carbon-14.

At the request of Ecology, a minimum of two samples collected within the Hanford formation will be analyzed for metals as identified in Table A.2.

The data obtained from the above analyses will be used to evaluate the location of contamination plumes in the sediment column. The results of the above analyses will also be used to determine if additional analyses are warranted. Additional analyses would be performed based on the judgment and expertise of the responsible Pacific Northwest National Laboratory geochemist, with concurrence from the CHG technical representative and Ecology. The following analyses would be performed as additional analyses:

- Cation exchange capacity
- Mineralogy
- Matric potential
- Distribution coefficient
- Bulk density
- Moisture retention
- Saturated hydraulic conductivity.

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Radionuclide		RR[a]	C/I[a]	GW[a, g]		pCi/L	pCi/L	pCi/g	pCi/g				
		pCi/g	pCi/g	pCi/L									
Americium-241	14596-10-2	31	210	TBD	Americium Isotopic - Alpha Energy Analysis (AEA)	1	400	1	4000	+-20%	70-130%	+-35%	70-130%
Carbon-14	14762-75-5	5.2[f]	33100	TBD	Carbon-14 - Liquid Scintillation	200	N/A	50	N/A	+-20%	70-130%	+-35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	Gamma Energy Analysis	15	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	Gamma Energy Analysis	25	200	0.05	2000	+-20%	70-130%	+-35%	70-130%
Europium-152	14683-23-9	3.3	12	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Europium-154	15585-10-1	3	11	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Europium-155	14391-16-3	125	449	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Hydrogen-3	10028-17-8	359[f]	14200	20000	Tritium - Liquid Scintillation	400	400	400	400	+-20%	70-130%	+-35%	70-130%
Neptunium-237	13994-20-2	2.5	62.2	TBD	Neptunium-237 - AEA	1	N/A	1	8000	+-20%	70-130%	+-35%	70-130%
Nickel-63	13981-37-8	4026	3008000	TBD	Nickel-63 - Liquid Scintillation	15	N/A	30	N/A	+-20%	70-130%	+-35%	70-130%

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CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Radionuclide		RR[a] pCi/g	C/I[a] pCi/g	GW[a, e] PCi/g		pCi/L	pCi/L	pCi/g	pCi/g				
Plutonium-238	13981-16-3	37	483	15	Plutonium Isotopic - AEA	1	130	1	1300	+-20%	70-130%	+-35%	70-130%
Plutonium-239/240	PU-239/240	34	243	15	Plutonium Isotopic - AEA	1	130	1	1300	+-20%	70-130%	+-35%	70-130%
Total Radioactive Strontium	SR-RAD	4.5	2500	8	Total Radioactive Strontium - Gas Proportional Counting (GPC)	2	80	1	800	+-20%	70-130%	+-35%	70-130%
Technetium-99	14133-76-7	5.7[f]	410000	900	Technetium-99 - Liquid Scintillation	15	400	15	4000	+-20%	70-130%	+-35%	70-130%
Thorium-232	TH-232	1	5.1	15	Thorium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-234	13966-29-5	160	1200	15	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-235	15117-96-1	26	100	15	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-238	U-238	85	420	15	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics													
Ethyl alcohol	64-17-5	None	None	None	Non-Halogenated VOA - 8015c – GC	5	N//A	5	N/A	e	e	e	e
n-Butyl alcohol	71-36-3	8000	350	160	Non-Halogenated VOA - 8015 - GC	5	N/A	5	N/A	e	e	e	e
Methyl alcohol (methanol)	67-56-1	40000	160000	400	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	1	N/A	1	N/A	e	e	e	e
Kerosene (paraffin hydrocarbons)	8008-20-6	200000[h]	200000[h]	200000[h]	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	5	5	e	e	e	e
Carbon tetrachloride	56-23-5	7.69	224	0.0337	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-Propanone (Acetone)	67-64-1	8000	32000	80	Volatile Organics - 8260 - GCMS	0.02	0.02	0.02	0.02	e	e	e	e
Chloroform	67-66-3	164	3200	0.717	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Benzene	71-43-2	34.5	1380	0.151	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
1,1,1-trichlorethane	71-55-6	72000	288000	720	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Dichloromethane (methylene chloride)	75-09-2	133	5330	0.583	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Carbon Disulfide	75-15-0	8000	32000	80	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1-dichloroethane	75-34-3	8000	32000	80	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,1-dichloroethene	75-35-4	1.67	66.7	0.00729[f]	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,2-dichloropropane	78-87-5	14.7	588	0.0643	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-butanone	78-93-3	48000	192000	480	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,1,2-trichloroethane	79-00-5	17.5	702	0.0768	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2-trichloroethylene	79-01-6	90.9	3640	0.398	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethane	79-34-5	5	200	0.0219	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Ethyl benzene	100-41-4	8000	32000	80	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,2-dichloroethane	107-06-2	11	440	0.0481	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
4-methyl-2-pentanone	108-10-1	6400	25600	64	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
Toluene	108-88-3	16000	64000	160	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Chlorobenzene	108-90-7	1600	6400	16	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethene	127-18-4	19.6	784	0.0858	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-hexanone	591-78-6	None	None	64	Volatile Organics - 8260 - GCMS	0.02	0.02	0.02	0.02	e	e	e	e
cis-1,3-dichloropropene	10061-01-5	5.56	96	0.0243[i]	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Trans-1,3-dichloropropene	10061-02-6	5.56	96	0.0243[i]	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Xylene (total)	1330-20-7	160000	640000	1600	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits: Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level	Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Dibenz[a,h]anthrax-cene	53-70-3	0.137[f]	5.48	0.0012[o]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Hexachloroethane	67-72-1	71.4	320	0.625	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Hexachlorobutadiene	87-68-3	12.8	64	0.0561[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Pentachlorophenol	87-86-5	8.33	333	0.0729[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2-methylphenol (o-cresol)	95-48-7	4000	16000	80	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,2-dichlorobenzene	95-50-1	7200	28800	72	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Nitrobenzene	98-95-3	40	160	0.8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
4-methylphenol (p-cresol)	106-44-5	400	1600	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,4-dichlorobenzene	106-46-7	41.7	1670	0.0182[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Pyridine	110-86-1	80	320	1.6	Semi-Volatiles - 8270 - GCMS	0.02	0.1	0.66	2	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Hexachlorobenzene	118-74-1	0.625	25	0.00547[o]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,2,4-trichlorobenzene	120-82-1	800	3200	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2,4-Dinitrotoluene	121-14-2	160	640	3.2	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Tributyl phosphate	126-73-8	None	None	None	Semi-Volatiles - 8270 - GCMS	0.1	0.5	3.3	5	e	e	e	e
1,3-dichlorobenzene	541-73-1	41.7	1670[j]	0.018[f,j]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Benzo(a)pyrene	50-32-8	0.137[f]	5.48	0.0012[o]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2,4,5-Trichlorophenol	95-95-4	8000	32000	160	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Gamma-BHC (Lindane)	58-89-9	0.769	30.8	0.00673	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Dieldrin	60-57-1	0.0625	2.5	0.000547[o]	Pesticides - 8081 - GC	0.0001	N/A	0.0033	N/A	e	e	e	e
Endrin	72-20-8	24	96	0.48	Pesticides - 8081 - GC	0.0001	N/A	0.0033	N/A	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Heptachlor	76-44-8	0.222	8.89	0.00194	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Aldrin	309-00-2	0.0588	2.35	0.000515[f]	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Alpha-BHC	319-84-6	0.159	6.35	0.00139[f]	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Beta-BHC	319-85-7	0.556	2.22	0.00486	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Toxaphene	8001-35-2	0.909	36.4	0.00795[o]	Pesticides - 8081 - GC	0.005	N/A	0.165	N/A	e	e	e	e
Total Organic Carbon	TOC	N/A	N/A	None	TOC - 9060- Combustion	1	1	100	100	+-20%	70-130%	+-35%	70-130%
Polychlorinated biphenyls (PCBs)	1336-36-3	0.13	5.19	0.00114[o]	PCBs - 8082 - GC	0.0005	0.005	0.0165	0.1	e	e	e	e
Inorganics													
Ammonia/ammonium	7664-41-7	2720000	10900000	27100	Ammonia - 350.Nd	0.05	800	0.5	8000	e	e	e	e
Phosphate	14265-44-2	N/A	N/A	None	Anions - 9056 - IC	0.5	15	5	40	e	e	e	e
Nitrate	14797-55-8	128000	512000	2560	Anions - 9056 - IC	0.25	10	2.5	40	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Inorganics (Cont'd)													
Nitrite	14797-65-0.	8000	32000	160	Anions - 9056 - IC	0.25	15	2.5	20	e	e	e	e
Sulfate	14808-79-8	25000[k]	25000[k]	25000	Anions - 9056 - IC	0.5	15	5	40	e	e	e	e
Chloride	16887-00-6	25000[k]	25000[k]	25000	Anions - 9056 - IC	0.2	5	2	5	e	e	e	e
Fluoride	16984-48-8	96[k]	200[k]	96	Anions - 9056 - IC	0.5	5	5	5	e	e	e	e
Bromide	24959-67-9	N/A	N/A	None	Anions - 9056 - IC	0.25	N/A	2.5	N/A	e	e	e	e
Chromium VI	18540-29-9	400	1600	8	Chromium (hex) - 7196 - Colorimetric	0.01	4	0.5	200	e	e	e	e
Mercury	7439-97-6	24	96	0.48	Mercury - 7470 - CVAA	0.0005	0.005	N/A	N/A	e	e	e	e
Mercury	7439-97-6	24	96	0.48	Mercury - 7471 - CVAA	N/A	N/A	0.2	0.2	e	e	e	e
Lead	7439-92-1	25000[h]	25000[h]	N/A	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Nickel	7440-02-0	1600	6400	32	Metals - 6010 - ICP	0.04	0.04	4	4	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Inorganics (Cont'd)													
Silver	7440-22-4	400	1600	8	Metals - 6010 - ICP	0.02	0.02	2	2	e	e	e	e
Antimony	7440-36-0	321	1281	6	Metals - 6010 - ICP	0.06	0.12	6	12	e	e	e	e
Arsenic	7440-38-2	6.5[m]	66.7	0.00583[o]	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Barium	7440-39-3	5600	22400	112	Metals - 6010 - ICP	0.2	0.2	20	20	e	e	e	e
Beryllium	7440-41-7	0.233	9.3	0.00203[o]	Metals - 6010 - ICP	0.005	0.01	0.5	1	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	Metals - 6010 - ICP	0.005	0.01	0.5	1	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	Metals - 6010 - ICP	0.01	0.01	1	2	e	e	e	e
Copper	7440-50-8	2960	11800	59.2	Metals - 6010 - ICP	0.025	0.025	2.5	2.5	e	e	e	e
Selenium	7782-49-2	400	1600	8[f]	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Lead	7439-92-1	25000[h]	25000[h]	N/A	Metals - 6010 - ICP (TRACE)	0.01	N/A	1	N/A	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Inorganics (Cont'd)													
Silver	7440-22-4	400	1600	8	Metals - 6010 - ICP(TRACE)	0.005	N/A	0.5	N/A	e	e	e	e
Antimony	7440-36-0	321	1281	6	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
Arsenic	7440-38-2	6.5[m]	66.7	0.00583[o]	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
Barium	7440-39-3	5600	22400	112	Metals - 6010 - ICP(TRACE)	0.005	N/A	0.5	N/A	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	Metals - 6010 - ICP(TRACE)	0.005	N/A	0.5	N/A	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
Selenium	7782-49-2	400	1600	8	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
PH	pH	N/A	N/A	None	pH - 9045 - Electrode	N/A	N/A	N/A	N/A	e	e	e	e
Sulfides	18496-25-8	N/A	N/A	None	Sulfide - 9030 - Colorimetric	0.5	N/A	5	N/A	e	e	e	e
Cyanide	57-12-5	1600	6400	32	Total Cyanide - 9010 - Colorimetric	0.005	0.005	0.5	0.5	e	e	e	e

Table A.2. Constituents and Methods for Sediment Sample Analyses for WMAs T and TX-TY (12 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Inorganics (Cont'd)													
Uranium (total)	7440-61-1	240[n]	960[n]	4.8	Uranium Total - Kinetic Phosphorescence Analysis	0.0001	0.02	1	0.2	+-20%	70-130%	+-35%	70-130%

Source: This is Table 1-6 of RPP-7455.

Note: This table may not have the same constituents as identified for B-BX-BY – see DQO for WMA T and TX-TY.

[a]RR - Rural Residential, C/I – Commercial Industrial, GW - Groundwater Protection Radionuclide values from WDOH "Hanford Guidance for Radiological Cleanup," WDOH/320-015. Radionuclide values are calculated using parameters from WDOH guidance.
[b]Water values for sampling QC (e.g., equipment blanks/rinses) or drainable liquid (if recovered).
[c]All four-digit numbers refer to "Test Methods for Evaluating Solid Waste" (EPA SW-846).
[d]"Methods of Analysis of Water and Waste" (EPA-600/4-79-020).
[e]Precison and Accuracy Requirements as identified and defined in the referenced EPA procedures.
[f]If quantitation to action level lower than nominal RDL is required, prior notification/concurrence with the laboratory will be required to address special low-level detection limits.
[g]The 100 times GW rule does not apply to residual radionuclide contaminants. GW protection is demonstrated through technical evaluation using RESRAD (DOE/RL-96-17, Rev. 2).
[h]This value is based upon MTCA Method A values.
[i]Value based upon most restrictive dichlorpropene 1,3.
[j]Value based upon most restrictive dichlorobenzene compound.
[k]Value based upon soil concentration for groundwater protection RAGs.
[l]Value based upon most restrictive antimony compound.
[m]Default to background.
[n]Value based upon uranium soluble salts value.
[o]Detection limits below this value not achievable by listed technology. No routine technology likely available to achieve this detection limit.

Table A.2 identifies the analyses and laboratory methods to be used for the sample analyses. For the chemical and radiological constituents, the preferred methods are those listed in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA SW-846) or *Standard Test Methods for Materials* (ASTM 1998). The requested constituents may be analyzed by laboratory-specific procedures, provided that the procedures are validated and conform to requirements in DOE/RL-96-68. Both the EPA SW-846 methods and the Pacific Northwest National Laboratory methods listed in Table A.2 are based on techniques from "Methods of Soil Analysis." Therefore, these procedures should be comparable. The detection limit, precision, and accuracy guidelines for the parameters of interest are listed in RPP-7455.

A.3.0 REFERENCES

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