SGW-59564
Revision 1

ENGINEERING EVALUATION REPORT FOR LOW-LEVEL BURIAL GROUNDS TRENCHES 31 AND 34 GROUNDWATER MONITORING

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

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APPROVED
By Mary P. Curry at 3:13 pm, Sep 17, 2018

Release Approval | Date

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Statement of certification:

I am a licensed Professional Engineer in the State of Washington, No. 41198, with a degree in Environmental Engineering. I have over 26 years of professional experience, including 15 years with groundwater systems. I reviewed the attached engineering study referenced as "Engineering Evaluation Report for Low-Level Burial Grounds Trenches 31 and 34 Groundwater Monitoring, SGW-59564, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington" and I certify that it demonstrates completeness in compliance with WAC 173-303-806(4)(a).

August 29, 2018

Date

Leonard D. Habel, P.E.
Sr. Principal Engineer
North Wind Infrastructure and Technology, LLC

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Terms

AEA	*Atomic Energy Act of 1954*
API	American Petroleum Institute
CAS	Chemical Abstracts Service
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CPGWM	Central Plateau Groundwater Model
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DWMU	dangerous waste management unit
Ecology	Washington State Department of Ecology
ECF	environmental calculation file
EPA	U.S. Environmental Protection Agency
FY	fiscal year
HDPE	high-density polyethylene
K_d	distribution coefficient
LCRS	leachate collection and removal system
LDR	land disposal restriction
LLBG	Low-Level Burial Grounds
MT3DMS	Modular 3-D Transport Multispecies
OU	operable unit
P&T	pump and treat
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
SALDS	State-Approved Land Disposal Site
TOC	total organic carbon
TOX	total organic halogen
VOC	volatile organic compound
WIDS	Waste Information Data System
WMA	waste management area

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1 Introduction

This engineering evaluation report provides information to support the proposed final status groundwater monitoring for the Low-Level Burial Grounds (LLBG) Trenches 31 and 34 based on evaluation of contaminants associated with LLBG Trenches 31 and 34, and the expected migration behavior of contaminants in the waste management area (WMA). This evaluation includes results of groundwater transport simulations conducted using the Central Plateau Groundwater Model (CPGWM) (CP-47631, *Model Package Report: Central Plateau Groundwater Model Version 8.3.4*). LLBG Trenches 31 and 34 are the only operating trenches in LLBG WMA-3 and comprise an active operating unit group that will be modified into WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8C (hereinafter referred to as the Hanford Facility RCRA Permit). This report provides supporting documentation regarding the protection of groundwater required by the *Resource Conservation and Recovery Act of 1976* (RCRA) permitting process for final status facilities.

LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads comprise a single unit group; however, only LLBG Trenches 31 and 34 are subject to groundwater monitoring. The trenches are located within LLBG WMA-3 in the 200 West Area of the Hanford Site in Washington State and overlie the 200-ZP-1 Groundwater Operable Unit (OU) (Figure 1-1). LLBG Trenches 31 and 34 have received dry low-level mixed waste generated from offsite facilities and from the Hanford Site since 1999 and 2005, respectively. LLBG Trenches 31 and 34 are land disposal units constructed with a double liner and leachate collection and removal system (LCRS).

Revision 0 of this report was issued in 2016 and was intended to address specific information requested in Washington State Department of Ecology (Ecology) Letter 15-NWP-157, "Groundwater Monitoring Requirements for Low-Level Burial Grounds Trenches 31/34 Permit Modification to the *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 9, for the Treatment, Storage, and Disposal of Dangerous Waste*." The letter required submittal of an engineering report with the following information included for LLBG Trenches 31 and 34:

- Information necessary to support the design of the groundwater monitoring well network, such that it is capable of yielding representative samples of groundwater potentially impacted by releases from the two regulated units under the influence of the adjacent 200-ZP-1 OU pump and treat (P&T) injection well(s)
- Information supporting design of the groundwater monitoring program that is capable of detecting significant statistical increases in groundwater contamination at the earliest practicable time, reflecting the influence of the adjacent injection well(s)
- Information describing the approach, input data, any additional information needs, and analysis proposed to evaluate and respond to changes in the groundwater flow regime as it evolves over time under the influence of the adjacent injection well(s)

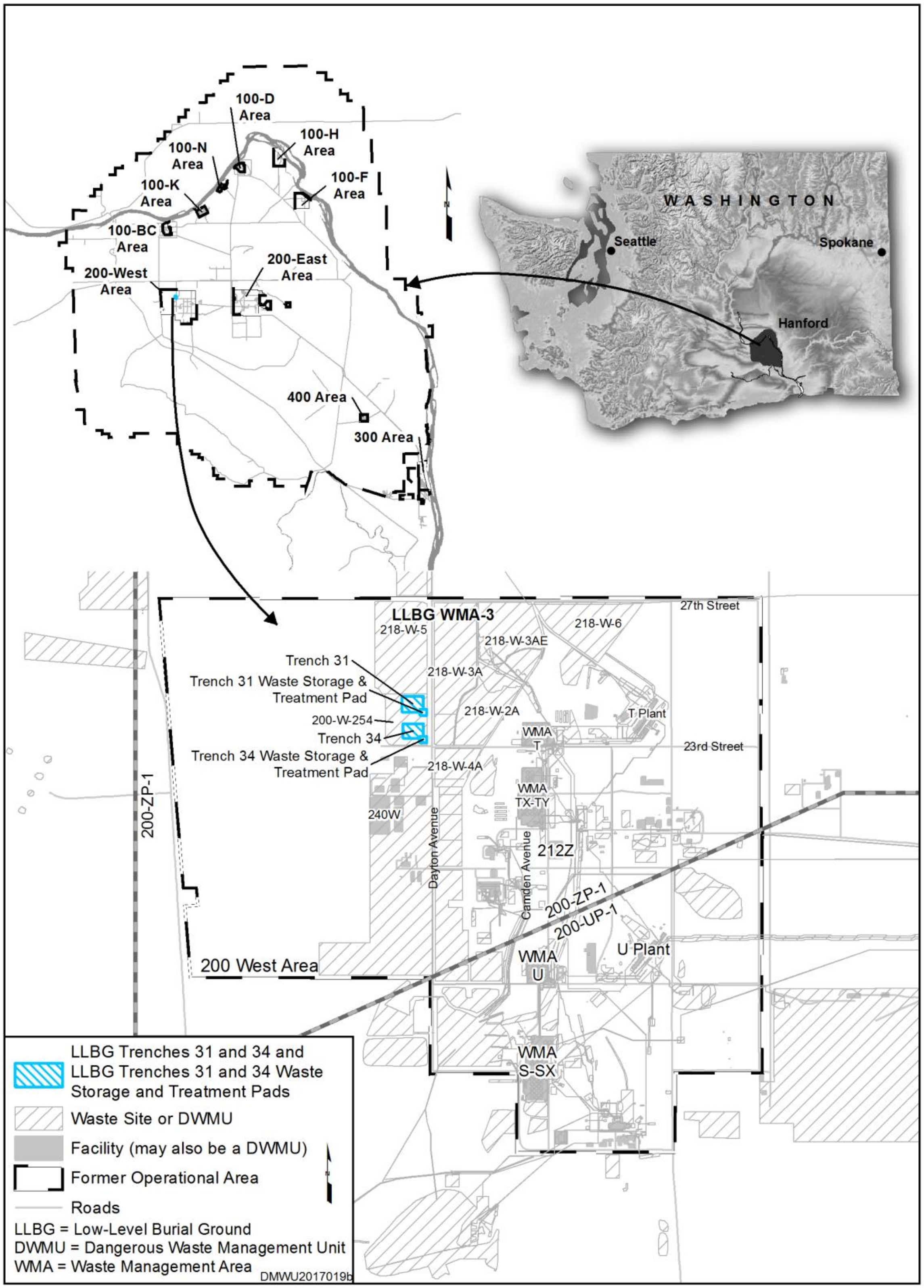


Figure 1-1. Location Map for LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads

Letter 15-NWP-157 also required that the groundwater monitoring plan include both indicator parameters and dangerous waste constituents pursuant to WAC 173-303-645(4), "Dangerous Waste Regulations," "Releases from Regulated Units." It further stated that the engineering report would be in "preparation of a permit modification request to incorporate LLBG Trenches 31/34 Dangerous Waste Management Units (DWMUs) into the current *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste* (Permit, Rev. 8C) pursuant to the Ecology (2014), *Agreed Order and Stipulated Penalty No. DE 10156*. The permit modification request to be submitted pursuant to the Ecology (2014) must provide the applicable information required by WAC 173-303-806, "Final Facility Permits." This includes the additional information requirements for regulated units subject to groundwater monitoring found in WAC 173-303-806(4)(xx)."

The analysis documented in this report complies with WAC 173-303-806, which outlines the contents of the Part B permit application pertinent to the protection of groundwater. WAC 173-303-806(4)(a)(xx)(E) and (F)(I) and (II) requires the preparation of detailed plans and an engineering report describing the proposed monitoring program to meet the requirements of WAC 173-303-645(8), "Releases from Regulated Units," "General Groundwater Monitoring Requirements." WAC 173-303-645(8) requires a groundwater monitoring system consisting of a sufficient number of wells installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer. These samples are intended to represent the quality of background groundwater that has not been affected by the leakage from a regulated unit, represent the quality of groundwater passing the point of compliance, and allow for the detection of contamination when dangerous waste constituents have migrated from the DWMU to the uppermost aquifer.

WAC 173-303-806(4)(a)(xx)(E) and (F)(I) and (II) specify that a detailed plan describing the proposed groundwater monitoring program be included in the Part B application with this engineering evaluation report. This engineering evaluation report provides the technical basis for the groundwater monitoring that will be described in that plan. As groundwater monitoring under the detection monitoring program (WAC 173-303-645(9)) will be performed along with the general monitoring requirements (WAC 173-303-645(8)), this engineering evaluation report also provides the supporting information for the detection monitoring requirements. There is no groundwater monitoring plan specific to LLBG Trenches 31 and 34 under interim status as they were monitored as part of LLBG WMA-3.

In addition, this report provides information required by WAC 173-303-806(4)(a)(xx)(C) (topographic map), WAC 173-303-806(4)(a)(xx)(A) (summary of interim status groundwater monitoring data), and WAC 173-303-806(4)(a)(xx)(B) (hydrogeological information). Plume maps of regional contaminants in the area of the regulated unit are also provided.

Applicable groundwater monitoring requirements of WAC 173-303-645 and WAC 173-303-806(4)(a)(xx) are detailed in Table 1-1. This revision adds additional information, with changes detailed in Table 1-2.

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-806(4)(a)(xx)(A) A summary of the groundwater monitoring data obtained during the interim status period under 40 C.F.R. 265.90 through 265.94, where applicable	Appendix A
WAC 173-303-806(4)(a)(xx)(B) Identification of the uppermost aquifer and aquifers hydraulically interconnected beneath the facility property, including groundwater flow direction and rate, and the basis for such identification (that is, the information obtained from hydrogeologic investigations of the facility area)	Section 3.2 Section 3.3
WAC 173-303-806(4)(a)(xx)(C) On the topographic map required under (a)(xviii) of this subsection, a delineation of the waste management area, the property boundary, the proposed "point of compliance" as defined under WAC 173-303-645(6), the proposed location of groundwater monitoring wells as required under WAC 173-303-645(8), and, to the extent possible, the information required in (a)(xx)(B) of this subsection.	Appendix C
WAC 173-303-806(4)(a)(xx)(D)[a] A description of any plume of contamination that has entered the groundwater from a regulated unit at the time that the application was submitted that: (I) Delineates the extent of the plume on the topographic map required under (a)(xviii) of this subsection; (II) Identifies the concentration of each constituent throughout the plume or identifies the maximum concentrations of each constituent in the plume.	Appendix D
WAC 173-303-806(4)(a)(xx)(E) Detailed plans and an engineering report describing the proposed groundwater monitoring program to be implemented to meet the requirements of WAC 173-303-645(8)	Chapter 9
WAC 173-303-806(4)(a)(xx)(F) If the presence of dangerous constituents has not been detected in the groundwater at the time of permit application, the owner or operator must submit sufficient information, supporting data, and analyses to establish a detection monitoring program which meets the requirements of WAC 173-303-645(9). This submission must address the following items specified under WAC 173-303-645(9): (I) A proposed list of indicator parameters, waste constituents, or reaction products that can provide a reliable indication of the presence of dangerous constituents in groundwater (II) A proposed groundwater monitoring system	Chapter 9
WAC 173-303-645(2)(a) Owners and operators subject to this section must conduct a monitoring and response program as follows: (iv) In all other cases, the owner or operator must institute a detection monitoring program under subsection (9) of this section.	Chapter 9

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-645(6)(a) The department will specify in the facility permit the point of compliance...at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.	Section 9.2
WAC 173-303-645(8)(a) The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that: (i) Represent the quality of background groundwater that has not been affected by leakage from a regulated unit (ii) Represent the quality of groundwater passing the point of compliance (iii) Allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the waste management area to the uppermost aquifer	Section 9.3
WAC 173-303-645(8)(c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing must allow collection of representative groundwater samples. Wells must be constructed in such a manner as to prevent contamination of the samples, the sampled strata, and between aquifers and water bearing strata. Wells must meet the requirements applicable to resource protection wells, which are set forth in chapter WAC 173-160, "Minimum standards for construction and maintenance of wells."	Section 9.3 Appendix E
WAC 173-303-645(8)(h) The owner or operator will specify one of the following statistical methods to be used in evaluating groundwater monitoring data for each hazardous constituent which, upon approval by the department, will be specified in the unit permit. The statistical test chosen must be conducted separately for each dangerous constituent in each well. Where practical quantification limits (pqls) are used in any of the following statistical procedures to comply with (i)(v) of this subsection, the pql must be proposed by the owner or operator and approved by the department. Use of any of the following statistical methods must be protective of human health and the environment and must comply with the performance standards outlined in (i) of this subsection.	Appendix H
WAC 173-303-645(8)(i) Any statistical method chosen under (h) of this subsection for specification in the unit permit must comply with [standards provided in WAC 173-303-645(8)(i)(i), (ii), (iii), (iv), (v), and (vi)] as appropriate.	Appendix H
WAC 173-303-645(9)(a) The owner or operator must monitor for indicator parameters (e.g., pH, specific conductance, total organic carbon (TOC), total organic halogen (TOX), or heavy metals), waste constituents, or reaction products that provide a reliable indication of the presence of dangerous constituents in groundwater. The department will specify the parameters or constituents to be monitored in the facility permit, after considering the following factors:	Chapter 8 Chapter 9

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
(i) The types, quantities, and concentrations of constituents in wastes managed at the regulated unit; (ii) The mobility, stability, and persistence of waste constituents or their reaction products in the unsaturated zone beneath the waste management area; (iii) The detectability of indicator parameters, waste constituents, and reaction products in groundwater; and (iv) The concentrations or values and coefficients of variation of proposed monitoring parameters or constituents in the groundwater background.	
WAC 173-303-645(9)(b)[b] The owner or operator must install a groundwater monitoring system at the compliance point, as specified under subsection (6) of this section. The groundwater monitoring system must comply with subsection (8)(a)(ii), (b) [b] and (c) of this subsection.	Chapter 9

a. WAC 173-303-806(4)(a)(xx)(D) is not applicable because LLBG Trenches 31 and 34 has not contaminated the groundwater. However, plume maps of regional contaminants that are in the vicinity of LLBG Trenches 31 and 34 are included in Appendix D.

b. WAC 173-303-645(8)(b) is not applicable because LLBG Trenches 31 and 34 comprise one regulated unit. They are not being monitored as part of a group of regulated units.

Table 1-2. Main Differences Between this Revision and the Previous Revision

Type of Change	Previous Revision (SGW-59564, Rev. 0)	Current Revision (Rev. 1)	Justification Summary
Groundwater Modeling	Modeling performed with CPGWM version 6.3.3 (CP-47631, Rev. 2). The modeling included evaluations that were completed for three different 200 West P&T system flow rates or “scenarios” (including one scenario with no P&T operation, representing conditions after completion of the P&T operation). For the scenarios with 200 West P&T system operations, six different configurations of injection rates from the injection wells were evaluated.	Modeling performed with CPGWM version 8.3.4 (CP-47631, Rev. 3). The modeling still includes evaluations completed for three different 200 West P&T system flow rates or “scenarios” (including one scenario with no P&T system operations). For the scenarios with 200 West P&T system operations, 18 different configurations of injection rates from the injection wells were evaluated.	A new model version was available and the modeling was performed using the current model version. Between revisions of the document, the decision was made to expand the modeling performed to examine the impact of varying injection rates on additional facilities throughout the 200 West Area. The previous injection rate configurations focused on injection wells near the subject facility. The current 18 different configurations evaluate injection wells throughout the 200 West Area.

Table 1-2. Main Differences Between this Revision and the Previous Revision

Type of Change	Previous Revision (SGW-59564, Rev. 0)	Current Revision (Rev. 1)	Justification Summary
	The modeling was presented in a single ECF for the subject facility, ECF-200ZP1-16-0054, Rev. 0*.	The modeling is presented in two ECF documents, ECF-200W-17-0070, Rev. 0 and ECF-200ZP1-16-0054, Rev. 2.	Between revisions of the document, the decision was made to expand the modeling performed to examine the impact of varying injection rates on additional facilities throughout the 200 West Area. ECF-200W-17-0070, Rev. 0 presents results of the modeling on the regional scale (200 West Area) and ECF-200ZP1-16-0054, Rev. 2 presents local, site-specific results.
	The modeling was completed before new wells on the western side of LLBG WMA-4 (south of the subject facility) were installed and did not consider injection from these wells.	The modeling considers injection rates from new injection wells on the western side of LLBG WMA-4.	It was appropriate to consider any impact that the potential injection rates from the new wells might have on the monitoring well network.
	The modeling report included spatial snapshots of the results of the particle tracking calculations for a hypothetical release from the facility. However, it did not include the corresponding spatial snapshots of the results of the transport modeling calculations.	The modeling report includes spatial snapshots of the results of both the particle tracking and the transport modeling of a hypothetical release from the facility. The "release unit plume maps" are included as Appendix B to ECF-200ZP1-16-0054, Rev. 2.	The spatial snapshots of the results of the transport modeling were added for clarity. By having results of both calculation methods presented in a similar manner, it facilitates understanding of the results of the different calculations that were performed.
Proposed Well Network	299-W9-2 299-W10-29 299-W10-30 C9625 C9626 C9627	299-W9-2 299-W10-29 299-W10-30 T-31-34_PW-1 T-31-34_PW-2 T-31-34_PW-3	The locations for the proposed wells was changed so that the wells would be located on the point of compliance.
Groundwater Flow Direction	East-southeast	Same	No change
Waste Inventory Evaluation and Selection of Monitoring Constituents	Waste constituents identified from SWITS waste container records were converted into a calculated pore volume concentration for screening.	The determination of site-specific monitoring constituents was revised to evaluate and screen the wastes associated with the LLBG Part A Application. The methodology and outcomes of the evaluation are documented in a	Evaluation and screening of the Part A wastes provides a comprehensive list of wastes that are present, or may be present in the future, for the unit.

Table 1-2. Main Differences Between this Revision and the Previous Revision

Type of Change	Previous Revision (SGW-59564, Rev. 0)	Current Revision (Rev. 1)	Justification Summary
	Leachate sample results were compared to MCL and MRDL with no further screening.	calculation (ECF-HANFORD-17-0233).	The calculation provides additional details and documentation of selection process for clarity.
Proposed Monitoring Constituents	Indicator parameter dangerous waste constituents: arsenic, cadmium, mercury, benzene, 1,1,1-trichloroethane, 4-methyl-2-pentanone, and dichloromethane	Includes 140 monitoring constituents derived from the Part A Application to detect release from regulated unit.	The proposed monitoring constituents are revised due to changes in the site-specific constituent evaluation and screening methodology.
	Groundwater quality parameters: alkalinity, anion, metals	Not included	The proposed monitoring constituents are revised due to changes in the site-specific constituent evaluation and screening methodology.
	Field parameters: pH, specific conductance dissolved oxygen, temperature, turbidity	Field parameters: pH, dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, turbidity.	Added oxidation-reduction potential for groundwater chemistry information and evaluation of potential microbial growth and corrosion within the well casing
Proposed Sampling Frequency	Indicator parameter dangerous waste constituents: quarterly for 2 years, then semiannual	Monitoring constituents to detect release from regulated unit: same.	No change
	Groundwater quality parameters: annual	Not included	The proposed monitoring constituents were revised
	Field parameters: quarterly for 2 years, then semiannual	Same	No change
Type of Groundwater Monitoring Program	Detection monitoring program	Same	No change
Statistical Evaluation Method	Not proposed	Provides statistical evaluations of monitoring constituent results to be used to determine the appropriate statistical method under final status monitoring.	Provides a plan to determine the statistical method after a sufficient number of samples are collected.

Table 1-2. Main Differences Between this Revision and the Previous Revision

Type of Change	Previous Revision (SGW-59564, Rev. 0)	Current Revision (Rev. 1)	Justification Summary
Supporting Information	Provided a brief background of the facility and waste disposed at the facility	Added a new Chapter 2 to provide a more thorough description of the facility and waste disposal, regulatory basis, and a detailed interim status groundwater monitoring history. New Appendix A provides a summary of interim status monitoring information obtained from annual reports and the interim status monitoring data collected from the LLBG WMA-3 network wells during the operational period of the LLBG Trenches 31 and 34.	Provides additional details that will also be incorporated in the future groundwater monitoring plan. Provides a summary of the groundwater monitoring data obtained during the interim status period to support final status permit requirements (WAC 173-303-806(4)(a)(xx)(A)).

Note: Complete reference citations are provided in Chapter 11.

* ECF-200ZP1-16-0054, Rev. 0, is presented in Appendix B of SGW-59564, Rev. 0.

MCL = maximum contaminant level

MRDL = maximum residual disinfectant levels

SWITS = Solid Waste Information and Tracking System

Documented releases to groundwater have not occurred at LLBG Trenches 31 and 34. Details of the operational, regulatory, and groundwater monitoring history can be found in Chapter 2.

This report is organized as follows:

- Chapter 2 includes historical information to support the final status groundwater monitoring program determination.
- Chapter 3 describes the geology and hydrogeology in the area of LLBG Trenches 31 and 34.
- Chapter 4 describes the contaminant migration conceptual model.
- Chapter 5 describes groundwater flow simulations for the 200 West Area.
- Chapter 6 describes calculations performed to evaluate wells for the proposed LLBG Trenches 31 and 34 monitoring well network.
- Chapter 7 presents conclusions from the calculations performed in Chapters 5 and 6.
- Chapter 8 identifies the groundwater monitoring constituents of interest.
- Chapter 9 describes the proposed final status groundwater monitoring program.
- Chapter 10 describes how the monitoring well network will be maintained.
- Chapter 11 lists the references cited in this report.
- Appendix A contains the interim status groundwater monitoring data summary.

- Appendix B contains the identification of site-specific monitoring constituents environmental calculation file (ECF) (ECF-HANFORD-17-0233, *Identification of Site-Specific Monitoring Constituents for the Low-Level Burial Grounds*).
- Appendix C contains the topographic map.
- Appendix D contains regional plume maps in the vicinity of LLBG Trenches 31 and 34.
- Appendix E contains well as-built diagrams and proposed well designs.
- Appendix F contains the 200 West Area modeling ECF (ECF-200W-17-0070, *Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network*).
- Appendix G contains the LLBG Trenches 31 and 34 modeling ECF (ECF-200ZP1-16-0054, *Groundwater Flow and Migration Calculations to Support Assessment of the LLBG Trenches 31 and 34 Monitoring Network*).
- Appendix H contains the process for defining the groundwater monitoring statistical method.

2 Supporting Historical Information

This chapter describes LLBG Trenches 31 and 34, their operations, regulatory basis, waste characteristics, and interim status groundwater monitoring history. A description of the LLBG Trenches 31 and 34 Waste Storage and Treatment Pads is included as supplemental information only, as they are not subject to groundwater monitoring.

2.1 Background

LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads, constructed in 1994, are operating DWMUs that are used for treatment, storage, and disposal of mixed wastes. The trenches and adjacent pads are located in the 200 West Area, within LLBG WMA-3 on the Hanford Site in Washington State. LLBG WMA-3 consists of 76 unlined trenches and 2 lined trenches that are managed in 4 burial grounds: 218-W-3A, 218-W-3AE, 218-W-5, and 200-W-254. LLBG Trenches 31 and 34 (the 2 lined trenches within LLBG WMA-3) and the adjoining pads are within the 200-W-254 Burial Ground. The 200-W-254 Burial Ground was originally part of the 218-W-5 Burial Ground. In 2014, a new site code (200-W-254) was identified in the Hanford Site Waste Information Data System (WIDS) database to identify the operating units of the LLBG (Trenches 31 and 34). The locations of LLBG Trenches 31 and 34, LLBG Trenches 31 and 34 Waste Storage and Treatment Pads, and LLBG WMA-3 in the 200 West Area are shown in Figure 2-1.

The base dimensions of each trench area are 76 by 31 m (250 by 100 ft) (2,325 m^2 [25,000 ft^2]), with surface grade dimensions of 91 by 137 m (300 by 450 ft) (12,500 m^2 [135,000 ft^2]) at each trench (DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*, Addendum C, Table C-4 [issued in 16-ESQ-0028, "Submittal of DOE/RL-2015-74, Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex – Waste Receiving and Processing Facility Operating Unit Groups"]). Each trench is designed for 21,408 m^3 (28,000 yd^3) of mixed waste. The floor of both trenches slopes slightly, providing a variable depth of 9.1 to 12.2 m (30 to 40 ft). The floor slope is a minimum of 2%, draining to a recessed area at the eastern end that houses the sump for leachate collection. The side slope ratio is 3:1 (horizontal to vertical). Access to the trench floor is provided by a ramp with an 8% slope. Design drawings for LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads are available in DOE/RL-2015-74, Addendum C, Appendix C-B (presented in 16-ESQ-0028).

2.1.1 Trenches 31 and 34 Liner Systems

The principal design features of LLBG Trenches 31 and 34 include provisions for liquid collection systems using geomembrane trench liners. The liner systems are designed to prevent migration of leachate out of the lined trenches during their active life and comply with requirements for dangerous waste landfills in WAC 173-303-665, "Landfills." Each trench was constructed with a double liner and an LCRS. The storage and treatment pads direct surface runoff to the LCRS of the lined trenches. The bottom and sides of each trench are covered with a 0.9 m (3 ft) layer of soil to protect the liner system during fill operations. There is a separation distance of approximately 40 m (130 ft) between the synthetic liners of LLBG Trenches 31 and 34 and groundwater (DOE/RL-2015-74, Addendum C, Section C4.1.2 [presented in 16-ESQ-0028]). The layers of the liner systems and LCRS, from bottom to top, are provided in Table 2-1.

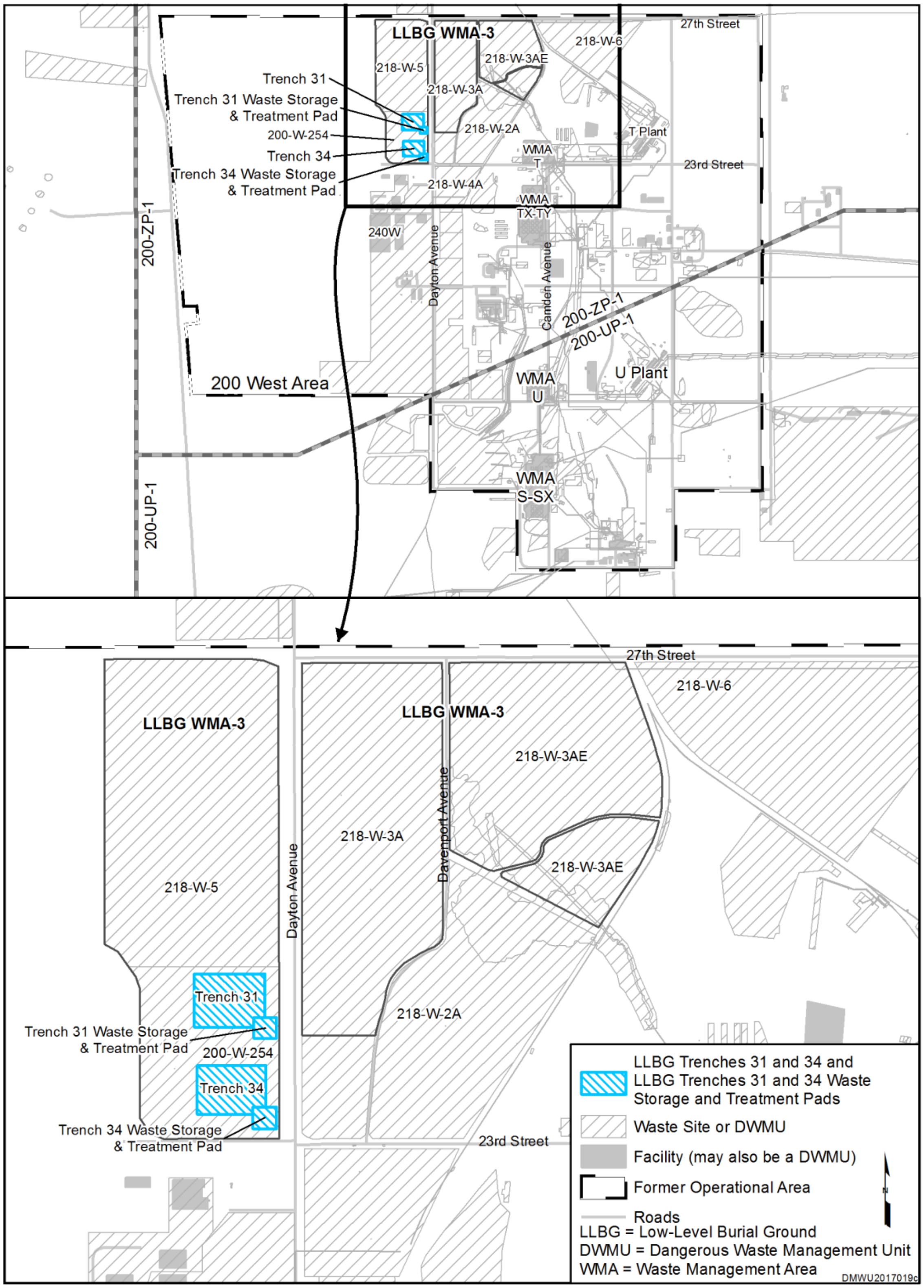


Figure 2-1. LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads in the 200 West Area

Table 2-1. LLBG Trenches 31 and 34 Lining and Leachate Collection and Removal Systems

Layer	Landfill Base	Landfill Slopes
Secondary liner	Admix soil, 0.94 m (3.1 ft) thick	Admix soil, 0.94 m (3.1 ft) thick
	HDPE liner, 60 mil, smooth	HDPE liner, 60 mil, textured
Secondary LCRS[a]	Geotextile[b] 237 g/m^2 (7 oz/yd^2)	Geonet-geotextile Geocomposite
	Geonet	
	Geotextile, 542 g/m^2 (16 oz/yd^2)	
	Drainage gravel, 0.3 m (1 ft) thick	
	Geotextile, 542 g/m^2 (16 oz/yd^2)	
Primary liner	Admix soil, 0.5 m (1.5 ft) thick	HDPE liner, 60 mil, textured
	HDPE liner, 60 mil, smooth	
Primary LCRS[a]	Geotextile[b], 237 g/m^2 (7 oz/yd^2)	Geonet-geotextile Geocomposite
	Geonet	
	Geotextile, 542 g/m^2 (16 oz/yd^2)	
	Drainage gravel, 0.3 m (1 ft) thick	
	Geotextile[b], 237 g/m^2 (7 oz/yd^2)	
Operations layer	Gravel/eolian sand, 0.9 m (3 ft) thick	Eolian sand, 0.9 m (3 ft) thick

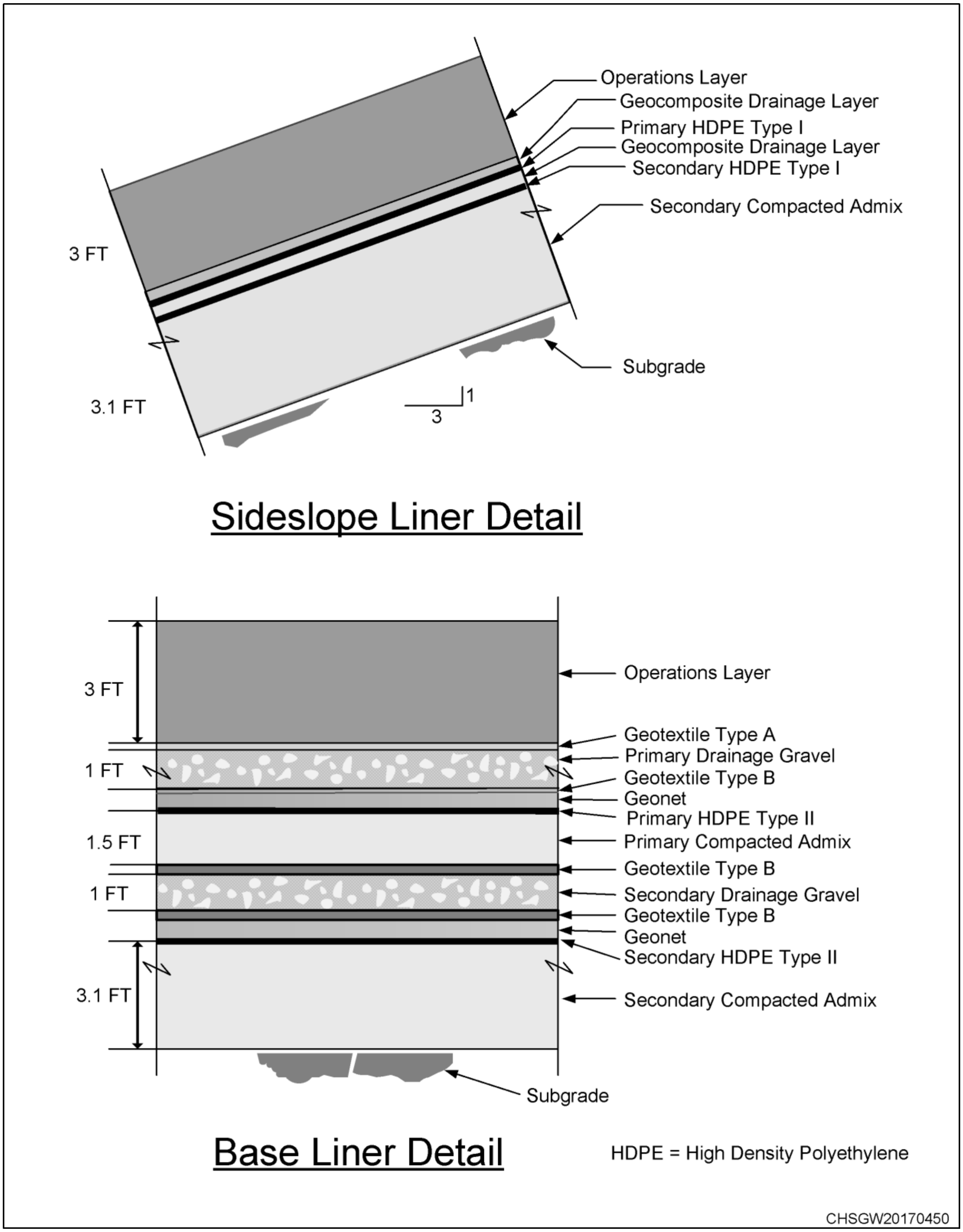
Source: DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*, Addendum C, Table C-6 (issued in 16-ESQ-0028).

a. Leachate removal systems include pumps, HDPE piping, and stainless steel piping required to move leachate to storage.

b. Geotextile 237 g/m^2 (7 oz/yd^2) is installed only in Trench 34.

HDPE = high-density polyethylene

A depiction of the liner system is presented in Figure 2-2. The following details from DOE/RL-2015-74, Addendum C, Section C4.1 (presented in 16-ESQ-0028), generally describe the secondary liner and primary liner systems presented in Table 2-1.



Adapted from DOE/RL-2015-74, Figure C-3 (presented in 16-ESQ-0028).
Complete reference citations are provided in Chapter 11.

Figure 2-2. Schematic of Liner System

Secondary Liner System

- Soil Liner – The secondary admix soil liner is composed of imported bentonite and onsite eolian sand that had been stockpiled during excavation activities. The upper layer was trimmed to the design grades and tolerances planned in the design report (WHC-SD-W025-FDR-001, *Design Report Project W-025 Radioactive Mixed Waste (RMW) Land Disposal Facility Non-Drag-Off*). Lastly, the surface was rolled with a smooth drum roller in preparation for the high-density polyethylene (HDPE) geomembrane liner.
- Synthetic Liner – The secondary synthetic liner is composed of both smooth and textured HDPE geomembrane. It was installed in overlapping paneled sections. The smooth geomembrane was installed on the floor of the landfill, while the textured geomembrane was installed on the side slopes and in the sump area.
- Leachate Collection and Removal System – The secondary LCRS consists of geosynthetic materials and granular drainage material that collects leachate in the landfill. The leachate is then removed using a submersible pump and HDPE piping.

Primary Liner System

- Soil Liner – Construction of the primary soil liner was conducted in a manner similar to that used to install the secondary soil liner. However, the primary soil liner was placed only on the floor of the landfill and in the anchor trench on the access ramp.
- Synthetic Liner – The materials, methods, and equipment used to install the primary HDPE geomembrane liner were generally the same as those used to install the secondary HDPE geomembrane liner.
- Included in the primary geomembrane lining system is the 80 mil thick HDPE geomembrane liner installed in the northwest corner of the waste storage and treatment pad. The 80 mil thick HDPE geomembrane liner was installed on a prepared subgrade consisting of eolian sand.
- Leachate Collection and Removal System – The primary LCRS consists of geosynthetic materials and granular drainage material, a leachate collection piping system, and a leachate collection well. The leachate removal portion of the primary system consists of a submersible pump, a self-priming pump, and HDPE piping.
- Operations Layer – This layer serves to protect the underlying liner from damage during operations. It consists of onsite eolian sand and/or sandy gravel that had been stockpiled during excavation activities.

2.1.2 Trenches 31 and 34 Leachate Collection and Removal Systems

As described in DOE/RL-2015-74, Addendum C, Section C4.4 (presented in 16-ESQ-0028), the purpose of the LCRS is to provide sufficient permeability and storage volume to collect, retain, and dispose, in a timely manner, fluids falling on or moving through the waste. The LCRS includes the piping required to move leachate to a storage unit. The primary LCRS provides the preferential path along which the leachate flows into the primary LCRS sump. The secondary LCRS (also called the leak detection system) is located between the primary and secondary geomembranes and provides the preferential path along which any fluids leaking through the primary liner system flow to the secondary LCRS sump. The primary and secondary LCRSs are described in the following paragraphs.

Primary LCRS System

The base of the primary LCRS is defined by the primary geomembrane. On the floor of the landfill, the primary geomembrane is overlain by geonet, geocomposite, and/or granular drainage layers. A granular drainage layer is used, and pipes are located at regular intervals to increase flow capacity. Geotextile layers at the top of the LCRS prevent migration of fine soil particles into the gravel or geonet and thus prevent clogging.

On the side slopes, a geocomposite layer is used over the geomembrane. The geocomposite includes bonded geotextiles on both sides that increase the interface shear strength and allow this material to be used on the side slopes. Because of construction limitations, no drainage gravel is placed on the side slopes.

The primary LCRS is covered by the operations layer. The layer provides protection for the underlying liner and drainage materials. The operations layer covers both the landfill floor and side slopes. The primary LCRS is designed, operated, and maintained to control run-on during a 25-year storm (WAC 173-303-665(2)(c)) and run-off during a 25-year, 24-hour storm (WAC 173-303-665(2)(d)).

The primary LCRS will be emptied and otherwise managed expeditiously after the storm event in accordance with WAC 173-303-665(2)(e). Should a greater than 25-year, 24-hour storm event occur, the primary LCRS sump is designed to store leachate temporarily at a depth greater than 30.5 cm (12.0 in.). The primary LCRS sump is equipped with two sump pumps. One pump is high capacity, capable of rapid removal of large volumes of leachate, suitable for the transfer of batch quantities of leachate and capable of handling the larger volumes of leachate anticipated from the 25-year, 24-hour storm event. The other pump is a low-capacity submersible pump located in the base of the primary sump. The pumps are fabricated from stainless steel or other corrosion-resistant material.

Secondary LCRS System

The base of the secondary LCRS is formed by the secondary geomembrane. The secondary LCRS is similar to the primary LCRS except that pipes are not included. The pipes are not needed because high flow capacity is not required for the low leachate volumes. The secondary LCRS drains to the secondary sump, which is located immediately below the primary sump. Because of the low volumes, the secondary LCRS is equipped with only one low-capacity submersible pump.

2.1.3 LLBG Trenches 31 and 34 Waste Storage and Treatment Pads

The LLBG Trenches 31 and 34 Waste Storage and Treatment Pads provide storage and treatment for containerized mixed waste, as well as land disposal restriction (LDR)-compliant containerized waste before disposal. The pads are constructed with an asphalt base. The LLBG Trench 31 Waste Storage and Treatment Pad has a total area of approximately 2,150 m^2 (23,200 ft^2; (49.4 m [162 ft] wide by 43.6 m [143 ft] long) (DOE/RL-2015-74, Addendum C, Table C-2 [issued in 16-ESQ-0028]). The LLBG Trench 34 Waste Storage and Treatment Pad has a total area of approximately 2,160 m^2 (23,200 ft^2) (48.8 m [160 ft] wide by 44.2 m [145 ft] long) (DOE/RL-2015-74, Addendum C, Table C-2 [issued in 16-ESQ-0028]).

The container storage process design capacity for the Trench 31 Waste Storage and Treatment Pad is approximately 1,150 m^3 (1,500 yd^3), and the Trench 34 Waste Storage and Treatment Pad is approximately 1,240 m^3 (1,620 yd^3) for a combined process design capacity of approximately 2,390 m^3 (3,120 yd^3) (DOE/RL-2015-74, Addendum C, Table C-2 [issued in 16-ESQ-0028]).

Waste treatment to meet the LDR requirements will be performed on the LLBG Trench 31 and 34 Waste Storage and Treatment Pads. As described in the Part B Permit Application (DOE/RL-2015-74, Addendum A [issued in 16-ESQ-0028]), the treatment capability consists of the use of microencapsulation, macroencapsulation, and sealing for mixed waste debris as identified under 40 CFR 268.45, "Land Disposal Restrictions," "Treatment Standards for Hazardous Debris," Table 1, "Alternative Treatment Standards for Hazardous Debris," and macroencapsulation as defined in 40 CFR 268.42, "Treatment Standards Expressed as Specified Technologies." Mixed waste containers will meet the 90% full container requirements following treatment.

2.2 Regulatory Basis

In May 1987, the U.S. Department of Energy (DOE) issued a final rule (10 CFR 962, "Byproduct Material") stating that the hazardous waste components of mixed waste are subject to RCRA regulations. Ecology gained regulatory authority over the hazardous waste components of mixed waste on August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*. This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes LLBG Trenches 31 and 34. Groundwater monitoring is conducted at LLBG Trenches 31 and 34 in accordance with WAC 173-303-645 as specified by the Hanford Facility RCRA Permit, Part II, Condition II.F.

Dangerous waste is regulated under RCW 70.105, "Hazardous Waste Management," and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include "source, special nuclear, and byproduct materials" as defined in the *Atomic Energy Act of 1954* (AEA). The AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the State of Washington under RCRA or RCW 70.105. LLBG WMA-3 has an AEA component and is monitored for AEA under DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*.

Interim status groundwater monitoring at LLBG WMA-3 began in 1987 based on the interim status indicator evaluation program requirements of 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring" and WAC 173-303-400, "Interim Status Facility Standards." Operation of LLBG Trenches 31 and 34 within LLBG WMA-3 began in 1999. LLBG WMA-3 has been monitored under an indicator evaluation program throughout the operational period of LLBG Trenches 31 and 34.

In 2015, Ecology provided the groundwater monitoring requirements needed to support a permit modification request to incorporate the LLBG Trenches 31 and 34 DWMUs into the Hanford Facility RCRA Permit (15-NWP-157). 15-NWP-157 required submittal of an engineering report that evaluated the impacts of the adjacent 200-ZP-1 OU P&T injection wells on the design of the monitoring network, contaminant detection, and changes to the flow regime over time. 15-NWP-157 also required that the groundwater monitoring plan include both indicator parameters and dangerous waste constituents pursuant to WAC 173-303-645(4).

In 2016, the DOE, Richland Operations Office (DOE-RL) submitted a Part B Permit Application for LLBG Trenches 31 and 34 under the Hanford Facility RCRA Permit to Ecology that included the LLBG Trenches 31-34-94 Operating Unit Group (16-ESQ-0028). The Part B submittal grouped LLBG Trench 94 (located in LLBG WMA-2) and Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste

Storage and Treatment Pads (located in LLBG WMA-3) into a single unit group comprising the five operating DWMUs and a closing DWMU, the FS-1 Outdoor Container Storage Area, located adjacent to Trench 34. The unit group comprised three landfills (LLBG Trenches 31 and 34 and LLBG Trench 94) and two waste storage and treatment pads (LLBG Trenches 31 and 34 Waste Storage and Treatment Pads).

The submittal was determined to be incomplete (16-NWP-083, "Completeness Determination for the Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex – Waste Receiving and Processing Facility Operating Unit Groups, received January 28, 2016"). In 16-NWP-083, Ecology identified the information needs for groundwater monitoring of Trenches 31 and 34 under a final status permit per WAC 173-303-806(4)(a)(xx) and WAC 173-303-645, which includes the following:

- A groundwater monitoring plan specific to Trenches 31 and 34 (and a groundwater monitoring plan specific to Trench 94)
- Specification of dangerous waste constituents
- Provision of an engineering report

These requirements are integrated into this revised engineering report and the associated groundwater monitoring plan for LLBG Trenches 31 and 34.

The clean closure certification for the FS-1 DWMU was accepted by Ecology in October 2016 (16-NWP-185, "Determination on Closure Certification for the FS-1 Outdoor Container Storage Area"). FS-1 is not addressed further in this report.

Upon modification of the Hanford Facility RCRA Permit, LLBG Trenches 31 and 34 will become final status operating DWMUs. Part II, Condition II.F of the Hanford Facility RCRA Permit specifies that final status groundwater monitoring program requirements will comply with WAC 173-303-645. This engineering evaluation report is prepared in accordance with WAC 173-303-806(4)(a)(xx)(E) and (F)(I) and (II) to implement the detection monitoring program requirements of WAC 173-303-645.

This engineering evaluation report also provides supporting information for Part B application general requirements of WAC 173-303-806(4)(a)(xx)(C) (topographic map), WAC 173-303-806(4)(a)(xx)(A) (summary of interim status groundwater monitoring data), and WAC 173-303-806(4)(a)(xx)(B) (hydrogeological information).

2.3 Waste Characteristics

LLBG Trenches 31 and 34 are designed for disposal of miscellaneous dry wastes from various operations at the Hanford Site and from offsite facilities. LLBG Trenches 31 and 34 began receiving low-level mixed dry waste in 2005 and 1999, respectively. Mixed waste disposed in LLBG Trenches 31 and 34 include bulk wastes, containerized wastes, inherently stable waste, and long-length contaminated equipment. A diverse range of waste containers can be disposed at LLBG Trenches 31 and 34 including, but not limited to, containers/drums, waste boxes, and miscellaneous equipment.

Mixed waste destined for disposal in LLBG Trenches 31 and 34 must meet LDR requirements (WAC 173-303-140, "Land Disposal Restrictions," which includes, by reference, 40 CFR 268) and 69 FR 39449, "Record of Decision for the Solid Waste Program, Hanford Site, Richland WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for

Shipment to the Waste Isolation Pilot Plant." A site-specific treatability variance approved by Ecology must be obtained for waste not meeting these requirements.

The dangerous wastes managed at LLBG Trenches 31 and 34 are included in the Hanford Facility RCRA Permit Part A Permit Application for the LLBG (Operating Unit 17), last revised October 1, 2008 (Revision 14) (WA7890008967, 2008, *Dangerous Waste Permit Application Part A Form - Low Level Burial Grounds 9/22/2008*). Dangerous wastes specifically associated with Trenches 31 and 34 are not identified; therefore, Trenches 31 and 34 may manage any of the identified dangerous wastes (Table 2-2).

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
D004	Arsenic	U162	Methyl methacrylate (I,T); 2-Propenoic acid, 2-methyl-,methyl ester (I,T)
D005	Barium	U163	Guanidine, -methyl-N'-nitro-N-nitroso-; MNNG
D006	Cadmium	U164	Methylthiouracil; 4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2- thioxo-
D007	Chromium	U165	Naphthalene
D008	Lead	U166	1,4-Naphthalenedione; 1,4-Naphthoquinone
D009	Mercury	U167	1-Naphthalenamine; alpha-Naphthylamine
D010	Selenium	U168	2-Naphthalenamine; beta-Naphthylamine
D011	Silver	U169	Benzene, nitro-; Nitrobenzene (I,T)
D012	Endrin	U170	p-Nitrophenol; Phenol, 4-nitro-
D013	Lindane	U171	2-Nitropropane (I,T); Propane, 2-nitro- (I,T)
D014	Methoxychlor	U172	1-Butanamine, N-butyl-N-nitroso-; N-Nitrosodi-n-butylamine
D015	Toxaphene	U173	Ethanol, 2,2'- (nitrosoimino)bis-; N-Nitrosodiethanolamine
D016	2,4-D	U174	Ethanamine, -ethyl-N-nitroso-; N-Nitrosodiethylamine
D017	2,4,5-TP Silvex	U176	N-Nitroso-N-ethylurea; Urea, N-ethyl-N-nitroso-
D018	Benzene	U177	N-Nitroso-N-methylurea; Urea, N-methyl-N-nitroso-
D019	Carbon tetrachloride	U178	Carbamic acid, methylnitroso-,ethyl ester; N-Nitroso-N-methylurethane
D020	Chlordane	U179	N-Nitrosopiperidine; Piperidine, 1-nitroso-
D021	Chlorobenzene	U180	N-Nitrosopyrrolidine; Pyrrolidine,1-nitroso-
D022	Chloroform	U181	Benzenamine, 2-methyl-5-nitro-; 5-Nitro-o-toluidine

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
D023	o-Cresol	U182	1,3,5-Trioxane, 2,4,6-trimethyl-; Paraldehyde
D024	m-Cresol	U183	Benzene, pentachloro-; Pentachlorobenzene
D025	p-Cresol	U184	Ethane, pentachloro-; Pentachloroethane
D026	Cresol	U185	Benzene, pentachloronitro-; Pentachloronitrobenzene (PCNB)
D027	1,4-Dichlorobenzene	U186	1-Methylbutadiene(I); 1,3-Pentadiene(I)
D028	1,2-dichloroethane	U187	Acetamide, -(4-ethoxyphenyl)-; Phenacetin
D029	1,1-dichloroethylene	U188	Phenol
D030	2,4-dinitrotoluene	U189	Phosphorus sulfide (R); Sulfur phosphide (R)
D031	Heptachlor (and its epoxide)	U190	1,3-Isobenzofurandione; Phthalic anhydride
D032	Hexachlorobenzene	U191	2-Picoline; Pyridine, 2-methyl-
D033	Hexachlorobutadiene	U192	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2- propynyl)-; Pronamide
D034	Hexachloroethane	U193	1,2-Oxathiolane, 2,2-dioxide; 1,3-Propane sultone
D035	Methyl ethyl ketone	U194	1-Propanamine (I,T); n-Propylamine (I,T)
D036	Nitrobenzene	U196	Pyridine
D037	Pentachlorophenol	U197	p-Benzoquinone; 2,5-Cyclohexadiene-1,4-dione
D038	Pyridine	U200	Reserpine; Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenz oyl)oxy]-, methylester,(3beta,16beta,17alpha, 18beta,20alpha)-
D039	Tetrachloroethylene	U201	1,3-Benzenediol; Resorcinol
D040	Trichlorethylene	U203	1,3-Benzodioxole, 5-(2-propenyl)-; Safrole
D041	2,4,5-Trichlorophenol	U204	Selenious acid; Selenium dioxide
D042	2,4,6-Trichlorophenol	U205	Selenium sulfide; Selenium sulfide SeS2 (R,T)
D043	Vinyl chloride	U206	Glucopyranose, 2-deoxy-2-(3-methyl-3- nitrosoureido)-, D-; D-Glucose, 2-deoxy-2-[[(methylnitrosoamino)-carbonyl]amino]-; Streptozotocin

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
WSC2	Solid or semi-solid corrosive wastes - dangerous waste	U207	Benzene, 1,2,4,5-tetrachloro-; 1,2,4,5-Tetrachlorobenzene
WT01	Toxic dangerous wastes - extremely hazardous waste	U208	Ethane, 1,1,1,2-tetrachloro-; 1,1,1,2-Tetrachloroethane
WT02	Toxic dangerous wastes - dangerous waste	U209	Ethane, 1,1,2,2-tetrachloro-; 1,1,2,2-Tetrachloroethane
WP01	Persistent dangerous wastes halogenated organic compounds - extremely hazardous waste	U210	Ethene, tetrachloro-; Tetrachloroethylene
WP02	Persistent dangerous wastes halogenated organic compounds - dangerous waste	U211	Carbon tetrachloride; Methane, tetrachloro-
WP03	Polycyclic aromatic hydrocarbons - extremely hazardous waste	U213	Furan, tetrahydro-(I); Tetrahydrofuran (I)
WPCB	Washington polychlorinated biphenyls - dangerous waste	U214	Acetic acid, thallium(1+)salt; Thallium(I) acetate
F001	Spent halogenated solvents (T)	U215	Carbonic acid, dithallium(1+) salt; Thallium(I) carbonate
F002	Spent halogenated solvents (T)	U216	Thallium(I) chloride; Thallium chloride TlCl
F003	Spent nonhalogenated solvents (I)	U217	Nitric acid, thallium(1+) salt; Thallium(I) nitrate
F004	Spent nonhalogenated solvents (T)	U218	Ethanethioamide; Thioacetamide
F005	Spent non-halogenated solvents (I,T)	U219	Thiourea
F006	Wastewater treatment sludges (T)	U220	Benzene, methyl-; Toluene
F007	Spent cyanide plating bath solutions (R,T)	U221	Benzenediamine, ar-methyl-; Toluenediamine
F008	Plating bath residues (R,T)	U222	Benzenamine, 2-methyl-, hydrochloride; o-Toluidine hydrochloride
F009	Spent stripping and cleaning bath solutions (R,T)	U223	Benzene, 1,3-diisocyanatomethyl-(R,T); Toluene diisocyanate (R,T)
F010	Quenching bath residues (R,T)	U225	Bromoform; Methane, tribromo-
F011	Spent cyanide solutions (R,T)	U226	Ethane, 1,1,1-trichloro-; Methyl chloroform; 1,1,1-Trichloroethane
F012	Quenching wastewater treatment sludges (T)	U227	Ethane, 1,1,2-trichloro-; 1,1,2-Trichloroethane
F019	Wastewater treatment sludges (T)	U228	Ethene, trichloro-; Trichloroethylene

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
F027	Discarded unused formulations containing tri-, tetra-, or pentachlorophenol or discarded unused formulations containing compounds derived from chlorophenols (H)	U234	Benzene, 1,3,5-trinitro-; 1,3,5-Trinitrobenzene (R,T)
F039	Leachate (T)	U235	1-Propanol, 2,3-dibromo-, phosphate (3:1); Tris(2,3-dibromopropyl) phosphate
U001	Acetaldehyde (I); Ethanal (I)	U236	2,7-Naphthalenedisulfonicacid, 3,3'-[(3,3'- dimethyl[1,1'-biphenyl]-4,4'-diyl) bis(azo)bis [5-amino-4-hydroxy]-, tetrasodium salt; Trypan blue
U002	Acetone (I); 2-Propanone (I)	U237	2,4-(1H,3H)-Pyrimidinedione, 5-[bis (2-chloroethyl)amino]-; Uracil mustard
U003	Acetonitrile (I,T)	U238	Carbamic acid, ethyl ester; Ethyl carbamate (urethane)
U004	Acetophenone; Ethanone, 1-phenyl-	U239	Benzene, dimethyl- (I); Xylene (I)
U005	Acetamide, -9H-fluoren-2-yl-; 2-Acetylaminofluorene	U240	Acetic acid, (2,4-dichlorophenoxy)-, salts & esters; 2,4-D, salts & esters
U006	Acetyl chloride (C,R,T)	U243	Hexachloropropene; 1-Propene, 1,1,2,3,3,3-hexachloro-
U007	Acrylamide; 2-Propenamide	U244	Thioperoxydicarbonic diamide [(H2N)C(S)]2S2, tetramethyl-; Thiram
U008	Acrylic acid (I); 2-Propenoic acid (I)	U246	Cyanogen bromide(CN)Br
U009	Acrylonitrile; 2-Propenenitrile	U247	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis [4-methoxy-; Methoxychlor
U010	Azirino[2',3':3,4]pyrrolo[1,2-a]indol e-4,7-dione, 6-amino-8-[[(aminocarbonyl)oxy]me thyl] -1,1a,2,8,8a,8b-hexahydro-8a-metho xy-5- methyl-, [1aS-(1aalpha,8beta,8aalpha, 8balpha)]-; Mitomycin C	U248	2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1- phenyl-butyl)-, & salts, when present at concentrations of 0.3% or less; Warfarin, & salts, when present at concentrations of 0.3% or less
U011	Amitrole; 1H-1,2,4-Triazol-3-amine	U249	Zinc phosphide Zn3 P2, when present at concentrations of 10% or less
U012	Aniline (I,T); Benzenamine (I,T)	U271	Benomyl; Carbamic acid, [1-[(butylamino)carbonyl]-1H-benzimidazol -2-yl]-, methylester
U014	Auramine; Benzenamine, 4,4'-carbonimidoylbis [N,N-dimethyl-	U278	Bendiocarb; 1,3-Benzodioxol-4-ol, 2,2-dimethyl-, methyl carbamate

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U015	Azaserine; L-Serine, diazoacetate (ester)	U279	Carbaryl; 1-Naphthalenol, methylcarbamate
U016	Benz[c]acridine	U280	Barban; Carbamic acid, (3-chlorophenyl)-, 4-chloro-2- butynyl ester
U017	Benzal chloride; Benzene, (dichloromethyl)-	U328	Benzenamine, 2-methyl-; o-Toluidine
U018	Benz[a]anthracene	U353	Benzenamine, 4-methyl-; p-Toluidine
U019	Benzenesulfonic acid chloride(C,R)	U359	Ethanol,2-ethoxy-; Ethyleneglycol monoethylether
U020	Benzenesulfonyl chloride(C,R)	U364	Bendiocarb phenol; 1,3-Benzodioxol-4-ol, 2,2-dimethyl-,
U021	Benzidine; [1,1'-Biphenyl]-4,4'-diamine	U367	7-Benzofuranol, 2,3-dihydro-2,2-dimethyl-; Carbofuran phenol
U022	Benzo[a]pyrene	U372	Carbamic acid, 1H-benzimidazol-2-yl, methylester; Carbendazim
U023	Benzene, (trichloromethyl)-; Benzotrichloride (C,R,T)	U373	Carbamic acid, phenyl-, 1-methylethyl ester; Propham
U024	Dichloromethoxy ethane; Ethane, 1,1'-[methylenebis(oxy)]bis[2-chloro -	U387	Carbamothioic acid, dipropyl-, S-(phenylmethyl) ester; Prosulfocarb
U025	Dichloroethyl ether; Ethane, 1,1'-oxybis[2-chloro-	U389	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3,3-trichloro-2-propenyl) ester; Triallate
U026	Chlornaphazin; Naphthalenamine, N,N'-bis(2-chloroethyl)-	U394	A2213; Ethanimidothioic acid, 2-(dimethylamino)-N- hydroxy-2-oxo-, methyl ester
U027	Dichloroisopropyl ether; Propane, 2,2'-oxybis[2-chloro-	U395	Diethylene glycol, dicarbamate; Ethanol, 2,2'-oxybis-,dicarbamate
U028	1,2-Benzenedicarboxylic acid,bis(2-ethylhexyl) ester; Diethylhexyl phthalate	U404	Ethanamine, N,N-diethyl-; Triethylamine
U029	Methane, bromo-; Methyl bromide	U409	Carbamic acid, [1,2-phenylenebis (iminocarbonothioyl)]bis, dimethyl ester; Thiophanate-methyl
U030	Benzene, 1-bromo-4-phenoxy-; 4-Bromophenyl phenyl ether	U410	Ethanimidothioic acid, N,N'-[thiobis [(methylimino)carbonyloxy]]bis-, dimethyl ester; Thiodicarb
U031	1-Butanol (I); n-Butyl alcohol (I)	U411	Phenol, 2-(1-methylethoxy)-, methylcarbamate; Propoxur
U032	Calcium chromate; Chromic acid H2 CrO4, calcium salt	P001	2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1- phenylbutyl)-, &

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
			salts, when present at concentrations greater than 0.3%; Warfarin, & salts, when present at concentrations greater than 0.3%
U033	Carbonic difluoride	P002	Acetamide, -(aminothioxomethyl)-; 1-Acetyl-2-thiourea
U034	Acetaldehyde, trichloro-; Chloral	P003	Acrolein; 2-Propenal
U035	Benzenebutanoic acid, 4-[bis(2-chloroethyl) amino]-; Chlorambucil	P004	Aldrin; 1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexa- chloro-1,4,4a,5,8,8a,-hexahydro-, (1alpha,4alpha,4abeta,5alpha,8alpha,8abeta)
U036	Chlordane, alpha & gamma isomers; 4,7-Methano-1H-indene,1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a- hexahydro-	P005	Allyl alcohol; 2-Propen-1-ol
U037	Benzene, chloro-; Chlorobenzene	P006	Aluminum phosphide (R,T)
U038	Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-, ethyl ester; Chlorobenzilate	P007	5-(Aminomethyl)-3-isoxazolol; 3(2H)-Isoxazolone, 5-(aminomethyl)-
U039	p-Chloro-m-cresol; Phenol, 4-chloro-3-methyl-	P008	4-Aminopyridine; 4-Pyridinamine
U041	Epichlorohydrin; Oxirane, (chloromethyl)-	P009	Phenol, 2,4,6-trinitro-, ammonium salt (R)
U042	2-Chloroethyl vinyl ether; Ethene, (2-chloroethoxy)-	P010	Arsenic acid H3 AsO4
U043	Ethene, chloro-; Vinyl chloride	P011	Arsenic oxide As2 O5; Arsenic pentoxide
U044	Chloroform; Methane, trichloro-	P012	Arsenic oxide As2 O3; Arsenic trioxide
U045	Methane,chloro- (I,T); Methyl chloride (I,T)	P013	Barium cyanide
U046	Chloromethylmethyl ether; Methane, chloromethoxy-	P014	Benzenethiol; Thiophenol
U047	beta-Chloronaphthalene; Naphthalene, 2-chloro-	P015	Beryllium powder
U048	o-Chlorophenol; Phenol, 2-chloro-	P016	Dichloromethyl ether; Methane, oxybis[chloro-
U049	Benzenamine, 4-chloro-2-methyl-, hydrochloride; 4-Chloro-o-toluidine, hydrochloride	P017	Bromoacetone; 2-Propanone, 1-bromo-
U050	Chrysene	P018	Brucine; Strychnidin-10-one, 2,3-dimethoxy-

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U051	Creosote	P020	Dinoseb; Phenol, 2-(1-methylpropyl)-4,6-dinitro-
U052	Cresol (Cresylic acid); Phenol, methyl-	P021	Calcium cyanide; Calcium cyanide Ca(CN)2
U053	2-Butenal; Crotonaldehyde	P022	Carbon disulfide
U055	Benzene, (1-methylethyl)-(I); Cumene (I)	P023	Acetaldehyde, chloro-; Chloroacetaldehyde
U056	Benzene, hexahydro-(I); Cyclohexane (I)	P024	Benzenamine, 4-chloro-; Chloroaniline
U057	Cyclohexanone (I); Cyclophosphamide	P026	1-(o-Chlorophenyl)thiourea; Thiourea, (2-chlorophenyl)-
U058	2H-1,3,2-Oxazaphosphorin-2-amine, N,N-bis (2-chloroethyl)tetrahydro-, 2-oxide	P027	3-Chloropropionitrile; Propanenitrile, 3-chloro-
U059	Daunomycin; 5,12-Naphthacenedione, 8-acetyl-10-[(3-amino-2,3,6-trideoxy)-alpha-L-lyxo-hexopyranosyl)oxy]- 7,8,9,10-tetrahydro-6,8,11- trihydrox y-1-methoxy-, (8S-cis)-	P028	Benzene, (chloromethyl)-; Benzyl chloride
U060	Benzene, 1,1'-(2,2-dichloroethylidene)bis [4-chloro-; DDD	P029	Copper cyanide; Copper cyanide Cu(CN)
U061	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis [4-chloro-; DDT	P030	Cyanides (soluble cyanide salts), not otherwise specified
U062	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester; Diallate	P031	Cyanogen; Ethanedinitrile
U063	Dibenz[a,h]anthracene	P033	Cyanogen chloride; Cyanogen chloride (CN)Cl
U064	Benzo[rst]pentaphene; Dibenzo[a,i]pyrene	P034	Cyclohexyl-4,6- dinitrophenol; Phenol, 2-cyclohexyl-4,6-dinitro-
U066	1,2-Dibromo-3-chloropropane; Propane, 1,2-dibromo-3-chloro-	P036	Arsonous dichloride, phenyl-; Dichlorophenylarsine
U067	Ethane,1,2-dibromo-; Ethylene dibromide	P037	Dieldrin; 2,7:3,6-Dimethanonaphth[2,3-b] oxirene, 3,4,5,6,9,9-hexachloro- 1a,2,2a,3,6,6a,7,7a-octahydro-, (1aalpha,2beta,2aalpha,3beta,6beta, 6aalpha,7beta, 7aalpha)-

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U068	Methane, dibromo-; Methylene bromide	P038	Arsine, diethyl-; Diethylarsine
U069	1,2-Benzenedicarboxylic acid, dibutyl ester; Dibutyl phthalate	P039	Disulfoton; Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio) ethyl]ester
U070	Benzene, 1,2-dichloro-; o-Dichlorobenzene	P040	O,O-Diethyl O-pyrazinyl phosphorothioate; Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester
U071	Benzene, 1,3-dichloro-; m-Dichlorobenzene	P041	Diethyl-p-nitrophenyl phosphate; Phosphoric acid, diethyl 4-nitrophenyl ester
U072	Benzene, 1,4-dichloro-; p-Dichlorobenzene	P042	1,2-Benzenediol, 4-[1-hydroxy-2-(methylamino) ethyl]-, (R)-; Epinephrine
U073	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-; 3,3'-Dichlorobenzidine	P043	Diisopropylfluorophosphate (DFP); Phosphorofluoridic acid, bis(1-methylethyl) ester
U074	2-Butene, 1,4-dichloro-(I,T); 1,4-Dichloro-2-butene (I,T)	P044	Dimethoate; Phosphorodithioic acid, O,O-dimethyl S-[2-(methyl amino)-2-oxoethyl] ester
U075	Dichlorodifluoromethane; Methane, dichlorodifluoro-	P045	2-Butanone, 3,3-dimethyl-1-(methylthio)-, O-[(methylamino)carbonyl]oxime; Thiofanox
U076	Ethane, 1,1-dichloro-; Ethylidene dichloride	P046	Benzeneethanamine,alpha,alpha-dimethyl-; alpha,alpha-Dimethylphenethylamine
U077	Ethane, 1,2-dichloro-; Ethylene dichloride	P047	4,6-Dinitro-o-cresol, & salts; Phenol, 2-methyl-4,6-dinitro-, & salts
U078	1,1-Dichloroethylene; Ethene, 1,1-dichloro-	P048	2,4-Dinitrophenol; Phenol, 2,4-dinitro-
U079	1,2-Dichloroethylene; Ethene, 1,2-dichloro-, (E)-	P049	Dithiobiuret; Thioimidodicarbonic diamide[(H2 N)C(S)]2 NH
U080	Methane, dichloro-; Methylene chloride	P050	6,9-Methano-2,4,3-benzodioxathiepin,6,7,8, 9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro -, 3-oxide
U081	2,4-Dichlorophenol; Phenol, 2,4-dichloro-	P051	2,7:3,6-Dimethanonaphth [2,3-b]oxirene, 3,4,5,6,9,9- hexachloro-1a,2,2a,3,6,6a,7,7a- octahydro-, (1aalpha,2beta,2abeta, 3alpha,6alpha,6abeta,7beta, 7aalpha)-, & metabolites; Endrin; Endrin, & metabolites
U082	2,6-Dichlorophenol; Phenol, 2,6-dichloro-	P054	Aziridine; Ethyleneimine
U083	Propane, 1,2-dichloro-; Propylene dichloride	P056	Fluorine

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U084	1,3-Dichloropropene; 1-Propene, 1,3-dichloro-	P057	Acetamide, 2-fluoro-; Fluoroacetamide
U085	2,2'-Bioxirane; 1,2:3,4-Diepoxybutane (I,T)	P058	Acetic acid, fluoro-, sodium salt; Fluoroacetic acid, sodium salt
U086	N,N'-Diethylhydrazine; Hydrazine, 1,2-diethyl-	P059	Heptachlor; 4,7-Methano-1H-indene,1,4,5,6,7,8,8-heptachloro- 3a,4,7,7a-tetrahydro-
U087	O,O-Diethyl S-methyldithiophosphate; Phosphorodithioic acid, O,O-diethyl S- methyl ester	P060	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexa- chloro-1,4,4a,5,8,8a-hexahydro-, (1alpha,4alpha,4abeta,5beta,8beta,8abeta)-; Isodrin
U088	1,2-Benzenedicarboxylic acid, diethyl ester; Diethyl phthalate	P062	Hexaethyl tetraphosphate; Tetraphosphoric acid, hexaethyl ester
U089	Diethylstilbesterol; Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-, (E)	P063	Hydrocyanic acid; Hydrogen cyanide
U090	1,3-Benzodioxole, 5-propyl-; Dihydrosafrole	P064	Methane, isocyanato-; Methyl isocyanate
U091	[1,1'-Biphenyl]-4,4'-diamine, 3,3'- dimethoxy-; 3,3'-Dimethoxybenzidine	P065	Fulminic acid, mercury(2+) salt (R,T); Mercury fulminate (R,T)
U092	Dimethylamine (I); Methanamine, -methyl-(I)	P066	Ethanimidothioic acid, N-[[(methylamino)carbonyl] oxy]-, methyl ester; Methomyl
U093	Benzenamine, N,N-dimethyl-4- (phenylazo)-; p-Dimethylaminoazobenzene	P067	Aziridine, 2-methyl-; 1,2-Propylenimine
U094	Benz[a]anthracene, 7,12-dimethyl-; 7,12-Dimethylbenz[a]anthracene	P068	Hydrazine, methyl-; Methyl hydrazine
U095	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-; 3,3'-Dimethylbenzidine	P069	2-Methyllactonitrile; Propanenitrile, 2-hydroxy-2-methyl-
U096	alpha,alpha-Dimethylbenzylhydroperoxide (R); Hydroperoxide, 1-methyl-1-phenylethyl-(R)	P070	Aldicarb; Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime
U097	Carbamic chloride, dimethyl-; Dimethylcarbamoyl chloride	P071	Methylparathion; Phosphorothioic acid, O,O,-dimethyl O-(4-nitrophenyl)ester
U098	1,1-Dimethylhydrazine; Hydrazine, 1,1-dimethyl-	P072	alpha-Naphthylthiourea; Thiourea, 1-naphthalenyl-

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U099	1,2-Dimethylhydrazine; Hydrazine, 1,2-dimethyl-	P073	Nickel carbonyl; Nickel carbonyl Ni(CO)4, (T-4)-
U101	2,4-Dimethylphenol; Phenol, 2,4-dimethyl-	P074	Nickel cyanide; Nickel cyanide Ni(CN)2
U102	1,2-Benzenedicarboxylicacid, dimethyl ester; Dimethylphthalate	P075	Nicotine, & salts; Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-, & salts
U103	Dimethyl sulfate; Sulfuric acid, dimethyl ester	P076	Nitric oxide; Nitrogen oxide NO
U105	Benzene, 1-methyl-2,4-dinitro-; 2,4-Dinitrotoluene	P077	Benzenamine, 4-nitro-; p-Nitroaniline
U106	Benzene, 2-methyl-1,3-dinitro-; 2,6-Dinitrotoluene	P078	Nitrogen dioxide; Nitrogen oxide NO2
U107	1,2-Benzenedicarboxylic acid, dioctyl ester; Di-n-octylphthalate	P081	Nitroglycerine (R); 1,2,3-Propanetriol, trinitrate (R)
U108	1,4-Diethyleneoxide; 1,4-Dioxane	P082	Methanamine, -methyl-N-nitroso-; N-Nitrosodimethylamine
U109	1,2-Diphenylhydrazine; Hydrazine, 1,2-diphenyl-	P084	N-Nitrosomethylvinylamine; Vinylamine, -methyl-N-nitroso-
U110	Dipropylamine(I); 1-Propanamine, N-propyl-(I)	P085	Diphosphoramide, octamethyl-; Octamethylpyrophosphoramide
U111	Di-n-propylnitrosamine; 1-Propanamine,N-nitroso-N- propyl-	P087	Osmium oxide OsO4, (T-4)-; Osmium tetroxide
U112	Acetic acid ethyl ester(I); Ethyl acetate (I)	P088	Endothall; 7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
U113	Ethyl acrylate(I); 2-Propenoic acid, ethyl ester (I)	P089	Parathion; Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester
U114	Carbamodithioic acid, 1,2-ethanediylbis-, salts & esters; Ethylenebisdithiocarbamic acid, salts & esters	P092	Mercury, (acetato-O)phenyl-; Phenylmercury acetate
U115	Ethylene oxide (I,T); Oxirane (I,T)	P093	Phenylthiourea; Thiourea, phenyl-
U116	Ethylenethiourea; 2-Imidazolidinethione	P094	Phorate; Phosphorodithioic acid, O,O-diethyl S-[(ethylthio) methyl]ester
U117	Ethane, 1,1'-oxybis-(I); Ethyl ether (I)	P095	Carbonic dichloride; Phosgene
U118	Ethyl methacrylate; 2-Propenoic acid, 2-methyl-,ethyl ester	P096	Hydrogen phosphide; Phosphine
U119	Ethyl methanesulfonate; Methanesulfonic acid, ethyl ester	P097	Famphur; Phosphorothioic acid, O-[4-[(dimethylamino)sulfonyl]phenyl]O,O -dimethyl ester

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U120	Fluoranthene	P098	Potassiumcyanide; Potassium cyanide K(CN)
U121	Methane, trichlorofluoro-; Trichloromonofluoromethane	P099	Argentate(1-), bis(cyano-C)-, potassium; Potassium silvercyanide
U122	Formaldehyde	P101	Ethyl cyanide; Propanenitrile
U123	Formic acid (C,T)	P102	Propargyl alcohol; 2-Propyn-1-ol
U124	Furan (I); Furfuran (I)	P103	Selenourea
U125	2-Furancarboxaldehyde (I); Furfural (I)	P104	Silvercyanide; Silvercyanide Ag(CN)
U126	Glycidylaldehyde; Oxiranecarboxyaldehyde	P105	Sodium azide
U127	Benzene, hexachloro-; Hexachlorobenzene	P106	Sodium cyanide; Sodium cyanide Na(CN)
U128	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-; Hexachlorobutadiene	P108	Strychnidin-10-one, & salts; Strychnine, & salts
U129	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha, 5alpha,6beta)-; Lindane	P109	Thiodiphosphoric acid,tetraethyl ester
U130	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-; Hexachlorocyclopentadiene	P110	Plumbane, tetraethyl-; Tetraethyl lead
U131	Ethane, hexachloro-; Hexachloroethane	P111	Diphosphoric acid, tetraethylester; Tetraethyl pyrophosphate
U132	Hexachlorophene; Phenol, 2,2'-methylenebis[3,4,6-trichloro-	P112	Methane, tetranitro-(R); Tetranitromethane (R)
U133	Hydrazine (R,T)	P113	Thallic oxide; Thallium oxide Tl2 O3
U134	Hydrofluoric acid (C,T); Hydrogen fluoride (C,T)	P114	Selenious acid,dithallium(1+) salt; Thallium(I) selenite
U135	Hydrogen sulfide; Hydrogen sulfide H2S	P115	Sulfuric acid, dithallium(1+) salt; Thallium(I) sulfate
U136	Arsinic acid, dimethyl-; Cacodylic acid	P116	Hydrazinecarbothioamide; Thiosemicarbazide
U137	Indeno[1,2,3-cd]pyrene	P118	Methanethiol, trichloro-; Trichloromethanethiol
U138	Methane, iodo-; Methyl iodide	P119	Ammonium vanadate; Vanadic acid, ammonium salt
U140	Isobutyl alcohol (I,T); 1-Propanol, 2-methyl- (I,T)	P120	Vanadium oxide V2O5; Vanadium pentoxide

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U141	1,3-Benzodioxole, 5-(1-propenyl)-; Isosafrole	P121	Zinc cyanide; Zinc cyanide Zn(CN)2
U142	Kepone; 1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-	P122	Zinc phosphide Zn3 P2, when present at concentrations greater than 10% (R,T)
U143	2-Butenoic acid, 2-methyl-, 7-[[2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy] methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-1-yl ester, [1S-[1alpha(Z),7(2S*,3R*),7aalpha]]-; Lasiocarpine	P123	Toxaphene
U144	Acetic acid, lead(2+) salt; Lead acetate	P127	7-Benzofuranol, 2,3-dihydro-2,2- dimethyl-, methylcarbamate; Carbofuran
U145	Lead phosphate; Phosphoric acid, lead(2+)salt (2:3)	P128	Mexacarbate; Phenol, 4-(dimethylamino)-3,5-dimethyl-, methylcarbamate(ester)
U146	Lead, bis(acetato-O)tetrahydroxytri-; Lead subacetate	P185	1,3-Dithiolane-2-carboxaldehyde, 2,4-dimethyl-, O-[(methylamino)-carbonyl]oxime; Tirpate
U147	2,5-Furandione; Maleic anhydride	P188	Benzoic acid, 2-hydroxy-,compd. with (3aS-cis)-1,2,3,3a,8,8a-hexahydro-1,3a,8-trimethylpyrrolo [2,3-b]indol-5-yl methylcarbamate ester (1:1); Physostigmine salicylate
U148	Maleic hydrazide; 3,6-Pyridazinedione, 1,2-dihydro-	P189	Carbamic acid,[(dibutylamino)-thio]methyl-,2,3-dihydro-2,2-dimethyl-7-benzofuranyl ester; Carbosulfan
U149	Malononitrile; Propanedinitrile	P190	Carbamic acid, methyl-, 3-methylphenyl ester; Metolcarb
U150	L-Phenylalanine, 4-[bis(2-chloroethyl)amino]-	P191	Carbamic acid, dimethyl-, 1-[(dimethyl-amino) carbonyl]-5-methyl-1H-pyrazol-3-yl ester; Dimetilan
U151	Mercury	P192	Carbamic acid, dimethyl-, 3-methyl-1-(1-methylethyl)-1H-pyrazol-5-yl ester; Isolan
U152	Methacrylonitrile (I,T); 2-Propenenitrile, 2-methyl- (I,T)	P194	Ethanimidthioic acid, 2-(dimethylamino)-N-[[(methylamino)carbonyl]oxy]-2-oxo-, methylester; Oxamyl

Table 2-2. Dangerous Wastes Identified for LLBG in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description*	Dangerous Waste Code	Contaminant Description*
U153	Methanethiol (I,T); Thiomethanol (I,T)	P196	Manganese,bis(dimethylcarbamodithioato-S,S')-,; Manganesedimethyldithiocarbamate
U154	Methanol (I); Methyl alcohol (I)	P197	Formparanate; Methanimidamide, N,N-dimethyl-N'-[2-methyl-4-[[(methylamino)carbonyl]oxy]phenyl]-
U155	1,2-Ethanediamine, N,N-dimethyl-N'-2- pyridinyl-N'-(2-t hienylmethyl)-; Methapyrilene	P198	Formetanate hydrochloride; Methanimidamide, N,N-dimethyl- N'-[3-[[(methylamino)-carbonyl]oxy]phenyl] -monohydrochloride
U156	Carbonochloridic acid, methylester (I,T); Methyl chlorocarbonate (I,T)	P199	Methiocarb; Phenol, (3,5-dimethyl-4-(methylthio)-, methylcarbamate
U157	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-; 3-Methylcholanthrene	P201	Phenol, 3-methyl-5-(1-methylethyl)-, methylcarbamate; Promecarb
U158	Benzenamine, 4,4'-methylenebis[2-chloro-; 4,4'-Methylenebis(2-chloroaniline)	P202	m-Cumenyl methylcarbamate; 3-Isopropylphenyl N-methylcarbamate
U159	2-Butanone (I,T); Methyl ethyl ketone (MEK) (I,T)	P203	Aldicarb sulfone; Propanal, 2-methyl-2-(methyl-sulfonyl)-, O-[(methylamino)carbonyl]oxime
U160	2-Butanone, peroxide (R,T); Methyl ethyl ketone peroxide (R,T)	P204	Physostigmine; Pyrrolo[2,3-b]indol-5-ol,1,2,3,3a,8,8a-hexahydro-1,3a,8- trimethyl-methylcarbamate (ester), (3aS-cis)-
U161	Methyl isobutyl ketone (I); 4-Methyl-2-pentanone (I); Pentanol, 4-methyl-	P205	Zinc, bis (dimethylcarbamodithioato-S,S')-,; Ziram

Source: WA7890008967, *Dangerous Waste Permit Application Part A Form - Low Level Burial Grounds 9/22/2008*

* Dangerous waste code contaminant descriptions from WAC 173-303-090, "Dangerous Waste Regulations," "Dangerous Waste Characteristics"; WAC 173-303-104, "State-Specific Dangerous Waste Numbers"; WAC 173-303-9903, "Discarded Chemical Products List"; and WAC 173-303-9904, "Dangerous Waste Sources List."

C = corrosive waste
E = toxicity characteristic waste
H = acute hazardous waste
I = ignitable waste
R = reactive waste
T = toxic waste

2.4 Groundwater Monitoring and Sampling History

Table 2-3 identifies the interim status groundwater monitoring plans implemented at LLBG WMA-3, which includes LLBG Trenches 31 and 34. Operation of LLBG Trenches 31 and 34 began in 1999. Interim status groundwater monitoring for LLBG WMA-3 was already established at the time LLBG Trenches 31 and 34 began operation. Subsequent monitoring during the operational period of LLBG Trenches 31 and 34 was performed within the LLBG WMA-3 program. While the monitoring history of LLBG WMA-3 prior to 1999 predates the use of LLBG Trenches 31 and 34, the information from those years is included to provide background information on the initial interim status monitoring program for LLBG WMA-3 and an understanding of the impact that the declining groundwater elevation has had upon the well network. Figure 2-2 provides the locations of wells discussed in this section.

Appendix A contains the interim status data collected during the operational period of LLBG Trenches 31 and 34 and meets the requirement of WAC 173-303-806(4)(a)(xx)(A). The status of the monitoring wells through the plans indicated in Table 2-3 is provided in Appendix A.

Table 2-3. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program[a]
PNL-6772, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*	1987	Indicator Evaluation Program
WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds* ECN 113805 ECN 144234 ECN 618165 ECN 618180	1989 1991 1991 1994 1995	Indicator Evaluation Program
WHC-SD-EN-AP-022, *Interim-Status Ground-Water Quality Assessment Monitoring Plan for Waste Management Area 3 of the 200 Areas Low-Level Burial Grounds*	1990	Groundwater Quality Assessment[b]
PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington* PNNL-14859-ICN-1 PNNL-14859-ICN-2	2004 2006 2007	Indicator Evaluation Program
DOE/RL-2009-68, Rev. 0, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*	2010	Indicator Evaluation Program
DOE/RL-2009-68, Rev. 1, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*	2011	Indicator Evaluation Program

Table 2-3. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program[a]
DOE/RL-2009-68, Rev. 2, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*	2012	Indicator Evaluation Program

a. The indicator evaluation program satisfies the requirements of 40 CFR 265.92(b)(2), (b)(3), (d)(1), (d)(2) and (e), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." The groundwater quality assessment program's first determination satisfies the requirements of 40 CFR 265.93(d)(4) and (d)(6), "Preparation, Evaluation, and Response."

b. LLBG WMA-3 entered a groundwater quality assessment program in 1990 due to an exceedance of total organic halogen and total organic carbon. In January 1994, a groundwater quality assessment report was issued and found that elevated total organic halogens was not attributable to LLBG WMA-3 and elevated total organic carbon results were due to laboratory error (Section 3.2 in WHC-SD-EN-EV-026, *Results of Groundwater Quality Assessment Program at Low-Level Waste Management Area 3 of the Low-Level Burial Grounds*). Groundwater monitoring subsequently returned to an indicator evaluation program under WHC-SD-EN-AP-015.

In 1987, DOE-RL initiated an interim status groundwater monitoring program at LLBG WMA-3 in accordance with PNL-6772, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*, based on the interim status indicator evaluation program requirements of 40 CFR 265, Subpart F, and WAC 173-303-400. PNNL-6772 identified a total of 35 wells to be drilled amongst the burial grounds. LLBG WMA-3 was to have both an upgradient and downgradient deep monitoring well drilled to characterize the hydrogeology at depth and to assess the hydraulic potential and quality of groundwater near the base of the unconfined aquifer. A shallow well was to be located adjacent to each deep well. Samples were to be collected for the contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b), "Sampling and Analysis." Ammonium, calcium, magnesium, potassium, and total dissolved solids were also included for sampling. The LLBG WMA-3 monitoring wells installed in 1987 included downgradient wells 299-W6-2, 299-W7-1, 299-W7-2, 299-W7-3 (deep well), 299-W7-4, 299-W7-5, 299-W7-6, and 299-W8-1 and upgradient wells 299-W9-1, 299-W10-13, and 299-W10-14 (deep well) (Figure 2-3). Two additional downgradient wells were installed in 1989 (299-W7-7 and 299-W7-8).

The groundwater monitoring plan was revised in 1989 (WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*) and included an updated network for LLBG WMA-3 with four planned downgradient wells. The new wells were sited between existing wells to reduce the well spacing to between 91 and 137 m (300 to 450 ft) along the northern boundary of the 218-W-5 Burial Ground and to 152 m (500 ft) along the northern and northeastern boundaries of the 218-W-3AE Burial Ground. Samples were to be collected for the contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b), and ammonium, uranium, tritium, and volatile organic compounds (VOCs) (Section 3.5 in WHC-SD-EN-AP-015). The dangerous wastes listed in 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," were included for the first sample from each well and then annual sampling at selected wells (these wells were not identified in the plan) (Section 3.5 in WHC-SD-EN-AP-015). The two deep wells (299-W7-3 and 299-W10-14), which are screened at the bottom 6 m (20 ft) of the unconfined aquifer, were used to monitor for any dense nonaqueous-phase liquids from LLBG WMA-3 (Section 3.3.5.3 in WHC-SD-EN-AP-015). Groundwater at LLBG WMA-3 was considered to flow to the north-northeast at a velocity of 0.00003 to 0.2 m/d (0.001 to 0.6 ft/d) (Section 2.3.3.2 in WHC-SD-EN-AP-015).

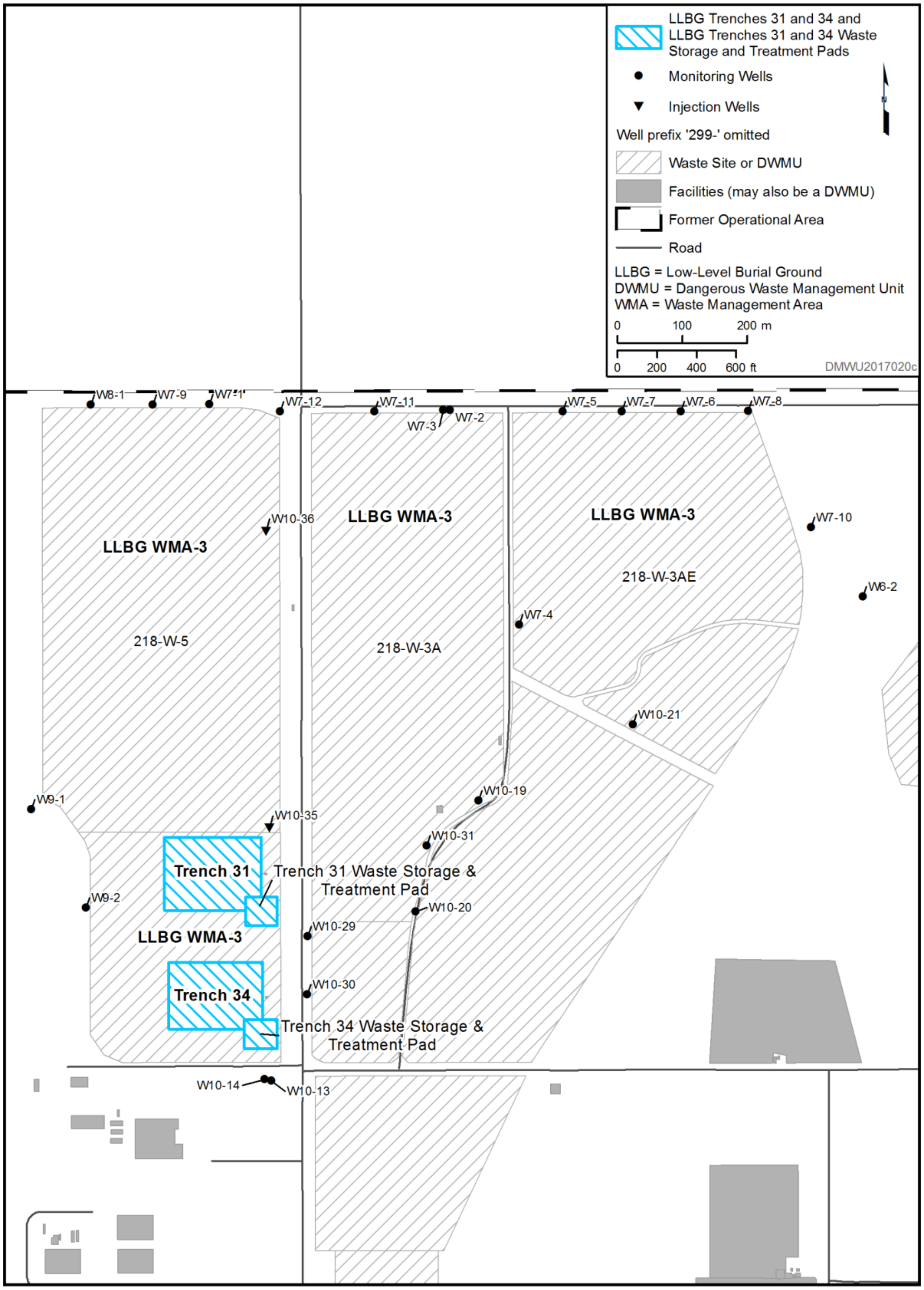


Figure 2-3. Wells Used During Interim Status Monitoring of LLBG WMA-3

In 1990, a groundwater quality assessment program was initiated (WHC-SD-EN-AP-022, *Interim-Status Ground-Water Quality Assessment Plan for Waste Management Area 3 of the 200 Areas Low-Level Burial Grounds*) due to sampling results from September 1989 in which total organic halogen (TOX) at downgradient well 299-W7-4, and total organic carbon (TOC) at downgradient wells 299-W7-5 and 299-W8-1 and upgradient well 299-W10-13, exceeded the statistical comparison value. Upgradient well 299-W10-13 also exceeded the statistical comparison value for TOC. Resampling confirmed the TOX exceedance; however, the TOC resampling could not exclude that the TOC results were not a result of a laboratory error (Section 3.0 in WHC-SD-EN-AP-022).

The groundwater quality assessment plan (WHC-SD-EN-AP-022) included quarterly sampling for VOCs and contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b) at the 11 existing and 4 planned network wells (Sections 4.2 and 4.4 in WHC-SD-EN-AP-022,). Additionally, the four wells that triggered the assessment (299-W7-4, 299-W7-5, 299-W8-1, and 299-W10-13) were to be sampled for the dangerous wastes listed in Appendix IX of 40 CFR 264 at least once. Sampling was temporarily discontinued in June 1990 due to cancelation of the laboratory contract. The sampling program resumed in June 1991 (Introduction in DOE/RL-92-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*).

Four new wells were drilled in 1990 (299-W7-9 and 299-W7-10) and 1991 (299-W7-11 and 299-W7-12) (Figure 2-3) bringing the network total to 3 upgradient and 14 downgradient. Additional upgradient wells were drilled in 1992 (299-W10-19) and 1993 (299-W10-20 and 299-W10-21), bringing the upgradient network to six wells (including deep well 299-W10-14, which was used for information only).

In 1991, ECN 113805, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, provided locations for 32 additional monitoring wells for LLBG and well numbers for 16 newly installed wells. Two new wells were proposed for LLBG WMA-3 (Table 3 in ECN 113805). ECN 144234, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, was also issued in 1991 but was specific to a LLBG WMA-4 well change that did not affect LLBG WMA-3.

A groundwater quality assessment report was prepared in January 1994 (WHC-SD-EN-EV-026, *Results of Groundwater Quality Assessment Program at Low-Level Waste Management Area 3 of the Low-Level Burial Grounds*). Results from three additional upgradient monitoring wells (299-W10-19, 299-W10-20, and 299-W10-21) indicated that the elevated TOX originated from the carbon tetrachloride plume in the 200 West Area and not from LLBG WMA-3 (Section 3.2 in WHC-SD-EN-EV-026). Chloroform and trichloroethylene plumes in the 200 West Area were also contributing to elevated TOX results (Section 3.2 in WHC-SD-EN-EV-026). Sampling for TOC in wells 299-W7-5 and 299-W8-1 indicated that the September 1989 values were erroneous and that the critical mean for TOC was not exceeded. Indicator evaluation monitoring subsequently resumed at LLBG WMA-3 under WHC-SD-EN-AP-015.

Due to the addition of three upgradient wells to the network, background values were reestablished for the contamination indicator parameters. Two sets of critical means were determined for LLBG WMA-3. One set included wells 299-W9-1 and 299-W10-13 and was used for comparisons with wells north of 218-W-3A and 218-W-5. The other set included wells 299-W10-19, 299-W10-20, and 299-W10-21 and was used for comparisons with wells to the north and east of 218-W-3AE (Section 4.10.3.4.2 in DOE/RL-96-01, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1995*). DOE/RL-96-01 also reported that trichloroethylene exceeded the drinking water standard in upgradient wells 299-W10-19, 299-W10-20, and 299-W10-21 but was not attributable to LLBG WMA-3 (Section 4.10.3.4.1 in DOE/RL-96-01).

ECN 618165, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, and ECN 618180, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, revised the constituents required for sampling after the first year of monitoring. The revised constituents for LLBG WMA-3 included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), gross alpha, gross beta, tritium, anion, metals, lead, mercury, VOCs, turbidity, and alkalinity.

Declining water elevations and changes in groundwater flow direction began to affect the network. Water elevation and flow direction changes were due to the dissipation of the groundwater mound caused by past disposal practices. In 1997, downgradient well 299-W7-2 became dry (Table A.15 in PNNL-11793, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*) and was no longer sampled. Downgradient well 299-W7-10 and upgradient well 299-W9-1 became dry in 2000 (Section 2.8.2.13 and Table A.16 in PNNL-13404, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*), followed by downgradient wells 299-W7-6, 299-W7-9, and 299-W7-11 in 2001 (Table A.24 in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*), and downgradient well 299-W7-8 and upgradient well 299-W10-13 in 2002 (Section 2.8.2.13 in PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*). In 2001, the groundwater flow direction determination was revised to east-northeast (previous flow direction was toward the north-northeast) (Table A.2 in PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). By 2002, upgradient wells 299-W10-19 and 299-W10-20 remained upgradient of the east portion of LLBG WMA-3, but were downgradient from the southwest part of the WMA. In 2004, downgradient wells 299-W7-1 and 299-W7-7 and upgradient well 299-W10-19 became dry (Table B.23 in PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*).

In 2004, dry wells were removed from the network with the issuance of a revised groundwater monitoring plan (PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*). Due to the groundwater flow direction change, the designations for wells 299-W10-20 and 299-W10-21 changed from upgradient to downgradient, leaving no upgradient wells monitoring the upper portion of the aquifer. Statistical evaluations for indicator parameters were suspended until new upgradient wells were installed and new background values could be established (Section 5.3 in PNNL-14859). The well network in PNNL-14859 comprised downgradient wells 299-W7-3 (deep well), 299-W7-4, 299-W7-5, 299-W7-12, 299-W8-1, 299-W10-20, and 299-W10-21 and upgradient well 299-W10-14 (deep well) (Table A.9 in PNNL-14859). Thirteen new wells were proposed, of which eight were prioritized for installation in 2005 and 2006 (Section 3.2.2 in PNNL-14859). The sampling constituents for LLBG WMA-3 included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), alkalinity, anions, metals, lead, mercury, and VOCs (Table A.9 in PNNL-14859).

In 2005, wells 299-W7-5 and 299-W10-21 became dry (Table B.24 in PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*). In 2006, PNNL-14859-ICN-1, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 1, was issued and removed dry wells 299-W7-5, 299-W7-12, and 299-W10-21 from the network. New downgradient wells 299-W10-29, 299-W10-30, and 299-W10-31 were added to the network.

In 2006, well 299-W10-20 became dry (Table B.24 in PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*). In 2007, PNNL-14859-ICN-2, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 2, was issued and removed well 299-W10-20 from the network. In 2008, well 299-W7-4 was removed from monitoring due to safety concerns associated with cave-in potential (Section 2.8.3.1 in DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*).

In 2010, the groundwater monitoring plan was revised (DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 0) to remove deep wells 299-W7-3 and 299-W10-14 and remove well 299-W8-1, which became crossgradient to LLBG WMA-3 due to changes in flow direction. Well 299-W7-4 was included as a downgradient well but was not able to be sampled due to access and safety issues (Table 3-1 in DOE/RL-2009-68, Rev. 0). The network included four downgradient wells (299-W7-4, 299-W10-29, 299-W10-30, and 299-W10-31), but no upgradient wells were available. The analyte list was revised to remove reduction-oxidation potential, mercury, and lead.

In 2011, well 299-W7-4 went dry (Section 3.2.10.3 in DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 1, was issued in 2011 and revised the monitoring network by removing dry downgradient well 299-W7-4 and adding a new planned upgradient well 299-W9-2. The downgradient wells included 299-W10-29, 299-W10-30, and 299-W10-31. Upgradient well 299-W9-2 was drilled in 2011 and was scheduled for quarterly sampling to support calculation of critical means for indicator parameters (Section 3.2.10.3 in DOE/RL-2011-118). In 2012, DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 2, was issued with updated information on newly drilled well 299-W9-2.

Elevated TOC was measured in new well 299-W9-2 in September 2012 (average 12,000 µg/L) and was attributed to vegetable grease. DOE/RL-2013-22, *Hanford Site Groundwater Monitoring for 2012*, p. ZP-33, provided that vegetable grease was used during well construction to lubricate casing connections. TOC sample results subsequently declined to an average 4,390 µg/L in December 2012, which suggested the vegetable grease was the source of the elevated TOC.

Beginning in 2013, critical means were re-established for LLBG WMA-3 and comparisons were again reported (Table B.55 in DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). Due to the elevated TOC values in upgradient well 299-W9-2 measured in 2012, the critical means for the downgradient wells were determined and compared on an intrawell basis for 2013 and 2014 (Table B.56 and p. ZP-35 in DOE/RL-2014-32; Section 12.11.3 and Table B-59 in DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*). The 2015 TOC critical mean was based on 2014 results in which TOC levels had decreased substantially from the 2012 levels. The TOC results in 299-W9-2 had decreased to less than detection in 2015, which supports the explanation that vegetable grease had been the source of elevated TOC (Section 12.11.3 in DOE/RL-2015-07).

Beginning in 2013, specific conductance exceeded the critical mean at one or more downgradient wells (299-W10-30 and 299-W10-31) and was attributed to increasing nitrate concentrations from the regional plume (p. ZP-35 and Table B.55 in DOE/RL-2014-32; Table B-58 in DOE/RL-2015-07). Specific conductance measurements for downgradient wells are also affected by treated groundwater that is injected upgradient of the downgradient wells (Section 12.11.3 in DOE/RL-2016-09, *Hanford Site RCRA Groundwater Monitoring Report for 2015*; Section 2.13 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*).

Beginning in 2014, TOX exceeded the critical mean in one or more downgradient wells (Table B-58 in DOE/RL-2015-07, Table B-52 in DOE/RL-2016-09). However, the elevated TOX concentrations at 299-W10-31 are consistent with observed levels of carbon tetrachloride in the area (Section 12.11.3 in DOE/RL-2016-09).

The influences from the regional nitrate and carbon tetrachloride plumes continued to lead to downgradient well results exceeding the critical means for specific conductance and TOX. Also, treated effluent from the 200 West P&T is injected downgradient of the upgradient well that is used to establish LLBG WMA-3 background. The treated effluent has higher specific conductance and TOC than the background data set. The regional carbon tetrachloride and nitrate plumes and influence from nearby 200 West P&T injection wells create spatial variability, potentially leading to false-positive exceedances at the LLBG WMA-3 downgradient wells, based on comparisons to upgradient monitoring well concentrations (Section 2.1.3 in DOE/RL-2016-66).

To account for spatial variability in the specific conductance, TOC, and TOX indicator parameters, statistical comparisons for 2016 were evaluated on an intrawell basis (Section 2.13 in DOE/RL-2016-66). No indicator parameters exceeded critical means that were calculated on an intrawell basis. For 2016, the reported groundwater flow is predominantly to the east but is locally affected by injection wells 299-W10-35 and 299-W10-36 that are within the LLBG WMA-3 boundary.

To date, interim status groundwater monitoring has not detected a release to the environment from LLBG WMA-3. Therefore, a detection monitoring program under WAC 173-303-645(9) is appropriate for LLBG Trenches 31 and 34 when they are added to Revision 8c of the Hanford Facility RCRA Permit as a final status operating unit group.

3 Geology and Hydrogeology

This chapter describes the geology and hydrogeology beneath the LLBG Trenches 31 and 34 area. This information is summarized from PNNL-16887, *Geologic Descriptions for the Solid-Waste Low Level Burial Grounds*; PNL-7336, *Geohydrology of the 218-W-5 Burial Ground, 200-West Area, Hanford Site*; PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*; and PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington,* and is included to provide a brief overview of the current understanding of the site.

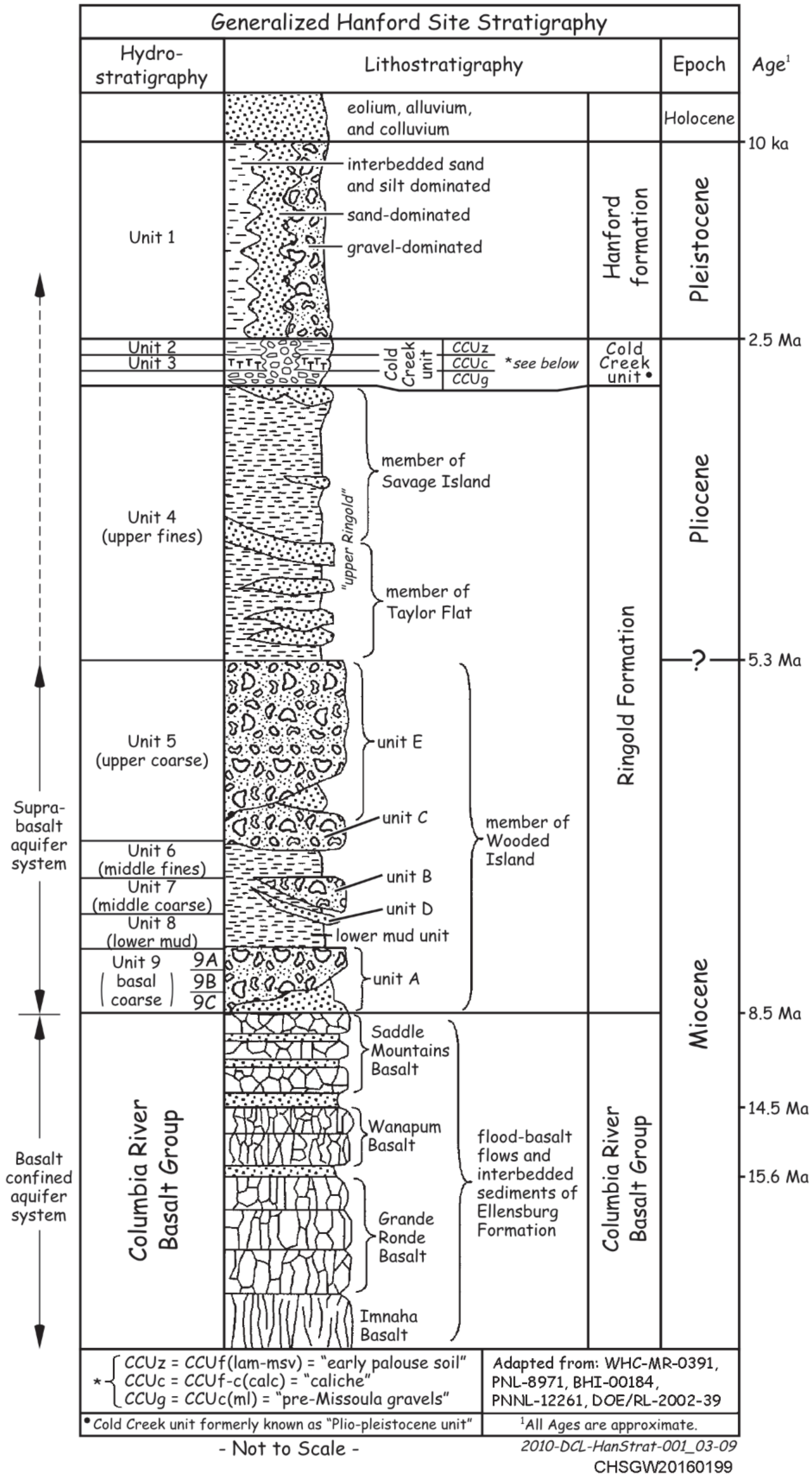
3.1 Stratigraphy

The generalized stratigraphy of the Hanford Site is shown in Figure 3-1. In descending order, Holocene surficial deposits and sediments of the Hanford formation, the Cold Creek unit (CCU), and the Ringold Formation are present at LLBG Trenches 31 and 34. These suprabasalt sediments overlie the Saddle Mountains basalt of the Columbia River Basalt Group. Figure 3-2 provides a geologic cross section.

Surficial deposits at the trenches consist of Holocene eolian sand and silt. These windblown soils are not continuous across the site and are up to several feet thick (Section 2.0 in PNNL-16887). These surficial deposits were removed during excavation of Trenches 31 and 34.

Basalt-rich glaciofluvial unconsolidated gravel and sand of the Hanford formation are present at the surface where surficial deposits are absent at the site. These sediments were deposited by Pleistocene cataclysmic floodwaters 13,000 years to 1 million years before present (Section 3.1.5 in PNL-7336). The gravel-dominated sequence consists of uncemented, matrix-poor, cross-stratified, coarse-grained sands and granule to boulder size gravel. The sand-dominated sequence consists of well-stratified fine to coarse sand with less gravel. Silt in these lithologies is variable. A silt-dominated sequence is also associated with the Hanford formation but does not appear to be present beneath trenches. The Hanford formation is 26 m (85 ft) to 40 m (131 ft) thick and thins to the north beneath the trenches.

The CCU, formerly known as the Plio-Pleistocene Unit/Early Palouse Soil, underlies the Hanford formation beneath the trenches (Section 3.1.3 in PNL-7336). This unit was deposited 1 to 3.9 million years before present. The CCU consists of two sequences, a carbonate-cemented sand and gravel unit that formed during soil development as precipitation evaporated and left behind minerals forming pedogenic $CaCO_3$ (i.e., caliche) (Section 2.2 in PNNL-16887), and an overlying fine-textured unit of unconsolidated muddy fine sand to fine sandy mud. In the 200 West Area, the CCU is 0 to 20 m (0 to 66 ft) thick. Beneath the trenches, the CCU is about 6 to 12 m (20 to 40 ft thick) and dips to the southwest (Section 3.1.3 in PNL-7336) and includes both the cemented unit and the overlying fine-textured unconsolidated unit. The contact between the top of the CCU and the overlying Hanford formation is the primary contact of interest with respect to potential for flow direction modification within the vadose zone. The CCU upper surface in the vicinity of Trenches 31 and 34 exhibits a generally south-southwest strike direction with a dip angle of about 1.4%. In an unsaturated flow condition, such as may be expected under a hypothetical release scenario from the trenches, fluid migration should be primarily vertical, and this condition should not produce substantial lateral movement of migrating water.



Note: Complete reference citations are provided in Chapter 11.

Figure 3-1. Stratigraphic Column for LLBG Trenches 31 and 34

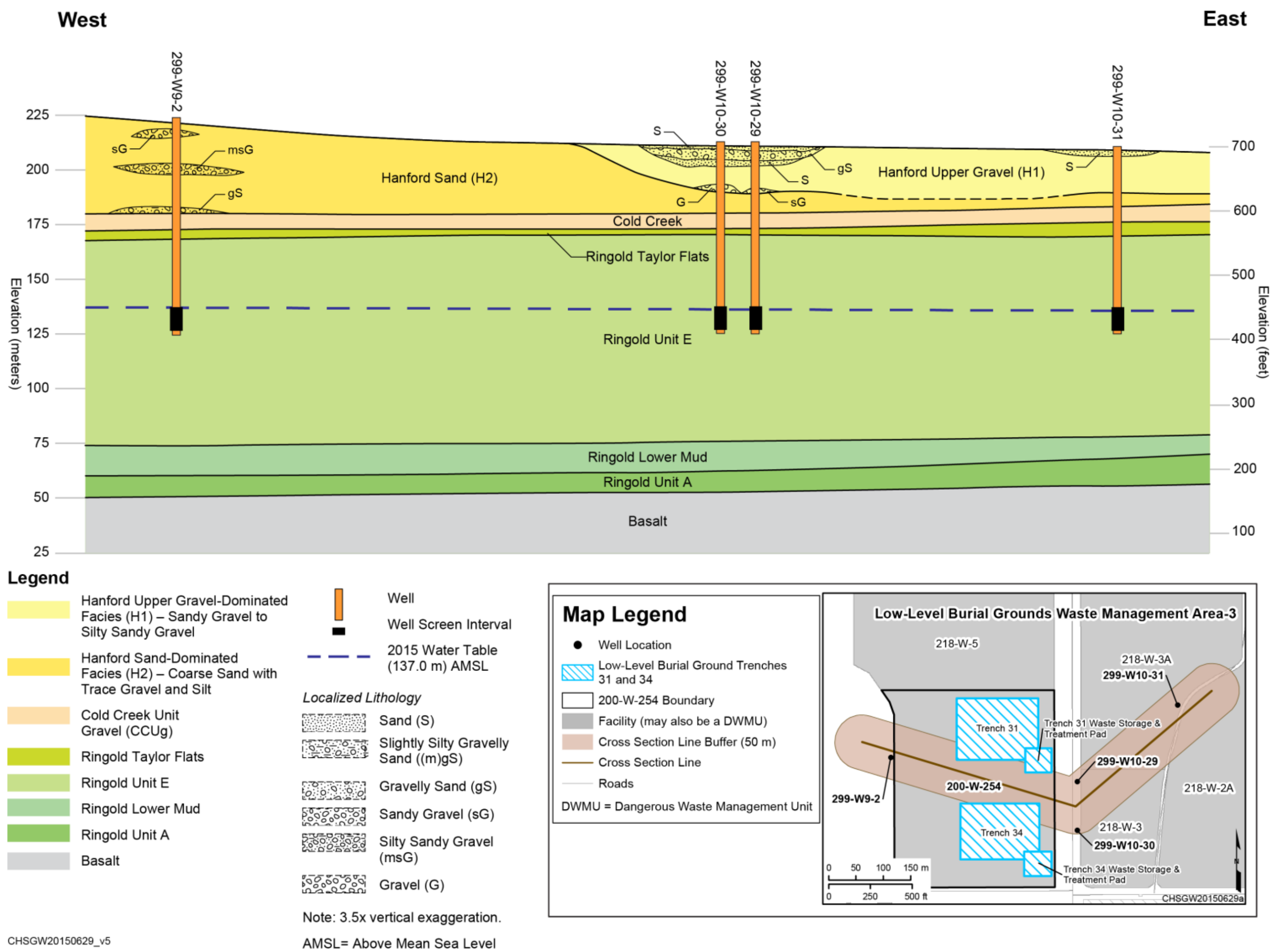


Figure 3-2. Geologic Cross Section Through LLBG Trenches 31 and 34

The Ringold Formation underlies the CCU and overlies basalt beneath the trenches. This formation consists of fluvial-lacustrine sediments deposited by the ancestral Columbia River about 3.9 to 10.5 million years before present (Section 2.1 in PNNL-16887). These semi-consolidated sediments consist of an intercalated mix of gravel, sand, and silts to silt-rich paleosols and lake deposits. Beneath the trenches, the Ringold Formation is subdivided into the four units in descending order: Member of Taylor Flat (upper Ringold), Unit E, Ringold lower mud, and Unit A. The Ringold Formation is up to 122 m (400 ft) thick beneath the trenches and dips to the south. A brief description of each unit is provided below.

- The Ringold Formation member of Taylor Flat consists of an abundance of well-sorted sand to muddy sand and gravelly sand. Deposition of this unit represents transition to a lower energy fluvial environment compared to Unit E. Beneath the trenches, this unit is about 4 to 7 m (13 to 23 ft) thick and thins to the south.

- Ringold Formation Unit E makes up over 75% of the Ringold Formation and intersects the water table surface at an elevation of about 136 m (446 ft). Unit E consists mostly of coarse-grained gravel and sand deposited in a high-energy fluvial environment and it is general more consolidated than Hanford formation sands and gravels (Section 3.1.1 in PNL-7336). This unit is about 92 m (302 ft) to 94 m (308 ft) thick near the trenches.

- The Ringold Formation lower mud unit represents the base of the unconfined aquifer beneath the trenches. This unit consists predominantly of silt with approximately equal amounts of sand and clay. Beneath the trenches this unit is about 9 to 13 m (30 to 42 ft) thick and thins to north where it pinches out north of the 200 West Area fence boundary and northeast of the trenches.

- Ringold Formation Unit A is similar in texture to Ringold Formation Unit E. Where the Ringold formation lower mud is not present it is difficult to differentiate between Unit E. Beneath the trenches this unit is about 11 to 13 m (36 to 43 ft) thick and directly overlies basalt of the Elephant Mountain Member.

- The Saddle Mountain Basalt is the uppermost formation of the Columbia River Basalt Group beneath the trenches. The uppermost basalt unit is Elephant Mountain Member dated about 10.5 million years before present (Section 3.1.1 in PNL-7336). The surface of the basalt slopes gently to the south at an elevation of 50 m (164 ft) to 56 m (184 ft).

3.2 Hydrogeology

This section describes the hydrogeology in the area of LLBG Trenches 31 and 34.

3.2.1 Aquifer Recharge

Natural recharge to the Hanford Site’s unconfined aquifer is from precipitation (~17 cm/yr [~7 in./yr]) and runoff from the Rattlesnake and Yakima ridges. The ridges are located south and west of the 200 Areas and expressed at the surface as long linear outcrops at an elevation of 1,060 m (3,527 ft). Recharge to the aquifer near LLBG Trenches 31 and 34 is mainly from artificial sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation range from 4 to 44 mm/yr (0.16 to 1.7 in./yr) and are largely dependent on the soil texture and the type and density of vegetation. (Table 4.15 in PNNL-14072). There is no vegetation in LLBG Trenches 31 and 34 themselves. Directly beneath LLBG Trenches 31 and 34 natural recharge to the aquifer may not occur because of the double liners and LCRS. Liquids are routinely sampled and pumped from the LCRS.

Artificial recharge to the aquifer near LLBG Trenches 31 and 34 occurred when effluent was discharged at or near the ground surface during Hanford Site operations and by the current injection of treated groundwater directly into the aquifer during the operation of the 200 West P&T remedy. After the startup of Hanford Site operations in 1944, water elevations in the unconfined aquifer increased as much as 20 m (66 ft) above the pre-Hanford operations natural water table. Hydrographs from selected wells show changes in the elevation of the water table in the 200 West Area (Figure 3-3). Discharges to T Pond (1944 to 1976) and U Pond (1944 to 1985) systems and other liquid waste receiving sites were the cause of water table elevation changes and changes in groundwater flow direction. The impact of artificial recharge on groundwater flow direction is discussed in Section 3.3.

Most discharges of effluent to the ground in the 200 Area ceased in the mid-1990s. The only current permitted discharge to the ground in the 200 West Area is from a State-Approved Land Disposal Site (SALDS). The SALDS is located about 1,200 m (4,000 ft) northeast of the trenches and began operation in 1995. Since 1995, more than 880 million L (232 million gal) of effluent has been discharged to the facility. Discharges to SALDS do not appear to impact the groundwater at LLBG Trenches 31 and 34. However, the discharges contribute to the collective groundwater regime in the northern portion of the 200 West Area. Hydrographs from well 699-48-77D (located near SALDS) and wells 299-W9-1 and 299-W10-13 (located closer to the LLBG Trenches 31 and 34) show that groundwater has continued to generally decline after SALDS began operations in 1995 (Figure 3-4). No measurable effects, in terms of a rise in the elevation of the water table, were observed after operations began at the SALDS in these wells.

Although the elevation of the regional water table has generally been declining in the 200 West Area since cessation of large-volume water discharges in the 1980s, operation of the 200 West P&T produces localized transient elevation increases of the water table near the trenches. The 200 West P&T system is a source of artificial recharge to the unconfined aquifer. The system came online in 2012 and is designed to capture and treat contaminated groundwater. Following treatment, water is reinjected into the aquifer and serves as a recharge source. Hydrographs from three LLBG WMA-3 network wells (299-W9-2, 299-W10-29, and 299-W10-30) show the impact of the P&T remedy (Figure 3-5). The elevation of the water table across the 200 West Area remains above 1944 levels. Following the expected end of operation of the P&T remedy in 2037, groundwater elevations are expected to decline near the trenches.

3.2.2 Hydrogeologic Units

Hydrogeologic units near LLBG Trenches 31 and 34 are Holocene surficial deposits (removed in the area of Trenches 31 and 34), the Hanford formation, the CCU, the Ringold Formation (member of Taylor Flats, Unit E, Ringold Lower Mud Unit, Unit A), and basalt of the Elephant Mountain Member. The Hanford formation, the CCU, and Ringold Formation member of Taylor Flats occur entirely in the unsaturated zone (i.e., vadose zone), while the Ringold Formation Unit E is partially within the vadose zone and partially within the unconfined aquifer (i.e., saturated zone). Based on the maximum surface elevations near the top of the trenches, the unsaturated thickness of the vadose zone around LLBG Trenches 31 and 34 is approximately 74 to 78 m (243 to 256 ft). Within the open areas of the trenches, which have been excavated to a variable depth of 9.1 to 12.2 m (30 to 40 ft), the unsaturated thickness of the vadose zone is about 67 m (219 ft).

Ringold Unit E intersects the water table (i.e., unconfined aquifer) at an elevation of 136 m (446 ft). The saturated thickness of the unconfined aquifer is 59 to 63 m (194 to 207 ft). The Ringold Lower Mud Unit underlies Unit E and is the base of the unconfined aquifer (Section 4.0 in PNL-7336). It separates the unconfined aquifer from the confined aquifer that resides within Unit A. The saturated thickness of Unit A is about 9 to 13 m (30 to 43 ft) beneath the trench. Unit A thins to north where it pinches out north of the 200 West Area fence boundary. The uppermost surface of the Elephant Mountain Member (basalt) is considered the base of the suprabasalt aquifer system (bedrock).

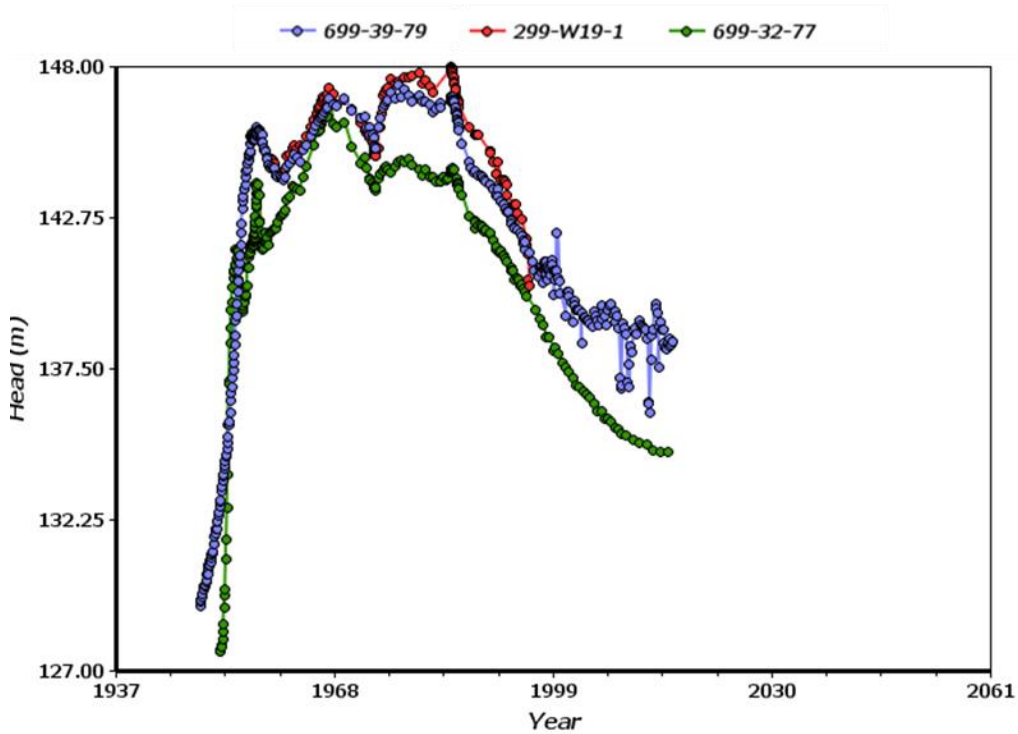


Figure 3-3. Hydrograph from Selected Wells in the 200 West Area

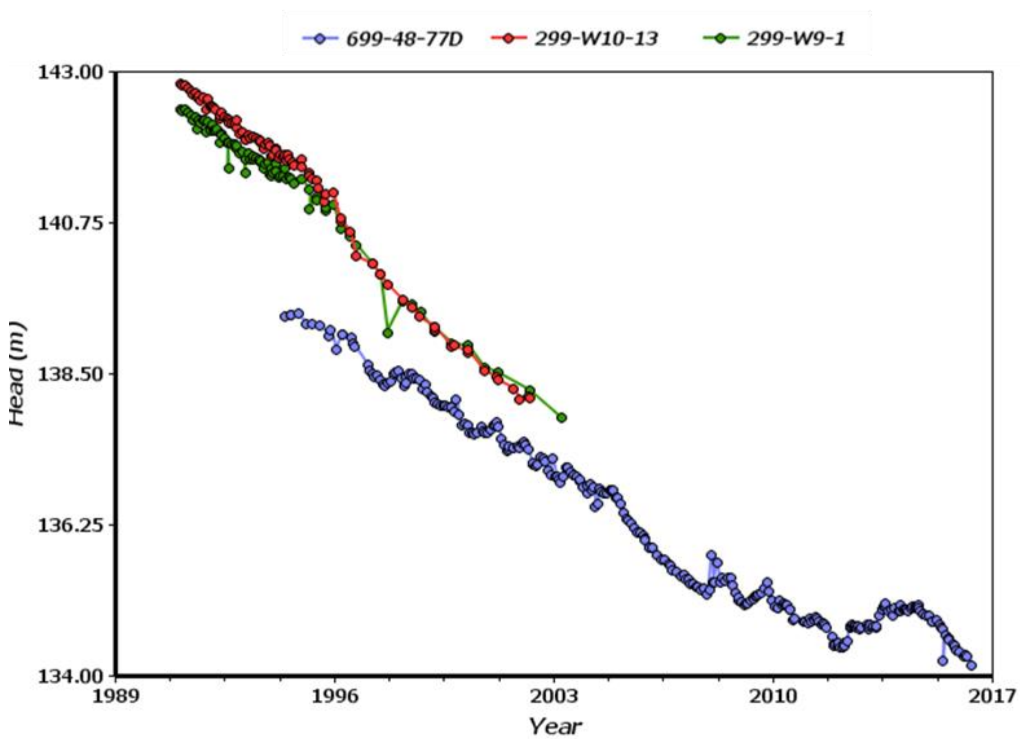


Figure 3-4. Hydrograph from Wells Near the SALDS and LLBG Trenches 31 and 34

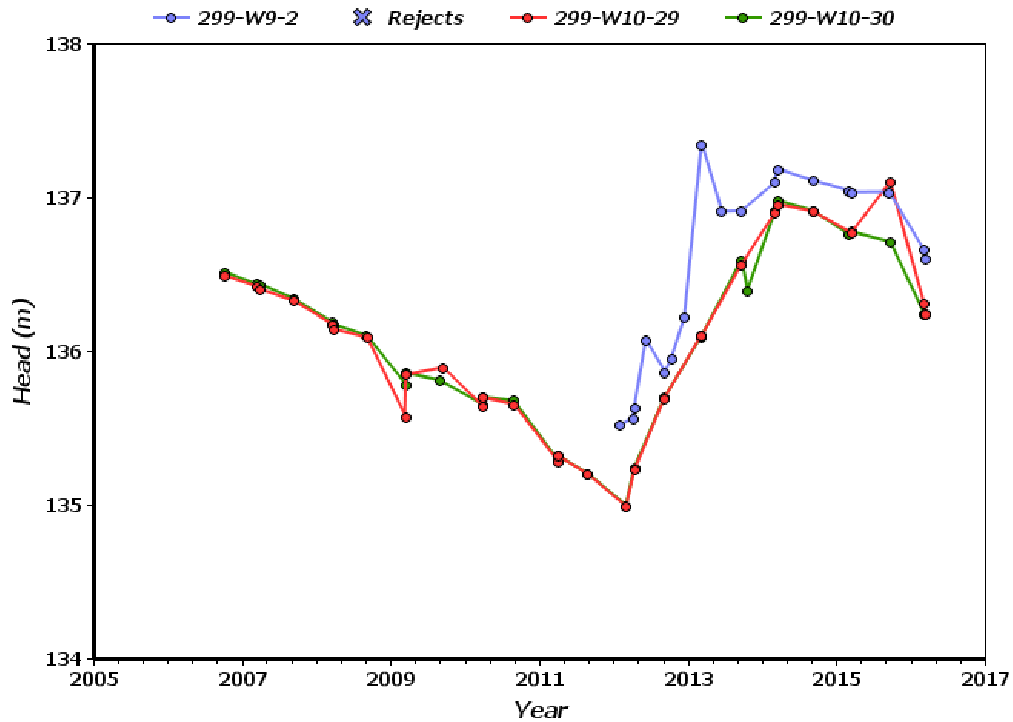


Figure 3-5. LLBG Hydrographs – Impacts to Groundwater from P&T Remedy in 2012

The saturated hydraulic conductivity of the Ringold E unit underlying LLBG Trenches 31 and 34 is 5 m/d (16.4 ft/d) (Table 4-9 in CP-47631). Table 1 in PNL-8337, *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System*, gives a range of saturated hydraulic conductivities ranging from 0.05 to 4.9 m/d (0.16 to 16 ft/d) based on field measurements. Soil properties of the CCU indicate that this horizon will likely slow the rate of downward movement and promote lateral spreading in the vadose zone; however, in an unsaturated condition fluid migration should be primarily vertical and this condition should not produce substantial lateral movement of migrating water.

Large erosional window in the Ringold Lower Mud located about 1 km (0.6 mi) to the northeast of the site provides a pathway for groundwater movement between the two aquifers (Section 4.2.4 in PNNL-13858). This interconnection is further exemplified by the presence of an extensive carbon tetrachloride plume in both the unconfined and confined aquifers within 200 West Area (Figure 3-37 in DOE/RL-2015-06, *Calendar Year 2014 Annual Summary Report for the 200-ZP-1and 200-UP-1 Operable Unit Pump and Treat Operations*). However, Ringold Lower Mud is projected to be present beneath the entirety of the site as presented in ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*. Based on the geologic framework modeling, interconnection between the unconfined and confined aquifers beneath LLBG Trenches 31 and 34 is not known to exist.

3.3 Groundwater Flow

The hydrologic conditions at LLBG Trenches 31 and 34 have changed over time. This section describes the groundwater flow system of the region before and during Hanford Site operations, and current conditions resulting from the operation of the 200 West P&T system.

3.3.1 Groundwater Flow Prior to 200 West P&T Operations

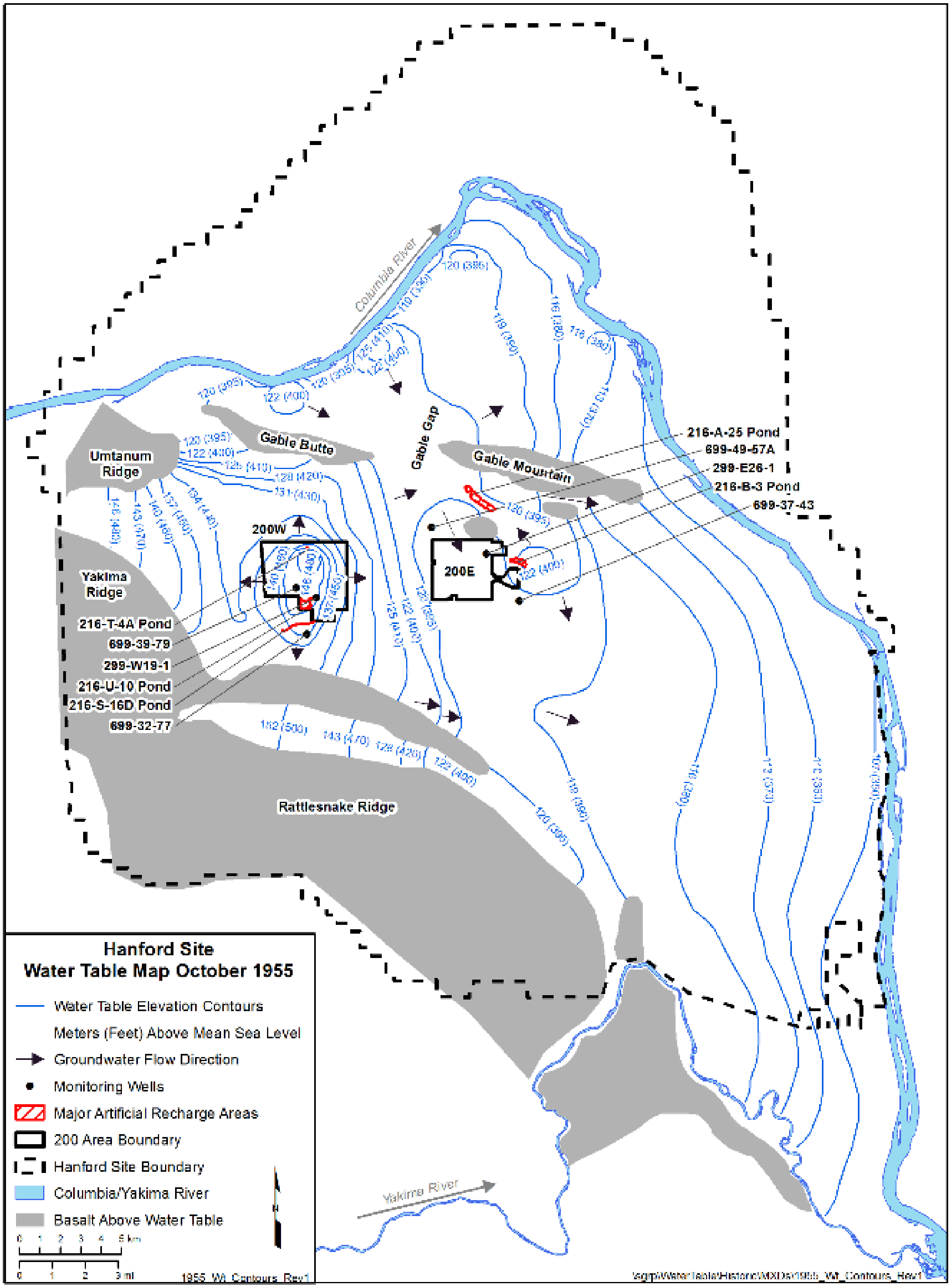
The groundwater flow direction prior to Hanford Site operations was toward the east in the 200 West Area (BNWL-B-360, S*elected Water Table Contour Maps and Well Hydrographs for the Hanford Reservation, 1944-1973*). After Hanford Site operations began in 1944, the water table beneath the 200 West Area and LLBG Trenches 31 and 34 was affected by disposal of large volumes of liquid effluent to various facilities. Discharges to liquid waste receiving sites that reached groundwater caused increases in the elevation of the water table and changes in groundwater flow direction. Radial groundwater flow away from groundwater recharge mounds was documented in the 200 West Area from 1948 to 1955. In 1955, groundwater flow in the area of LLBG Trenches 31 and 34 was to the west and south away from a groundwater mound located beneath the 216-T-4 Pond (Figure 3-6).

By 2000, most discharges of effluent to the ground in the 200 Areas had ceased. After 2000, and prior to the startup of 200 West Area P&T operations, the groundwater flow direction was predominantly eastward; however, the elevation of the water table remained elevated beneath the 200 West Area (Section 2.1.1.2 in PNNL-13404 and Section 2.1.1.2 in PNNL-15670).

3.3.2 Groundwater Flow Due to Operations of the P&T Remedy

The 200 West P&T system came on line in 2012 and is designed to capture and treat contaminated groundwater. The groundwater P&T technology is an element of the selected final remedy for the 200-ZP-1 Groundwater OU (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*) (hereinafter referred to as the 200-ZP-1 record of decision [ROD]) and the interim remedy for the 200-UP-1 OU (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*), located south of the 200-ZP-1 OU on the Hanford Site Central Plateau (Figure 3-7). At the 200 West P&T facility, the groundwater extracted from the 200-ZP-1 and 200-UP-1 OUs is combined and treated. Following treatment, water is reinjected into the aquifer to serve as a recharge source and as the flow-path control component of the remedy. According to DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*, the facility can treat up to 9,464 L/min (2,500 gal/min). The 200 West P&T system currently operates at 8,725 L/min (2,305 gal/min). With modifications to the system, the treatment capacity can be increased to 14,194 L/min (3,750 gal/min) if required; however, there are currently no plans for operating at this capacity. Figure 3-7 shows the locations of 200 West P&T system extraction and injection wells.

The impacts to site groundwater flow from the operations of the 200 West P&T system can be illustrated by comparing water table maps from prior to the start of operations to current conditions (Figures 3-8 and 3-9). Figure 3-8, a 2012 water table map, represents groundwater elevations prior to 200 West P&T operations. Water-level data obtained during June 2012 were evaluated by interpolation. During this time, groundwater flow direction was to the east-northeast. The hydraulic gradient is estimated to be 1.5×10^{-3} m/m in 2012 with an average linear velocity of 0.04 to 0.15 m/d (0.13 to 0.49 ft/d) (Table 3-1 in SGW-55438, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*).



Modified from BNWL-B-360, S*elected Water Table Contour Maps and Well Hydrographs for the Hanford Reservation, 1944-1973.*

Figure 3-6. 1955 Hanford Site Water Table Map

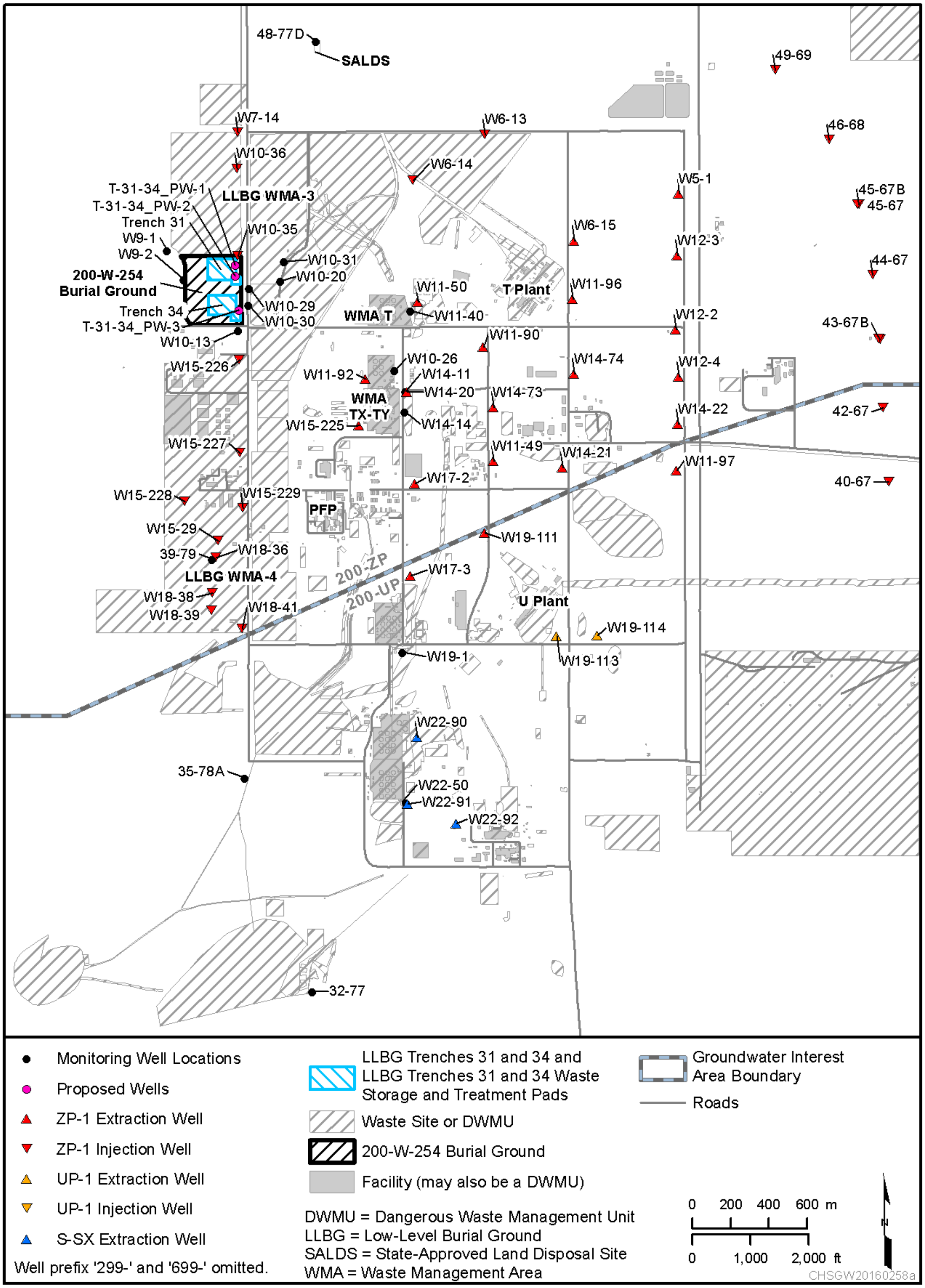


Figure 3-7. 200 West P&T System Well Location Map (as of June 2016)

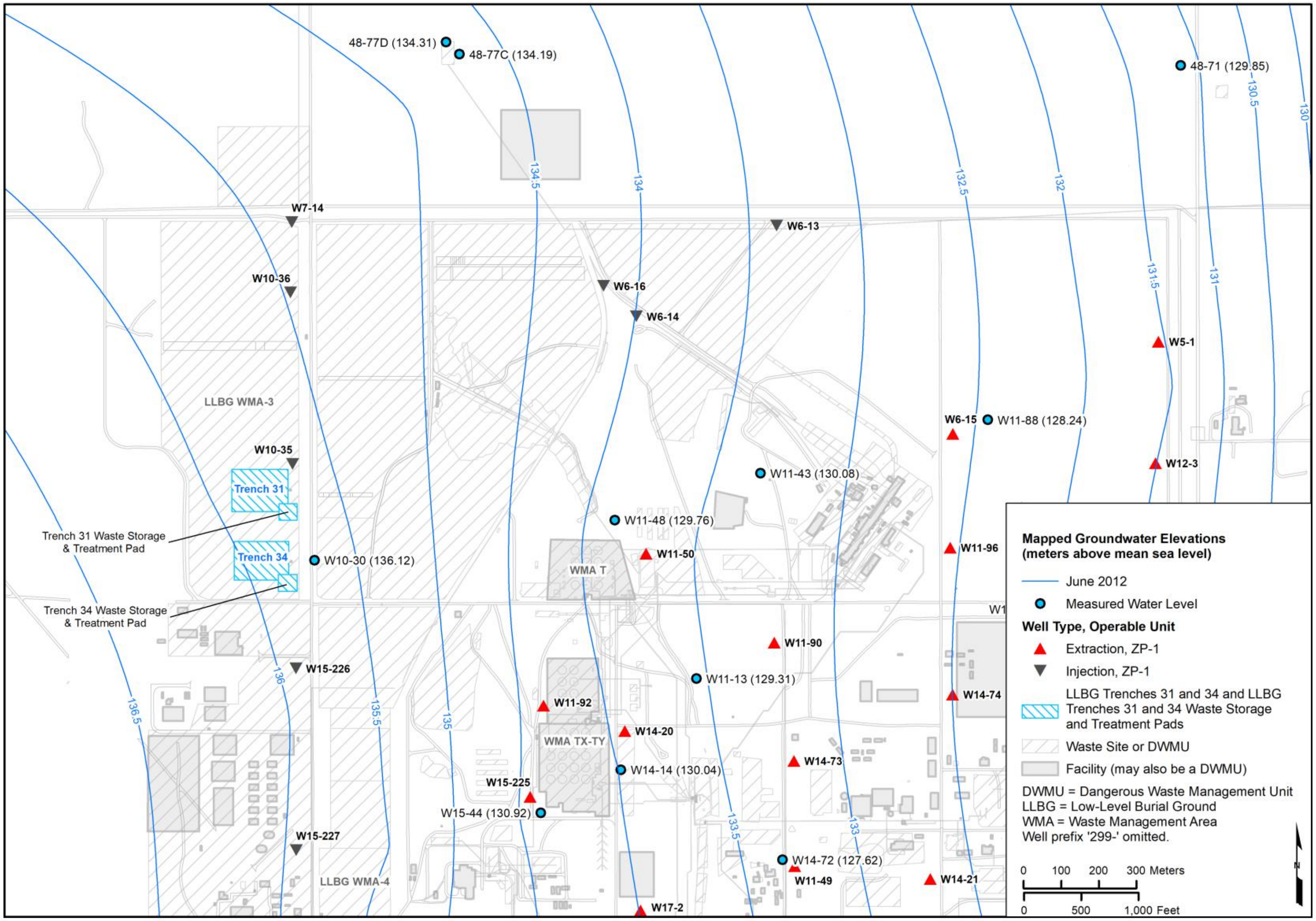


Figure 3-8. Water Elevation Contours in June 2012 Prior to Startup of the 200 West P&T

Water levels declined about 0.6 m to 0.8 m (2 to 2.6 ft) between 2015 and 2016. (Section 12.10.3 in DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*). The decline is primarily due to two factors simulated within the CPGWM:

1. The substantial reduction of wastewater discharges to the soil column associated with the cessation of discharges in the mid-1990s.

2. Commencement of operation of the 200 West P&T system in 2012. Water level changes associated with the start-up (SGW-50907, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site*, and ECF-200ZP1-12-0074, *Presentation & Initial Evaluation of Water-Level & Pumping Data for the Hanford 200-ZP-1 Groundwater Pump-and-Treat Remedy*).

The March 2016 Hanford Site water table map (Figure 3-9) shows groundwater flow direction is to the east-northeast beneath the LLBG Trenches 31 and 34 under current operating conditions of the 200 West P&T system. Several injection wells (299-W7-4, 299-W10-35, 299-W10-36, 299-W15-226, and 299-W15-227) are located near the trenches, which inject treated water into the aquifer below the water table. Another injection well (299-W6-14) is located east of the LLBG Trenches 31 and 34. Injection and extraction wells are shown on the 2016 water table map (Figure 3-9). The hydraulic gradient beneath LLBG Trenches 31 and 34 is estimated to be 7.0×10^{-3} m/m based on the 2016 water table map, with an average linear velocity of 0.18 to 0.70 m/d (0.59 to 2.3 ft/d) (Table 2-47 in DOE/RL-2016-66).
The groundwater flow rate and direction are further described in Section 4.3.

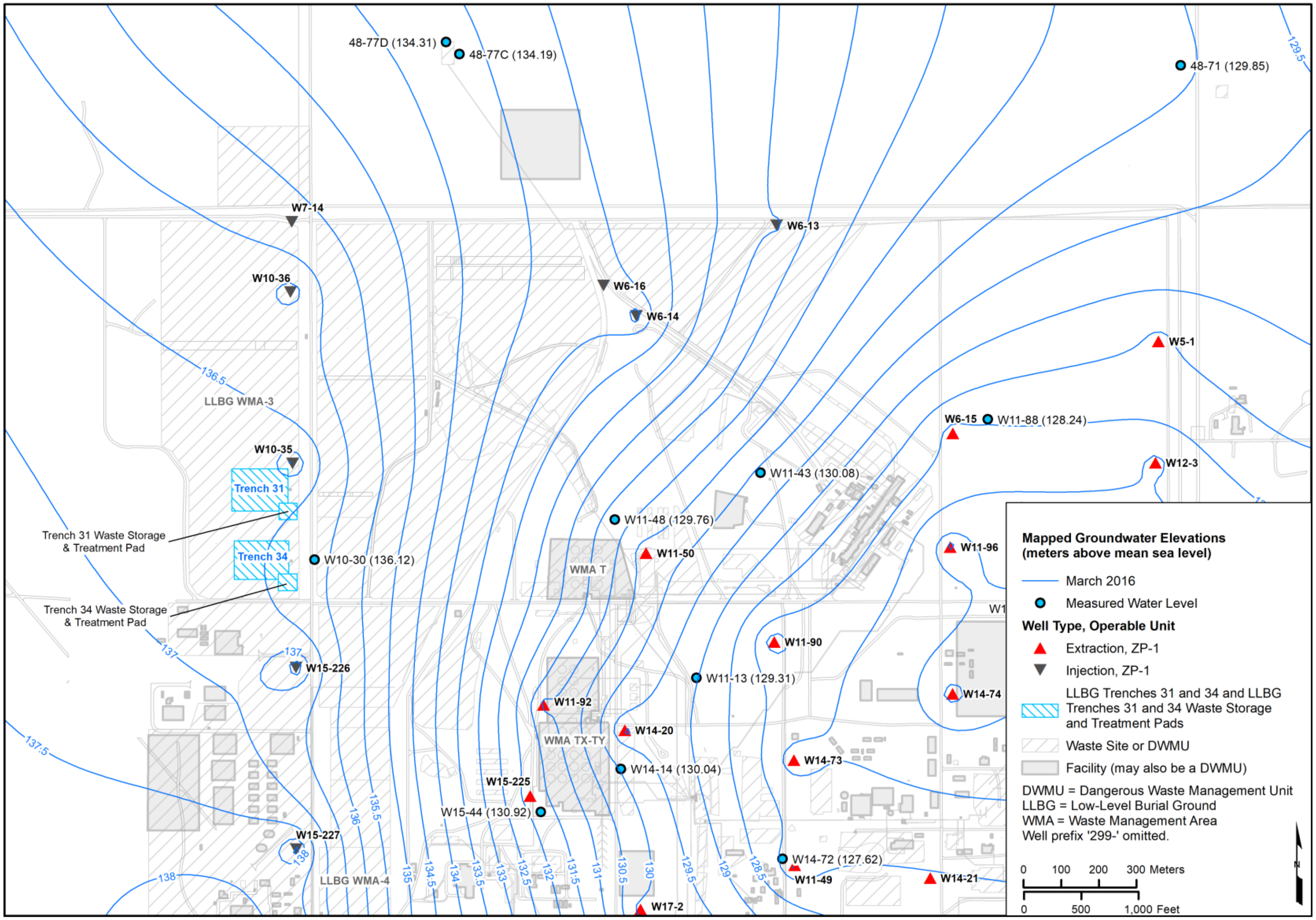


Figure 3-9. Water Elevation Contours in March 2016 During 200 West P&T Operations

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4 Contaminant Migration Conceptual Model

The conceptual model for contaminant release and transport through the vadose zone to groundwater is based on the following assumptions:

- Average precipitation of about 17 cm/yr (~7 in./yr) prevail over the timeframe of interest (operational lifespan and post-closure monitoring period) (Section 4.5.2.2 in PNNL-14702).
- Net infiltration is assumed to occur under gravity drainage on the trench floor and slopes into the LCRS.
- Leaching of mobile contaminants from buried waste in damaged/degraded sealed containers or contaminated soils in direct contact with the trench is assumed the major potential source for contamination to enter the leachate sumps.
- Release of contaminated leachate to the vadose zone beneath the trenches is assumed to occur only under a failure scenario involving leakage from sumps or damaged/degrading liners (i.e., such a release in neither continuous, nor over a wide area).
- Artificial sources of water (e.g., leaking potable or raw water lines) are not present based on Hanford Site drawings.
- Extreme conditions or accidental releases are recognized as factors but would be addressed under emergency response/corrective actions.

4.1 Vadose Zone

The vadose zone at LLBG Trenches 31 and 34 is approximately 76 m (246 ft) thick and consists of (from top to bottom) the Hanford formation, the CCU, and the Ringold Formation. The lower hydraulic conductivity of the CCU is likely to slow downward movement of moisture and contaminants because of the finer textured sediment and caliche cementing that characterize this stratigraphic feature in the vadose zone.

A finer grained lithologic unit lies below the CCU within the stratigraphic framework under LLBG Trenches 31 and 34. The Taylor Flat member of the Ringold Formation (shown in Figures 3-1 and 3-2) is interpreted from well construction geologic logs near LLBG Trenches 31 and 34. It is a fine-grained sequence consisting of interstratified, well-bedded, fine to coarse sand to silt and is equivalent to the upper Ringold Formation unit mentioned in earlier documents (e.g., PNNL-16887). The combined moisture-retention properties for the CCU and Taylor Flat member of the Ringold Formation within the vadose zone have high capacity to absorb and retain moisture.

4.2 Soil Moisture Factors

During the operating period of the trenches, direct precipitation contacting waste materials in the trenches is the primary driver for hypothetical leaching of waste constituents from the burial trenches to the LCRS. The amount of natural infiltration that can pass through the leachable buried waste and enter the vadose zone is controlled by the trenches' drainage, double liners, and LCRS.

Stratigraphic features in the soil column beneath LLBG Trenches 31 and 34 can also influence or slow the downward migration by spreading soil moisture laterally. Direct observational evidence to assess this effect at LLBG Trenches 31 and 34 is lacking, with no perched water zones in the vicinity. Under the gravity drainage assumption, only a small to moderate horizontal gradient component is likely to be available to produce lateral spreading of infiltrating water.

It is estimated that recharge rates in the northern portion of 200 West Area in the vicinity of the trenches range from 4 mm/yr (0.16 in./yr) in a shrub-steppe vegetated area to 44 mm/yr (1.7 in./yr) at a gravel-covered, nonvegetated site (Table 4.15 in PNNL-14702). Recharge under the trench operating conditions is expected to be 0.0 mm/yr with the LCRS in place.

No perched water has been observed during drilling recent wells that intersected the CCU in the vicinity of the trenches, although the CCU has historically supported perched water units under conditions of long-term, high-volume surface discharges. Present conditions beneath the trenches reflect unsaturated flow conditions in the vadose driven primarily by natural infiltration of meteoric water. There is no current injection of water into the vadose zone in the vicinity of the trenches and none is anticipated. Hypothetical release of leachate from the trenches would result in unsaturated flow through the vadose; unsaturated flow is not expected to produce substantial lateral migration along the contact between the CCU and the overlying Hanford formation.

4.3 Hydrogeologic Considerations

Prior to startup of the 200 West P&T system in 2012, the groundwater flow direction under LLBG Trenches 31 and 34 was east-northeast at a calculated rate (using the Darcy relationship) of 0.04 to 0.15 m/d (0.13 to 0.49 ft/d). The water table elevation in the vicinity of the trenches has increased in response to local groundwater injection (Figure 3-9), and the groundwater flow direction beneath the area of the trenches is now generally east to east-northeast as a result of groundwater extraction and injection for the 200 West P&T with a calculated groundwater velocity of 0.18 to 0.70 m/d (0.59 to 2.3 ft/d) (Table 2-47 in DOE/RL-2016-66).

Pump and treat operations are expected to continue in this region until 2037. After completion of active groundwater remediation and the 200 West P&T system is shut down, groundwater flow is anticipated to return to pre-200 West P&T startup conditions. The changing groundwater flow directions and gradients will be considered when evaluating the groundwater monitoring network. These factors are assessed in evaluating impact to groundwater beneath LLBG Trenches 31 and 34 in the simulations described in Chapters 4 through 6 of this report.

4.4 Groundwater Chemistry

The solubility and subsequent mobility of waste constituents in pore fluid depend on the chemical nature of the waste constituents, the volume of water and water contact time with the waste, and natural subsurface geochemical conditions.

Pore fluid and groundwater in the unsaturated and saturated zones beneath LLBG Trenches 31 and 34 is slightly alkaline ($7<pH<9$), with appreciable amounts of bicarbonate and very little natural organic material. Vadose soil and groundwater are generally well-aerated. The dissolved oxygen concentrations fall into the higher range for groundwater (7 to 10 mg/L). These general conditions favor sorption or retardation of many heavy metals (e.g., lead) and also favor stability of oxy-anionic species, which enhance mobility for other metals (e.g., hexavalent chromium). Laboratory sorption studies have documented these effects and related mobility issues in Hanford Site media. These conditions tend to allow chlorinated solvents (e.g., carbon tetrachloride) to remain persistent, as these compounds normally degrade more rapidly in reduced groundwater environments.

Regional groundwater contaminant sources are identified through *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation activities at the 200-ZP-1 OU. The 200-ZP-1 OU incorporates the groundwater beneath an area in the northern portion of the 200 West Area. Monitoring results for the 200-ZP-1 OU have shown that groundwater historically beneath much of the 200 West Area, including beneath the trenches, has been contaminated from other sources including the Plutonium Finishing Plant, 216-Z Trenches and Cribs, WMA T, and WMA TX-TY (Section 12.1 in DOE/RL-2016-09).

The principal contaminant plume from the 200 West Area that is present in the saturated zone under LLBG Trenches 31 and 34 is carbon tetrachloride. The footprints of LLBG Trenches 31 and 34 are located immediately adjacent to or within the northwestern edges of this large regional plume of carbon tetrachloride. In this area of the plume, the concentrations are above the drinking water standard for carbon tetrachloride (5 µg/L).

Nitrate is another contaminant plume from the 200 West Area that is found beneath LLBG Trenches 31 and 34. The footprints of LLBG Trenches 31 and 34 are located immediately adjacent to or within the edges of this large regional plume. In this area of the plume, the concentrations are currently low, ranging from 5.75 to 44.3 mg/L in groundwater samples collected in 2016, and close to the drinking water standard for nitrate (45 mg/L).

Additional regional plumes include nonregulated radionuclides that are monitored under the AEA.

4.5 Summary of Vertical Contaminant Distribution

Dangerous waste constituents specific to release from LLBG Trenches 31 and 34 are not present in groundwater. Evaluation of vertically distributed groundwater data is limited to the location of LLBG Trenches 31 and 34 within the context of regional plumes present in 200-ZP-1 OU. Available vertical distribution data is limited to nine completed wells in the vicinity of LLBG Trenches 31 and 34 collected during drilling and special studies. Identified wells include: 299-W10-31, 299-W10-35, and 299-W15-226 located near the perimeter of LLBG Trenches 31 and 34; and 299-W6-13, 299-W6-14, 299-W6-16, 299-W7-13, 299-W10-36, and 299-W11-43 located distally from LLBG Trenches 31 and 34. See Figure 4-1 for general well location in relation to LLBG Trenches 31 and 34. These wells were installed between 2005 and 2017 and have varying quantities of measurements, collected samples, and depths of characterization. The temporal separation in observations and measurements introduces substantial uncertainty in interpreting correlation between individual well data and the LLBG Trenches 31 and 34 operation. In addition, a CERCLA P&T remedial action is currently in operation in the vicinity of these wells.

Evaluated constituents were limited to available nonradiological vertical data associated with the surrounding wells and limited to the following: carbon tetrachloride, nitrate, and hexavalent chromium, representing widespread contaminants in 200-ZP-1 OU and present near LLBG Trenches 31 and 34. During drilling of the wells, groundwater samples were collected from the boreholes at selected depths and analyzed by field and/or laboratory methods. Laboratory data were selected where both field and laboratory data were available for each of the vertical contaminant distribution plots.

Limited vertical characterization data are available for well 299-W10-31, were collected during special study and included: carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene. Additionally, limited vertical characterization data is available for 299-W7-13 collected during drilling and included volatile organic compounds collected at three recorded elevations. Carbon tetrachloride results for well 299-W7-13 ranged from 3.7 to 17 µg/L. Due to the limited available data, wells 299-W10-31 and 299-W7-13 are not further evaluated.

Where duplicate samples were collected at a given interval, resulting values were averaged. See Figures 4-2 to 4-9 for observed vertical distribution of identified contaminants. Vertical zones of increased contaminant concentrations are provided within the figures and are based on visual observation of the vertical trends and are for visual reference only.

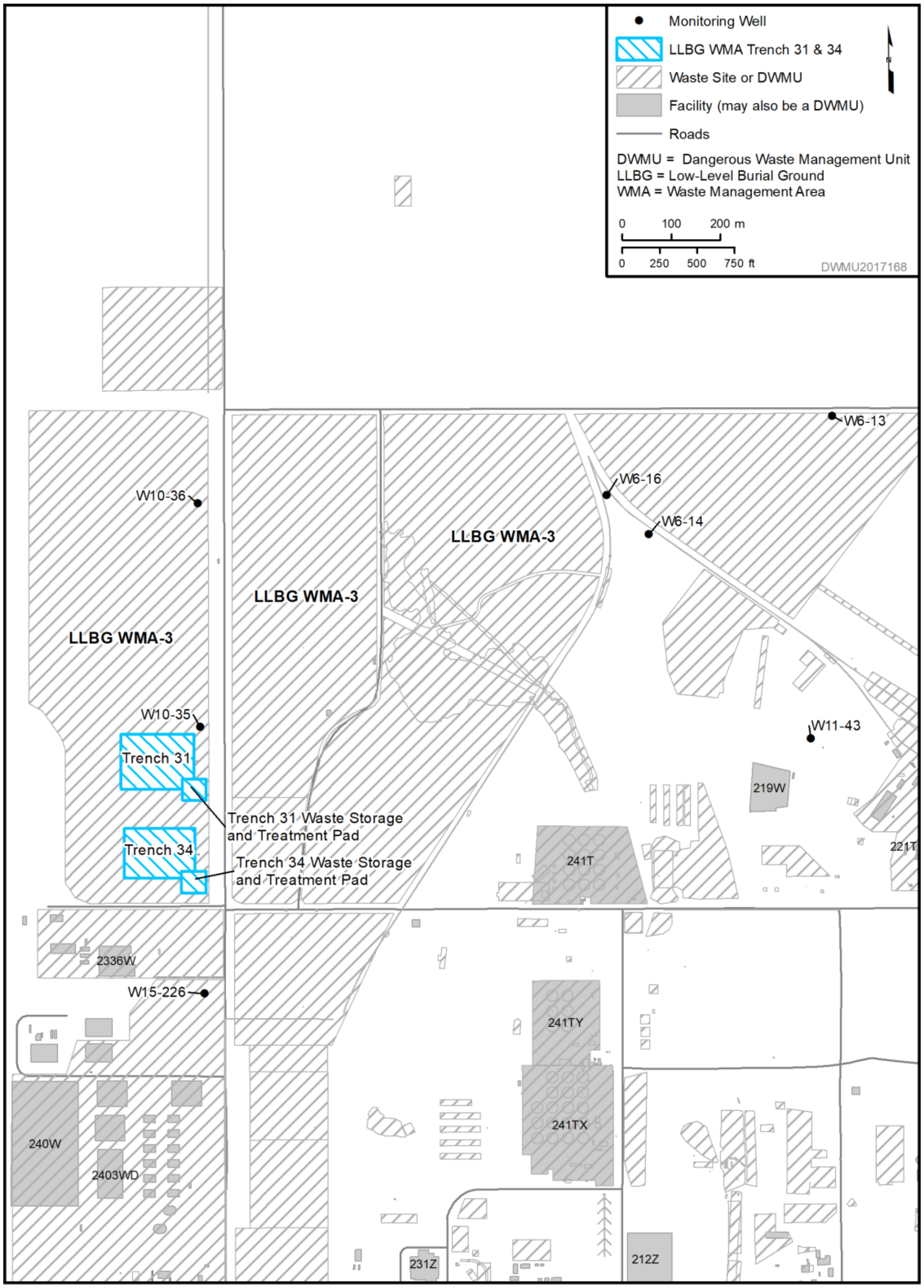


Figure 4-1. Well Location Map for Vertical Contaminant Characterization

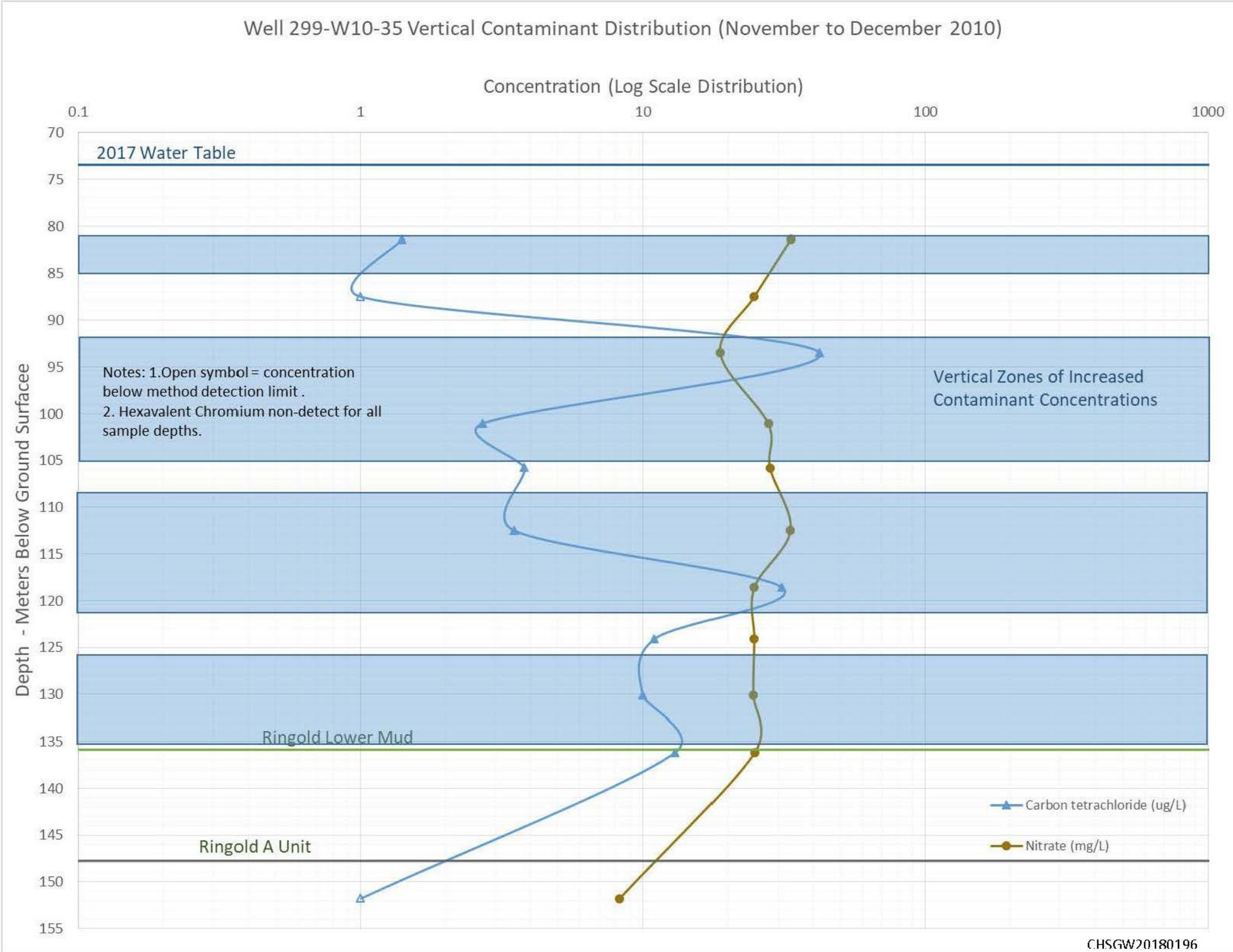


Figure 4-2. Vertical Contaminant Characterization Well 299-W10-35

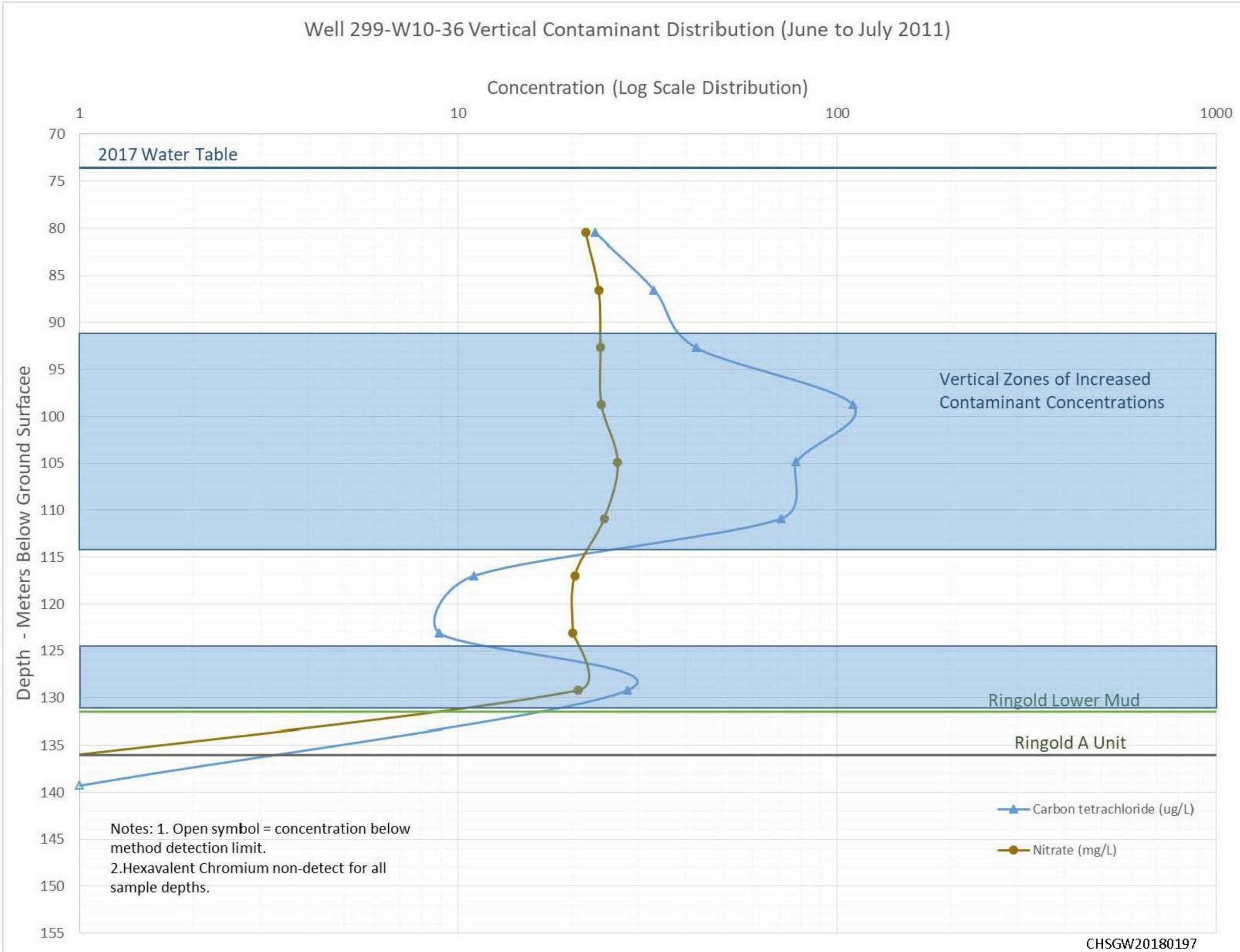


Figure 4-3. Vertical Contaminant Characterization Well 299-W10-36

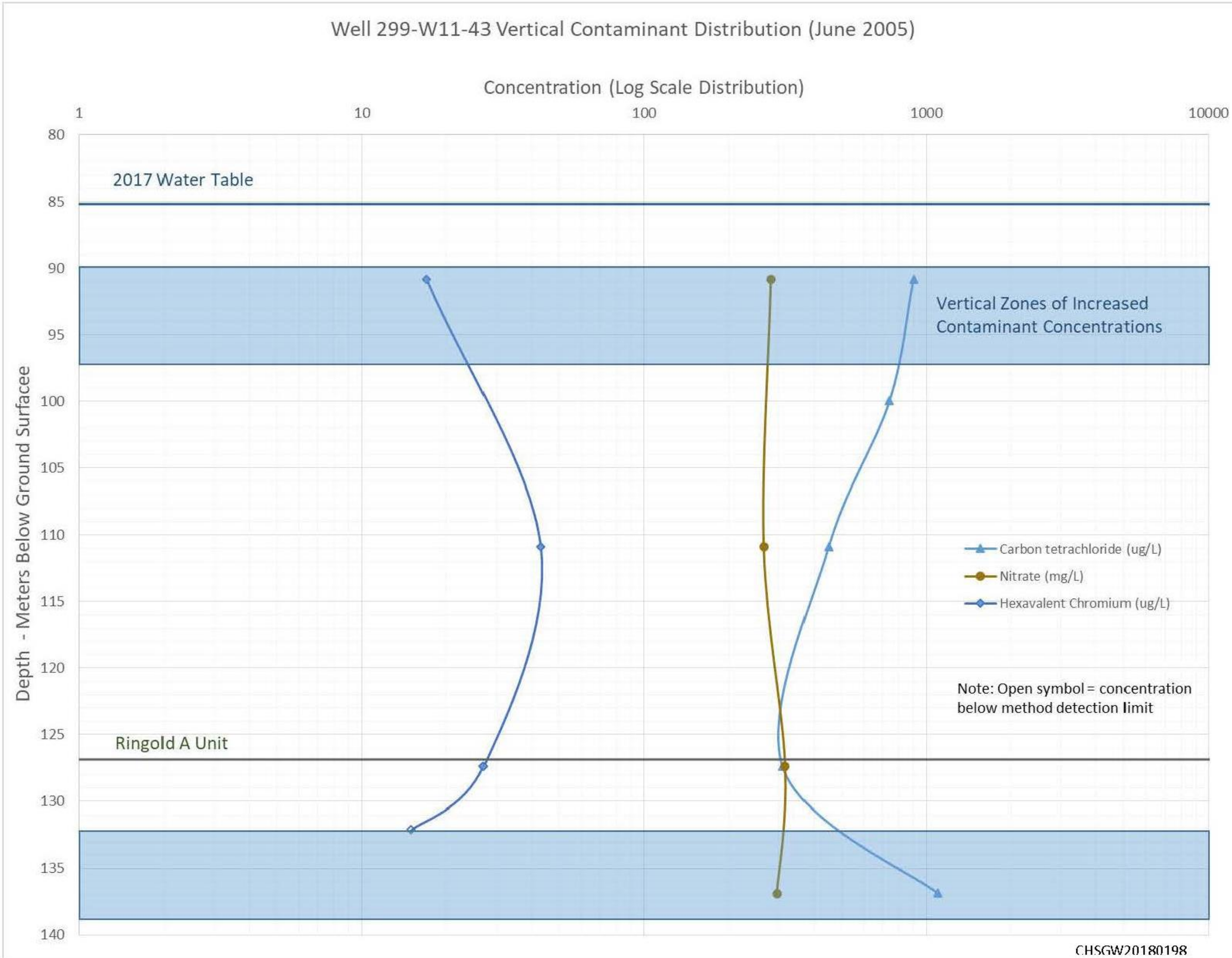


Figure 4-4. Vertical Contaminant Characterization Well 299-W11-43

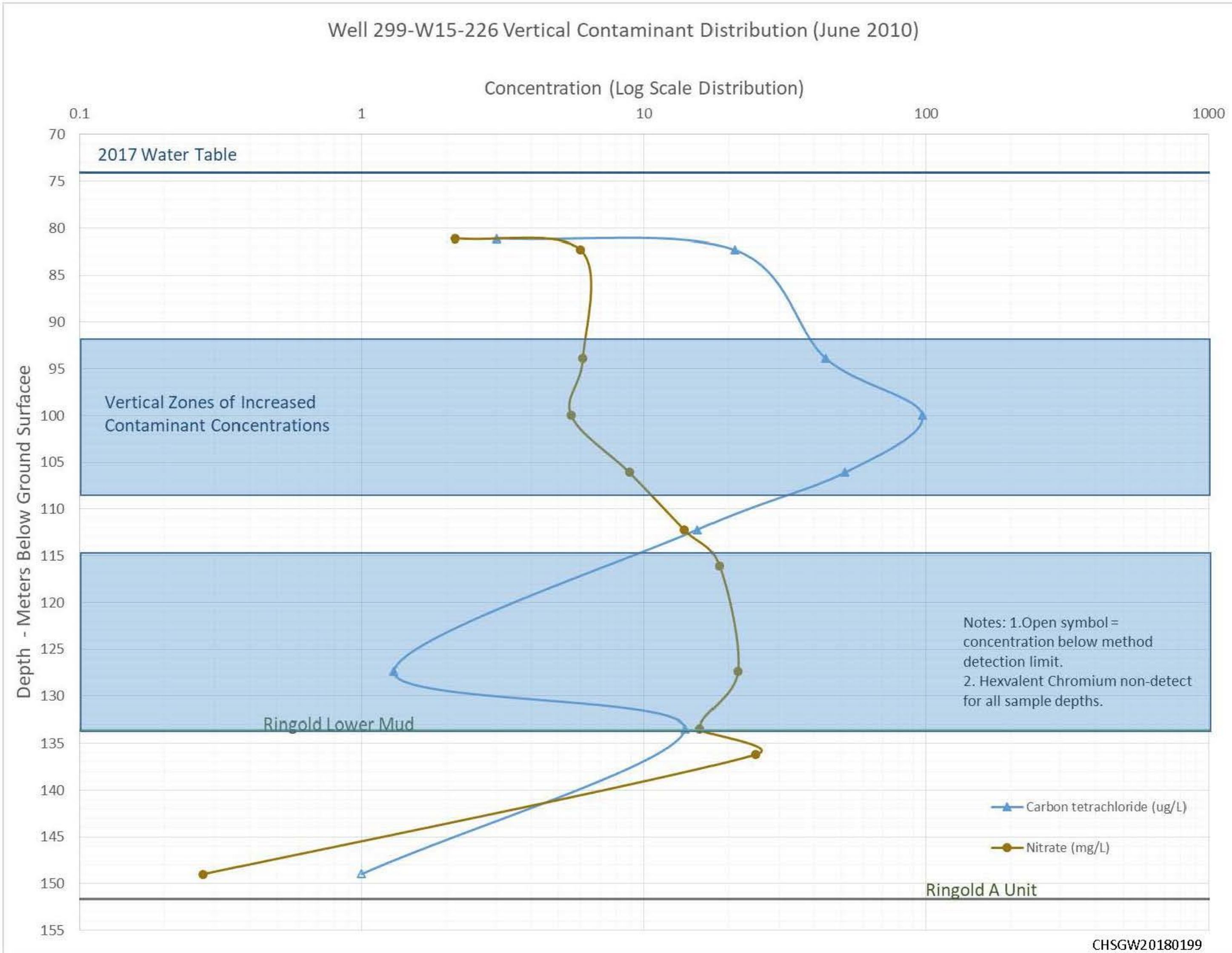


Figure 4-5. Vertical Contaminant Characterization Well 299-W15-226

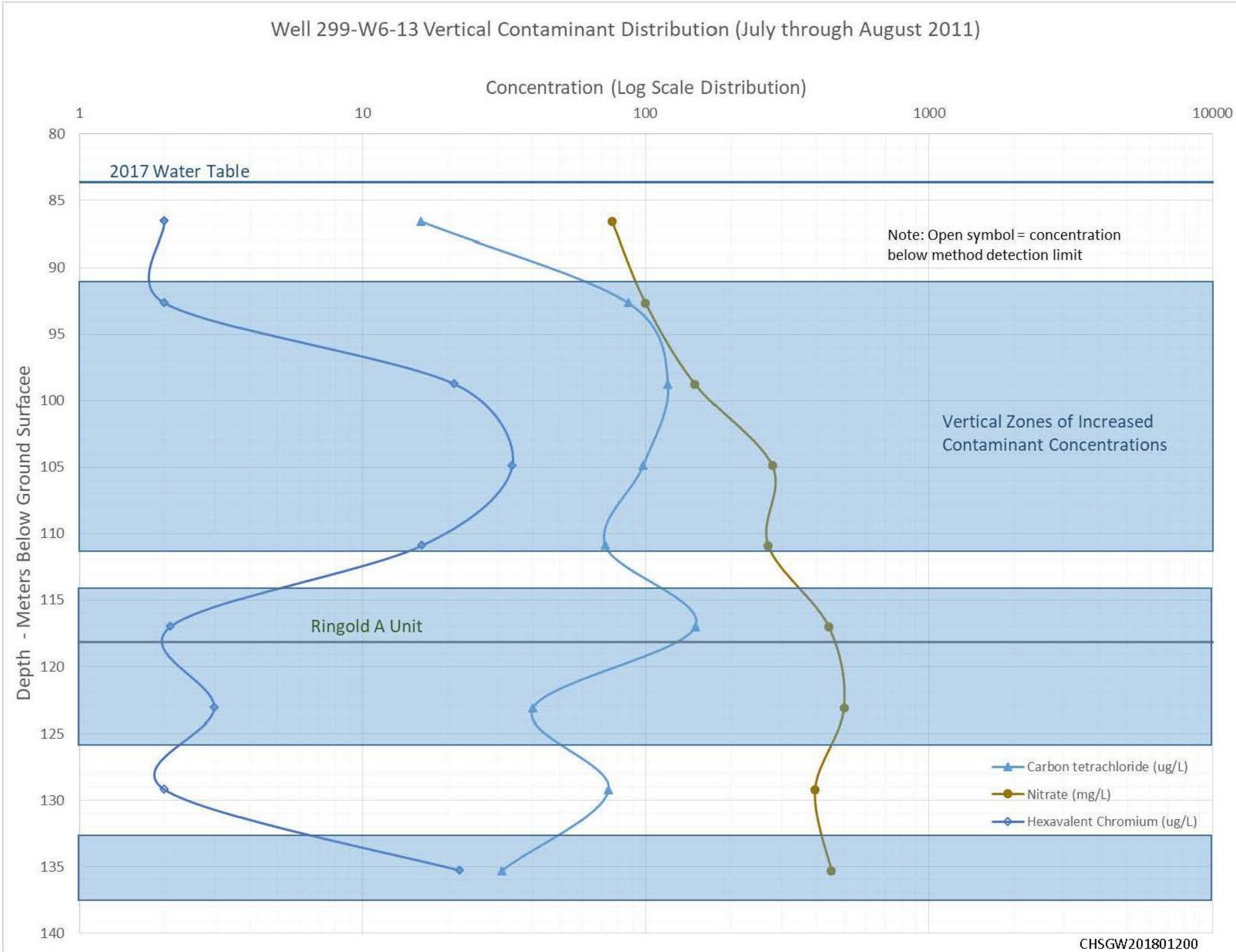


Figure 4-6. Vertical Contaminant Characterization Well 299-W6-13

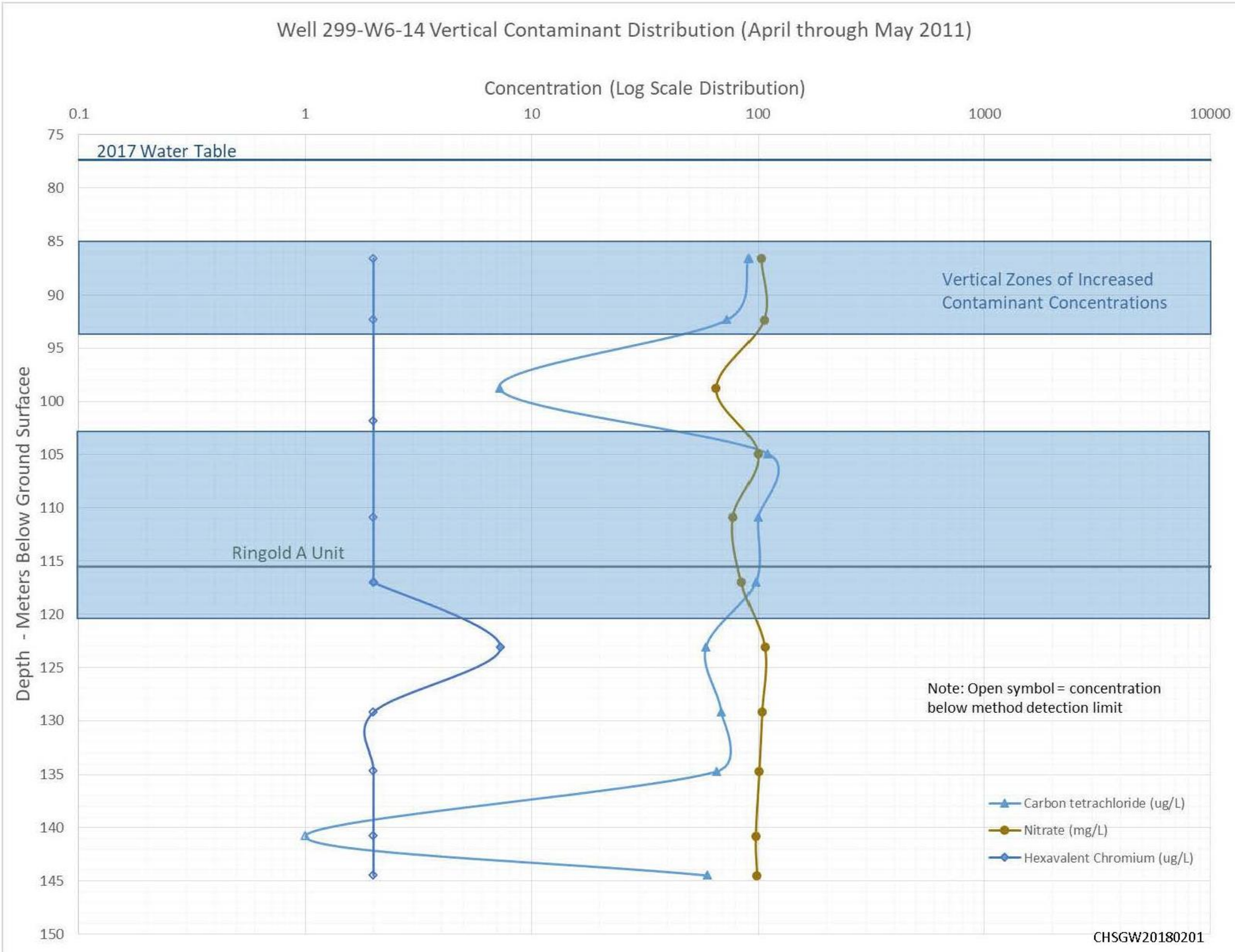


Figure 4-7. Vertical Contaminant Characterization Well 299-W6-14

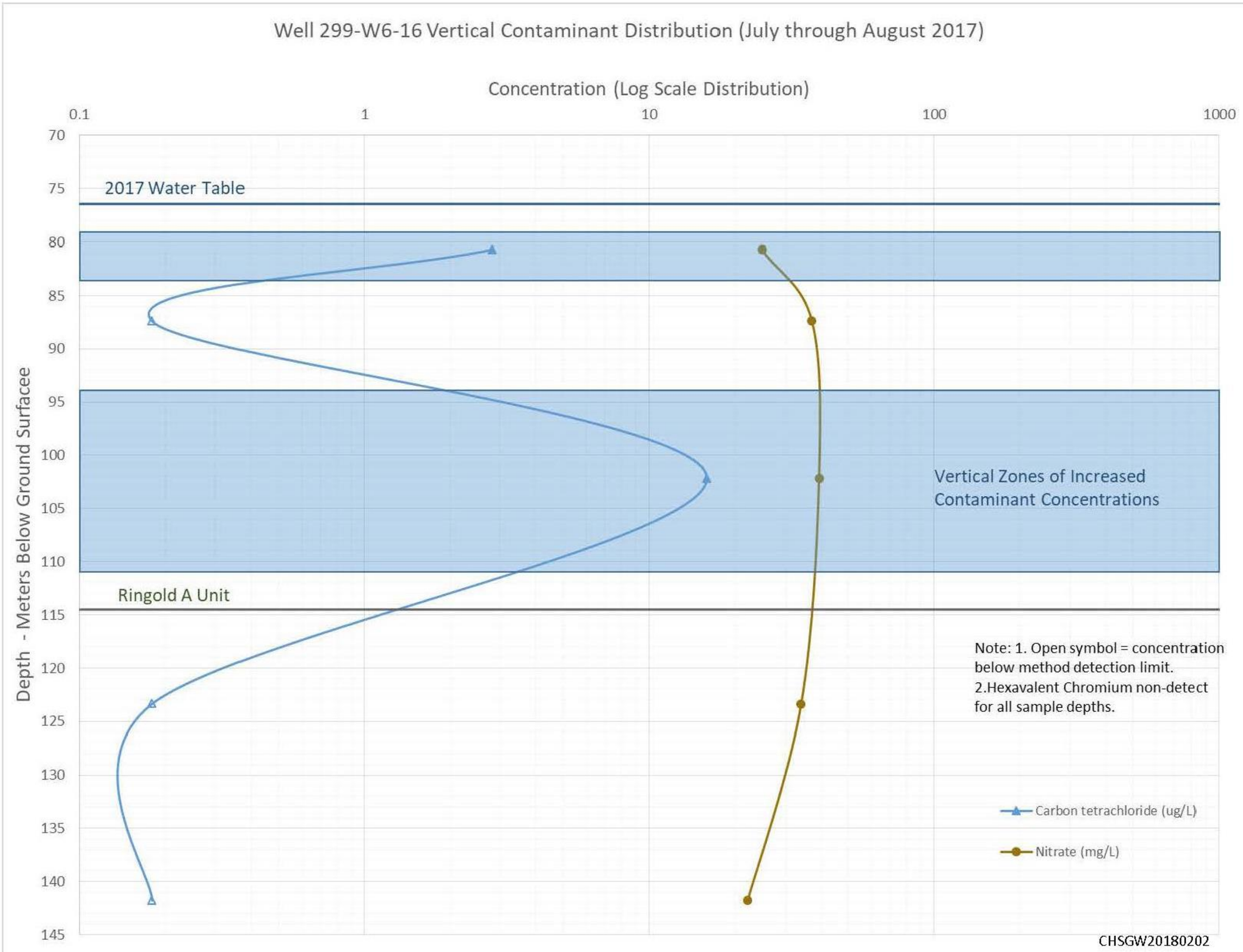


Figure 4-8. Vertical Contaminant Characterization Well 299-W6-16

Based on vertical characterization data, contaminants are present throughout the unconfined aquifer; consistent with the presence of multiple sources and extents of regional plumes. However, vertical zones of increased contaminant concentrations are evident to varying degrees within the wells. Evaluated wells show highest concentrations of carbon tetrachloride and/or nitrate at depths below the upper most portion of the aquifer. Wells 299-W15-226 and 299-W6-13 additionally indicate a general increasing concentration of nitrate with depth. The increase in concentrations at depth within wells is consistent with active 200 West P&T injection well operations in the vicinity of LLBG Trenches 31 and 34 and general locations at the periphery of the regional plumes.

In summary, the LLBG Trenches 31 and 34 are located within the periphery of the regional 200-ZP-1 OU plumes and are additionally impacted by nearby former 200-ZP P&T and current 200 West P&T injection well networks. Evaluated wells indicate varying concentration trends with depth in wells near LLBG Trenches 31 and 34. Available data for the wells is not sufficient to evaluate plume migration from a hypothetical release from LLBG Trenches 31 and 34.

5 Groundwater Flow Simulations

Groundwater flow simulations were conducted to evaluate the groundwater monitoring network for Trenches 31 and 34 (Figure 5-1) for its ability to detect increases in groundwater contamination due to hypothetical releases from the facility both under the influence of the 200 West P&T system and after cessation of P&T operations. The wells included in the interim status groundwater monitoring network are documented in Table 2-46 in DOE/RL-2016-66 and shown in Figure 5-1. The CPGWM is the principal computational tool used to simulate groundwater flow and evaluate the performance of the 200 West P&T groundwater remedy (CP-47631). The CPGWM and the scenarios that were simulated to evaluate the monitoring network are described briefly in this chapter. The modeling effort was aimed at potential future releases, and is not intended to address the effect of pre-existing contamination. A more detailed summary is included in Appendix F. Two simulation approaches were used: (1) a plume migration (transport modeling) analysis that provides insight into the dilution of groundwater contaminant concentrations at monitoring locations, and (2) a particle-tracking analysis that indicates the potential travel paths for contaminants released under hypothetical conditions. Both approaches are based on the continuous release of a hypothetical unit source at the water table beneath the trench leachate collection sumps.

5.1 Central Plateau Groundwater Model

The model package report describing the CPGWM (version 8.3.4) was released in 2016 (CP-47631). The CPGWM simulates groundwater flow using the U.S. Geological Survey modular three-dimensional, finite-difference groundwater flow model, MODFLOW.

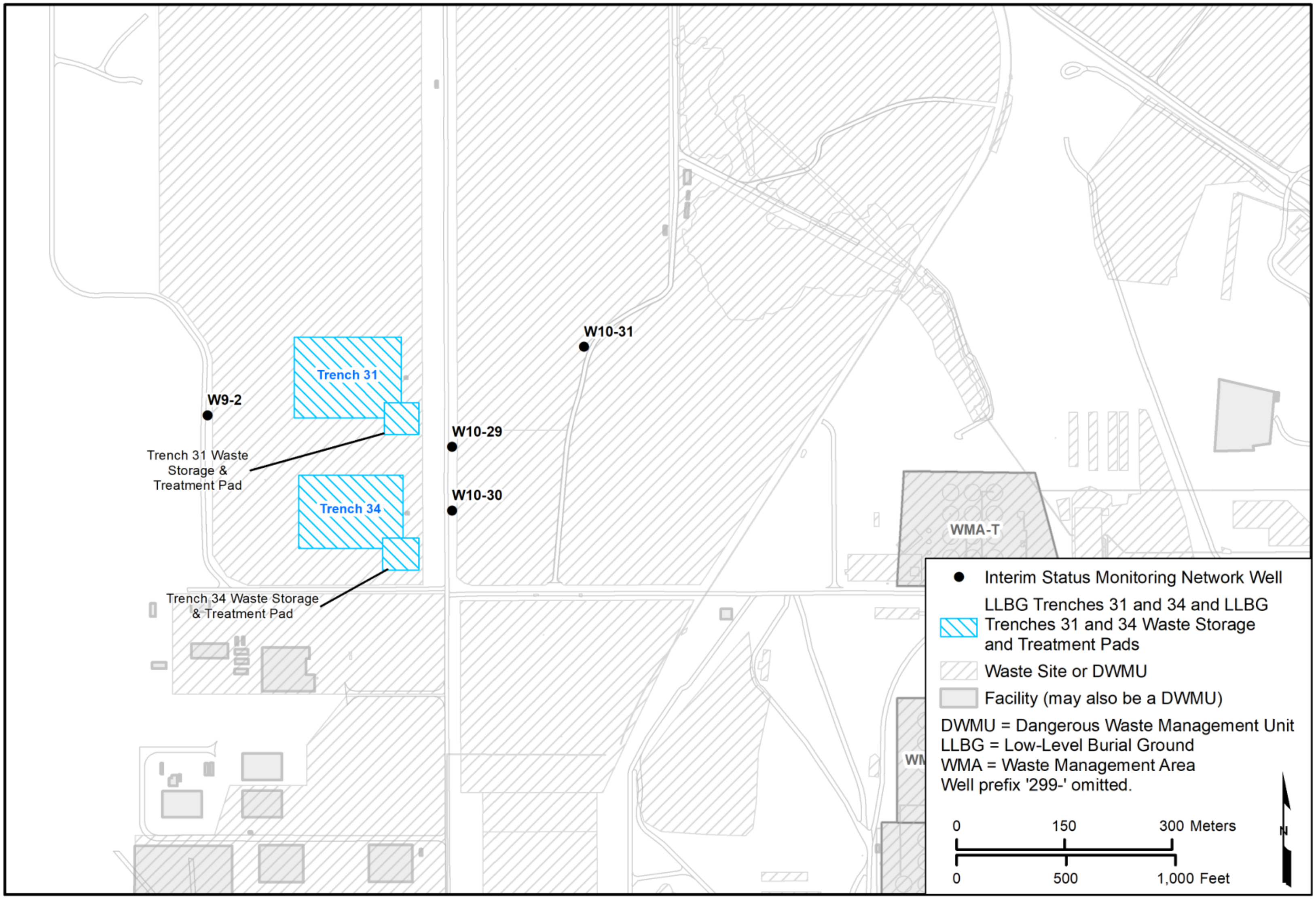
Contaminant transport is simulated using the Modular Three-Dimensional Multi-Species Transport Model (MT3DMS) code. MT3DMS was developed specifically for use with MODFLOW to simulate contaminant advection, dispersion, sources and sinks, and chemical reactions in groundwater systems.

Both particle-tracking and transport modeling calculations were performed to evaluate the monitoring well network. For particle tracking, the post-processor ModPath3DU was used to compute pathlines based on results obtained from the CPGWM flow simulations. Additional information on the model and processing, including a more detailed description of the model, time discretization, calibration, and software, is included in Appendix F.

5.2 Simulation Scenarios

Using the CPGWM, groundwater flow simulations were performed to evaluate a range of possible 200 West P&T system operating conditions, referred to as “scenarios” and “sub-scenarios.” These scenarios reflect the potential range of groundwater flow and contaminant migration directions that could result from varying the adjacent 200 West P&T system extraction rates and injection well operations. Three scenarios were evaluated:

- Scenario 1: 200 West P&T system operating at an expected capacity of 8,725 L/min (2,305 gal/min).
- Scenario 2: 200 West P&T system operating at the planned expanded capacity of 9,464 L/min (2,500 gal/min).
- Scenario 3: 200 West P&T system shut down. These conditions would apply when the remedy is complete.



Source: Table 2-46 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*.

Figure 5-1. Interim Status Groundwater Monitoring Network

Scenarios 1 and 2 both include 18 sub-scenarios (A through R) that evaluate how changes in the operation of injection wells could impact the effectiveness of the monitoring network. Extraction well pumping rates were not varied because the pumping within the plume is expected to continue at rates that maintain hydraulic capture until the P&T system operation is shut down in 30 years. Descriptions of the scenarios and sub-scenarios are provided in Table 5-1. The locations of the 200 West P&T system injection and extraction wells are shown in Figure 5-2. Average pumping rates for December 2016 are shown in parentheses next to the wells.

Table 5-1. Simulation Scenarios

Scenario	P&T System Capacity[a]	Sub-Scenario	Description	Scenario Weight (%)
1	2,305 gal/min (8,725 L/min)	A	Current conditions.[b]	55
		B	Injection well 299-W10-35 operating at 50%.	5
		C	Injection well 299-W10-35 not operating.	3
		D	Injection well 299-W15-226 operating at 50%.	3
		E	Injection well 299-W15-226 not operating.	3
		F	Injection wells 299-W10-35 and 299-W15-226 not operating.	1
		G	Injection well 299-W10-36 not operating.	2
		H	Injection wells 299-W10-36, 299-W10-35, and 299-W15-226 not operating.	1
		I	Injection well 299-W6-14 not operating.	3
		J	Injection well 299-W6-16 not operating.	3
		K	Injection wells 299-W6-14 and 299-W6-16 operating at 50%.	3
		L	Injection wells 299-W6-14 and 299-W6-16 not operating.	1
		M	Injection wells 299-W18-41 and 299-W15-229 not operating.	2
		N	Injection wells 299-W15-29, 299-W18-36, 299-W18-38, and 299-W18-39 not operating.	3
		O	Injection wells 299-W15-228, 299-W15-229, 299-W15-29, 299-18-44, 299-W18-36, and 299-W15-29 operating at 50%.	5
		P	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 operating at 50%.	5
		Q	Injection wells 299-W15-229, 299-W15-29, 299-18-44, and 299-W18-36 not operating.	1
		R	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 not operating.	1

Table 5-1. Simulation Scenarios

Scenario	P&T System Capacity[a]	Sub-Scenario	Description	Scenario Weight (%)
2	2,500 gal/min (9,464 L/min)	A	2,500 gal/min, injection rates rebalanced.	55
		B	Injection well 299-W10-35 operating at 50%.	5
		C	Injection well 299-W10-35 not operating.	3
		D	Injection well 299-W15-226 operating at 50%.	3
		E	Injection well 299-W15-226 not operating.	3
		F	Injection wells 299-W10-35 and 299-W15-226 not operating.	1
		G	Injection well 299-W10-36 not operating.	2
		H	Injection wells 299-W10-36, 299-W10-35, and 299-W15-226 not operating.	1
		I	Injection well 299-W6-14 not operating.	3
		J	Injection well 299-W6-16 not operating.	3
		K	Injection wells 299-W6-14 and 299-W6-16 operating at 50%.	3
		L	Injection wells 299-W6-14 and 299-W6-16 not operating.	1
		M	Injection wells 299-W18-41 and 299-W15-229 not operating.	2
		N	Injection wells 299-W15-29, 299-W18-36, 299-W18-38, and 299-W18-39 not operating.	3
		O	Injection wells 299-W15-228, 299-W15-229, 299-W15-29, 299-18-44, 299-W18-36, and 299-W15-29 operating at 50%.	5
		P	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 operating at 50%.	5
		Q	Injection wells 299-W15-229, 299-W15-29, 299-18-44, and 299-W18-36 not operating.	1
		R	Injection wells 299-W18-41, 299-W18-39, 299-W18-38, 299-18-42, and 299-18-43 not operating.	1
3	0		System shutdown following active P&T.	100

Notes: For injected treated water dilution calculations, unit concentrations released at injection wells correspond with initiation of each injection well (i.e., using actual dates/timing).

For release calculations, unit concentrations released at the facility assumed a late 2017 release date for scenarios 1 and 2 and 2037 for scenario 3.

a. Scenario 1 pumping rate = 2,305 gal/min (comprised of 305 gal/min from 200-UP-1 extraction wells and 2,000 gal/min from 200-ZP-1 extraction wells); Scenario 2 pumping rate = 2,500 gal/min (comprised of 305 gal/min from 200-UP-1 extraction wells and 2,195 gal/min from 200-ZP-1 extraction wells); In both cases, an extraction rate of 60 gal/min at well 299-E33-268, located in the 200-BP-5 OU, is included in the extraction total for 200-ZP-1.

b. Current conditions as defined in Appendix G.

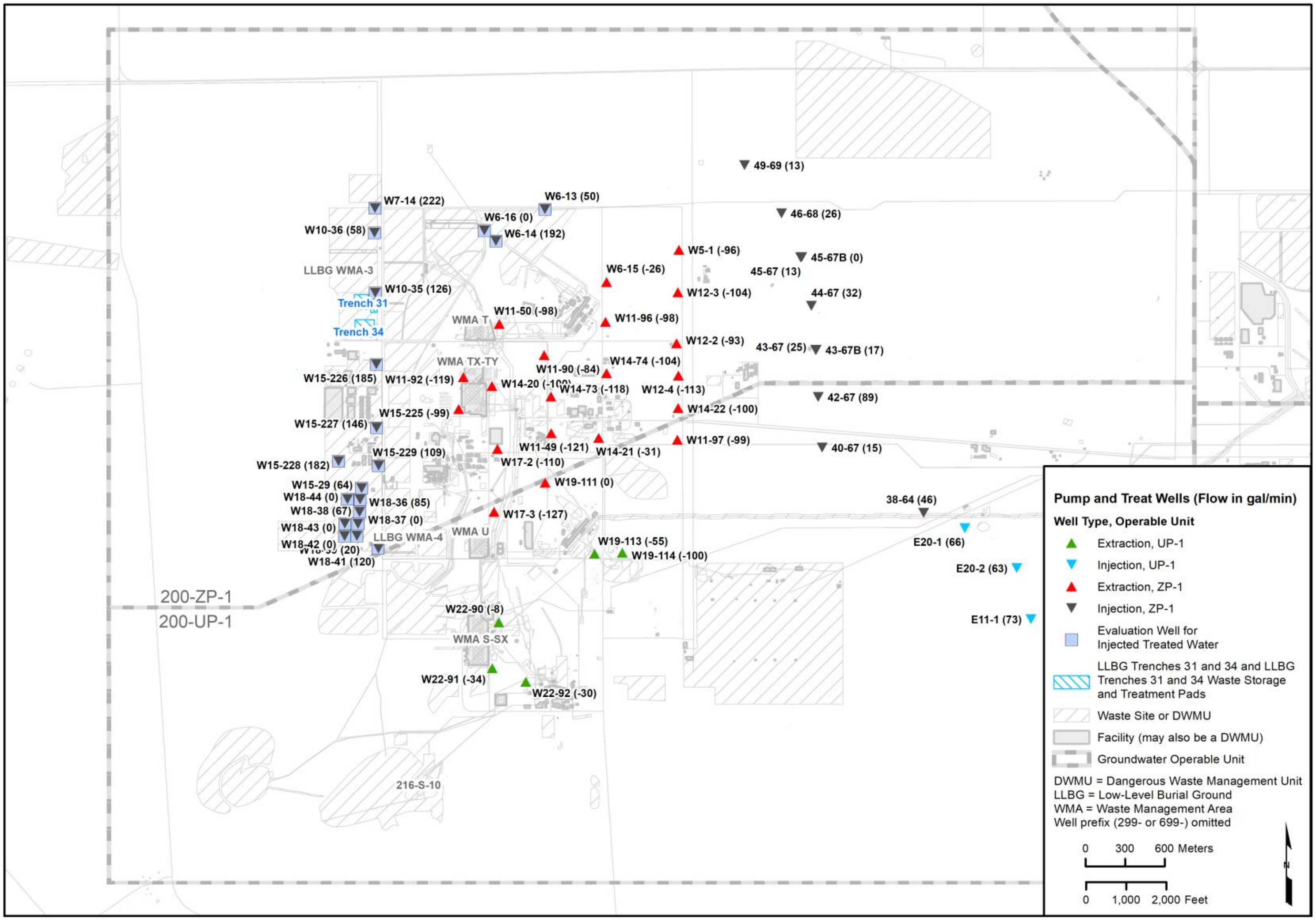


Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells

The scenarios and sub-scenarios were selected to describe a range of conditions near the facilities evaluated within the 200 West Area. Some sub-scenarios were selected to examine conditions under typical, current, or likely injection well operating conditions, whereas others were selected to represent extreme or unlikely operating conditions. These extreme operating conditions, or bounding scenarios, are included to provide a bounding set of resultant groundwater flow and contaminant migration directions that can be used to evaluate the locations of the interim status monitoring network wells for LLBG Trenches 31 and 34 and to assist in determining whether adjustment to the monitoring network is needed.

As described in Appendix F, a weight, in terms of a percentage, was assigned to each sub-scenario to reflect the relative probability of each operating condition. Those weights, shown in Table 5-1, are normalized on a scale of 0% to 100%. The highest weight is assigned to the most likely operating conditions, represented by sub-scenario A, while the extreme, or boundary, conditions are given low weights. The weights are used, as described in Section 6.2.2, in calculations that combine the results for all the sub-scenarios to identify areas where a hypothetical release to the water table would be most likely to migrate and be detectable.

Appendix A in Appendix F provides pumping rates for the 200 West P&T system extraction and injection wells for scenarios 1 and 2; scenario 3 evaluates conditions with no active extraction or injection well operations. The CPGWM represents the "as-built" screened intervals (i.e., top and bottom elevations) for extraction and injection wells (Konikow et al., 2009, *Revised Multi-Node Well (MNW2) Package for MODFLOW Ground-Water Flow Model*) and hence the depth below the water table at which injection (or extraction) at each well is focused. The monitoring wells were assumed to be screened across the water table, so that sampling from them focuses on the quality of water at or close to the water table. The P&T operations were assumed to end in year 2037, which is the end date of P&T operations per the 200-ZP-1 ROD.

Simulations were run for each scenario to examine dilution from the injection of treated water and particle pathlines of hypothetical releases from LLBG Trenches 31 and 34. The results of those simulations were used to evaluate the efficacy of the groundwater monitoring network to detect hypothetical releases from the trenches.

6 Calculations

Particle-tracking and transport simulations were performed to evaluate the efficacy of the groundwater monitoring network to detect significant increases in groundwater contamination that might occur from a hypothetical release from LLBG Trenches 31 and 34. The simulations also account for the hydraulic influence of the 200 West P&T system extraction and injection wells. The simulations performed and output produced during the evaluation of the monitoring well network are described briefly in this chapter. Additional details about the modeling, including software used, inputs, and assumptions, are described in Appendix F and Appendix G.

Particle tracking was performed first on a regional scale and then on a facility-specific scale. The regional-scale particle-tracking simulations presented in Appendix F included an analysis of the pathlines of injected treated water from 200 West P&T system injection wells for each scenario that considered advection only. Particle tracking using both advection and dispersion was then performed on a facility-specific scale to simulate a hypothetical release from LLBG Trenches 31 and 34.

Similarly, transport modeling was performed on a regional scale to represent the migration, mixing, and dilution of treated water injected at the 200 West P&T system injection wells for each of the scenarios. On a facility-specific scale, transport modeling was performed to evaluate the migration, mixing, and dilution of groundwater impacted by a hypothetical release to the water table beneath the trenches.

Particle-tracking and transport modeling calculations and the output produced for LLBG Trenches 31 and 34 are described in the following sections and discussed in more detail in Appendix G.

6.1 Principal Assumptions and Inputs

The principal inputs to the modeling performed to evaluate the monitoring network for LLBG Trenches 31 and 34 are the assumed extraction rates and injection well operations for the 200 West P&T system, model boundary conditions, and the assumed transport parameters of a hypothetical conservative contaminant release to groundwater beneath the trenches. The parameters of the groundwater flow component of the CPGWM have been formally calibrated to historical data and conditions. As discussed in Appendices F and G, the outputs of the flow model (i.e., heads and flow fields) correspond in general with measured data throughout the area of interest. The parameters of the transport component of the CPGWM have not been formally calibrated to historical data and conditions. The transport parameters, however, have been qualitatively corroborated via simulations conducted as part of the work to simulate tritium concentrations in monitoring wells adjacent to the State-Approved Land Disposal Site. Tritium is a conservative contaminant with respect to migration in groundwater.

Analysis presented in Section 7.4 of Appendix F shows that, based on present conditions, no significant vertical migration is expected in the 200 West Area. The vertical movement that is likely to occur is limited to areas near extraction wells. Section 7.4 of Appendix F also concludes that the American Petroleum Institute (API) calculator can be used to verify the appropriateness of the depths of the well screens for monitoring wells. In addition to confirming the use of the API calculator, the results of the analysis of particle vertical distribution agrees with the conclusion of Hantush, 1964, "Hydraulics of Wells," that the flows at locations that are a distance greater than approximately 1.5 to 2 times the saturated thickness from extraction wells are predominately horizontal. The facility-specific results of the API calculator are presented in Section 7.5 of Appendix G.

Transport parameters used in the simulations are unchanged from the transport parameters used in modeling performed for annual reports of the 200 West P&T operations (Section 3.5 in DOE/RL-2016-20, *Calendar Year 2015 Annual Summary Report for the 200-ZP-1 and 200-UP-1*

Operable Unit Pump and Treat Operations). Since these parameters are fundamental to the calculations, they are listed in Table 6-1, and references are provided in the table footnotes. Additional details on the inputs to and assumptions used in the calculations are included in Appendices F and G.

Table 6-1. Properties Assumed for Transport Calculations Using the CPGWM

Assumed Properties for Purposes of Conservative Dilution Calculations					
Distribution Coefficient (mL/g)	**Half-Life (yr)**	**Half-Life (d)**	**Degradation Rate (one/d)**	**Reference for Distribution Coefficient**	**Reference for Degradation Rate**
0.0	None assumed	None assumed	None assumed	None assumed	None assumed
Aquifer Dependent Transport Parameter Values for the Central Plateau Model					
Property	**Value**	**Comments**			
Effective porosity	0.15	Approximate central value (Table D-2 of DOE/RL-2007-28)			
Longitudinal dispersivity	3.5 m	Introduced for stability of the transport calculations based on recommendation from the MT3DMS manual (Zheng and Wang, 1999)			
Transverse dispersivity	0.7 m	20% of longitudinal (DOE/RL-2008-56)			
Vertical dispersivity	0.0 m	DOE/RL-2008-56			
Molecular diffusion constant	0.0 m^2/d	Negligible term			

References: DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*.

DOE/RL-2008-56, *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses*.

Zheng and Wang, 1999, *MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide*.

6.2 Particle Tracking

To evaluate the efficacy of the groundwater monitoring network to detect hypothetical increases in concentrations in groundwater due to releases from LLBG Trenches 31 and 34, facility-specific particle-tracking calculations were performed for each sub-scenario in scenarios 1 and 2 and for scenario 3. Particles were released to the water table annually and tracked forward with initial release in 2017 in a 20 m diameter circle located at the low point (i.e., collection sumps) of the LCRS in LLBG Trenches 31 and 34. The particle release locations are shown in Figure 6-1 in Appendix G. These "focused releases" reflect a hypothetical leak from the collection system sumps that reaches the water table. This release scenario does not incorporate any aspects of transport through the overlying vadose zone. Once released to the water table, the particle movement is then predominantly horizontal, with minor components of vertical migration in response to very limited infiltration from groundwater recharge and the operation of nearby extraction and injection wells.

In all sub-scenarios for scenarios 1 and 2, particles were released annually and tracked through to the end of fiscal year (FY) 2037, which is when the 200-ZP-1 groundwater P&T remedy component is expected to cease operation in accordance with the 200-ZP-1 ROD. For scenario 3, which evaluates conditions after cessation of P&T system operations, the initial release to the water table is the end of FY 2037, and the particles are released every 5 years thereafter for 100 years.

6.2.1 Particle Pathlines

The particle-tracking post-processor ModPath3DU was executed to track particles using both advection and dispersion. To simulate dispersion within particle tracking, the Random-Walk tracking option within ModPath3DU was used as discussed in Appendix F. The results were post-processed and superimposed upon figures showing injection and monitoring wells. These particle-tracking maps indicate if monitoring locations lie in the migration pathway of any hypothetical releases from the trenches.

Particles were tracked for hypothetical releases from LLBG Trenches 31 and 34 for each of the simulation scenarios identified in Table 5-1. Details on generation of the input files, particle tracking, and post-processing of the output data are provided in Appendices F and G.

6.2.2 Relative Detectability Calculations

For each scenario, a calculation was performed to identify areas of the aquifer where a hypothetical release to the water table beneath the low point of the LCRS within LLBG Trenches 31 and 34 would be most likely to migrate and be detectable. There is no assumption of a concentration, allowing a comparison between scenarios and also geographically between wells as the relative detectability stays the same. The effects of the spreading and reduction of detectability as the result of injection are not applied as a specific element. In each scenario, the groundwater flow rates and directions all explicitly include the effects of injection. Across scenarios modeled, the relative detectability calculation allows for the placement of wells in the most likely locations to detect a potential release. This calculation of “relative detectability” was performed on a finer spatial resolution than provided by the discretization of the CPGWM simulation grids. This refined calculation subgrid, shown in Figure 6-1, comprises 20 by 20 m (66 by 66 ft) cells, resulting in 25 calculation cells within each CPGWM simulation cell (100 by 100 m [328 by 328 ft], also shown in Figure 6-1). The relative detectability was calculated as follows:

- As described for particle tracking, particles are released to the water table within the focused release area for the conditions in each sub-scenario. A particle count map is then produced for each sub-scenario by counting the number of particles that pass through each pre-defined calculation subgrid cell, which enables development of a contour map of the particle count for each grid cell.
- For each scenario, the relative detectability was then determined by calculating the weighted sum of all the particles that traversed each refined calculation subgrid cell over all the sub-scenarios within that scenario. The weights given to the sub-scenarios are shown in Table 5-1. The weighted sum of these counts was computed as described in Appendix G. This method produces a relative detectability map for each scenario that gives more weight to the more likely scenarios and less weight to the more extreme and less likely scenarios. The relative detectability map for scenario 3 is equivalent to the particle count map because scenario 3 has no sub-scenarios.

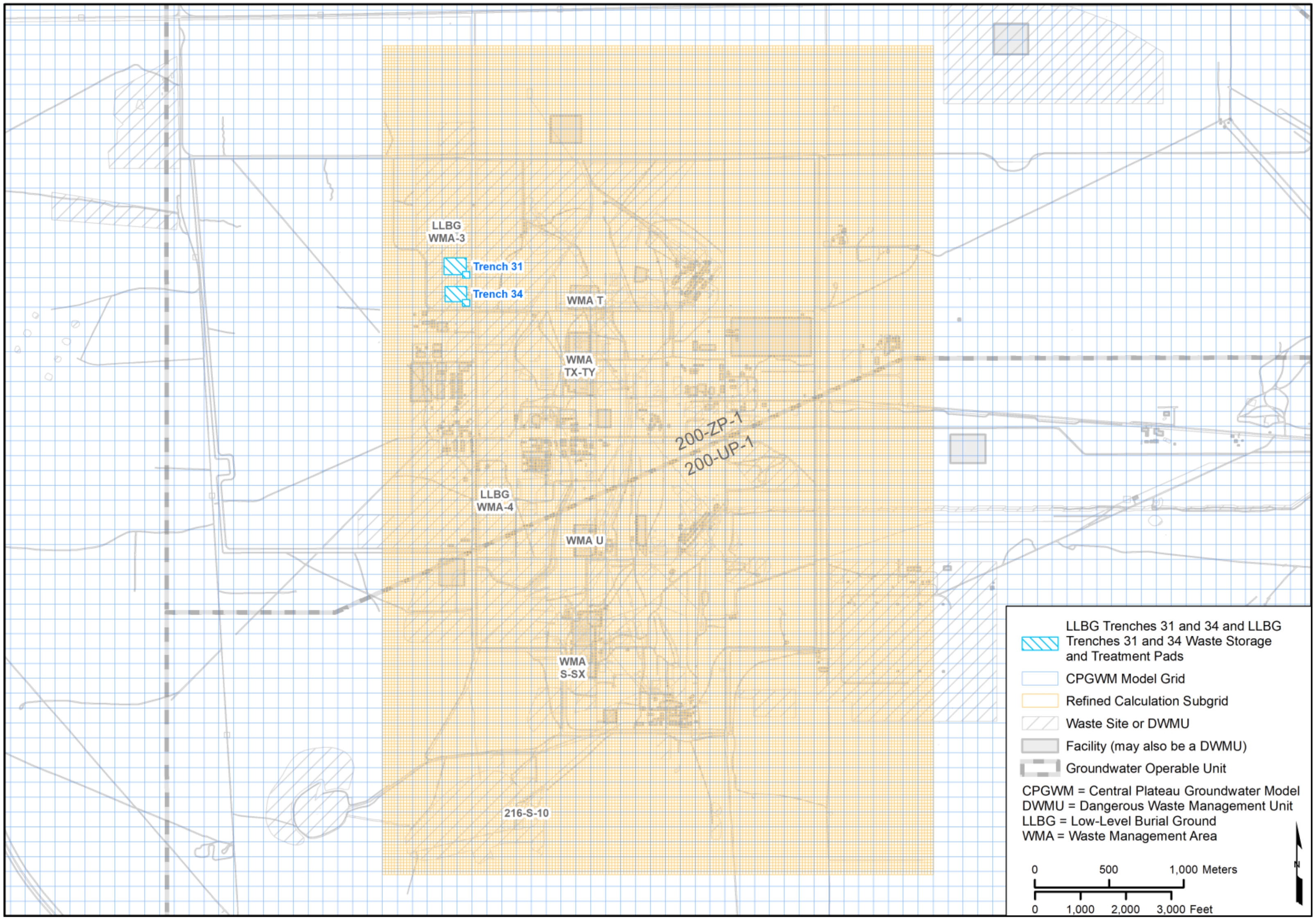


Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix F

The resulting maps of relative detectability for each scenario show the overall distribution for a release from the trenches considering both advection and dispersion. The release distributions are color-coded to reflect the weighted percent distributions of particle counts throughout the release pathline. Where the weighted percent distribution of particle counts is higher, the probability of release detection is also higher.

6.3 Transport Calculations

Transport calculations were performed to evaluate the impact of the injection of treated water at injection wells as well as the impact of hypothetical releases from the trenches to the underlying water table. Treated water injected at the 200 West P&T system injection wells will mix with ambient groundwater, resulting in dilution of the ambient groundwater to varying degrees at different locations and times. A release of contamination from the trenches that ultimately reaches the underlying water table will be diluted as a result of this same mixing process.

The potential effects of dilution were evaluated using a "unit-plume" approach to transport simulation. When using a unit-plume approach, the unit concentration can represent a single contaminant, a combination of contaminants, or treated water. In each case, for purposes of the analysis performed, the unit concentration is referred to as a "unit source." The objective is to use the concept of a unit source to simulate in relative rather than absolute terms the likely fate (i.e., migration and mixing) of the injected treated water or of a particular release of contaminant(s) in the subsurface.

For this analysis, a unit concentration (C = 1.0) is used to represent either the treated water that is injected at the 200 West P&T system injection wells or water that is impacted by a release from a DWMU that mixes continuously with groundwater over an area immediately beneath the facility. Consistent with the unit-plume concept, the ascribed value of 1.0 at the unit source – whether an injection well or the impacted water table beneath the facility – denotes that the water at the location of interest comprises 100% of the quantity of interest (i.e., it has not yet undergone any mixing with other water sources). The effects of mixing and dispersion within the aquifer are simulated as water migrates away from the location of the unit source. As a result, over time and throughout space, the simulated concentration represents that fraction of the original water present that remains out of the water released or injected at the unit source location. For example, a concentration of 0.5 indicates that at that time and location, 50% of the water comprises water that was released at the unit source location, and 50% of the water comprises other water – typically, ambient groundwater with which the water originating from the unit source has mixed and migrated. The simulated concentrations from these calculations can be interpreted in terms of a dilution factor.

- If the unit source represents injection of treated water, then the simulated concentration at any point or time represents the fraction of the water at that location that comprises injected treated water, demonstrating how that fraction has been reduced via the processes of advection and dispersion. This calculation was performed only for scenarios 1 and 2 because scenario 3 assumes cessation of 200 West P&T system operations.

- If the unit source represents a contaminant release or water table impact, then the simulated concentration at any point or time can be interpreted two ways:

  - First, as representing the fraction of the water at that location that comprises the originally impacted groundwater from beneath the facility where the release occurred. That value, 1.0 minus the concentration, thus represents the fraction of other water (typically a combination of ambient groundwater and injected treated water from the P&T system) with which the water originating from the unit source has mixed and migrated.

  - Second, as representing a dilution factor or ratio to which the concentration at the source has been reduced via the processes of advection and dispersion.

The following "unit plume" transport calculations were performed to illustrate the potential effects of dilution via mixing.

- To represent the migration, mixing, and dilution of treated, injected water, unit concentrations representing injected water were released to the water table from injection wells to simulate the injected water migration and transport through FY 2037.
- To represent the migration, mixing, and dilution of groundwater impacted by a continuous release from a hypothetical contaminant source at the trenches, unit concentrations representing the hypothetical contaminant were released at the water table in three model grid cells representing the LLBG Trenches 31 and 34 collection system sumps (shown in Figure 6-1 in Appendix G). The migration and transport of the release in groundwater were simulated through FY 2037 for scenarios 1 and 2. Scenario 3 was simulated from 2037 through 2137.

In each case, two sets of outputs from these dilution calculations were prepared. These comprise time-series plots of concentrations at selected spatial locations and spatial "snapshots" of concentrations at the water table throughout the aquifer at certain times.

- The interpretation and thus the descriptor of the figures that plot the simulated concentrations over time at selected spatial locations differ depending on the type of unit source that was simulated:
  - In the case of treated water injection as the unit source, the time-series plots are referred to as "injected treated water dilution breakthrough curves."
  - In the case of a simulated release to the water table being the unit source, the time-series plots are referred to as "release concentration breakthrough curves."
- The figures that depict the simulated concentrations at the water table throughout the 200 West Area at a selected time are similarly referred to as:
  - "Injected treated water dilution plumes" for the cases where the unit source is the injected water entering the aquifer via the 200 West P&T system injection wells. Those figures indicate the fraction of the water at those locations that comprises treated water injected at the 200 West P&T system injection wells.
  - "Release unit plume maps" for the cases where the unit source is the release to the water table from the facility. Those figures indicate the fraction of the water at those locations that comprises the originally impacted groundwater from beneath the facility where the release occurred.

7 Simulation Results and Conclusions

This chapter presents the simulation results and conclusions regarding the groundwater monitoring network's ability to detect hypothetical releases from LLBG Trenches 31 and 34 under various 200 West P&T system operating conditions. The interim status groundwater monitoring network wells that were evaluated are shown in Figure 5-1. The results presented here (conclusions can be found in Section 7.4) derive from the calculations described in Chapter 6, which were performed for the various scenarios described in Chapter 5. Throughout this chapter, sub-scenario A represents current operating conditions as defined in Appendix G.

Both transport and particle-tracking calculations accounted for advection and dispersion processes, and both types of calculations were considered in the evaluation of the monitoring well network. As described in Chapter 6, the output of transport calculations include the following:

- Injected treated water dilution breakthrough curves – Time-series plots for each monitoring well of simulated treated water concentrations from treated water injected at 200 West P&T system injection wells.
- Release concentration breakthrough curves – Time-series plots for each monitoring well of simulated unit contaminant concentrations from the hypothetical release in the CPGWM model grid cell(s) beneath the facility's defined release area.
- Injected treated water dilution plumes – Maps that indicate, at a selected point in time, the relative fraction of the groundwater that comprises the treated water injected at 200 West P&T system injection wells.
- Release unit plume maps – Maps that indicate, at a selected point in time, the relative fraction of the groundwater that comprises the hypothetical release to groundwater beneath the facility.

Outputs of the particle-tracking calculations include the following:

- Particle-tracking maps – Maps that show the particle pathlines of a hypothetical release to groundwater.
- Particle count maps – Maps that show the count of particles that traverse each cell of the refined calculation subgrid over a selected time-frame.
- Relative detectability maps – Maps that show the distribution of a release from the facility. The relative detectability map combines all the particle count maps within each scenario, assigning greater weight to the results for more likely scenarios and less weight to scenarios that are characterized by unlikely or extreme operating conditions.

For each existing downgradient well location, breakthrough curves for injected treated water dilution and release concentrations can be compared to evaluate which well locations will likely have higher dilutions from injected treated water and which will likely have more detectable concentrations from releases from the facility. The breakthrough curves for the existing monitoring wells are discussed in Section 7.1.

Differences between transport modeling and particle-tracking methods can result in variations in outputs. Those variations are apparent when comparing the release unit plume maps created using transport modeling and the particle-tracking maps created using particle tracking. Each type of map shows the results of each calculation method for the same selected point in time for the hypothetical release to the groundwater table beneath the facility for each sub-scenario. Selected release unit plume and particle-tracking maps are included in Sections 7.1 and 7.2, respectively. The maps represent conditions at the end of the operation of the 200 West P&T system in 2037 for scenarios 1 and 2 and in 2137 for scenario 3.

Maps of relative detectability for scenarios 1, 2, and 3 identify where a hypothetical release to the groundwater table beneath LLBG Trenches 31 and 34 would most likely migrate and be detectable. The relative detectability maps are discussed in Section 7.2. Section 7.3 presents an evaluation of proposed monitoring wells, and Section 7.4 presents the conclusions to the evaluation of the monitoring well network.

7.1 Breakthrough Curves and Release Unit Plume Maps

Transport modeling was used to create breakthrough curves for unit concentrations of injected treated water and release concentrations for each monitoring well location. It was also used to create spatial snapshots of the release unit concentration plumes, or release unit plume maps.

Injected treated water dilution breakthrough curves and release concentration breakthrough curves for monitoring wells 299-W9-2, 299-W10-29, 299-W10-30, and 299-W10-31 were prepared for each sub-scenario under scenarios 1 and 2 and for scenario 3. For both types of breakthrough curves, bold black lines are used to show sub-scenario A, which is considered to represent the most likely future operating scenario.

The injected treated water dilution breakthrough curves indicate, for each sub-scenario, the estimated dilution at the monitoring well from the treated water injected at the 200 West P&T system injection wells and the relative time of arrival of the treated water at the monitoring well. The start of the simulation represents 2012, the year of startup of the 200 West P&T operations. The simulations assume the operating conditions for the 200 West P&T system stipulated for sub-scenario A continue until October 1, 2017, at which time the operating conditions for each separate sub-scenario are assumed to start. This assumption is reflected in the breakthrough curves by the single trend line for injected treated water dilution until October 2017, followed by diverging curves representing adjustments to the injection well operations for each sub-scenario. Figures 7-1 through 7-4 show the injected treated water dilution breakthrough curves for monitoring wells 299-W9-2, 299-W10-29, 299-W10-30, and 299-W10-31, respectively, for scenario 1. Table 7-1 shows the range of the injected treated water dilution breakthrough curves for the monitoring wells for scenarios 1 and 2.

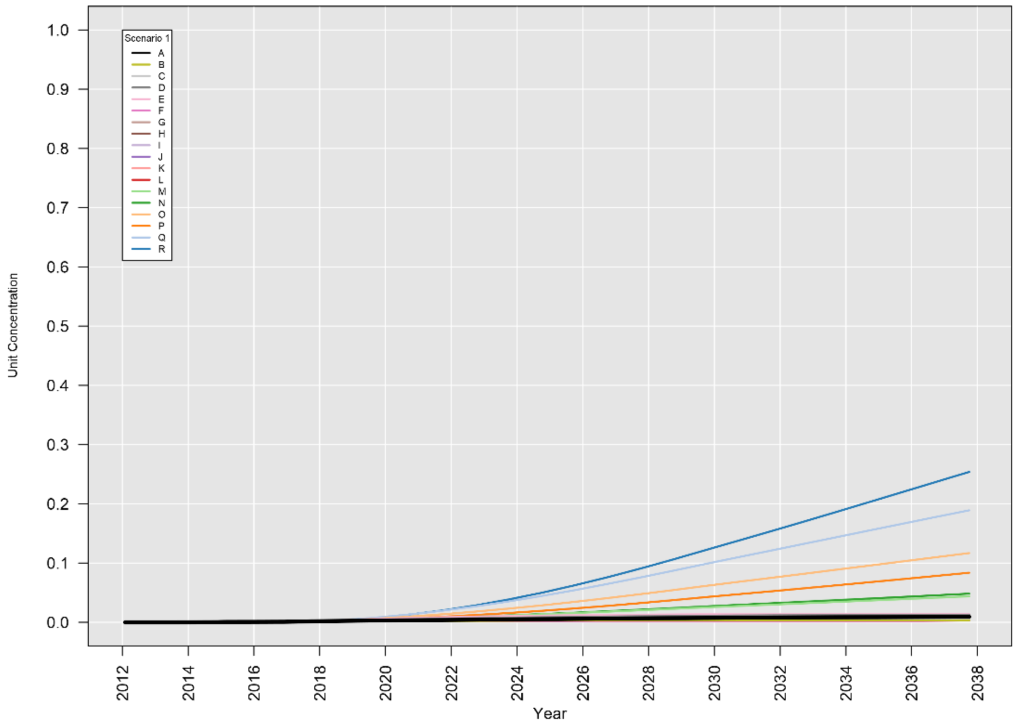


Figure 7-1. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W9-2

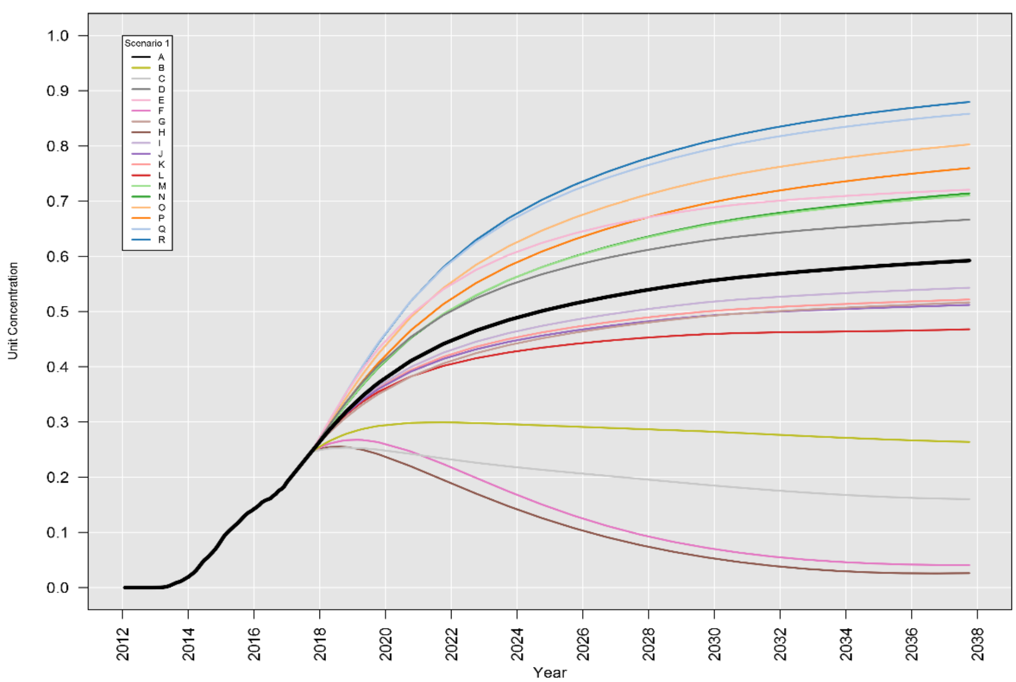


Figure 7-2. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-29

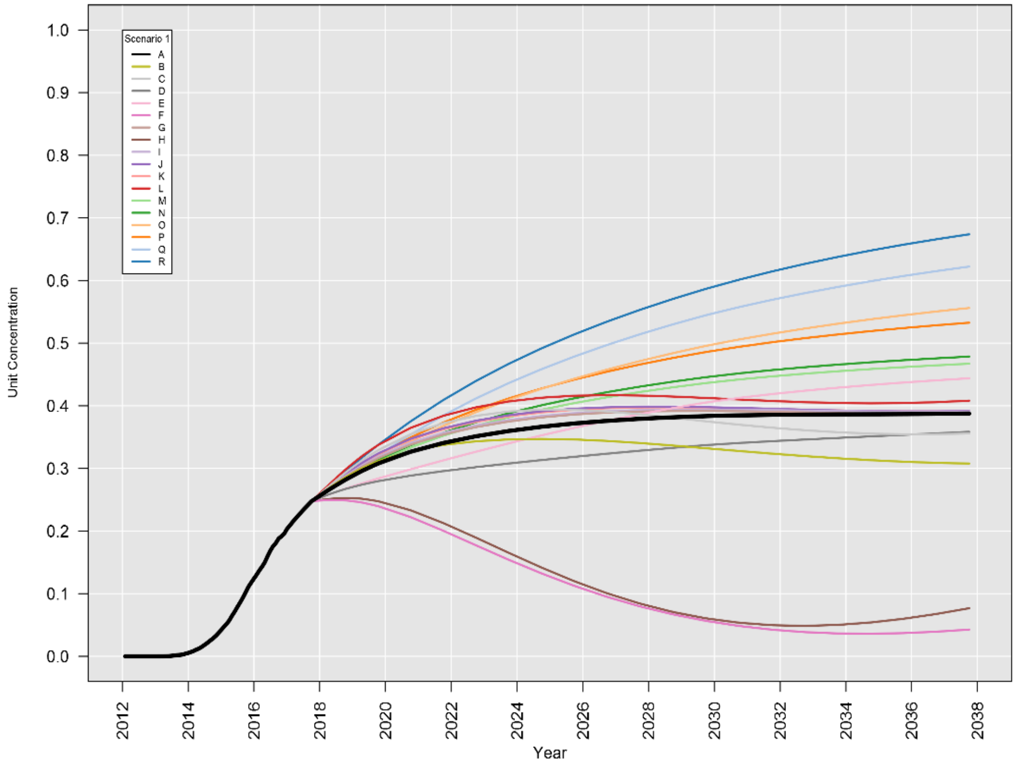


Figure 7-3. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-30

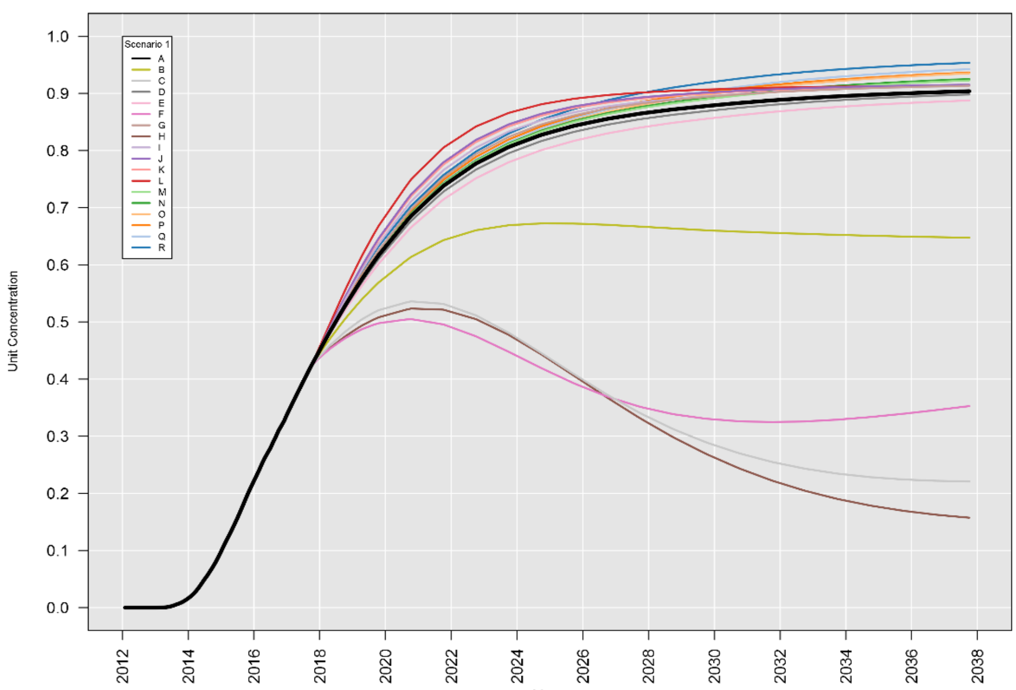


Figure 7-4. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-31

Table 7-1. Range of Unit Concentrations of Injected Treated Water Dilution Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average
299-W9-2	1	0.003	0.254	0.024
	2	0.004	0.254	0.030
299-W10-29	1	0.026	0.880	0.580
	2	0.030	0.880	0.599
299-W10-30	1	0.043	0.674	0.403
	2	0.053	0.674	0.420
299-W10-31	1	0.157	0.954	0.863
	2	0.167	0.954	0.870

Each well and each sub-scenario has a unique injected treated water dilution breakthrough curve. In general, the treated water breakthrough curves indicate the dilution at wells 299-W10-29 and 299-W10-31 are more variable depending on the operating conditions of each sub-scenario, with several sub-scenarios (e.g., sub-scenarios Q and R) resulting in notable dilution at the well locations. Well 299-W10-31 indicates high injected water dilution for sub-scenario A, the most likely operating conditions. The results for scenario 2 (included in Appendix G) were similar to those for scenario 1.

The release concentration breakthrough curves for monitoring wells 299-W9-2, 299-W10-29, 299-W10-30, and 299-W10-31 for the sub-scenarios in scenario 1 are shown in Figures 7-5 through 7-8, respectively. These figures, which depict the simulated breakthrough of a unit-source release to the groundwater table from LLBG Trenches 31 and 34, provide for a relative comparison of the monitoring well locations. The plotted unit concentrations are the ratios of the simulated concentration that would be observed at a downgradient monitoring well location to the original concentration of the release. A unit concentration of 1 represents the original concentration of the release reaching the monitoring well. The breakthrough curves show the relative time of arrival of the release concentration at the monitoring well in terms of years after release to groundwater beneath the facility. The release time (represented on the figures as arrival time year 0) corresponds to October 1, 2017. The unit concentrations and arrival times consider advection and dispersion but do not include chemical-specific, predictive calculations for more complex, constituent-dependent processes such as sorption and degradation (decay) that would decrease the concentration or delay arrival time at the wells.

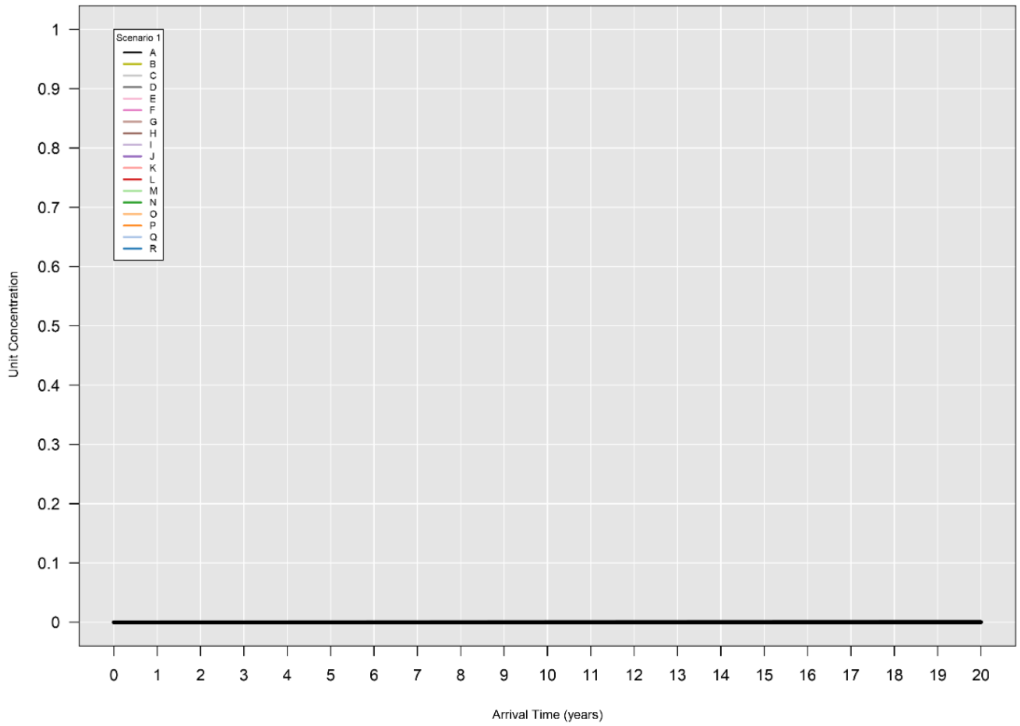


Figure 7-5. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W9-2

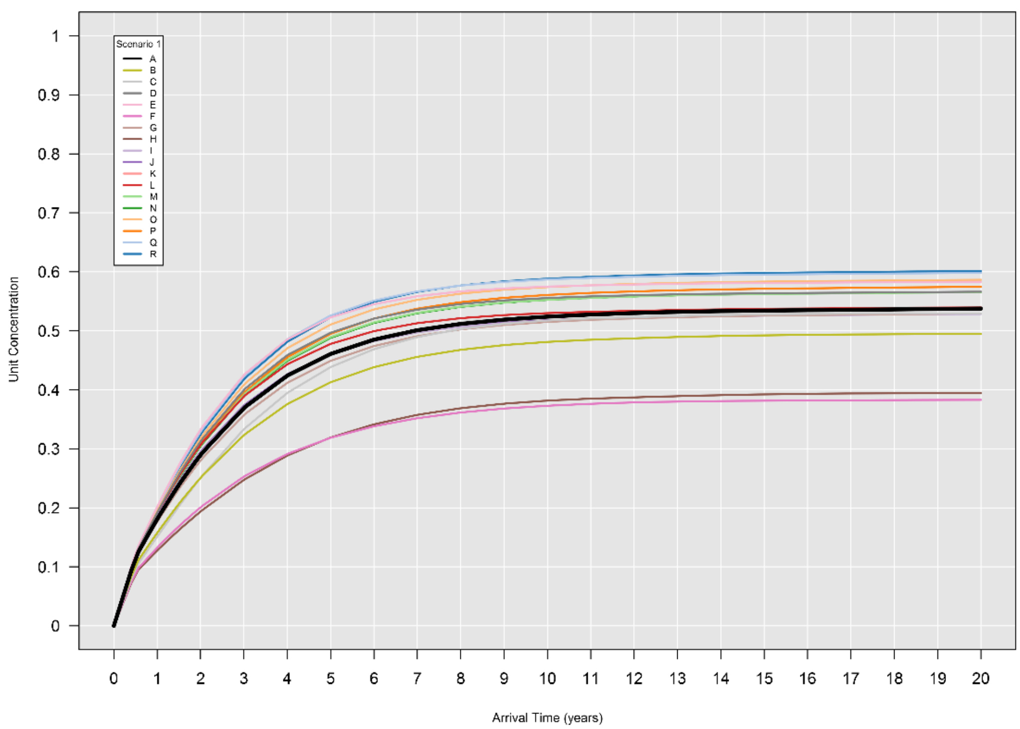


Figure 7-6. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-29

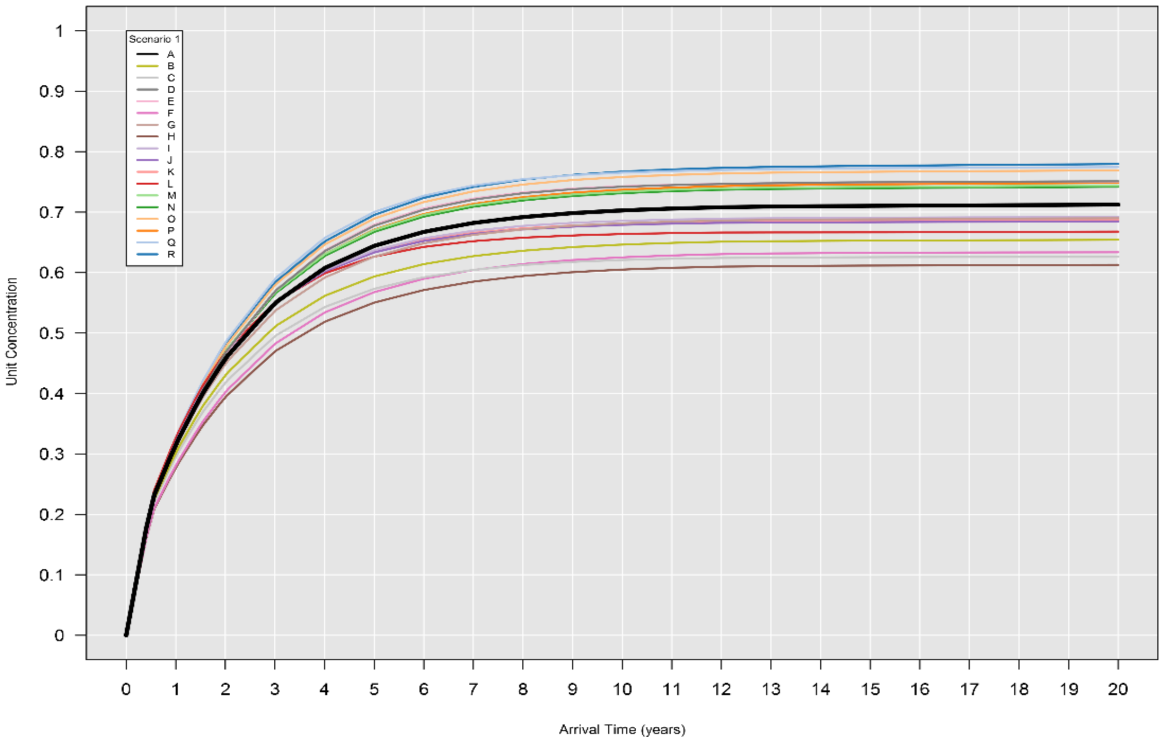


Figure 7-7. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-30

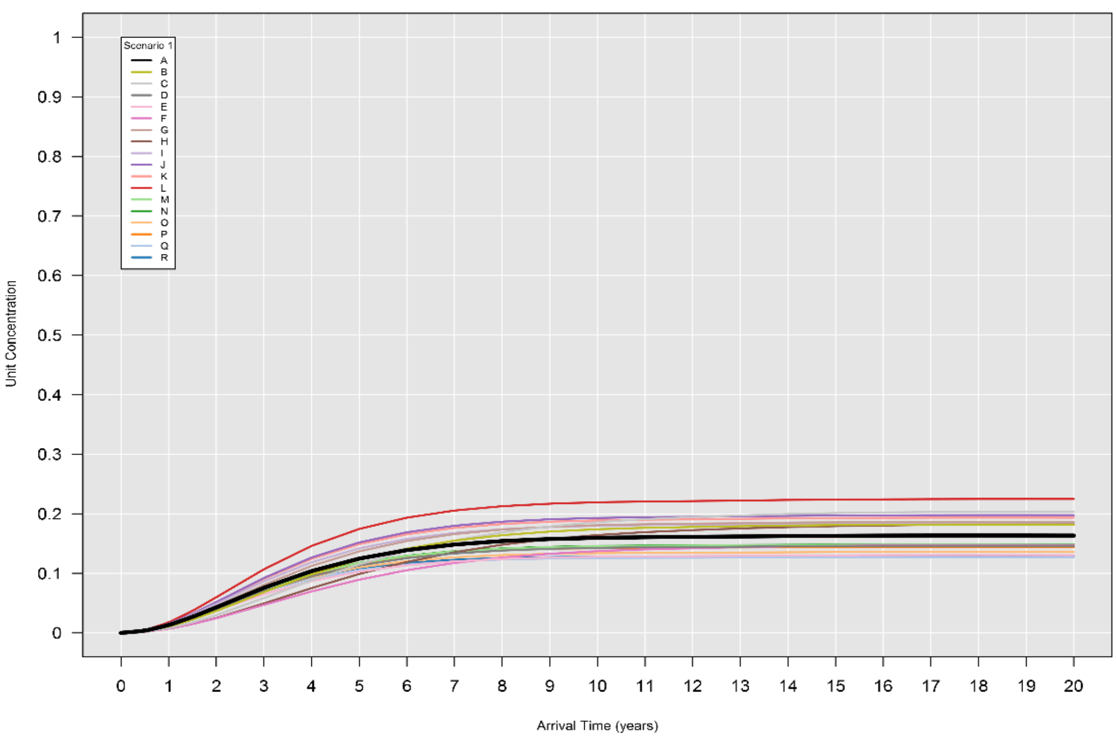


Figure 7-8. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W10-31

In general, release concentration breakthrough curves displaying higher unit concentrations for a larger range of operating conditions (different sub-scenarios) and, in particular, displaying higher unit concentrations for sub-scenario A, indicate well locations that are effective for monitoring for releases from the facility. Wells for which breakthrough curves display high variation among different operating scenarios are sensitive to changes in the 200 West P&T system operating conditions. Wells for which breakthrough curves display lower unit concentrations (in particular, for the most likely operating conditions) indicate less optimal well locations.

Figures 7-6 through 7-8 show that wells 299-W10-29 and 299-W10-30 are well located for the full range of 200 West P&T system operating scenarios, whereas well 299-W10-31 will have relatively more dilution (less of the original release concentration) and, therefore, somewhat less likely to detect releases for the various operating scenarios. The results for scenario 2 (included in Appendix G) were similar to those for scenario 1. Table 7-2 shows the range of the release concentration breakthrough curves for the monitoring wells for scenarios 1, 2, and 3.

Table 7-2. Range of Unit Concentrations of Release Concentration Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average	Scenario 3
299-W9-2	1	0.000	0.000	0.000	0.000
	2	0.000	0.000	0.000	
299-W10-29	1	0.383	0.601	0.540	0.406
	2	0.385	0.601	0.543	
299-W10-30	1	0.613	0.779	0.712	0.588
	2	0.613	0.779	0.714	
299-W10-31	1	0.127	0.225	0.164	0.399
	2	0.125	0.223	0.162	

The release concentration breakthrough curves for downgradient wells for scenario 3 (Figure 7-9) indicate lower unit concentrations for monitoring wells 299-W10-29 and 299-W10-30 and slightly higher unit concentrations for well 299-W10-31 than it has in other scenarios. The unit concentration for monitoring well 299-W10-31 remains significantly lower than unit concentrations for well 299-W10-30 and equivalent to the value for 299-W10-29 in scenario 3. The release time for scenario 3 (represented on the figure as arrival time year 0) corresponds to October 1, 2037.

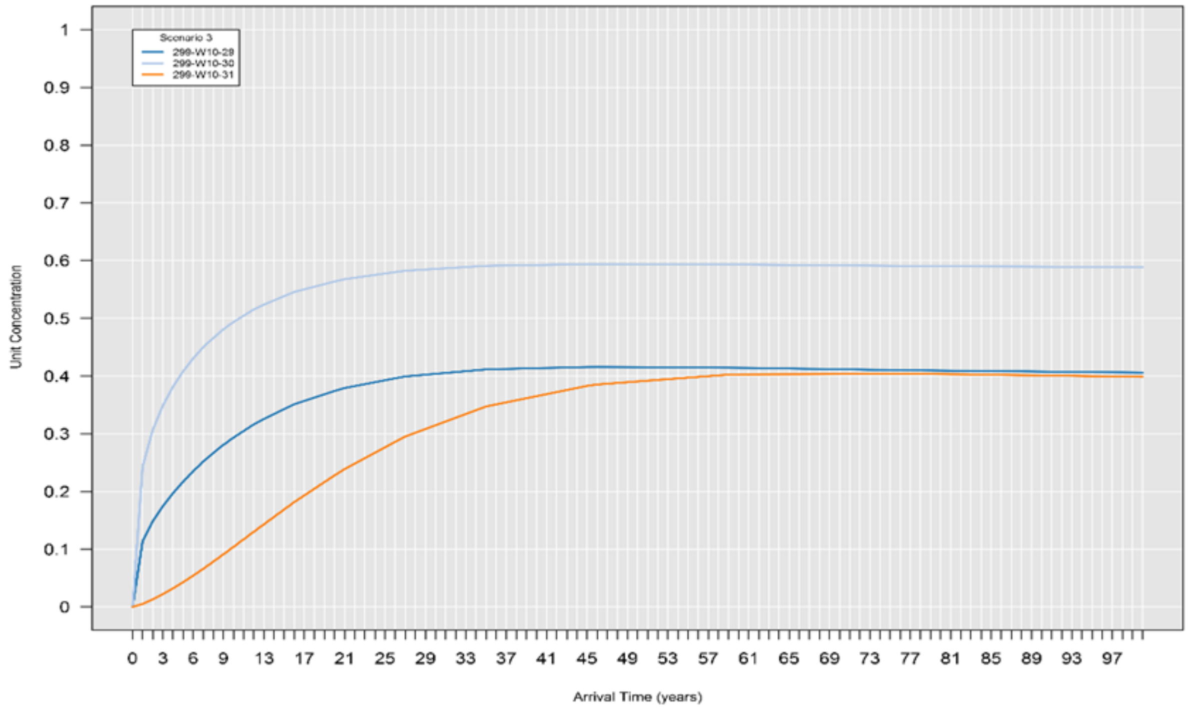


Figure 7-9. Release Concentration Breakthrough Curves, Scenario 3, Monitoring Wells 299-W10-29, 299-W10-30, and 299-W10-31

Figures 7-10 through 7-12 show plume maps of release unit concentrations based on transport modeling representing conditions at the end of the 200 West P&T system operations in 2037 for scenarios 1 and 2 and in 2137 for scenario 3. Figures 7-10 and 7-11 depict sub-scenario A for scenarios 1 and 2, which corresponds to the bold black lines on the breakthrough curves. Release unit plume maps for all sub-scenarios in scenarios 1 and 2 are included in Appendix B in Appendix G.

The release unit plume maps provide a visual representation of the release dispersion predicted by the transport modeling results. The release plumes are produced using a bilinear interpolation process within ArcGIS™ to smooth the grid block modeling results that are calculated on the 100 by 100 m (328 by 328 ft) CPGWM grid cells. This interpolation process is performed to depict a visually smooth transition between concentrations calculated for the model grid cells; the unit plume maps would have a blocky appearance if they represented only the outputs obtained directly from the model. This interpolation process does, however, result in some spread of the unit plumes, particularly at the margins, and some differences in the visual representation of the transport modeling results when compared to results of particle-tracking calculations. Differences between the results shown in the release concentration breakthrough curves and the release unit plume maps generally are a result of this interpolation.

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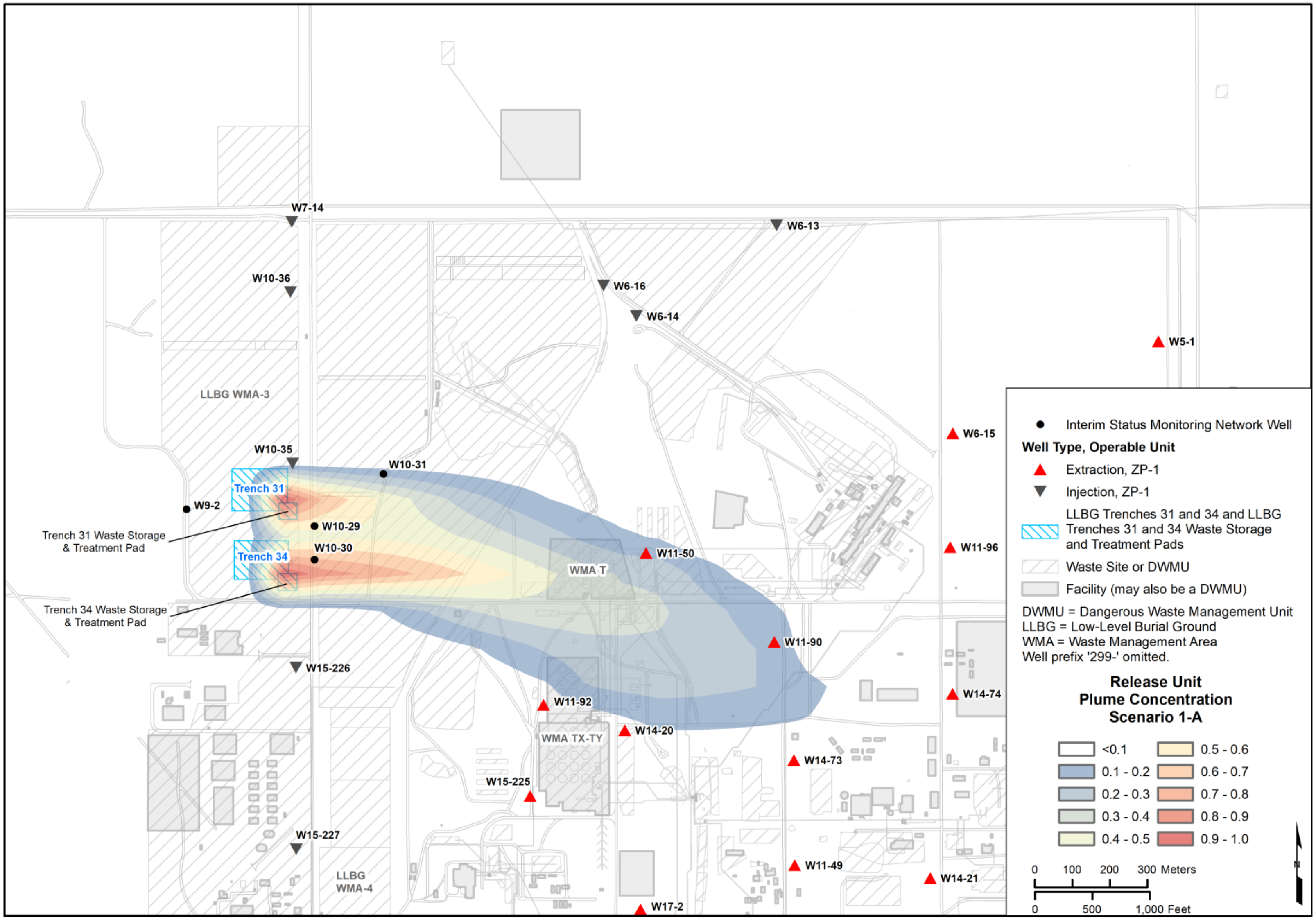

Figure 7-10. Release Unit Plume Map Scenario 1, Sub-Scenario A

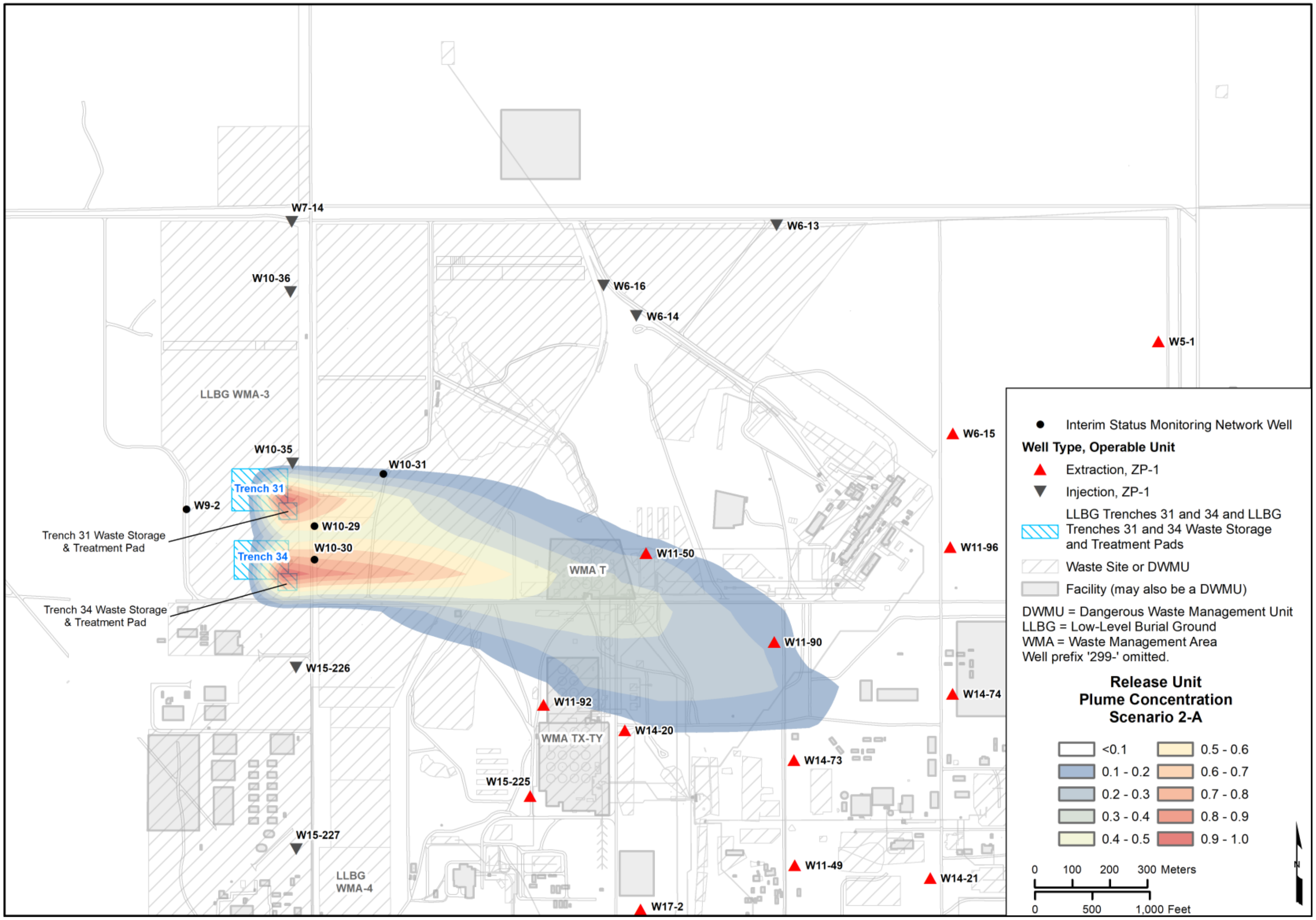

Figure 7-11. Release Unit Plume Map Scenario 2, Sub-Scenario A

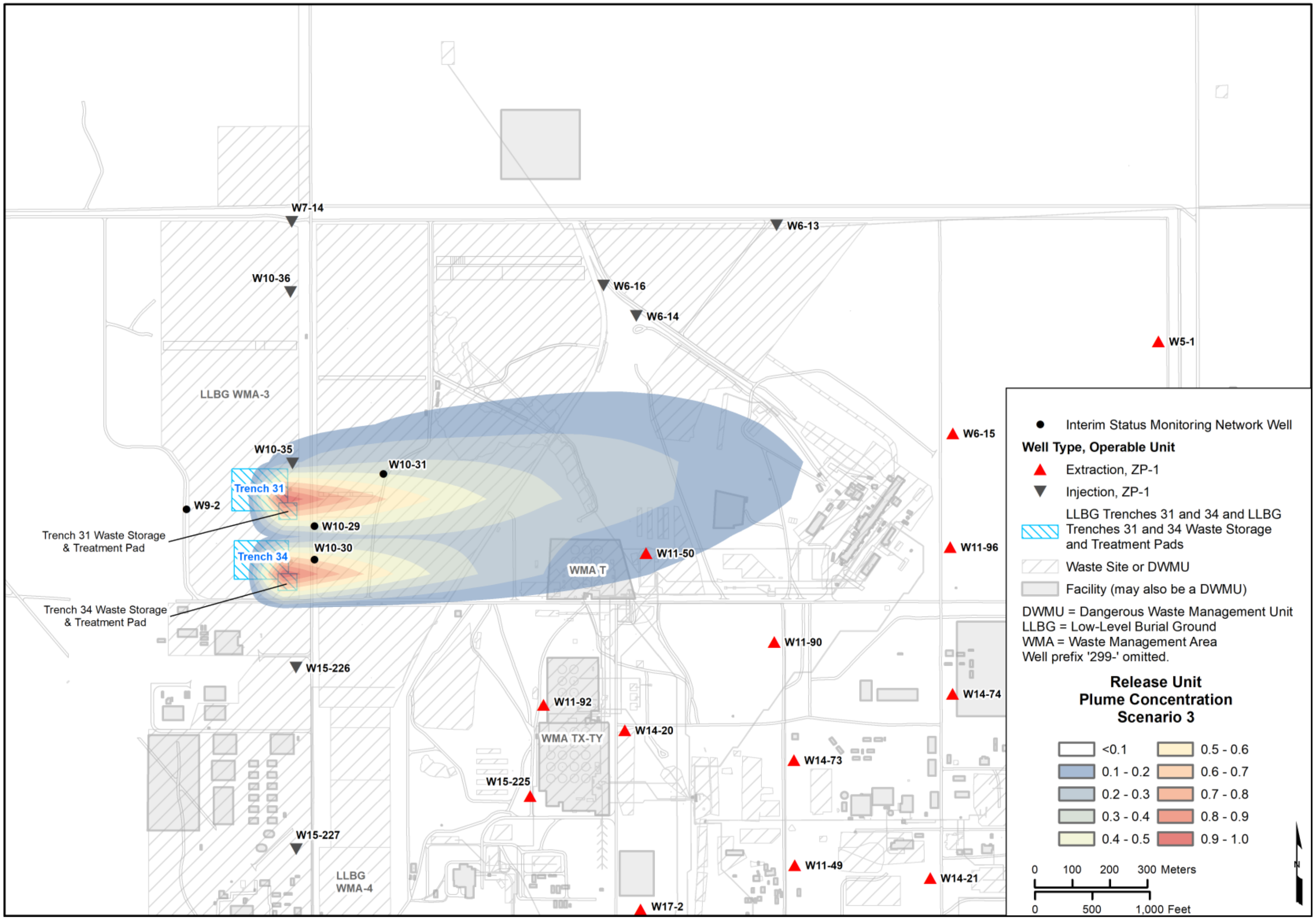

Figure 7-12. Release Unit Plume Map, Scenario 3

The release unit plume maps are one of the methods used in evaluating the robustness of the monitoring well network for coverage of the interpolated plume spread. However, because of the size of the model grid used in transport modeling and the plume spread caused by the interpolation between the nodes (centers) of the model cells, particle-tracking results are used in conjunction with the release unit plume maps for proper interpretation of model results.

Figures 7-10 through 7-12 show that downgradient wells 299-W10-29 and 299-W10-30 are well located for detecting releases, whereas well 299-W10-31 is on the edge of the unit plumes indicating it will have relatively more dilution and therefore will be less likely to detect releases. These conclusions are consistent with the conclusions based on the breakthrough curves.

7.2 Particle-Tracking and Relative Detectability Maps

Particle-tracking and relative detectability maps generated using particle-tracking calculations show for each scenario the overall distribution, given advection and dispersion, of a hypothetical release to the water table below the trenches. For scenarios 1 and 2, the maps represent conditions in 2037; for scenario 3, the maps represent conditions in 2137.

Based on the calculations, particles released to the water table exhibited predominantly horizontal migration, with minor components of vertical migration in response to very limited infiltration from groundwater recharge and the operation of nearby extraction and injection wells.

Figures 7-13 and 7-14 show particle pathlines superimposed upon injected treated water dilution plume maps (created using transport modeling) for sub-scenario A of scenarios 1 and 2 (the most likely operating conditions). The dilution factor represents the simulated relative fraction of injected water from injection wells. Similar figures for all sub-scenarios in scenarios 1 and 2 are included in Appendix G.

The particle tracking indicates wells 299-W10-29 and 299-W10-30 generally are well located for detecting releases from the facility for the scenarios evaluated, whereas well 299-W10-31 is outside of the release particle pathlines. Well 299-W9-2 is upgradient in all scenarios.

The particle-tracking map for scenario 3 (Figure 7-15) represents conditions after cessation of the 200 West P&T system operations and therefore has no injected treated water component. Figure 7-15 indicates 299-W10-30 remains within the particle pathlines for groundwater flow conditions after P&T operations cease, while 299-W10-29 is no longer in the extent of the mapped particle tracks. In this scenario, 299-W10-31 is within the extent of release particle pathlines.

Maps of relative detectability identify areas of the aquifer where a hypothetical release that impacts the water table beneath the low point of the LCRS within LLBG Trenches 31 and 34 would be most likely to migrate and be detectable. Whereas particle-tracking maps present the results for each sub-scenario separately, the relative detectability maps evaluate the sub-scenarios together while accounting for the weighting (estimated relative probability) of the various operating scenarios.

As described in Section 6.2.2, the relative detectability was determined by first calculating, for each sub-scenario, the number of released particles that traversed each calculation subgrid cell. Particle count maps generated for each sub-scenario are included as Appendix A in Appendix G. Using the particle counts, relative detectability for each scenario was determined by computing a weighted sum of the particle counts for each individual cell for all sub-scenarios within each scenario using the weights shown in Table 5-1 to account for the estimated relative probability of each sub-scenario.

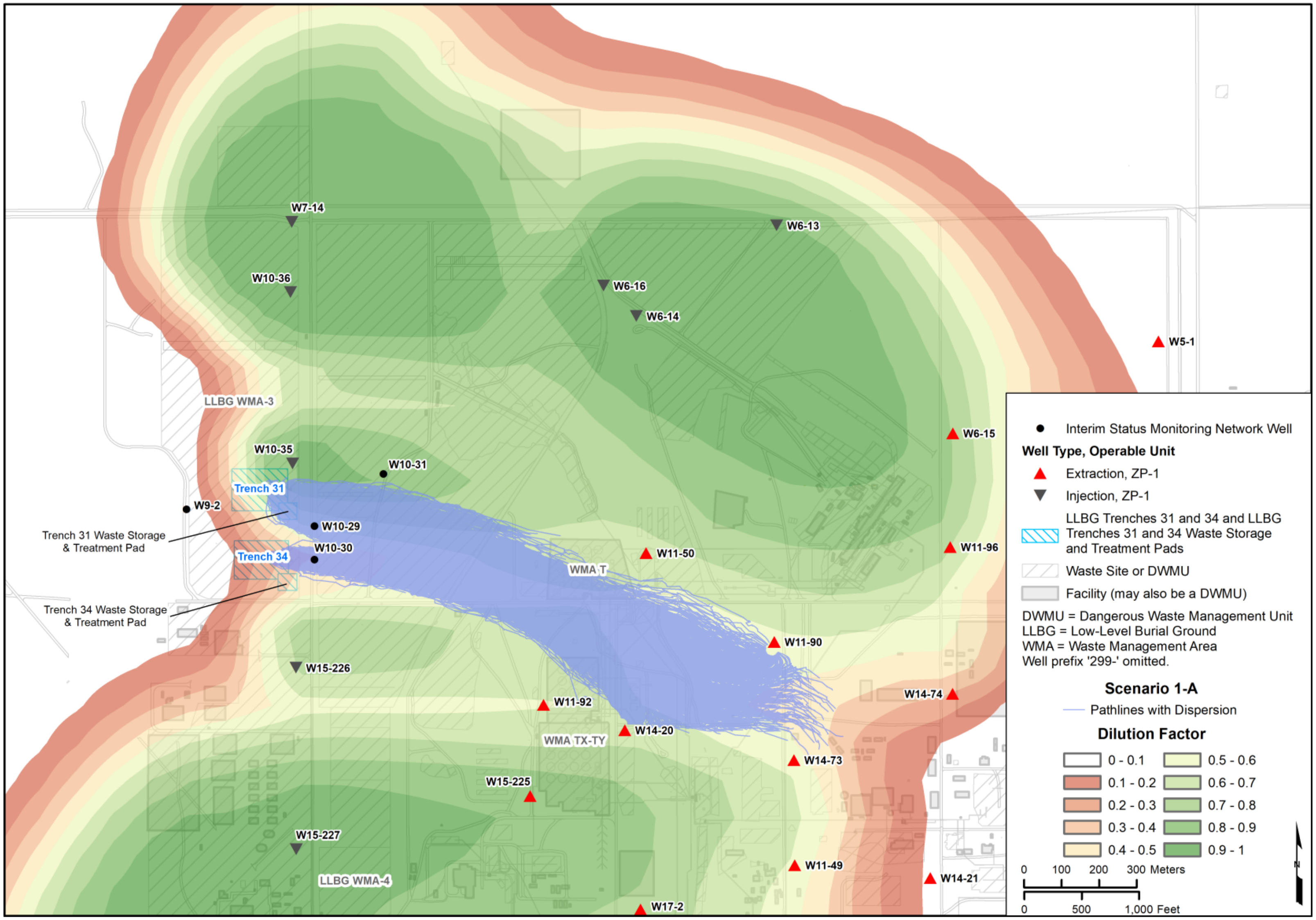

Figure 7-13. Particle Pathlines Superimposed on Injected Treated Water Unit Plumes, Scenario 1, Sub-Scenario A

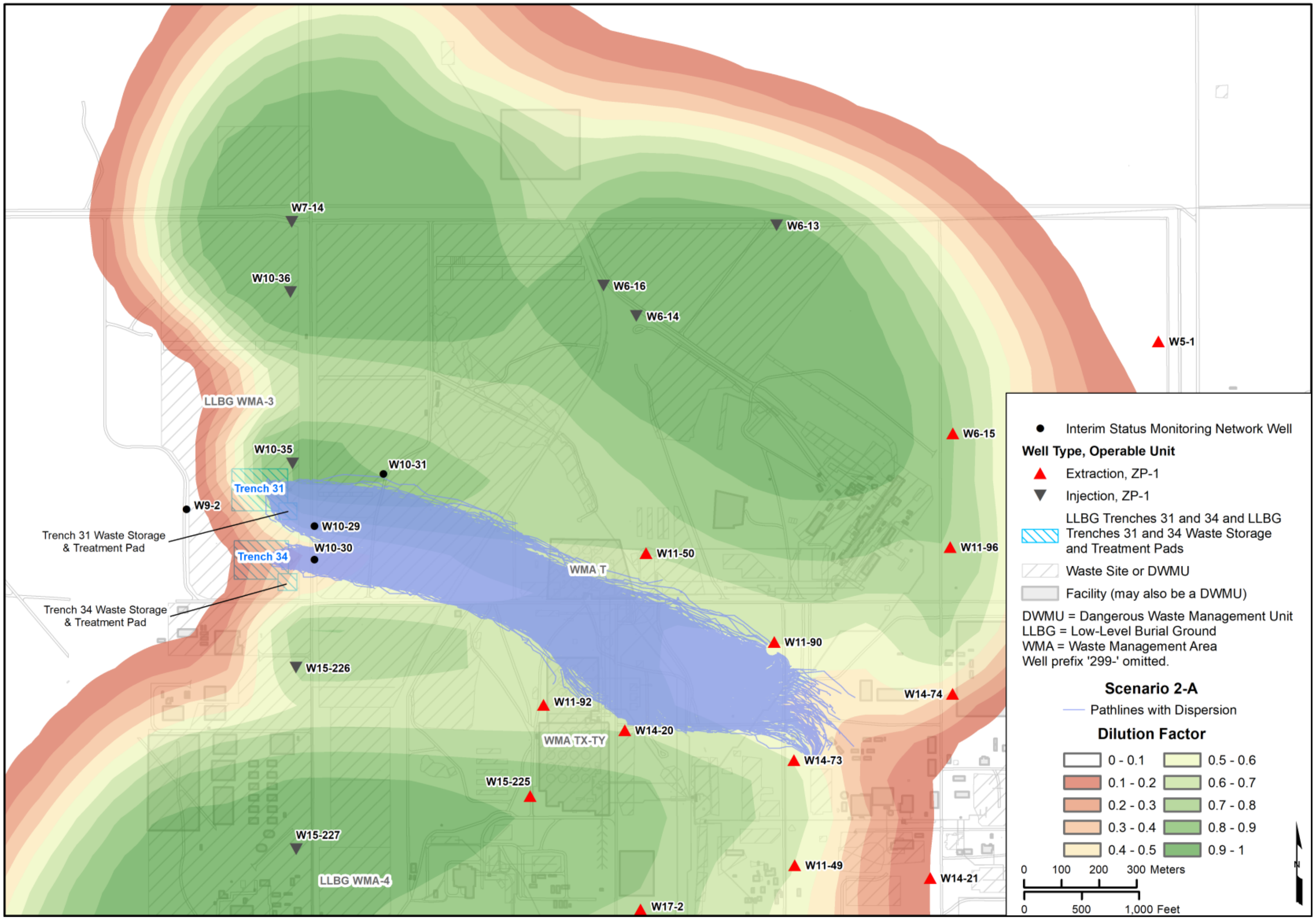

Figure 7-14. Particle Pathlines Superimposed on Injected Treated Water Unit Plumes, Scenario 2, Sub-Scenario A

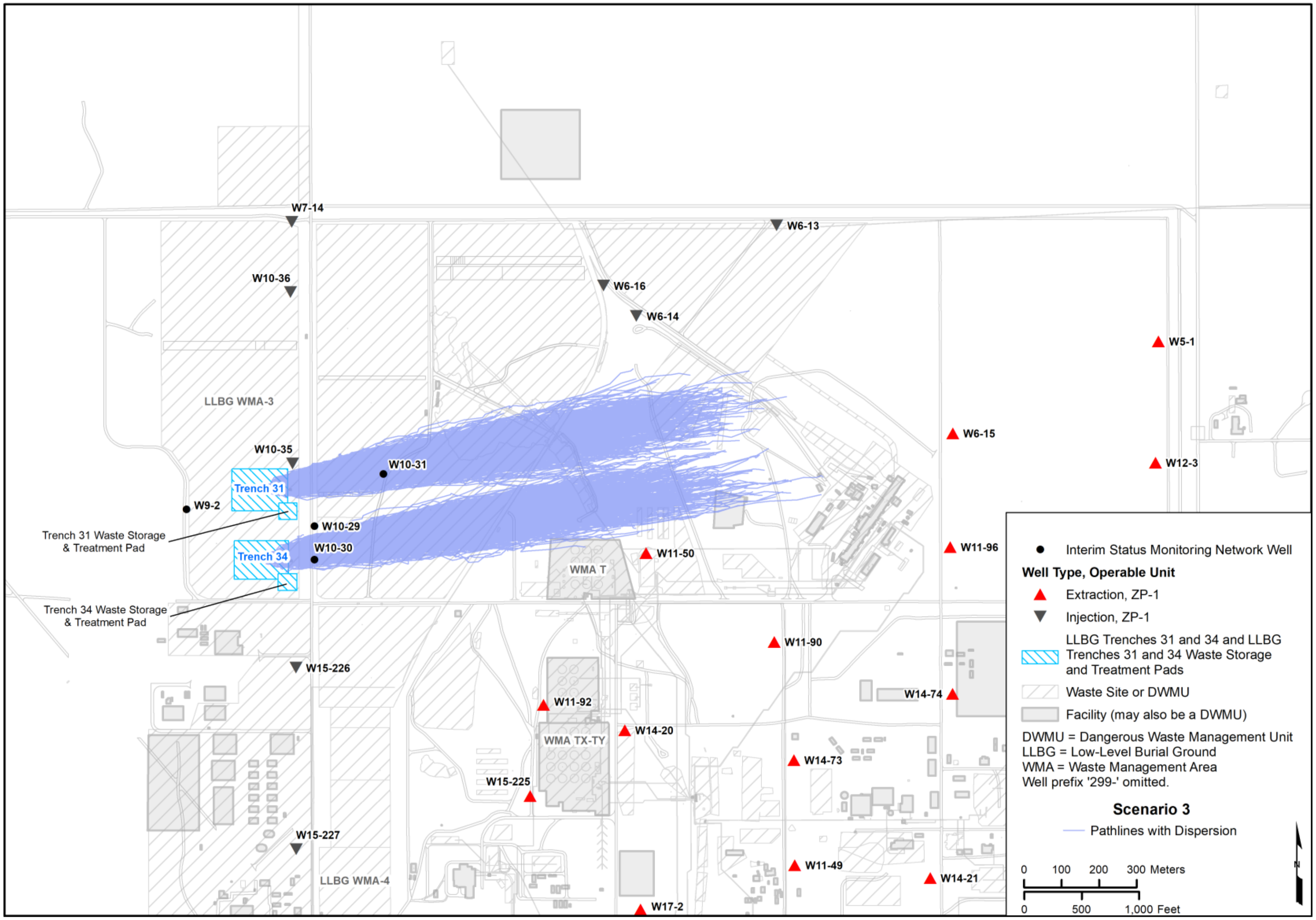

Figure 7-15. Particle Pathlines Scenario 3

Figures 7-16 through 7-18 depict the relative detectability distribution for releases to the water table beneath the facility for scenarios 1, 2, and 3, respectively. The release distribution is color-coded to reflect the results of the weighted percent distribution of particle counts throughout the release pathline. Where the weighted percent distribution of particle counts is higher, the probability of release detection is also higher.

The relative detectability maps for scenarios 1 and 2 show that the downgradient groundwater monitoring wells 299-W10-29 and 299-W10-30 generally are located in areas of high relative detectability for particle releases from the trenches. After cessation of 200 West P&T system operations, the shift in the groundwater flow direction from an east-southeast direction toward the east-northeast results in existing monitoring well 299-W10-30 being in an area of high relative detectability in scenario 3. In addition, existing monitoring well 299-W10-31 is located in an area of detectability only in scenario 3.

The relative detectability maps (Figures 7-16 through 7-18) show significant detectable areas where there are no downgradient monitoring wells, indicating the need for additional wells to monitor the full range of the detectable areas. Three new monitoring well locations, wells T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3 are proposed as shown in Figures 7-16 through 7-18 to provide monitoring across the extent of the release pathline distribution. Figures 7-16 and 7-17 indicate proposed well locations for monitoring wells T-31-34_PW-1 and T-31-34_PW-2 are located in the northern extent of the detectable areas for scenarios 1 and 2. Proposed monitoring well T-31-34_PW-1 is located in an area of higher relative detectability in scenario 3 (Figure 7-18) and is located closer to the facility than existing monitoring well 299-W10-31. The location of proposed well T-31-34_PW-3 is on the southern edge of the area of relative detectability.

The proposed monitoring wells are proposed to become part of the final monitoring plan to supplement monitoring from existing monitoring wells 299-W10-29 and 299-W10-30. The evaluation of the proposed well locations is included in Section 7.3.

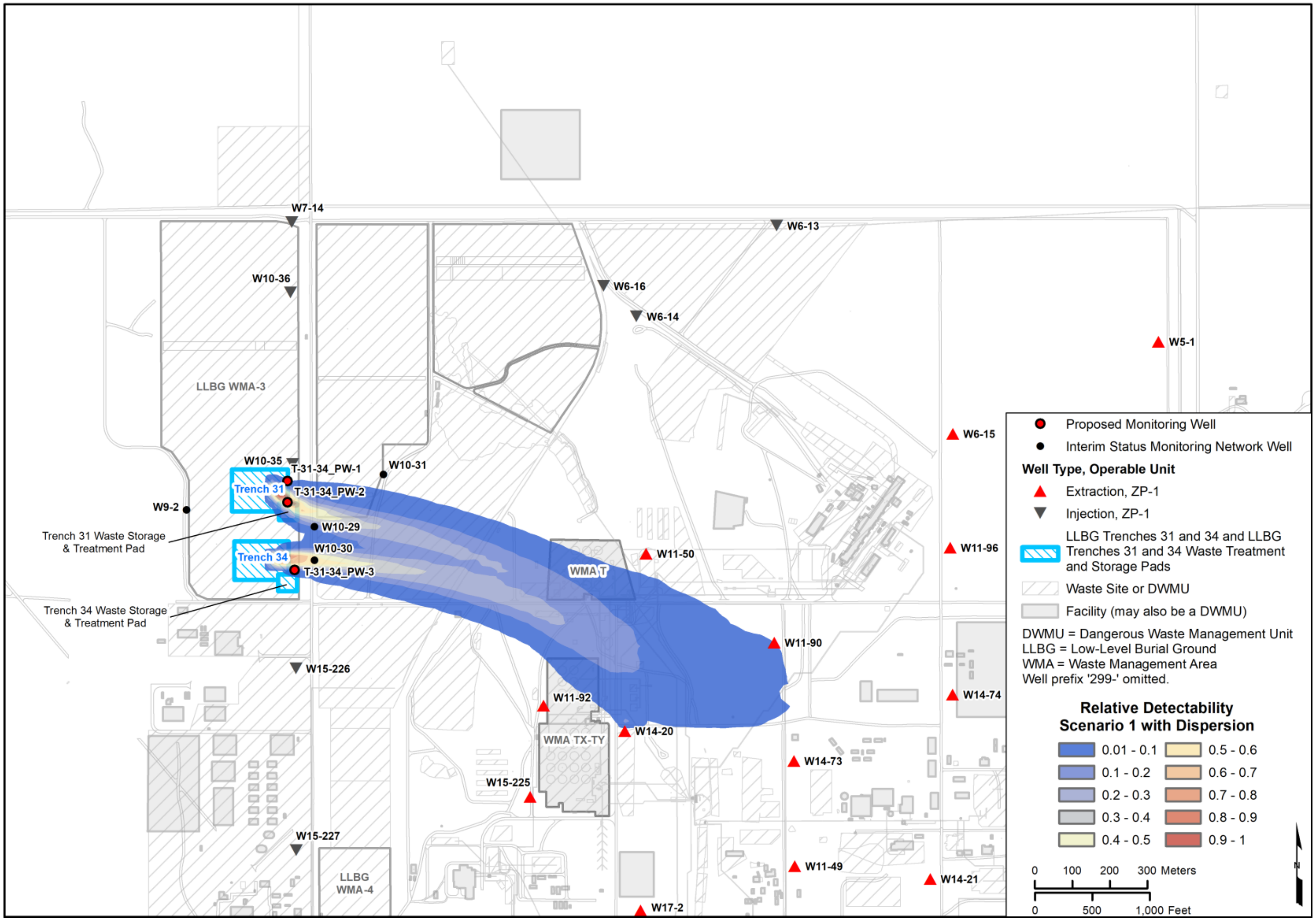

Figure 7-16. Relative Detectability of Release, Scenario 1

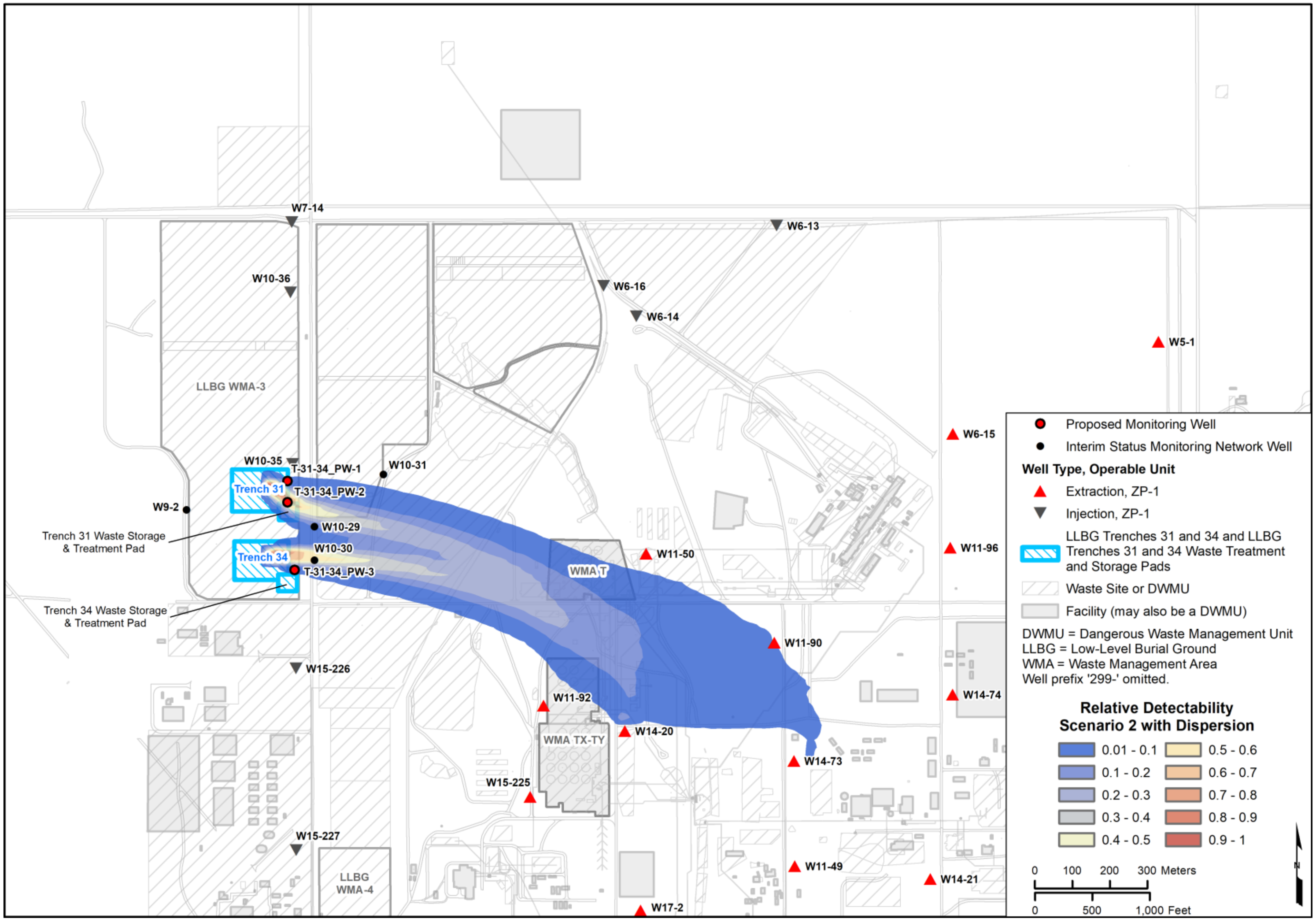

Figure 7-17. Relative Detectability of Release, Scenario 2

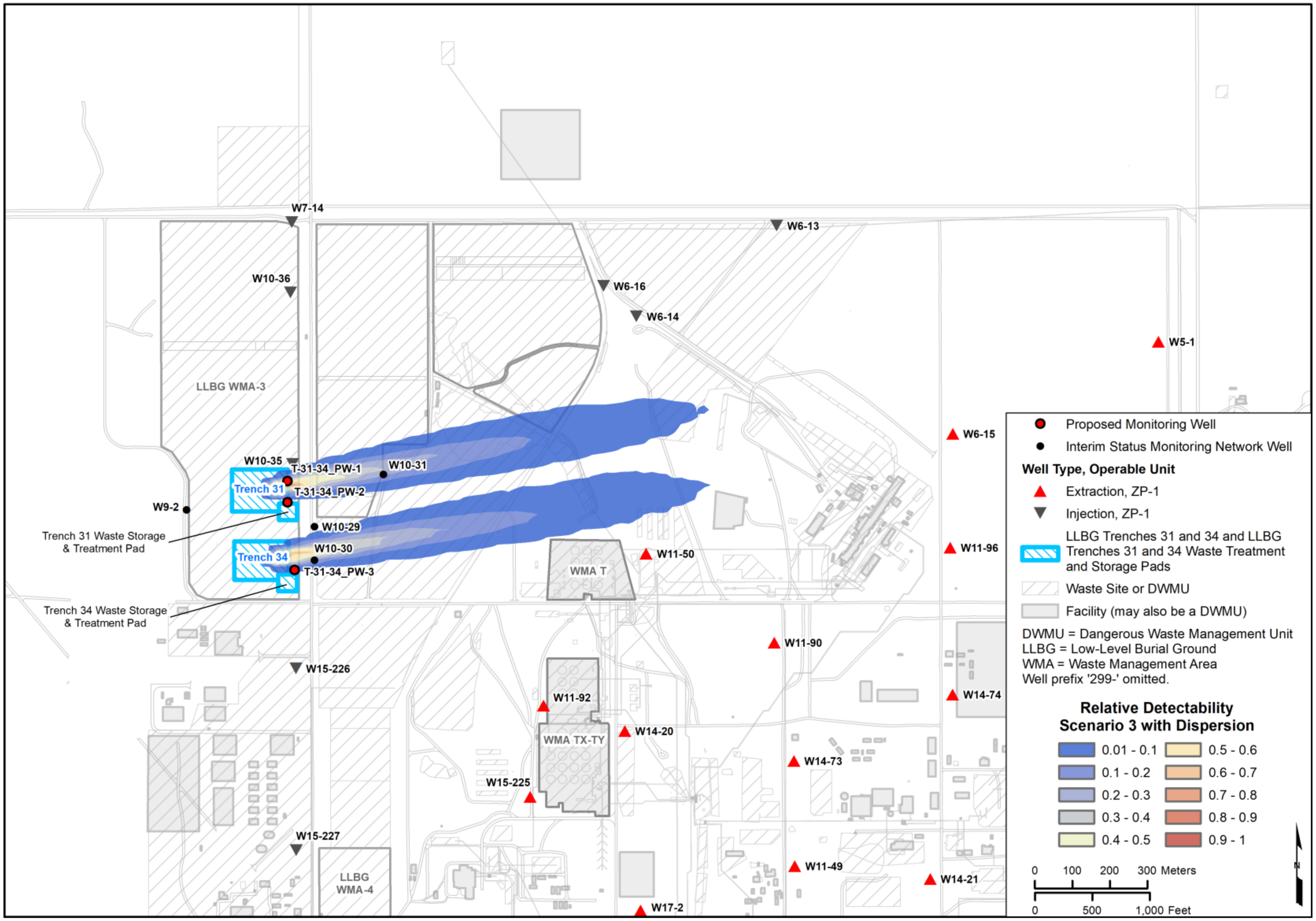

Figure 7-18. Relative Detectability of Release, Scenario 3

7.3 Breakthrough Curves for Proposed Wells

Using transport calculations, injected treated water dilution breakthrough curves and release concentration breakthrough curves were generated for each scenario and sub-scenario to evaluate the proposed well locations. Figures 7-19 through 7-21 show injected treated water dilution breakthrough curves for the proposed wells T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3 for scenario 1. The injected treated water dilution breakthrough curves for scenario 2 for the proposed wells are included in Appendix G. The results for scenario 2 were similar to the results shown for scenario 1. Table 7-3 shows the range of the injected treated water dilution breakthrough curves for the proposed wells for scenarios 1 and 2.

Figures 7-22 through 7-24 show release concentration breakthrough curves for the proposed wells for scenario 1. The release concentration breakthrough curves for scenario 2 for the proposed wells are included in Appendix G. The results for scenario 2 were similar to the results shown for scenario 1. The release concentration breakthrough curves for scenario 3 for the proposed wells are shown in Figure 7-25. Table 7-4 shows the range of the release concentration breakthrough curves for the proposed wells for scenarios 1, 2, and 3.

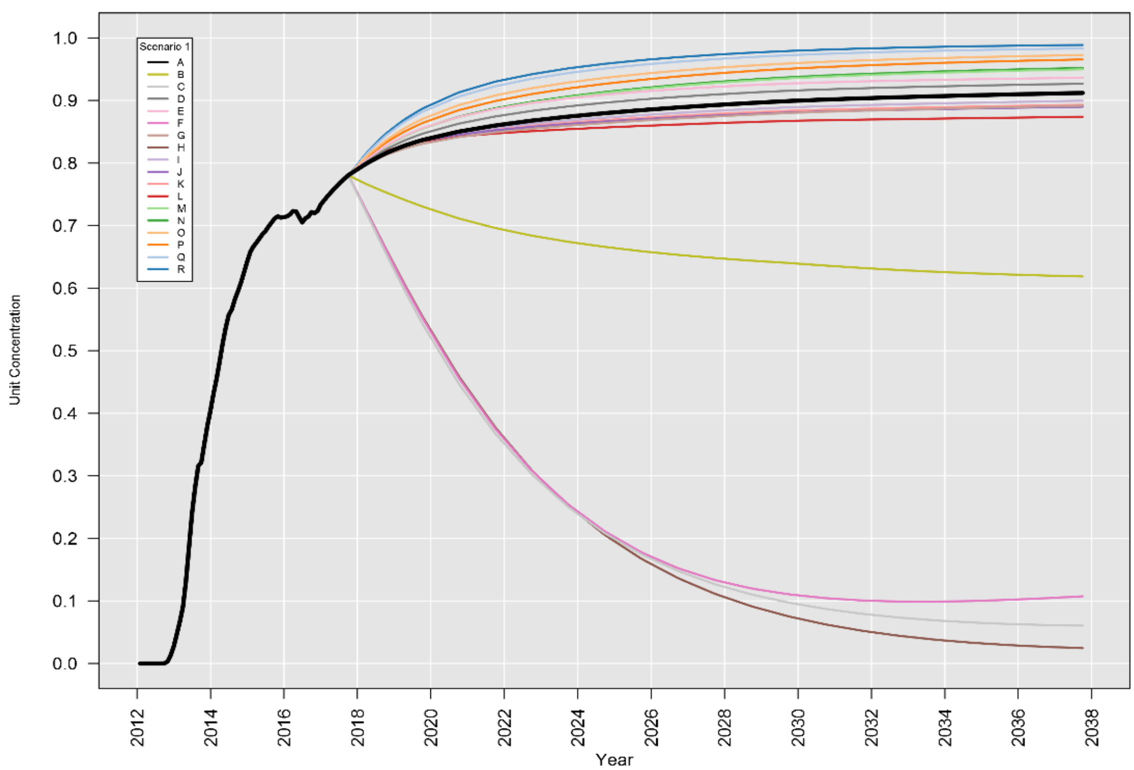

Figure 7-19. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Proposed Monitoring Well T-31-34_PW-1

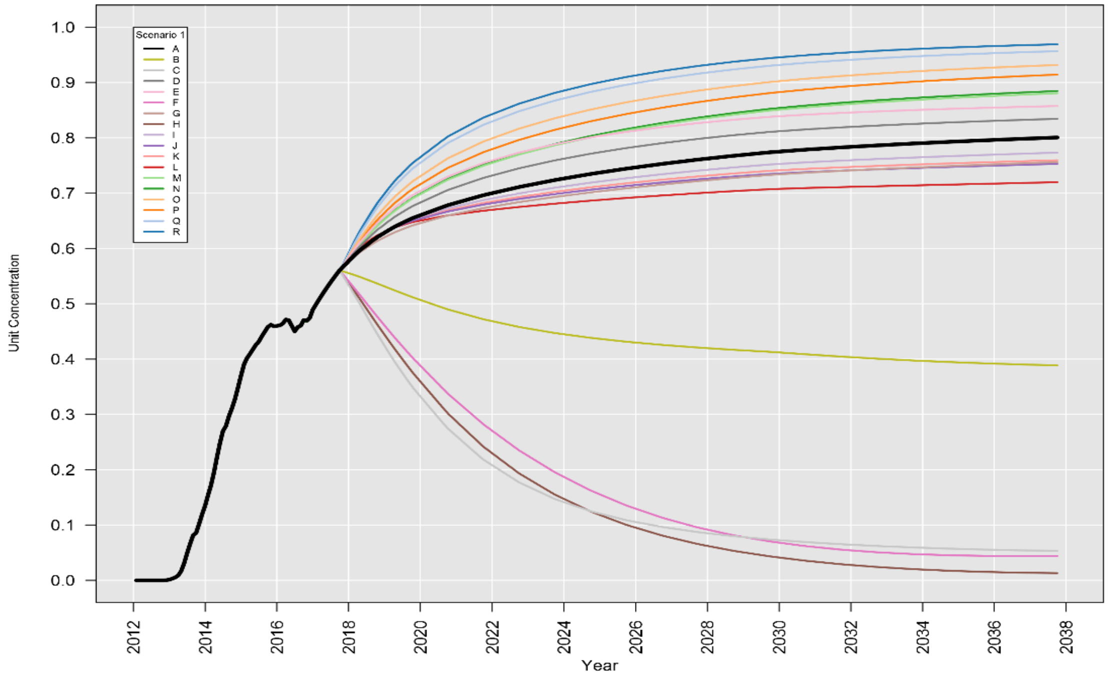

Figure 7-20. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Proposed Monitoring Well T-31-34_PW-2

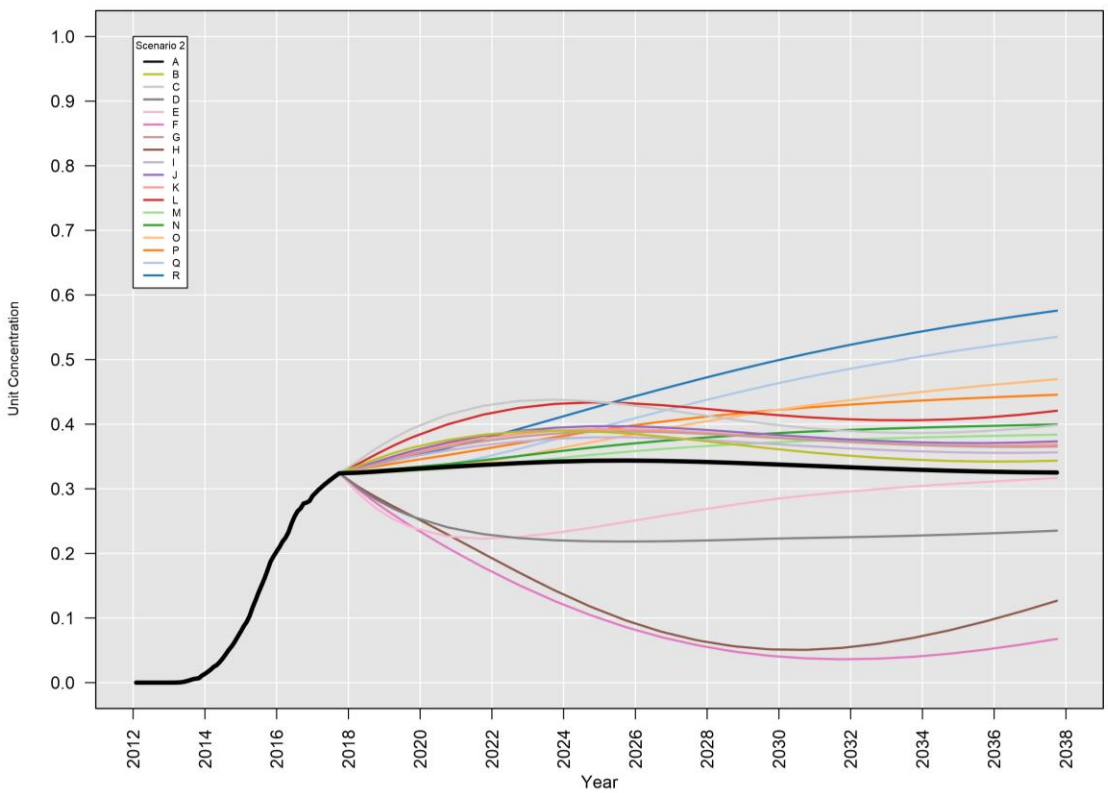

Figure 7-21. Injected Treated Water Dilution Breakthrough Curves, Scenario 1, Proposed Monitoring Well T-31-34_PW-3

Table 7-3. Range of Unit Concentrations of Injected Treated Water Dilution Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average
T-31-34_PW-1	1	0.024	0.989	0.861
	2	0.025	0.989	0.867
T-31-34_PW-2	1	0.013	0.969	0.759
	2	0.014	0.969	0.772
T-31-34_PW-3	1	0.052	0.576	0.333
	2	0.068	0.576	0.347

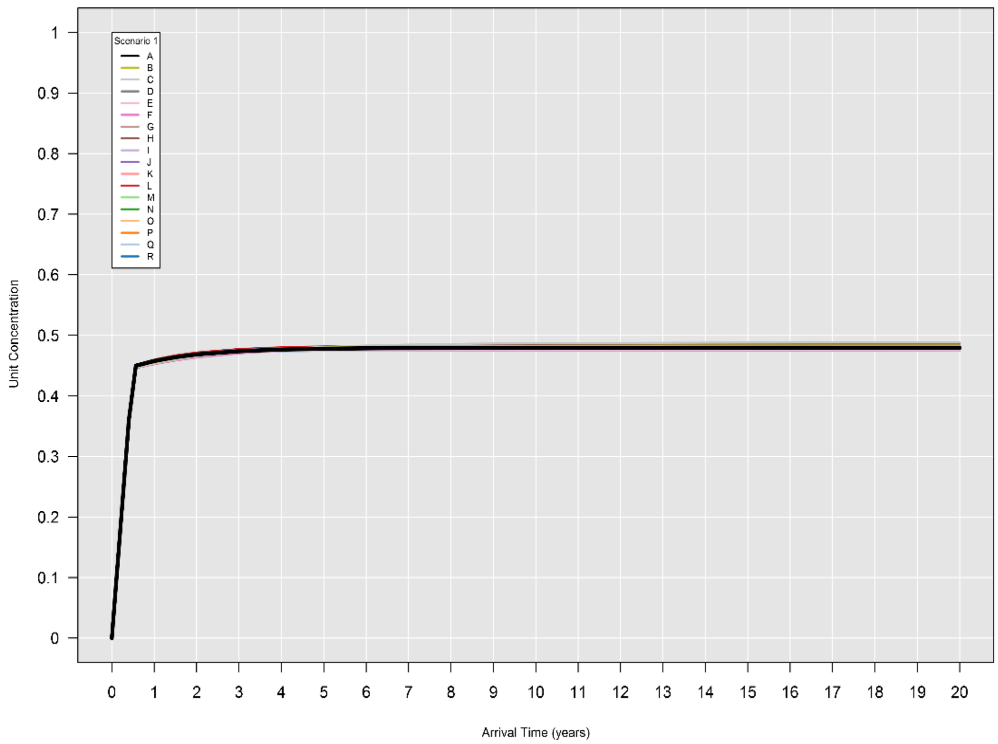

Figure 7-22. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well T-31-34_PW-1

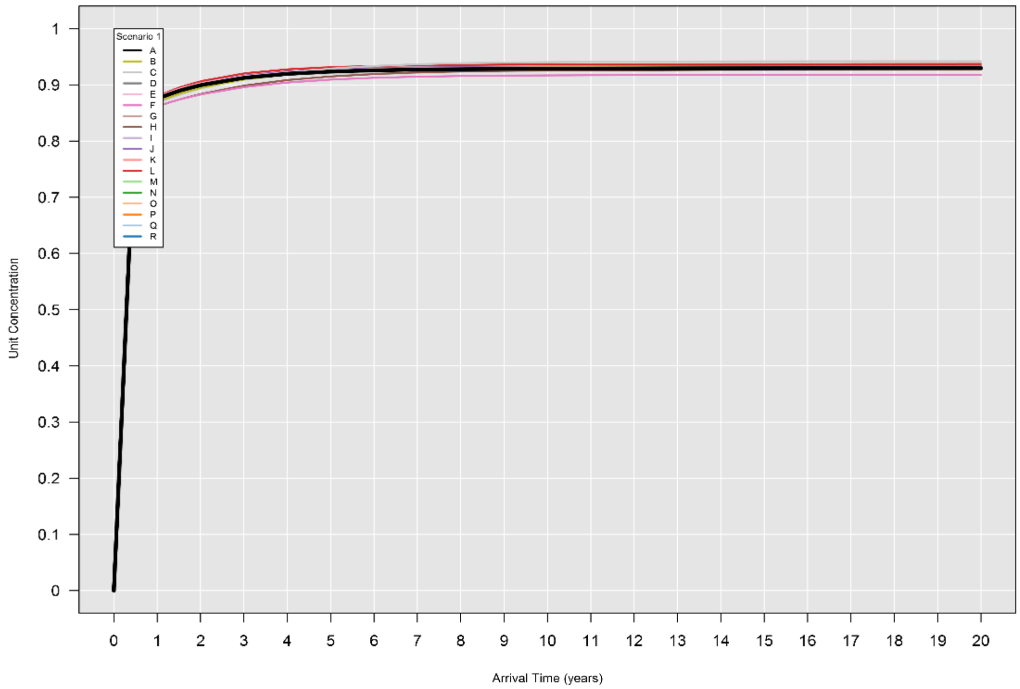

Figure 7-23. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well T-31-34_PW-2

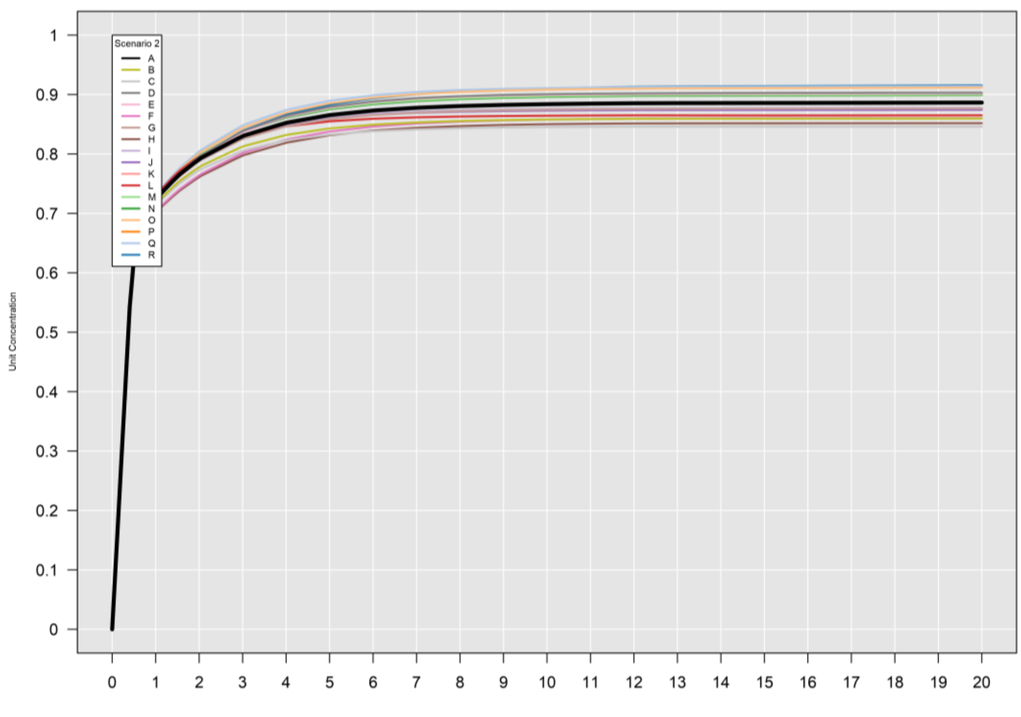

Figure 7-24. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well T-31-34_PW-3

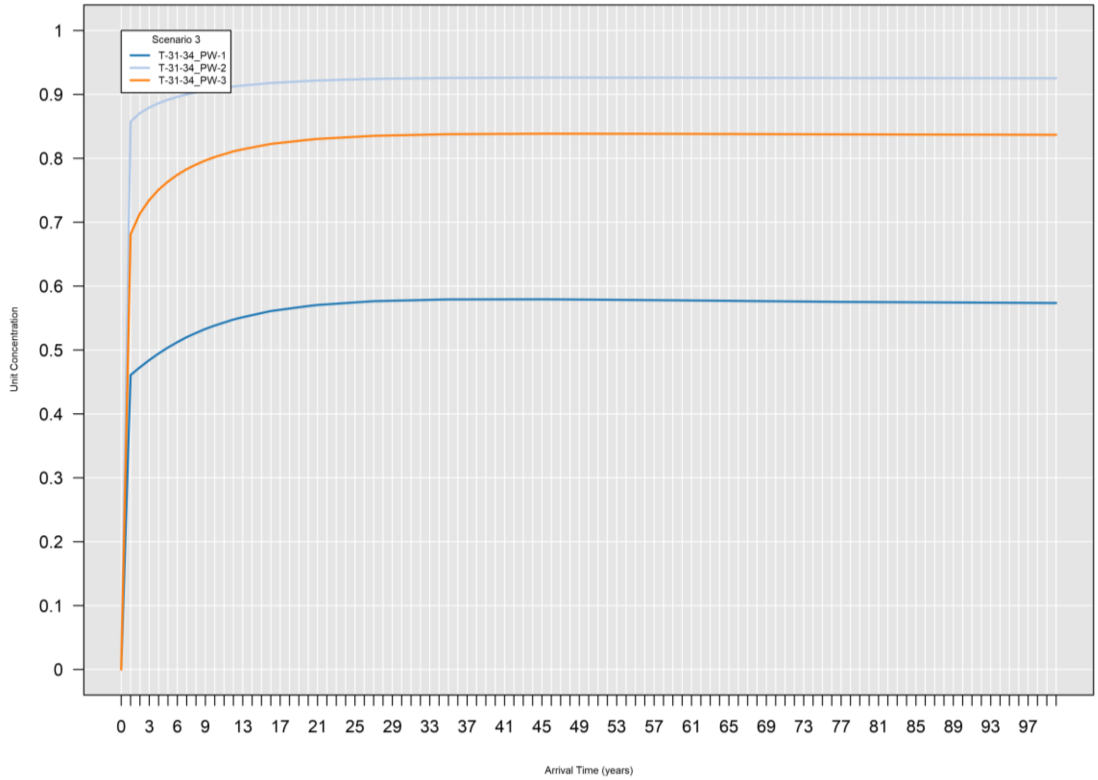

Figure 7-25. Release Concentration Breakthrough Curves, Scenario 3, Proposed Monitoring Wells T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3

Table 7-4. Range of Unit Concentrations of Release Concentration Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average	Scenario 3
T-31-34_PW-1	1	0.484	0.498	0.489	0.574
	2	0.484	0.498	0.489	
T-31-34_PW-2	1	0.917	0.941	0.930	0.925
	2	0.917	0.941	0.930	
T-31-34_PW-3	1	0.846	0.915	0.885	0.837
	2	0.846	0.915	0.886	

The injected treated water dilution plumes indicate that proposed monitoring wells T-31-34_PW-1 and T-31-34_PW-2 have higher relative dilution from injected treated water and that the dilution varies more between sub-scenarios at these well locations. The release concentration breakthrough curves for the proposed wells T-31-34_PW-2 and T-31-34_PW-3 indicate the wells are located in areas without significant dilution of the release concentrations. There is little to no variation in the release concentration dilution between the different scenarios for the proposed well locations.

7.4 Modeling Conclusions

The proposed final status groundwater monitoring network for LLBG Trenches 31 and 34 includes retaining existing upgradient well 299-W9-2 and existing downgradient wells 299-W10-29 and 299-W10-30. In addition, three new wells, T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3 are proposed to intersect and detect potential contamination along the northern and southern region of the mapped hypothetical releases. Downgradient well 299-W10-31 is not included in the final status monitoring network. The proposed final status monitoring well network is based on the results of the simulation scenarios presented in Appendix G and summarized herein.

Well 299-W10-31 (current interim status monitoring network well) is not included in the final status network because particle-tracking calculations indicate it is outside the detectable area in scenarios 1 and 2. Although it is within the detectable area in scenario 3, proposed new well T-31-34_PW-1 is located within the scenario 3 detectable area and is closer to LLBG Trenches 31 and 34. Transport calculations confirm 299-W10-31 is in a location where it would have relatively more dilution (less of the original release concentration) and, therefore, would be somewhat less likely to detect releases for all the operating scenarios. Figure 7-8 indicates the dilution of the release concentration at the well under the current 200 West P&T operating scenario is 87% (corresponding to a unit concentration of 0.13).

Figure 7-26 shows the final status monitoring network wells compared to the combined extents of relative detectability greater than 0.01 for scenarios 1, 2, and 3 from particle tracking and the combined extents of release unit plumes greater than 0.1 for sub-scenario A of scenarios 1 and 2, and scenario 3 from transport modeling.

The simulations indicate that, under the scenarios evaluated, upgradient monitoring well 299-W9-2, along with the five downgradient groundwater monitoring wells (299-W10-29, 299-W10-30, T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3) are well placed for detection of a release to the water table from LLBG Trenches 31 and 34. These wells are proposed as the monitoring well network for LLBG Trenches 31 and 34. Downgradient wells are shown to be in locations spanning the range of particle distribution as released from LLBG Trenches 31 and 34. The well placement is suitable for detecting releases to the water table from LLBG Trenches 31 and 34 under the evaluated range of conditions.

The release concentration breakthrough curves for the recommended downgradient monitoring network wells indicate a range of dilution of approximately 6%[1] to 62%[2] for release unit concentrations. After cessation of the 200 West P&T system operations (scenario 3), this dilution range becomes approximately 7% to 59%[3]. Additional discussion regarding each well is provided in Section 9.3.

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[1] 6% dilution corresponds to a release unit concentration of approximately 0.94 at monitoring well T-31-34_PW-2 for sub-scenario C of scenario 1 (Figure 7-23).

[2] 62% dilution corresponds to a release unit concentration of approximately 0.38 at monitoring well 299-W10-29 for sub-scenario F of scenario 1 (Figure 7-6).

[3] 7%-59% dilution for scenario 3 corresponds to a release unit concentration of approximately 0.93 and approximately 0.41 for wells T-31-34_PW-2 and 299-W10-29, respectively (Figures 7-25 and 7-9, respectively).

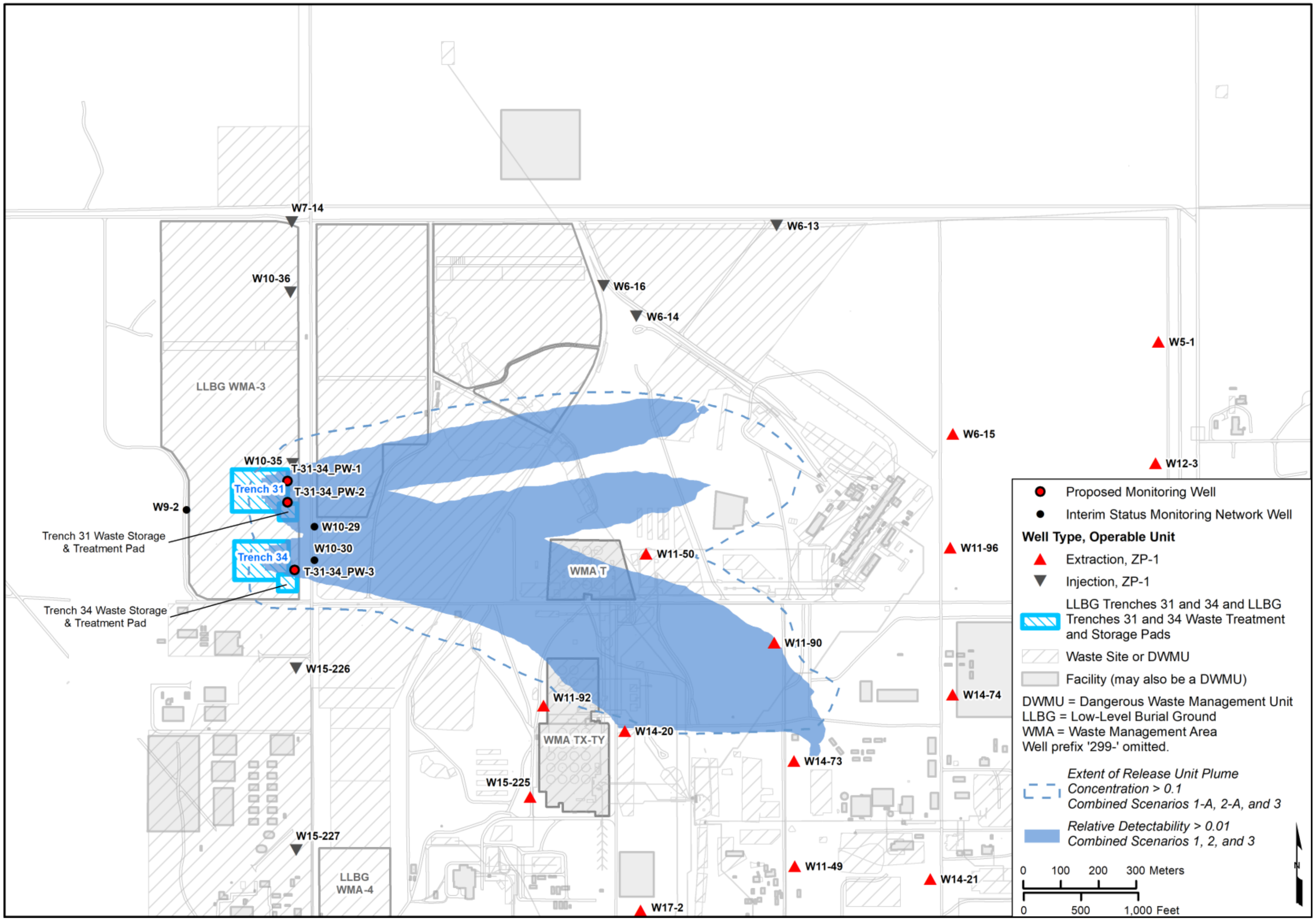

Figure 7-26. Proposed Final Status Groundwater Monitoring Network with Combined Relative Detectability and Release Unit Plume Results

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8 Identification of Site-Specific Monitoring Constituents

An evaluation of the waste constituents associated with the LLBG unit group (Operating Unit 17), which includes LLBG Trenches 31 and 34, was performed to identify the proposed groundwater monitoring constituents to include in the final status groundwater monitoring program. The evaluation process and proposed monitoring constituents are summarized in this chapter and detailed in Appendix B.

8.1 Selection Process for Monitoring Constituents

The waste constituents associated with LLBG Trenches 31 and 34 are the dangerous wastes that are identified in the Hanford Facility RCRA Permit Part A Permit Application for LLBG (Table 2-2). These wastes were used to identify potential monitoring constituents for LLBG. Potential monitoring constituents underwent evaluation to identify the proposed monitoring constituents to be monitored under the final status permit.

The evaluations were performed in accordance with the summary descriptions provided in Sections 8.1 and 8.2. Additional details of the methodology are provided in Chapter 3 of Appendix B with assumptions documented in Chapter 4 of Appendix B.

8.1.1 Hanford Facility RCRA Permit Part A Form Dangerous Wastes

The Hanford Facility RCRA Permit Part A Application for LLBG identifies the dangerous waste codes associated with the unit, which includes LLBG Trenches 31 and 34. A list of dangerous wastes and their corresponding Chemical Abstracts Service (CAS) numbers was compiled using the waste codes presented in Table 2-2.

The specified dangerous wastes were screened to identify mobile constituents by comparing literature reference values for constituent distribution coefficients (K_d) to a Hanford Site-derived K_d value of 0.8 mL/g that was developed and applied to a known mobile constituent in Hanford Site vadose soils (hexavalent chromium) (Section 6.1 in ECF-Hanford-11-0165, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area*). Constituents with a $K_d \leq 0.8$ mL/g were identified as mobile constituents and further evaluated as potential monitoring constituents (Tables 1 and 3 in Appendix B). If no reference K_d value was available for a constituent, the constituent was conservatively retained for further evaluation as a potential monitoring constituent.

8.1.2 Identification of Potential Monitoring Constituents Already Prescribed for Monitoring at LLBG

Ecology Letter 16-NWP-143, "Groundwater Engineering Report and Final Status Groundwater Monitoring Plan Requirements for the Integrated Disposal Facility, Nonradioactive Dangerous Waste Landfill, Low Level Burial Grounds Trench 94, and Low Level Burial Grounds "Green Islands" Dangerous Waste Management Units," provided direction for preparation of documents to support the final status permit revision for LLBG containing dangerous waste. The letter directed that monitoring for WAC 173-303-110(3)(c) and (7) constituents would be performed for 1 year. WAC 173-303-110(3)(c) references Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, and WAC 173-303-110(7) references Appendix 5 of Ecology Publication No. 97-407. While Ecology Letter 15-NWP-157 did not specify monitoring of Appendix 5 constituents for Trenches 31 and 34, it will be included as a conservative measure (see Section 9.4). Because the waste constituents identified in Appendix 5 of Ecology Publication No. 97-407 will be included for background monitoring at the LLBG under the final status permit, the potential monitoring constituents that are also listed in Appendix 5 of Ecology Publication No. 97-407 were identified as proposed monitoring constituents without evaluation or screening.

8.1.3 Final Monitoring Constituent Evaluation

The constituents retained as potential monitoring constituents in Sections 8.1.1 and 8.1.2 were compiled for the final evaluation described in this section. A final evaluation identified potential monitoring constituents to be included as proposed monitoring constituents to detect and monitor wastes from LLBG that impact groundwater. The evaluation was performed as follows:

- Evaluation of physical properties. Potential monitoring constituents that are gases were removed from consideration.
- Identification of related chemicals (e.g., parent compounds and isomers) that were already identified as proposed monitoring constituents. Such potential monitoring constituents were evaluated on a case-by-case basis.
- Availability of analysis. The potential monitoring constituents that are not routinely analyzed by commercial laboratories were removed from consideration.

Potential monitoring constituents that were not excluded due to physical property, analysis by related chemicals, or unavailability of analysis were identified as proposed monitoring constituents. These proposed monitoring constituents, combined with the proposed monitoring constituents from the evaluation in Section 8.1.2, comprise the proposed monitoring constituents for the LLBG unit, as applicable.

8.2 Results of Selection of Groundwater Monitoring Constituents

Based on the evaluation of the dangerous wastes identified from the LLBG Part A Permit Application, 140 waste constituents are identified as proposed monitoring constituents to detect and monitor any groundwater impacts from hypothetical dangerous waste releases at LLBG (Table 8-1). LLBG Trenches 31 and 34 was part of the LLBG; therefore, the identified waste constituents will be monitored at LLBG Trenches 31 and 34. Details of the constituent screening and selection process outcomes are provided in Chapter 7 of Appendix B of this document.

Table 8-1. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
1-Butanol (n-Butyl alcohol)	71-36-3
1-Naphthylamine	134-32-7
1,1-Dichloroethane	75-34-3
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4
1,1,1-Trichloroethane	71-55-6
1,1,1,2-Tetrachloroethane	630-20-6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,1,2-Trichloroethane	79-00-5
1,1,2,2-Tetrachloroethane	79-34-5
1,2-Dibromo-3-chloropropane	96-12-8

Table 8-1. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
1,2-Dibromoethane	106-93-4
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1
1,2-Dichloroethane	107-06-2
1,2-Dichloropropane	78-87-5
1,2-Diphenylhydrazine	122-66-7
1,2,4,5-Tetrachlorobenzene	95-94-3
1,4-Dichlorobenzene	106-46-7
1,4-Dioxane	123-91-1
1,4-Naphthoquinone	130-15-4
2-Acetylaminofluorene	53-96-3
2-Butanone (Methyl ethyl ketone)	78-93-3
2-Chloroethyl vinyl ether	110-75-8
2-Chlorophenol	95-57-8
2-Methylphenol (o-Cresol)	95-48-7
2-Naphthylamine	91-59-8
2-Nitropropane	79-46-9
2-Picoline	109-06-8
2-Propanone (Acetone)	67-64-1
2,3,4,6-Tetrachlorophenol	58-90-2
2,4-D (2,4-Dichlorophenoxyacetic acid)	94-75-7
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)	93-76-5
2,4,5-TP Silvex (2-(2,4,5-trichlorophenoxy)propionic acid)	93-72-1
2,4,6-Trichlorophenol	88-06-2
2,6-Dichlorophenol	87-65-0
2,6-Dinitrotoluene	606-20-2

Table 8-1. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
3-Methylcholanthrene	56-49-5
3-Methylphenol (m-Cresol)	108-39-4
3,3′-Dichlorobenzidine	91-94-1
3,3′-Dimethylbenzidine	119-93-7
4,4'-Methylenebis (2-chloroaniline)	101-14-4
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1
4-Methylphenol (p-cresol)	106-44-5
5-Nitro-o-toluidine	99-55-8
7,12-Dimethylbenz[a]anthracene	57-97-6
Acetonitrile (Methyl cyanide)	75-05-8
Acetophenone	98-86-2
Acrolein	107-02-8
Acrylamide	79-06-1
Acrylonitrile	107-13-1
alpha, alpha-Dimethylphenethylamine	122-09-8
Aniline	62-53-3
Benzene	71-43-2
Benzyl chloride	100-44-7
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))	108-60-1
Bis(2-chloroethoxy)methane	111-91-1
Bis(2-chloroethyl)ether	111-44-4
Bromoform	75-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chlorobenzilate	510-15-6
Chloroform	67-66-3

Table 8-1. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Cyclohexane	110-82-7
Cyclohexanone	108-94-1
Diallate	2303-16-4
Dichlorodifluoromethane	75-71-8
Diethyl phthalate	84-66-2
Dimethoate	60-51-5
Dimethyl phthalate	131-11-3
Disulfoton	298-04-4
Ethyl acetate	141-78-6
Ethyl ether	60-29-7
Ethyl methacrylate	97-63-2
Ethyl methanesulfonate	62-50-0
Ethylbenzene	100-41-4
Famphur	52-85-7
Formaldehyde	50-00-0
Formic acid	64-18-6
Hexachlorophene	70-30-4
Hexachloropropene	1888-71-7
Hydrazine	302-01-2
Isobutanol (Isobutyl alcohol)	78-83-1
Isodrin	465-73-6
Isopropylbenzene	98-82-8
Isosafrole	120-58-1
Kepone	143-50-0
m-Dichlorobenzene	541-73-1
Methacrylonitrile	126-98-7
Methanol	67-56-1
Methapyrilene	91-80-5
Methyl bromide (Bromomethane)	74-83-9
Methyl chloride (Chloromethane)	74-87-3

Table 8-1. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Methyl iodide (Iodomethane)	74-88-4
Methyl methacrylate	80-62-6
Methyl parathion	298-00-0
Methylene bromide (Dibromomethane)	74-95-3
Methylene chloride	75-09-2
Nitrobenzene	98-95-3
Nitroglycerine	55-63-0
n-Nitrosodiethylamine	55-18-5
n-Nitrosodimethylamine	62-75-9
n-Nitrosodi-n-butylamine	924-16-3
n-Nitroso-di-n-dipropylamine (n-Nitrosodipropylamine)	621-64-7
n-Nitrosopiperidine	100-75-4
n-Nitrosopyrrolidine	930-55-2
O,O-Diethyl-O-pyrazinylthiophosphate	297-97-2
o-Toluidine	95-53-4
p-(Dimethylamino)azobenzene	60-11-7
Parathion	56-38-2
p-Chloroaniline (4-Chloroaniline)	106-47-8
Pentachlorobenzene	608-93-5
Pentachloroethane	76-01-7
Pentachloronitrobenzene	82-68-8
Pentachlorophenol	87-86-5
Phenacetin	62-44-2
Phenol	108-95-2
Phorate	298-02-2
p-Nitroaniline (4-Nitroaniline)	100-01-6
p-Nitrophenol (4-Nitrophenol)	100-02-7
Pronamide	23950-58-5

Table 8-1. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Propionitrile (Ethyl cyanide)	107-12-0
Pyridine	110-86-1
Safrole	94-59-7
sym-Trinitrobenzene	99-35-4
Tetrachloroethene	127-18-4
Tetraethyl dithiopyrophosphate	3689-24-5
Tetrahydrofuran	109-99-9
Thiophenol	108-98-5
Toluene	108-88-3
trans-1,2-Dichloroethylene	156-60-5
Trichloroethene (TCE)	79-01-6
Trichlorofluoromethane	75-69-4
Vinyl chloride (Chloroethene)	75-01-4
Xylenes (total)	1330-20-7

CAS = Chemical Abstracts Service

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9 Groundwater Monitoring

This chapter includes a description of the proposed final status groundwater monitoring program and identifies the monitoring network, constituents to be sampled and analyzed, and the sample frequency. A detailed groundwater monitoring plan will include corresponding details (e.g., sampling protocols, quality assurance project plan) necessary to meet the requirements of WAC 173-303-806(4)(xx)(E) and (F)(I) and (II).

9.1 Final Status Groundwater Monitoring Program Determination

The appropriate groundwater monitoring program (i.e., detection monitoring, compliance monitoring, corrective action monitoring) is determined using the requirements in WAC 173-303-645(2)(a). If there is no statistically significant evidence of a release (contamination) at the point of compliance, the DWMU is monitored under WAC 173-303-645(9), "Detection Monitoring Program." If groundwater monitoring has shown statistically significant evidence of a release (contamination) at the point of compliance, the DWMU is monitored under WAC 173-303-645(10), "Compliance Monitoring Program." If the groundwater protection standard (which may be defined at the time of permit issuance, or when dangerous constituents from a regulated unit have been detected [WAC 173-303-645(3)]) is exceeded, a corrective action program is implemented and the DWMU is monitored under WAC 173-303-645(11), "Corrective Action Program."

To date, a release to the environment (statistically significant evidence of contamination at the point of compliance) has not been observed at LLBG Trenches 31 and 34. Therefore, LLBG Trenches 31 and 34 will be in detection monitoring under WAC 173-303-645(9) when they become a final status operating unit group in the Hanford Facility RCRA Permit.

9.2 Point of Compliance Monitoring

The point of compliance is defined in WAC 173-303-645(6)(a) as "…a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units." WAC 173-303-645(6)(b) further states, "The waste management area is the limit projected in the horizontal plane of the area on which waste will be placed during the active life of a regulated unit. The waste management area includes horizontal space taken up by any liner, dike, or other barrier designed to contain waste in a regulated unit. If the facility contains more than one regulated unit, the waste management area is described by an imaginary line circumscribing the several regulated units."

The results of the modeling described in Chapter 7 indicate that the locations of the five downgradient wells proposed for the monitoring well network (existing wells 299-W10-29 and 299-W10-30 and proposed wells T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3) span the range of particle distribution as released from the LLBG Trenches 31 and 34. The well placement is suitable for detecting releases to the water table from LLBG Trenches 31 and 34 under the evaluated range of conditions. The proposed well locations are intended to comply with the intent of WAC 173-303-645(6), which is to detect releases of waste constituents from the facility that would pose a potential risk to ground and surface water. The downgradient wells are proposed as the point of compliance wells. Additional details regarding selection of these wells are presented in Chapter 7. In order to monitor the vertical contamination distribution at the point of compliance, data from available deep wells will be evaluated from other groundwater monitoring programs in the immediate area of the DWMU. These additional wells will be defined in the groundwater monitoring plan and added to the monitoring well network for the DWMU as appropriate.

9.3 Proposed Groundwater Monitoring Network

The proposed groundwater monitoring network for LLBG Trenches 31 and 34 consists of one background (upgradient) and five point of compliance (downgradient) wells to monitor for releases to the water table from LLBG Trenches 31 and 34 (Figure 9-1). The monitoring well locations were evaluated under a range of 200 West P&T system operating conditions, or scenarios, presented in Table 5-1, including conditions after shutdown of P&T operations. Results of the simulations of the various scenarios are presented in Chapter 7.

Well attributes are summarized in Table 9-1 and Appendix E. Each of the proposed network wells have been, or will be, constructed according to WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Each well is, or will be, screened in the upper unconfined aquifer in order to yield sufficient groundwater for representative sampling. Sections 9.3.1 through 9.3.6 provide details supporting the selection of each of the proposed locations. Based on the results of the API calculator (Section 7.5 in Appendix G), the depths of the monitoring wells, which are screened across the top of the water table, are appropriate.

Where possible, the groundwater monitoring network is intended to meet the requirements of WAC 173-303-645(8)(a). Groundwater conditions on the Central Plateau have been impacted in different ways throughout the history of the Hanford Site. A description of the impacts to groundwater flow direction pertaining to LLBG Trenches 31 and 34 is presented in Section 3.3. WAC 173-303-645(8)(a)(i) states that wells must be appropriately sited to, "Represent the quality of background groundwater that has not been affected by leakage from a regulated unit." To meet the intent of WAC 173-303-645(8)(a)(i), a background (upgradient) well has been selected that would be representative of ambient conditions under the currently operating 200 West P&T remedy. It does not however, represent groundwater not affected by Hanford Site operations. Characterization of the contaminated groundwater, including concentrations of dangerous constituents and parameters, will be performed after sufficient samples have been collected in the first 2 years of monitoring to conduct statistical analyses.

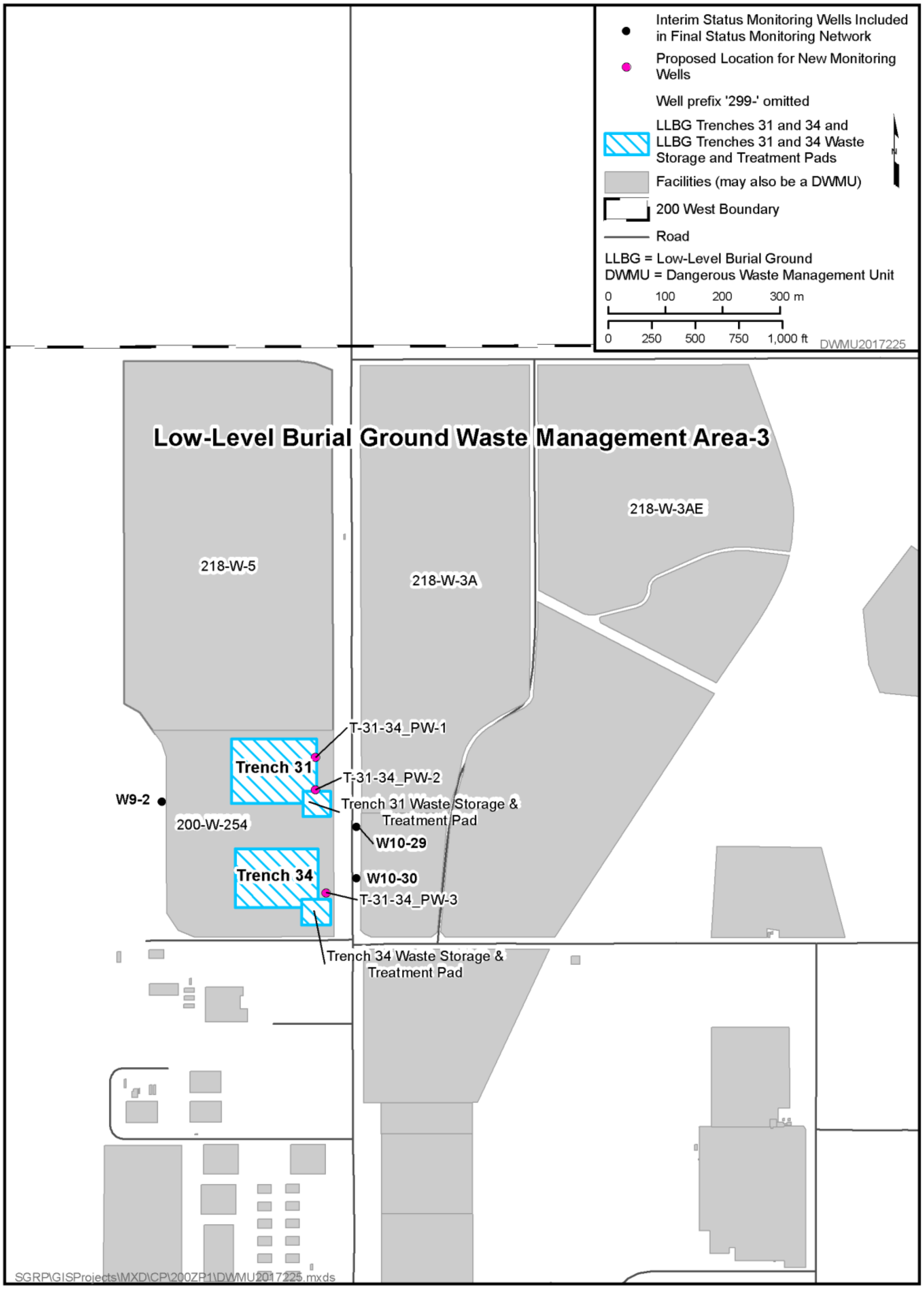

Figure 9-1. Proposed Final Status Groundwater Monitoring Network for LLBG Trenches 31 and 34

Table 9-1. Attributes for Wells in the LLBG Trenches 31 and 34 Groundwater Monitoring Network

Well Name	Completion Date	Easting* (m)	Northing* (m)	Top of Casing Elevation (m [ft]) (NAVD88)	Water Table Elevation (m [ft]) (amsl)	Water Depth (m [ft] bgs)	Depth of Water in Screen (m [ft])	Water-Level Date
299-W9-2	9/22/2011	565742.21	136872.84	223.77 (734.15)	137.0 (449.5)	87.6 (287.4)	9.8 (32.2)	03/13/2015
299-W10-29	3/13/2006	566082.98	136828.74	212.37 (696.75)	136.8 (448.8)	75.6 (248.0)	9.8 (32.2)	03/13/2015
299-W10-30	4/3/2006	566082.78	136739.33	211.65 (694.39)	136.8 (448.8)	74.9 (245.6)	9.7 (31.8)	03/13/2015
T-31-34_PW-1	TBD	566081.99	136951.00	TBD	TBD	TBD	9.1 (30)	TBD
T-31-34_PW-2	TBD	566082.98	136893.38	TBD	TBD	TBD	9.1 (30)	TBD
T-31-34_PW-3	TBD	566084.36	136654.20	TBD	TBD	TBD	9.1 (30)	TBD

Reference: NAVD88, *North American Vertical Datum of 1988*.

amsl = above mean sea level

bgs = below ground surface

TBD = to be determined. Information will be obtained after well construction.

* Coordinates are in Washington State Plane (south zone), NAD83, *North American Datum of 1983*; 1991 adjustment.

Note: Proposed well coordinates, elevations, and projected well design are estimates and are subject to modification based on final well location survey and conditions encountered during drilling.

WAC 173-303-645(8)(h), states,

> "In detection monitoring…data on each dangerous constituent specified in the permit will be collected from background wells and at the compliance point(s). The number and kinds of samples collected to establish background must be appropriate for the form of statistical test employed, following generally accepted statistical principles. The sample size must be as large as necessary to ensure with reasonable confidence that a contaminant release to groundwater from a facility will be detected…" However, since WAC 173-303-645(8)(h)(v) allows that, "Another statistical test method may be submitted by the owner or operator and approved by the department."

The process for selection of a statistical method is found in Appendix H. Selection of the statistical method for use in LLBG Trenches 31 and 34 is discussed in Section 9.5.

Based on current groundwater flow direction to the east (Section 2.13 in DOE/RL-2016-66), the selected point of compliance wells will provide representative samples of the quality of groundwater passing the point of compliance (WAC 173-303-645(8)(a)(ii)). These locations allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the WMA to the uppermost aquifer (WAC 173-303-645(8)(a)(iii)). Using the API calculator to assess the vertical component of contaminant migration indicates that the wells, which are screened in the top of the uppermost unconfined aquifer are suitable for monitoring (Section 7.5 in Appendix G) and determination of compliance with groundwater protections standards (WAC 173-303-645(10)(a)).

9.3.1 Groundwater Monitoring Well 299-W9-2

Groundwater monitoring well 299-W9-2 is proposed as a background well. It was constructed in 2011 to the standards of WAC 173-160. This well is also used in the interim status groundwater monitoring network for LLBG WMA-3. The well is upgradient and is screened from elevation 135.9 m (445.8 ft) to elevation 125.2 m (410.8 ft) (Appendix E). Based on 2015 water elevation data, well 299-W9-2 is screened across the upper 5.05 m (16.6 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction at well 299-W9-2 is predominantly to the east-northeast at this well (Figure 3-9); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release. The results of particle tracking calculations (Figures 7-13 through 7-15) and the results of transport calculations (Figures 7-10 through 7-12) indicate that this well will remain upgradient of LLBG Trenches 34 and 34 under the scenarios evaluated. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that the injection of treated water associated with the final 200 West P&T system could dilute the water at this location by as much as 25% for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.25 shown on the injection injected treated water dilution breakthrough curve in Figure 7-1).

9.3.2 Groundwater Monitoring Well 299-W10-29

Groundwater monitoring well 299-W10-29 is proposed as a point of compliance well. It was constructed in 2006 to the standards of WAC 173-160. This well is also used in the interim status groundwater monitoring network for LLBG WMA-3. The well is downgradient of LLBG Trenches 31 and 34 and is screened from elevation 135.9 m (445.9 ft) to elevation 125.2 m (410.8 ft) (Appendix E). Based on 2015 water elevation data, well 299-W10-29 is screened across the upper 9.8 m (32.2 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the east at this well (Figure 3-9); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of particle-tracking calculations (Figures 7-13 through 7-15) indicate that this well is in the area of particle tracks for most (two out of three particle-tracking scenarios) of the groundwater flow scenarios evaluated. The results of transport calculations (Figures 7-10 and 7-12) also indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-16 through 7-18) indicate that this well is located centrally within the detectable area for scenarios 1 and 2 and close to but outside of the estimated area of detectability for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well for scenario 1 (Figure 7-6) indicate that some dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 46% (corresponding to a release unit concentration of approximately 0.54 as shown in Figure 7-6 through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 59% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.59 shown on the injection injected treated water dilution breakthrough curve in Figure 7-2). This could result in further dilution of the release concentration by some amount up to but likely less than 59%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination a should there be a release from LLBG Trenches 31 and 34 under the range of operating conditions evaluated.

9.3.3 Groundwater Monitoring Well 299-W10-30

Groundwater monitoring well 299-W10-30 is proposed as a point of compliance well. It was constructed in 2006 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for LLBG WMA-3. The well is downgradient of LLBG Trenches 31 and 34 and is screened from elevation 136.5 m (447.8 ft) down to elevation 125.8 m (412.7 ft) (Appendix E). Based on

2015 water elevation data, well 299-W10-30 is screened across the upper 9.7 m (31.8 ft) of the uppermost unconfined aquifer (Table 9-1) and yields sufficient groundwater for representative sampling.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the east at this well (Figure 3-9); however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of particle-tracking calculations (Figures 7-13 through 7-15) indicate this well is in an area of particle tracks for the scenarios evaluated. The results of transport calculations (Figures 7-10 through 7-12) also indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-16 through 7-18) indicate that this well is located centrally within the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-7) indicate that no substantial dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 29% (corresponding to a release unit concentration of approximately 0.71 as shown in Figure 7-7) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 39% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.39 as shown on the injection injected treated water dilution breakthrough curve in Figure 7-3). This could result in further dilution of the release concentration by some amount up to but likely less than 39%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale. Groundwater samples from this location are representative of groundwater quality at the point of compliance. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination should there be a release from LLBG Trenches 31 and 34 under the range of operating conditions evaluated.

9.3.4 Groundwater Monitoring Well T-31-34_PW-1

Groundwater monitoring well T-31-34_PW-1 is a proposed point of compliance well. If the well location is approved, it will be constructed according to WAC 173-160. The proposed location for the well is downgradient of LLBG Trenches 31 and 34 and conceptually, it will be constructed with 10.7 m (35 ft) of screen placed from approximately 1.5 m (5 ft) above and extending to 9.1 m (30 ft) below the uppermost portion of the unconfined aquifer. The proposed screened interval is anticipated to yield sufficient groundwater for representative sampling when constructed.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the east-southeast at this proposed well location; however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of the relative detectability evaluation (Figures 7-16 through 7-18) indicate that this well is located in the estimated area of detectability for the scenarios evaluated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-22) indicate some dilution of the release concentration is expected at the well location during 200 West P&T system operations.

The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 51% (corresponding to a release unit concentration of approximately 0.49 as shown in Figure 7-22 through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 91% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.91 shown on the injection injected treated water dilution breakthrough curve in Figure 7-19). This could result in further dilution of the release concentration by some amount up to but likely less than 91%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale.

Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination should there be a release from LLBG Trenches 31 and 34 under the range of operating conditions evaluated.

9.3.5 Groundwater Monitoring Well T-31-34_PW-2

Groundwater monitoring well T-31-34_PW-2 is a proposed point of compliance well. If the well location is approved, it will be constructed according to WAC 173-160. The proposed location for the well is downgradient of LLBG Trenches 31 and 34 and conceptually, it will be constructed with 10.7 m (35 ft) of screen placed from approximately 1.5 m (5 ft) above and extending to 9.1 m (30 ft) below the uppermost portion of the unconfined aquifer. The proposed screened interval is anticipated to yield sufficient groundwater for representative sampling when constructed.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the east-southeast at this proposed well location; however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of the relative detectability evaluation (Figures 7-16 through 7-18) indicate that this well is centrally located within the estimated area of detectability for the groundwater flow scenarios simulated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-23) indicate minimal dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 7% (corresponding to a release unit concentration of 0.93 as shown in Figure 7-23) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 80% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.80 shown on the injection injected treated water dilution breakthrough curve in Figure 7-20). This could result in further dilution of the release concentration by some amount up to but likely less than 48%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale.

Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination should there be a release from LLBG Trenches 31 and 34 under the range of operating conditions evaluated.

9.3.6 Groundwater Monitoring Well T-31-34_PW-3

Groundwater monitoring well T-31-34_PW-3 is a proposed point of compliance well. If the well location is approved, it will be constructed according to WAC 173-160. The proposed location for the well is downgradient of LLBG Trenches 31 and 34 and conceptually, it will be constructed with 10.7 m (35 ft) of screen placed from approximately 1.5 m (5 ft) above and extending to 9.1 m (30 ft) below the uppermost portion of the unconfined aquifer. The proposed screened interval is anticipated to yield sufficient groundwater for representative sampling when constructed.

Under 200 West P&T system operations in 2016, groundwater flow direction is predominantly to the east-southeast at this proposed well location; however, future groundwater flow direction may be impacted by ongoing 200 West P&T system operations (i.e., changes in operating conditions). Particle-tracking simulations and transport modeling were performed to evaluate the impacts on groundwater flow of various 200 West P&T system flow rates, including a scenario that assumed no flow through the 200 West P&T system (Appendix G and Chapter 7). Within each overall P&T system flow rate scenario, the simulations evaluated the impact of varying the injection rates at 200 West P&T system injection wells. Using this information, monitoring locations were evaluated against the ability to detect a release.

The results of the relative detectability evaluation (Figures 7-16 through 7-18) indicate this well is located at the southern edge of the estimated area of detectability for the groundwater flow scenarios simulated. The release concentration breakthrough curves for this well for scenario 1 (Figure 7-24) indicate that minimal dilution of the release concentration is expected at the well location during 200 West P&T system operations. The modeling performed for the most likely future 200 West P&T system operating conditions (scenario 1, sub-scenario A) calculates that a unit concentration released at the waste site would be reduced by approximately 11% (corresponding to a release unit concentration of 0.89 as shown in Figure 7-24) through the processes of advection, dispersion, and recharge, by the time it arrives at the monitoring well. The modeling performed also calculates that the injection of treated water associated with the final 200 West P&T system could, over time, contribute as much as 31% of the water at the well location for the most likely future 200 West P&T system operating conditions for scenario 1 (corresponding to the value of about 0.31 shown on the injection injected treated water dilution breakthrough curve in Figure 7-21). This could result in further dilution of the release concentration by some amount up to but likely less than 31%, because some amount of this injection dilution is already accounted for in the assumption of instantaneous mixing in both the release concentration dilution calculations and injected treated water dilution calculations. The actual amount of dilution of the release concentration that would result from the treated water injection would depend upon the relative locations of the release, of the injection well(s), and of the monitoring well, and other factors at the field-scale.

Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination should there be a release from LLBG Trenches 31 and 34 under the range of operating conditions evaluated.

9.4 Constituent List and Frequency

The proposed LLBG Trenches 31 and 34 final status groundwater monitoring network detailed in this report consists of one upgradient well (299-W9-2) and five downgradient wells (299-W10-29, 299-W10-30, T-31-34_PW-1, T-31-34_PW-2, and T-31-34_PW-3). The upgradient well (299-W9-2) and downgradient wells (299-W10-29 and 299-W10-30) are part of the LLBG WMA-3 interim status groundwater monitoring network (DOE/RL-2009-68, Rev. 2) and are shown in Figure 9-1.

For a detection monitoring program, WAC 173-303-645(9)(a) requires, “The owner or operator must monitor for indicator parameters (e.g., pH, specific conductance, total organic carbon (TOC), total organic halogen (TOX), or heavy metals), waste constituents, or reaction products that provide a reliable indication of the presence of dangerous constituents in groundwater. The department will specify the parameters or constituents to be monitored in the facility permit…” Based on the analysis in Chapter 8, 140 waste constituents were selected to detect and monitor groundwater impacts from potential dangerous waste releases at LLBG Trenches 31 and 34.

Table 9-2 identifies the proposed monitoring network and sampling frequency for LLBG Trenches 31 and 34, with the addition of arsenic, cadmium, and mercury (added at the discretion of Ecology). The proposed site-specific monitoring constituents (Table 9-3) will be sampled quarterly for the first 2 years of monitoring. After background concentrations are determined, the proposed monitoring constituents will be sampled semi-annually. Field measurements (pH, dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, and turbidity) will be collected each time a well is sampled. Water-level measurements at each monitoring well will be determined each time a sample is obtained (WAC 173-303-645(8)(f)). Analytical performance, data evaluation, reporting, sampling protocols, and quality assurance requirements will be specified in the final status groundwater monitoring plan to be prepared for LLBG Trenches 31 and 34.

Table 9-2. Monitoring Wells and Sample Schedule for LLBG Trenches 31 and 34

Well Name	Purpose	WAC Compliant	Water Level	Site-Specific Constituents to Detect Release from Regulated Unit[a]									Dangerous Wastes[b]	Field Parameters[g]
				Volatile Organic Compounds[c]	Semivolatile Organic Compounds[d]	Herbicides[e]	Formic acid	Formaldehyde	Hydrazine	Methanol	Nitroglycerine	Metals[f]	Table 9-4	
299-W9-2	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
299-W10-29	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
299-W10-30	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
T-31-34_PW-1	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
T-31-34_PW-2	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
T-31-34_PW-3	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S

Note: Complete reference citations are provided in Chapter 11.

a. Monitoring constituents will be sampled quarterly for the first 2 years of monitoring to determine background concentrations. After background concentrations are determined, these constituents will be monitored semiannually.

b. To establish background concentrations in accordance with 16-NWP-143, which addressed monitoring of LLBG containing mixed waste, and to support collection of sufficient samples to perform statistical testing (e.g., eight samples), quarterly sampling for Ecology Publication No. 97-407 Appendix 5 constituents will be performed for a 2-year period.

c. Volatile organic compounds are provided in Table 9-3 and include 1-butanol (n-butyl alcohol); 1,1-dichloroethane; 1,1-dichloroethene (1,1-dichloroethylene); 1,1,1-trichloroethane; 1,1,1,2-tetrachloroethane; 1,1,2-trichloro-1,2,2-trifluoroethane; 1,1,2-trichloroethane; 1,1,2,2-tetrachloroethane; 1,2-dibromo-3-chloropropane; 1,2-dibromoethane; 1,2-dichloroethane; 1,2-dichloropropane; 1,4-dichlorobenzene; 2-butanone (methyl ethyl ketone); 2-chloroethyl vinyl ether; 2-nitropropane; 2-propanone (acetone); 4-methyl-2-pentanone (methyl isobutyl ketone); acetonitrile (methyl cyanide); acrolein; acrylamide; acrylonitrile; benzene; benzyl chloride; bromoform; carbon disulfide; carbon tetrachloride; chlorobenzene; chloroform, cyclohexane; cyclohexanone, dichlorodifluoromethane; ethyl acetate, ethyl ether, ethyl methacrylate; ethyl methanesulfonate; ethylbenzene, isobutanol (isobutyl alcohol); isopropylbenzene; methacrylonitrile; methyl bromide (bromomethane); methyl chloride (chloromethane); methyl iodide (iodomethane); methyl methacrylate; methylene bromide (dibromomethane); methylene chloride; propionitrile (ethyl cyanide); tetrachloroethene; tetrahydrofuran; toluene, trans-1,2-dichloroethylene; trichloroethylene (TCE), trichlorofluoromethane, vinyl chloride (chloroethene), and xylene (total).

d. Semivolatile organic compounds are provided in Table 9-3 and include 1-naphthylamine; 1,2-dichlorobenzene (o-dichlorobenzene); 1,2-diphenylhydrazine; 1,2,4,5-tetrachlorobenzene; 1,4-dioxane; 1,4-naphthoquinone; 2-acetylaminofluorene; 2-chlorophenol; 2-methylphenol (o-cresol); 2-naphthylamine; 2-picoline; 2,3,4,6-tetrachlorophenol; 2,4-dichlorophenol; 2,4-dimethylphenol; 2,4-dinitrophenol; 2,4-dinitrotoluene; 2,4,6-trichlorophenol; 2,6-dichlorophenol; 2,6-dinitrotoluene;

Table 9-2. Monitoring Wells and Sample Schedule for LLBG Trenches 31 and 34

Well Name	Purpose	WAC Compliant	Water Level	Site-Specific Constituents to Detect Release from Regulated Unit[a]									Dangerous Wastes[b]	Field Parameters[g]
				Volatile Organic Compounds[c]	Semivolatile Organic Compounds[d]	Herbicides[e]	Formic acid	Formaldehyde	Hydrazine	Methanol	Nitroglycerine	Metals[f]	Table 9-4	

3-methylcholanthrene; 3-methylphenol (m-cresol); 3,3′-dichlorobenzidine; 3,3′-dimethylbenzidine; 4-methylphenol (p-cresol); 4,4'-methylenebis(2-chloroaniline); 4,6-dinitro-o-cresol (4,6-dinitro-2-methyl phenol); 4-chloro-3-methylphenol (p-chloro-m-cresol); 5-nitro-o-toluidine; 7,12-dimethylbenz[a]anthracene; acetophenone; alpha, alpha-Dimethylphenethylamine; aniline; bis(2-chloro-1-methylethyl) ether (2,2'-oxybis(1-chloropropane)); bis(2-chloroethoxy)methane; bis(2-chloroethyl)ether; chlorobenzilate; diallate; diethyl phthalate; dimethoate; dimethyl phthalate; disulfoton; famphur; hexachlorophene; hexachloropropene; isodrin; isosafrole; kepone; m-dichlorobenzene; methapyrilene; methyl parathion; nitrobenzene; n-nitrosodiethylamine; n-nitrosodimethylamine; n-nitrosodi-n-butylamine; n-nitroso-di-n-dipropylamine (n-nitrosodipropylamine); n-nitrosopiperidine; n-nitrosopyrrolidine; O,O-diethyl-O-pyrazinylthiophosphate; o-toluidine; p-(dimethylamino)azobenzene; parathion; p-chloroaniline (4-chloroaniline); pentachlorobenzene; pentachloroethane; pentachloronitrobenzene; pentachlorophenol; phenacetin; phenol; phorate; p-nitroaniline (4-nitroaniline); p-nitrophenol (4-nitrophenol); pronamide; pyridine; safrole; sym-trinitrobenzene; tetraethyl dithiopyrophosphate; and thiophenol.

e. Herbicides are provided in Table 9-3 and include 2,4-D (2,4-dichlorophenoxyacetic acid); 2,4,5-T (2,4,5-trichlorophenoxyacetic acid); and 2,4,5-TP Silvex (2-(2,4,5-trichlorophenoxy)propionic acid).

f. Metals include arsenic, cadmium, and mercury.

g. Field parameters include pH, dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, and turbidity. Field parameters will be measured at each sample event (quarterly for the first 2 years of monitoring and semiannually thereafter).

A = annually

E = each time the well is sampled

LLBG = Low-Level Burial Grounds

Q = quarterly

S = semiannually

WAC = *Washington Administrative Code*

Y = well is, or will be, constructed as a resource protection well (WAC 173-160, “Minimum Standard for Construction and Maintenance of Wells”)

Table 9-3. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Arsenic	7440-38-2
Cadmium	7440-43-9
Mercury	7439-97-6
1-Butanol (n-Butyl alcohol)	71-36-3
1-Naphthylamine	134-32-7
1,1-Dichloroethane	75-34-3
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4
1,1,1-Trichloroethane	71-55-6
1,1,1,2-Tetrachloroethane	630-20-6
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,1,2-Trichloroethane	79-00-5
1,1,2,2-Tetrachloroethane	79-34-5
1,2-Dibromo-3-chloropropane	96-12-8
1,2-Dibromoethane	106-93-4
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1
1,2-Dichloroethane	107-06-2
1,2-Dichloropropane	78-87-5
1,2-Diphenylhydrazine	122-66-7
1,2,4,5-Tetrachlorobenzene	95-94-3
1,4-Dichlorobenzene	106-46-7
1,4-Dioxane	123-91-1
1,4-Naphthoquinone	130-15-4
2-Acetylaminofluorene	53-96-3
2-Butanone (Methyl ethyl ketone)	78-93-3
2-Chloroethyl vinyl ether	110-75-8
2-Chlorophenol	95-57-8
2-Methylphenol (o-Cresol)	95-48-7
2-Naphthylamine	91-59-8

Table 9-3. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
2-Nitropropane	79-46-9
2-Picoline	109-06-8
2-Propanone (Acetone)	67-64-1
2,3,4,6-Tetrachlorophenol	58-90-2
2,4-D (2,4-Dichlorophenoxyacetic acid)	94-75-7
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)	93-76-5
2,4,5-TP Silvex (2-(2,4,5-trichlorophenoxy)propionic acid)	93-72-1
2,4,6-Trichlorophenol	88-06-2
2,6-Dichlorophenol	87-65-0
2,6-Dinitrotoluene	606-20-2
3-Methylcholanthrene	56-49-5
3-Methylphenol (m-Cresol)	108-39-4
3,3′-Dichlorobenzidine	91-94-1
3,3′-Dimethylbenzidine	119-93-7
4,4'-Methylenebis(2-chloroaniline)	101-14-4
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1
4-Methylphenol (p-cresol)	106-44-5
5-Nitro-o-toluidine	99-55-8
7,12-Dimethylbenz[a]anthracene	57-97-6
Acetonitrile (Methyl cyanide)	75-05-8
Acetophenone	98-86-2
Acrolein	107-02-8

Table 9-3. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Acrylamide	79-06-1
Acrylonitrile	107-13-1
alpha, alpha-Dimethylphenethylamine	122-09-8
Aniline	62-53-3
Benzene	71-43-2
Benzyl chloride	100-44-7
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))	108-60-1
Bis(2-chloroethoxy)methane	111-91-1
Bis(2-chloroethyl)ether	111-44-4
Bromoform	75-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chlorobenzilate	510-15-6
Chloroform	67-66-3
Cyclohexane	110-82-7
Cyclohexanone	108-94-1
Diallate	2303-16-4
Dichlorodifluoromethane	75-71-8
Diethyl phthalate	84-66-2
Dimethoate	60-51-5
Dimethyl phthalate	131-11-3
Disulfoton	298-04-4
Ethyl acetate	141-78-6
Ethyl ether	60-29-7
Ethyl methacrylate	97-63-2
Ethyl methanesulfonate	62-50-0
Ethylbenzene	100-41-4

Table 9-3. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Famphur	52-85-7
Formaldehyde	50-00-0
Formic acid	64-18-6
Hexachlorophene	70-30-4
Hexachloropropene	1888-71-7
Hydrazine	302-01-2
Isobutanol (Isobutyl alcohol)	78-83-1
Isodrin	465-73-6
Isopropylbenzene	98-82-8
Isosafrole	120-58-1
Kepone	143-50-0
m-Dichlorobenzene	541-73-1
Methacrylonitrile	126-98-7
Methanol	67-56-1
Methapyrilene	91-80-5
Methyl bromide (Bromomethane)	74-83-9
Methyl chloride (Chloromethane)	74-87-3
Methyl iodide (Iodomethane)	74-88-4
Methyl methacrylate	80-62-6
Methyl parathion	298-00-0
Methylene bromide (Dibromomethane)	74-95-3
Methylene chloride	75-09-2
Nitrobenzene	98-95-3
Nitroglycerine	55-63-0
n-Nitrosodiethylamine	55-18-5
n-Nitrosodimethylamine	62-75-9
n-Nitrosodi-n-butylamine	924-16-3
n-Nitroso-di-n-dipropylamine (n-Nitrosodipropylamine)	621-64-7

Table 9-3. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
n-Nitrosopiperidine	100-75-4
n-Nitrosopyrrolidine	930-55-2
O,O-Diethyl-O-pyrazinylthiophosphate	297-97-2
o-Toluidine	95-53-4
p-(Dimethylamino)azobenzene	60-11-7
Parathion	56-38-2
p-Chloroaniline (4-Chloroaniline)	106-47-8
Pentachlorobenzene	608-93-5
Pentachloroethane	76-01-7
Pentachloronitrobenzene	82-68-8
Pentachlorophenol	87-86-5
Phenacetin	62-44-2
Phenol	108-95-2
Phorate	298-02-2
p-Nitroaniline (4-Nitroaniline)	100-01-6
p-Nitrophenol (4-Nitrophenol)	100-02-7
Pronamide	23950-58-5
Propionitrile (Ethyl cyanide)	107-12-0
Pyridine	110-86-1
Safrole	94-59-7
sym-Trinitrobenzene	99-35-4
Tetrachloroethene	127-18-4
Tetraethyl dithiopyrophosphate	3689-24-5
Tetrahydrofuran	109-99-9
Thiophenol	108-98-5
Toluene	108-88-3
trans-1,2-Dichloroethylene	156-60-5
Trichloroethene (TCE)	79-01-6

Table 9-3. Proposed Groundwater Monitoring Constituents for LLBG Trenches 31 and 34

Waste Constituent	CAS Number
Trichlorofluoromethane	75-69-4
Vinyl chloride (Chloroethene)	75-01-4
Xylenes (total)	1330-20-7

CAS = Chemical Abstracts Service

In accordance with 16-NWP-143, performing 1 year of background monitoring for WAC 173-303-110(3)(c) and (7) constituents was established for burial grounds containing mixed waste. While Ecology Letter 15-NWP-157 did not specify monitoring of Appendix 5 constituents for Trenches 31 and 34, it will be included as a conservative measure. WAC 173-303-110(3)(c) references Ecology Publication No. 97-407, and WAC 173-303-110(7) references Appendix 5 of Ecology Publication No. 97-407. Accordingly, the constituents identified in Appendix 5 of Ecology Publication No. 97-407 (Table 9-4) will be sampled for background monitoring. However, to support collection of sufficient samples to perform statistical testing (e.g., eight samples) and establish background concentrations, sampling for Ecology Publication No. 97-407 Appendix 5 constituents will be extended to a 2-year period and performed on a quarterly basis, after which sampling to establish background concentrations will be discontinued. Section 9.5 provides details on the number of sample data required to determine a statistical method.

Statistical evaluation of sampling results will be performed for site-specific monitoring constituents (Table 9-3) and the Appendix 5 dangerous wastes (Table 9-4), as appropriate. Information on the statistical method is provided in Section 9.7.

When the groundwater monitoring plan for LLBG Trenches 31 and 34 is incorporated into the Hanford Facility RCRA Permit, it will replace any other groundwater monitoring plan(s) associated specifically with this DWMU under interim status.

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Inorganic Constituents			
Antimony	7440-36-0	Mercury	7439-97-6
Arsenic	7440-38-2	Nickel	7440-02-0
Barium	7440-39-3	Selenium	7782-49-2
Beryllium	7440-41-7	Silver	7440-22-4
Cadmium	7440-43-9	Sulfide	18496-25-8
Chromium	7440-47-3	Thallium	7440-28-0
Cobalt	7440-48-4	Tin	7440-31-5
Copper	7440-50-8	Vanadium	7440-62-2
Cyanide	57-12-5	Zinc	7440-66-6
Lead	7439-92-1	--	--

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Volatile Organic Compounds			
1,1-Dichloroethane	75-34-3	Carbon tetrachloride	56-23-5
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	Chlorobenzene	108-90-7
1,1,1-Trichloroethane	71-55-6	Chloroethane	75-00-3
1,1,1,2-Tetrachloroethane	630-20-6	Chloroform	67-66-3
1,1,2-Trichloroethane	79-00-5	Chloroprene	126-99-8
1,1,2,2-Tetrachloroethane	79-34-5	Dibromochloromethane	124-48-1
1,2-Dibromo-3-chloropropane	96-12-8	p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7
1,2-Dibromoethane	106-93-4	Dichlorodifluoromethane	75-71-8
1,2-Dichloroethane	107-06-2	Ethylbenzene	100-41-4
1,2-Dichloropropane	78-87-5	Ethyl methacrylate	97-63-2
trans-1,2-Dichloroethylene	156-60-5	Isobutanol (Isobutyl alcohol)	78-83-1
1,2,3-Trichloropropane	96-18-4	Methacrylonitrile	126-98-7
cis-1,3-Dichloropropene	10061-01-5	Methyl bromide (Bromomethane)	74-83-9
trans-1,3-Dichloropropene	10061-02-6	Methyl chloride (Chloromethane)	74-87-3
trans-1,4-Dichloro-2-butene	110-57-6	Methyl iodide (Iodomethane)	74-88-4
2-Butanone (Methyl ethyl ketone; MEK)	78-93-3	Methyl methacrylate	80-62-6
2-Propanone (acetone)	67-64-1	Methylene bromide (Dibromomethane)	74-95-3
2-Hexanone (Methyl butyl ketone)	591-78-6	Methylene chloride	75-09-2
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1	Propionitrile (Ethyl cyanide)	107-12-0
Acetonitrile (Methyl cyanide)	75-05-8	Styrene	100-42-5
Acrolein	107-02-8	Tetrachloroethene	127-18-4
Acrylonitrile	107-13-1	Toluene	108-88-3
Allyl chloride	107-05-1	Trichloroethene (TCE)	79-01-6
Benzene	71-43-2	Trichlorofluoromethane	75-69-4
Bromodichloromethane	75-27-4	Vinyl acetate	108-05-4
Bromoform	75-25-2	Vinyl chloride (Chloroethene)	75-01-4
Carbon disulfide	75-15-0	Xylenes (total)	1330-20-7

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Semivolatile Organic Compounds			
1-Naphthylamine	134-32-7	Dimethyl phthalate	131-11-3
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	Di-n-butyl phthalate	84-74-2
1,2,4-Trichlorobenzene	120-82-1	m-Dinitrobenzene	99-65-0
1,2,4,5-Tetrachlorobenzene	95-94-3	Di-n-octylphthalate	117-84-0
1,4-Dioxane	123-91-1	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	88-85-7
1,4-Naphthoquinone	130-15-4	Diphenylamine	122-39-4
2-Acetylaminofluorene	53-96-3	Disulfoton	298-04-4
2-Chloronaphthalene	91-58-7	Ethyl methanesulfonate	62-50-0
2-Chlorophenol	95-57-8	Famphur	52-85-7
2-Methylphenol (o-cresol)	95-48-7	Fluoranthene	206-44-0
2-Methylnaphthalene	91-57-6	9H-Fluorene (Fluorene)	86-73-7
2-Naphthylamine	91-59-8	Hexachlorobenzene	118-74-1
2-Nitrophenol (o-Nitrophenol)	88-75-5	Hexachlorobutadiene	87-68-3
2-Picoline	109-06-8	Hexachlorocyclopentadiene	77-47-4
2,3,4,6-Tetrachlorophenol	58-90-2	Hexachloroethane	67-72-1
2,4-Dichlorophenol	120-83-2	Hexachlorophene	70-30-4
2,4-Dimethylphenol	105-67-9	Hexachloropropene	1888-71-7
2,4-Dinitrophenol	51-28-5	Indeno(1,2,3-cd)pyrene	193-39-5
2,4-Dinitrotoluene	121-14-2	Isodrin	465-73-6
2,4,5-Trichlorophenol	95-95-4	Isophorone	78-59-1
2,4,6-Trichlorophenol	88-06-2	Isosafrole	120-58-1
2,6-Dichlorophenol	87-65-0	Kepone	143-50-0
2,6-Dinitrotoluene	606-20-2	Methapyrilene	91-80-5
3-Methylcholanthrene	56-49-5	Methyl methanesulfonate	66-27-3
3-Methylphenol (m-Cresol)	108-39-4	Methyl parathion	298-00-0
4-Methylphenol (p-cresol)	106-44-5	Naphthalene	91-20-3
3,3′-Dichlorobenzidine	91-94-1	Nitrobenzene	98-95-3
3,3′-Dimethylbenzidine	119-93-7	o-Nitroaniline (2-Nitroaniline)	88-74-4
4-Aminobiphenyl	92-67-1	m-Nitroaniline (3-Nitroaniline)	99-09-2
4-Bromophenyl phenyl ether	101-55-3	p-Nitroaniline (4-Nitroaniline)	100-01-6

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7	p-Nitrophenol (4-Nitrophenol)	100-02-7
4-Chlorophenyl phenyl ether	7005-72-3	N-Nitrosodi-n-butylamine	924-16-3
4-Nitroquinoline 1-oxide	56-57-5	N-Nitrosodiethylamine	55-18-5
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1	N-Nitrosodimethylamine	62-75-9
5-Nitro-o-toluidine	99-55-8	N-Nitrosodiphenylamine	86-30-6
7,12-Dimethylbenz[a]anthracene	57-97-6	n-Nitroso-di-n-dipropylamine (N-Nitrosodipropylamine; Di-n-propylnitrosamine)	621-64-7
Acenaphthene	83-32-9	N-Nitrosomethylethalamine	10595-95-6
Acenaphthylene	208-96-8	n-Nitrosomorpholine	59-89-2
Acetophenone	98-86-2	N-Nitrosopiperidine	100-75-4
Aniline	62-53-3	N-Nitrosopyrrolidine	930-55-2
Anthracene	120-12-7	Parathion	56-38-2
Aramite	140-57-8	Pentachlorobenzene	608-93-5
Benz[a]anthracene (Benzo[a]anthracene)	56-55-3	Pentachloroethane	76-01-7
Benz[e]acephenanthrylene (Benzo[b]fluoranthene)	205-99-2	Pentachloronitrobenzene	82-68-8
Benzo[k]fluoranthene	207-08-9	Pentachlorophenol	87-86-5
Benzo[ghi]perylene	191-24-2	Phenacetin	62-44-2
Benzo[a]pyrene	50-32-8	Phenanthrene	85-01-8
Benzyl alcohol	100-51-6	Phenol	108-95-2
Bis(2-chloroethoxy)methane	111-91-1	p-Phenylenediamine	106-50-3
Bis(2-chloroethyl)ether	111-44-4	Phorate	298-02-2
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))	108-60-1	Pronamide	23950-58-5
Bis(2-ethylhexyl) phthalate	117-81-7	Pyrene	129-00-0
Butylbenzylphthalate	85-68-7	Pyridine	110-86-1
p-Chloroaniline (4-Chloroaniline)	106-47-8	Safrole	94-59-7
Chlorobenzilate	510-15-6	Tetraethyl dithiopyrophosphate	3689-24-5
Chrysene	218-01-9	o-Toluidine	95-53-4
Diallate	2303-16-4	O,O,O-Triethyl phosphorothioate	126-68-1
Dibenz[a,h]anthracene	53-70-3	sym-Trinitrobenzene	99-35-4

Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring

Constituent	CAS Number	Constituent	CAS Number
Dibenzofuran	132-64-9	Aroclor 1016	12674-11-2
m-Dichlorobenzene (1,3-Dichlorobenzene)	541-73-1	Aroclor 1221	11104-28-2
Diethyl phthalate	84-66-2	Aroclor 1232	11141-16-5
O,O-Diethyl O-2-pyrazinyl phosphorothioate	297-97-2	Aroclor 1242	53469-21-9
Dimethoate	60-51-5	Aroclor 1248	12672-29-6
p-(Dimethylamino)azobenzene	60-11-7	Aroclor 1254	11097-69-1
alpha, alpha-Dimethylphenethylamine	122-09-8	Aroclor 1260	11096-82-5
Pesticides			
4,4′-DDD	72-54-8	Endosulfan I	959-98-8
4,4′-DDE	72-55-9	Endosulfan II	33213-65-9
4,4′-DDT	50-29-3	Endosulfan sulfate	1031-07-8
Aldrin	309-00-2	Endrin	72-20-8
alpha-BHC	319-84-6	Endrin aldehyde	7421-93-4
beta-BHC	319-85-7	Heptachlor	76-44-8
delta-BHC	319-86-8	Heptachlor epoxide	1024-57-3
gamma-BHC (Lindane)	58-89-9	Methoxychlor	72-43-5
Chlordane	57-74-9	Toxaphene	8001-35-2
Dieldrin	60-57-1	--	--
Herbicides			
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Silvex; 2,4,5-TP	93-72-1
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5	--	--
Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans			
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	Polychlorinated dibenzofurans	N/A
Polychlorinated dibenzo-p-dioxins	N/A	--	--

Note: This table identifies the dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*.

CAS = Chemical Abstracts Service

N/A = not applicable

9.5 Statistical Method

At this time, a specific statistical method for the determination of statistically significant evidence of contamination from LLBG Trenches 31 and 34 cannot be determined. EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, guidance requires a minimum of eight samples to be able to define background. The proposed compliance wells for LLBG Trenches 31 and 34 include two existing and three proposed wells. Given that three of the compliance wells are not yet drilled, there is insufficient data to assess baseline conditions and determine a statistical method.

An accelerated sampling program is recommended to obtain sufficient samples to define baseline and determine a statistical method. This accelerated sampling program will monitor each of the constituents in Table 9-2 at a quarterly frequency for 2 years. Quarterly monitoring will allow for sufficiently long enough time between samples so as to not cause a problem with autocorrelation of samples (i.e., resampling the same water). After 2 years of sampling is completed, the statistical test method can be determined using the decision matrix included as Appendix H. In addition to this methodology, hydrogeology of the area also will be considered. Following this initial monitoring period and determination of the statistical method, the statistical method will be periodically reassessed.

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10 Routine Evaluation of the Monitoring Network

The groundwater flow regime will evolve over time. The scenarios that were simulated (as described in Chapters 5, 6, and 7) are intended to be representative of the range of plausible conditions, but actual conditions may differ from the scenarios evaluated. The CPGWM is updated and run annually as part of the 200 West P&T program. Because of this, the CPGWM is maintained up-to-date to reflect recent operating conditions and can be used to model proposed changes to the operating conditions.

Throughout the year water level measurements are also taken as part of routine sampling, and annually for water-level mapping. Analysis of groundwater elevation, using universal kriging for water-level maps, and hydraulic gradient mapping will be used to interpret changes in the groundwater flow regime. Additionally, re-evaluation of the monitoring network will be performed annually in conjunction with the WAC 173-303-645(9)(e) determination of groundwater flow direction and rate in the uppermost aquifer. If the analysis suggests a change in the flow regime (e.g., changes resulting from modifications to the 200 West P&T system operations) that indicates that the likely migration direction of any hypothetical release is outside of or on the margins of the monitoring network for a DWMU, then the model will be used to re-evaluate the monitoring network for that DWMU.

Results of the re-evaluation of the monitoring network may result in a proposal to add additional monitoring well locations. In a given year, the results may show that there is no impact to a DWMU, in which case no action would be taken. If an impact to a DWMU is shown, the network would be re-evaluated and documented in an update to this engineering evaluation report, shared with Ecology, and placed in the operating record. An update to the engineering report would not necessarily result in an update to the associated groundwater monitoring plan if there is no resulting change needed to the groundwater monitoring network. If a change in the groundwater monitoring network is determined, a permit modification with a revised groundwater monitoring plan would be performed in accordance with WAC 173-303-815, "Facility-specific permit conditions."

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11 References

10 CFR 962, "Byproduct Material," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=24aad4966ac52acbeba416c2c1114889&mc=true&node=pt10.4.962&rgn=div5.

15-NWP-157, 2015, "Groundwater Monitoring Requirements for Low-Level Burial Grounds Trenches 31/34 Permit Modification to the *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 9, for the Treatment, Storage, and Disposal of Dangerous Waste*" (letter from S. Dahl to S.L. Charboneau, U.S. Department of Energy, Richland Operations Office, and J. Ciucci, CH2M HILL Plateau Remediation Company), Washington State Department of Ecology, Richland, Washington, August 13. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1508241436.

16-ESQ-0028, 2016, "Submittal of DOE/RL-2015-74, Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex – Waste Receiving and Processing Facility Operating Unit Groups," (letter to Jane Hedges, Washington State Department of Ecology, from Stacy Charboneau), U.S. Department of Energy, Richland Operations Office, Richland, Washington, January 28. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078648H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078647H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078646H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078645H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078644H.

16-NWP-083, 2016, "Completeness Determination for the Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex – Waste Receiving and Processing Facility Operating Unit Groups, received January 28, 2016," (letter to Stacy Charboneau, U.S. Department of Energy, Richland Operations Office, Richland, Washington from Jane Hedges), Washington State Department of Ecology, January 28. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0076953H.

16-NWP-143, 2016, "Groundwater Engineering Report and Final Status Groundwater Monitoring Plan Requirements for the Integrated Disposal Facility, Nonradioactive Dangerous Waste Landfill, Low Level Burial Grounds trench 94, and Low Level Burial Grounds "Green Islands" Dangerous Waste Management Units," (letter to Doug S. Shoop, U.S. Department of Energy, Richland Operations Office, Richland, Washington and John A. Ciucci, CH2M Hill Plateau Remediation Company from Suzanne Dahl), Washington State Department of Ecology, August 18. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075375H.

16-NWP-185, 2016, "Determination on Closure Certification for the FS-1 Outdoor Container Storage Area," (letter to Doug Shoop, U.S. Department of Energy, Richland Operations Office, Richland, Washington from Suzanne Dahl), Washington State Department of Ecology, October 25. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0074418H.

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-part264-appIX.xml.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5.

265.90, "Applicability."

265.91, "Ground-Water Monitoring System."

265.92, "Sampling and Analysis."

265.93, "Preparation, Evaluation, and Response."

265.94, "Recordkeeping and Reporting."

Subpart F, "Ground-Water Monitoring."

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*. Available at: https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr268_main_02.tpl.

268.42, "Treatment Standards Expressed as Specified Technologies."

268.45, "Treatment Standards for Hazardous Debris."

69 FR 39449, "Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant," *Federal Register*, Vol. 69, No. 125, pp. 39449-39455, June 30, 2004. Available at: http://www.gpo.gov/fdsys/pkg/FR-2004-06-30/pdf/04-14806.pdf.

Atomic Energy Act of 1954, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap23-divsnA.htm.

BHI-00184, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083482H.

BNWL-B-360, 1974, *Selected Water Table Contour Maps and Well Hydrographs for the Hanford Reservation, 1944-1973*, Pacific Northwest Laboratories Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196069236.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: https://www.csu.edu/cerc/researchreports/documents/CERCLASummary1980.pdf.

CP-47631, 2015, *Model Package Report: Central Plateau Groundwater Model Version 6.3.3*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0077133H.

CP-47631, 2016, *Model Package Report: Central Plateau Groundwater Model Version 8.3.4*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069098H.

DOE/RL-92-03, 1992, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196089863.

DOE/RL-96-01, 1996, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1995*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196064360.

DOE/RL-2000-72, 2006, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/878238.

DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081471H.

DOE/RL-2007-28, 2008, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0808050315. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098828.

DOE/RL-2008-56, 2012, *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081011H.

DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131281. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131282.

DOE/RL-2009-68, 2010, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070711.

DOE/RL-2009-68, 2011, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093745.

DOE/RL-2009-68, 2012, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091407.

DOE/RL-2009-124, 2016, *200 West Pump and Treat Operations and Maintenance Plan*, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0077130H.

DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091795.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring for 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087974.

DOE/RL-2014-32, 2014, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084842.

DOE/RL-2015-06, 2015, *Calendar Year 2014 Annual Summary Report for the 200-ZP-1and 200-UP-1 Operable Unit Pump and Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080209H.

DOE/RL-2015-07, 2015, *Hanford Site Groundwater Monitoring Report for 2014*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080600H.

DOE/RL-2015-74, 2016, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078647H.

DOE/RL-2016-09, 2016, *Hanford Site Groundwater Monitoring Report for 2015*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075314H.

DOE/RL-2016-20, 2016, *Calendar Year 2015 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump and Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0074339H.

DOE/RL-2016-66, 2017, *Hanford Site RCRA Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0077820H.

DOE/RL-2016-67, 2017, *Hanford Site Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0068229H.

ECF-200W-17-0070, 2018, *Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065259H.

ECF-200ZP1-12-0074, 2012, *Presentation & Initial Evaluation of Water-Level & Pumping Data for the Hanford 200-ZP-1 Groundwater Pump-and-Treat Remedy*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0076180H.

ECF-200ZP1-16-0054, 2018, *Groundwater Flow and Migration Calculations to Support Assessment of the LLBG Trenches 31 and 34 Monitoring Network*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0064878H.

ECF-Hanford-11-0165, 2012, *Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087250.

ECF-HANFORD-13-0029, 2017, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*, Rev. 4, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0072357H.

ECF-HANFORD-17-0233, 2018, *Identification of Site-Specific Monitoring Constituents for the Low-Level Burial Grounds*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065107H.

ECN 113805, 1991, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196046436.

ECN 144234, 1991, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196066230.

ECN 618165, 1994, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196046460.

ECN 618180, 1995, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007403.

EPA 530/R-09-007, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, Office of Resource Conservation and Recovery, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10055GQ.TXT.

Ecology, 2014, *Agreed Order and Stipulated Penalty No. DE 10156*, Washington State Department of Ecology, Olympia, Washington. Available at: https://ecology.wa.gov/DOE/files/ba/ba118fd5-cad1-4823-8b1b-79ee25c2ab36.pdf.

Ecology Publication No. 97-407, 2014, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, Hazardous Waste and Toxics Reduction Program, Washington State Department of Ecology, Olympia, Washington. Available at: https://fortress.wa.gov/ecy/publications/documents/97407.pdf.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

EPA, Ecology, and DOE, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098825.

EPA, Ecology, and DOE, 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*, United States Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091413.

Hantush, M.S., 1964, "Hydraulics of Wells," *Advances in Hydroscience*, V.T. Chow (editor), Academic Press, New York, pp. 281-442.

Konikow, L.F., G.Z. Hornberger, K.J. Halford, and R.T. Hanson, 2009, *Revised Multi-Node Well (MNW2) Package for MODFLOW Ground-Water Flow Model*, Techniques and Methods 6A-30, U.S. Geological Survey, Reston, Virginia.

NAD83, 1991, *North American Datum of 1983*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

NAVD88, 1988, *North American Vertical Datum of 1988*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

PNL-6772, 1987, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/biblio/6201649.

PNL-7336, 1990, *Geohydrology of the 218-W-5 Burial Ground, 200-West Area, Hanford Site*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/energycitations/servlets/purl/6932537-lkBMPl/6932537.pdf.

PNL-8337, 1992, *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199061221.

PNL-8971, 1993, *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY 1993 Status Report*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199061223.

PNNL-11793, 1998, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199132962.

PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0906180659.

PNNL-13116, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736610.

PNNL-13404, 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13404.pdf.

PNNL-13788, 2002, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2737262. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2740450.

PNNL-13858, 2002, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13858.pdf.

PNNL-14187, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2752375. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2755548.

PNNL-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14702rev1.pdf.

PNNL-14859, 2004, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D6541642.

PNNL-14859-ICN-1, 2006, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14859icn1.pdf.

PNNL-14859-ICN-2, 2007, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 2, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14859-ICN-2.pdf.

PNNL-15070, 2005, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15070.pdf.

PNNL-15670, 2006, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084078.

PNNL-16346, 2007, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084077.

PNNL-16887, 2007, *Geologic Descriptions for the Solid-Waste Low Level Burial Grounds*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16887.pdf.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

SGW-50907, 2011, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0078753H.

SGW-55438, 2013, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087999.

SGW-59564, 2016, *Engineering Evaluation of the 200 West Pump and Treat Influence on Groundwater Monitoring for the Low-Level Burial Ground Trenches 31 and 34*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075238H.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit*, *Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology. Available at: https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html.

WA7890008967, 2008, *Dangerous Waste Permit Application Part A Form - Low- Level Burial Grounds 9/22/2008*, Rev. 14, Washington State Department of Ecology. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0073832H.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

303-090, "Dangerous Waste Characteristics."

303-104, "State-Specific Dangerous Waste Numbers."

303-110, "Sampling, Testing Methods and Analytes."

303-140, "Land Disposal Restrictions."

303-400, "Interim Status Facility Standards."

303-645, "Releases from Regulated Units."

303-665, "Landfills."

303-806, "Final Facility Permits."

303-815, "Facility-Specific Permit Conditions."

303-9903, "Discarded Chemical Products List."

303-9904, "Dangerous Waste Sources List.

WHC-MR-0391, 1992, *Field Trip Guide to the Hanford Site*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196136627.

WHC-SD-EN-AP-015, 1989, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195063349.

WHC-SD-EN-AP-022, 1990, *Interim-Status Ground-Water Quality Assessment Plan for Waste Management Area 3 of the 200 Areas Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079142H.

WHC-SD-EN-EV-026, 1993, *Results of the Groundwater Quality Assessment Program at Low-Level Waste Management Area 3 of the Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196101188.

WHC-SD-W025-FDR-001, 1990, *Design Report Project W-025 Radioactive Mixed Waste (RMW) Land Disposal Facility Non-Drag-Off*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196017742.

Zheng, Chunmiao and P. Patrick Wang, 1999, *MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide*, Contract Report SERDP-99-1, U.S. Army Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, Mississippi. Available at: http://hydro.geo.ua.edu/mt3d/mt3dmanual.pdf.

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Appendix A

Interim Status Data Summary

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A1 Introduction

Section 2.4 of the main document summarizes the groundwater monitoring history at Low-Level Burial Grounds (LLBG) Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads. An interim status indicator parameter groundwater monitoring under 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" was intiated in 1987 for LLBG Waste Management Area (WMA)-3. Operation of LLBG Trenches 31 and 34, which are within the LLBG WMA-3 footprint, began in 1999. Interim status groundwater monitoring for LLBG WMA-3 was already established at the time LLBG Trenches 31 and 34 began operation. Subsequent monitoring during the operational period of LLBG Trenches 31 and 34 was performed within the LLBG WMA-3 program.

The interim status groundwater monitoring history of LLBG WMA-3 since 1999 was compiled to represent the monitoring history during the LLBG Trenches 31 and 34 operational period. Information from annual reporting documents and groundwater monitoring plans was utilized to compile a summary of wells in the LLBG WMA-3 network, groundwater flow direction and rate, monitoring constituents, statistical comparison values (e.g., critical means), and a summary of comparison value exceedances or other contaminants (e.g., plumes from upgradient sources) in a Microsoft® Excel® workbook. Sampling data through December 31, 2016 for each well is presented in separate Microsoft Excel workbooks. Sample data for each well were retrieved from the Hanford Environmental Information System database. The workbooks are contained in electronic files to accompany this report.

A2 References

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr264_main_02.tpl.

Appendix IX, "Ground-Water Monitoring List."

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5.

265.92, "Sampling and Analysis."

Appendix III, "EPA Interim Primary Drinking Water Standards."

DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098824.

DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131281. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0905131282.

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DOE/RL-2009-68, 2010, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070711.

DOE/RL-2009-68, 2011, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093745.

DOE/RL-2009-68, 2012, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091407.

DOE/RL-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009 Volumes 1 & 2*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084237.

DOE/RL-2011-01, 2011, *Hanford Site Groundwater Monitoring Report for 2010*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093693.

DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091795.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring for 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087974.

DOE/RL-2014-32, 2014, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084842.

DOE/RL-2015-07, 2015, *Hanford Site Groundwater Monitoring Report for 2014*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080600H.

DOE/RL-2016-09, 2016, *Hanford Site Groundwater Monitoring Report for 2015*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075314H.

DOE/RL-2016-12, 2016, *Hanford Site RCRA Groundwater Monitoring Report for 2015*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0073391H.

DOE/RL-2016-66, 2017, *Hanford Site RCRA Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0072146H.

ECN 618165, 1994, *Engineering Change Notice To WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196046460.

PNL-6772, 1987, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/biblio/6201649.

PNNL-13116, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736610. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2736978.

PNNL-13404, 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2743868. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2786917.

PNNL-13788, 2002, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2737262. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2740450.

PNNL-14187, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2752375. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2755548.

PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14548.pdf.

PNNL-14859, 2004, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D6541642.

PNNL-14859-ICN-1, 2006, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14859icn1.pdf.

PNNL-14859-ICN-2, 2007, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 2, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14859-ICN-2.pdf.

PNNL-15070, 2005, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15070.pdf.

PNNL-15670, 2006, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084078.

PNNL-16346, 2007, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084077.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

SGW-55438, 2013, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087999.

WHC-SD-EN-AP-015, 1989, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195063349.

Appendix B

Identification of Site-Specific Monitoring Constituents for the Low-Level Burial Grounds - ECF-HANFORD-17-0233

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The calculation ECF-HANFORD-17-0233, *Identification of Site-Specific Monitoring Constituents for the Low-Level Burial Grounds*, was performed evaluate the waste constituents associated with the Low-Level Burial Grounds to identify proposed groundwater monitoring constituents. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065107H.

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Appendix C

Topographic Map

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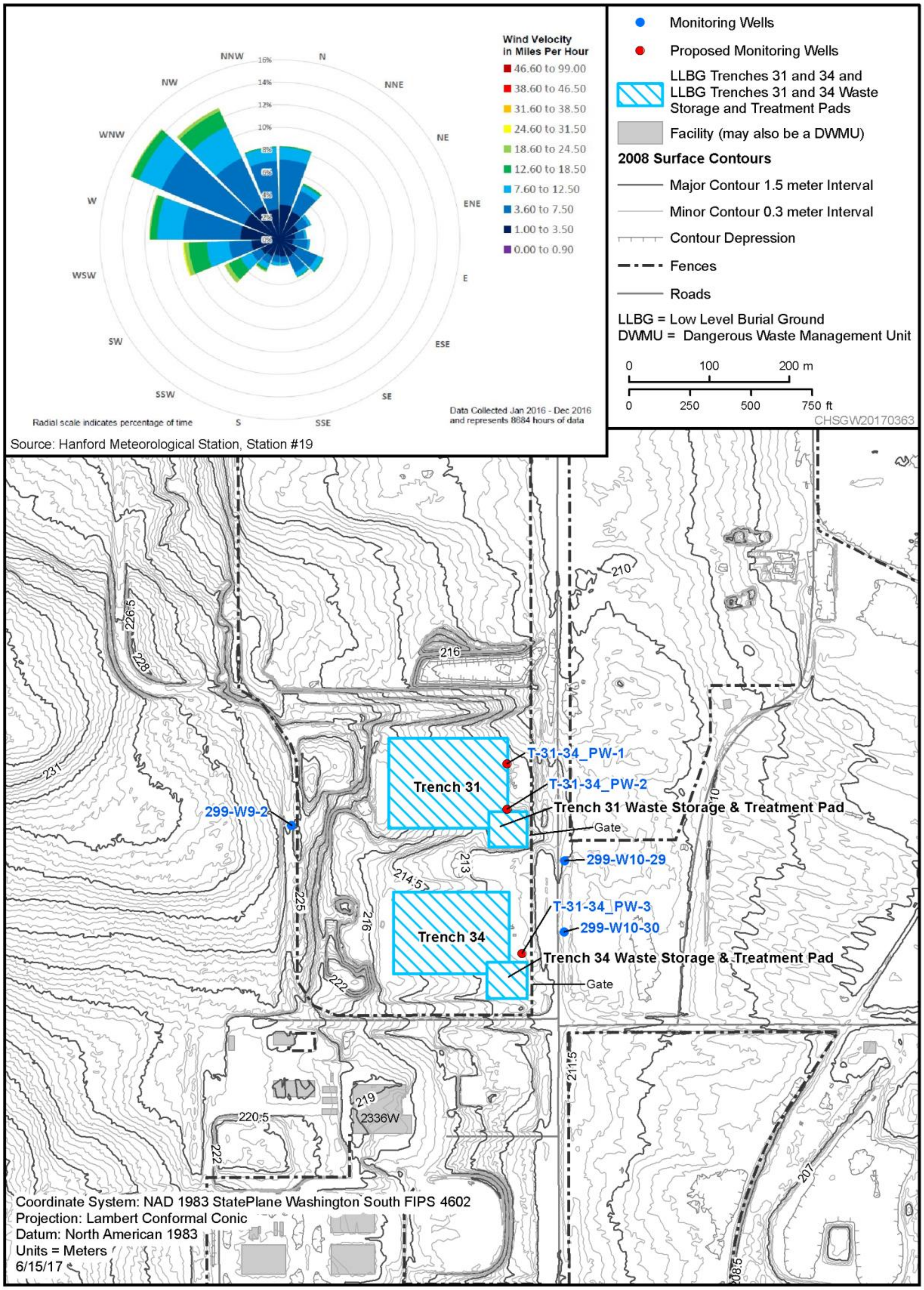

Figure C-1. Topographic Map

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Appendix D

Plume Maps

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This appendix presents regional plume maps in the vicinity of Low-Level Burial Grounds (LLBG) Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads. These plumes do not originate from LLBG Trenches 31 and 34, but are regional plumes in the area of the unit.

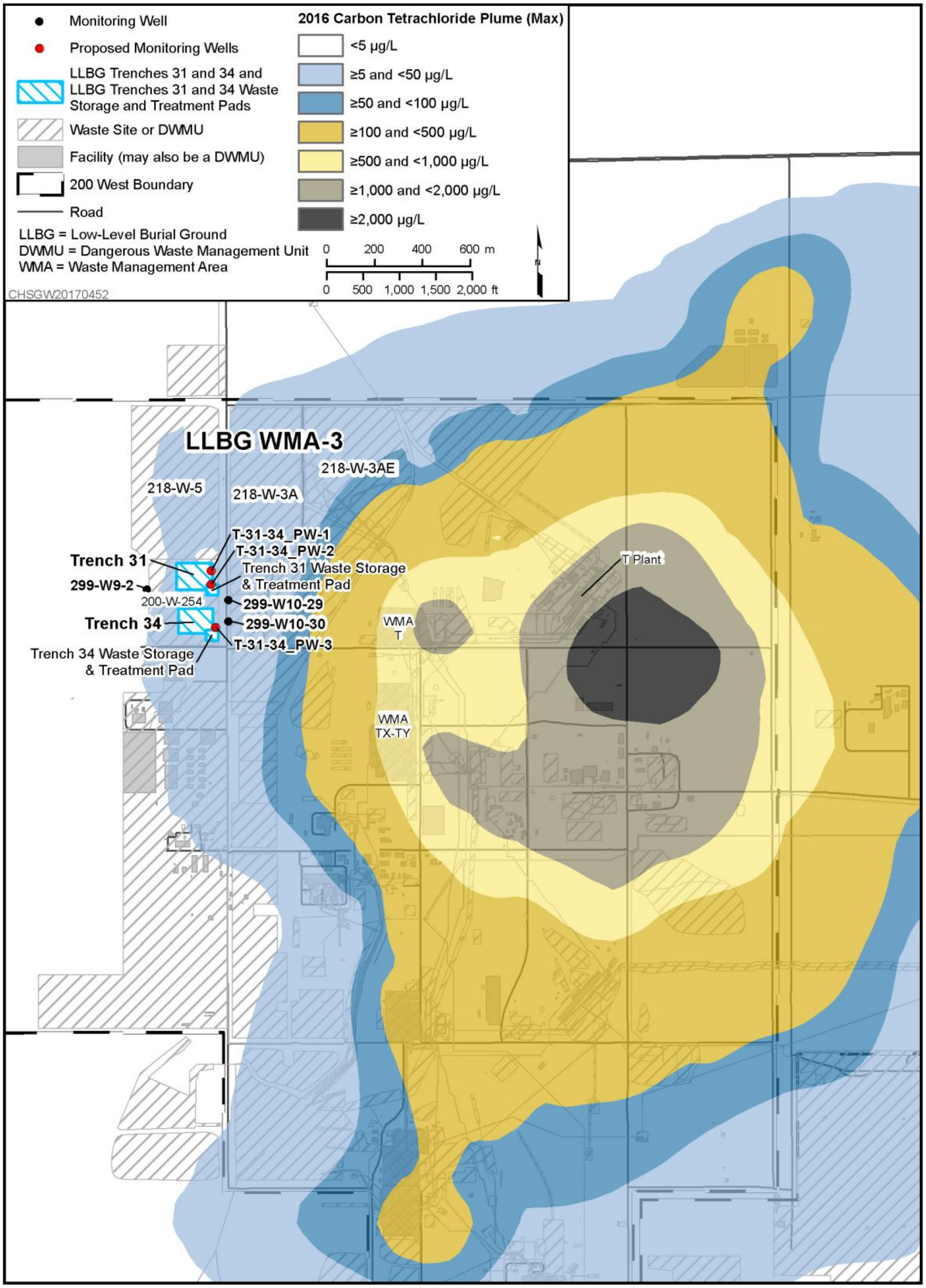

Figure D-1 Regional Carbon Tetrachloride Plume at LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads

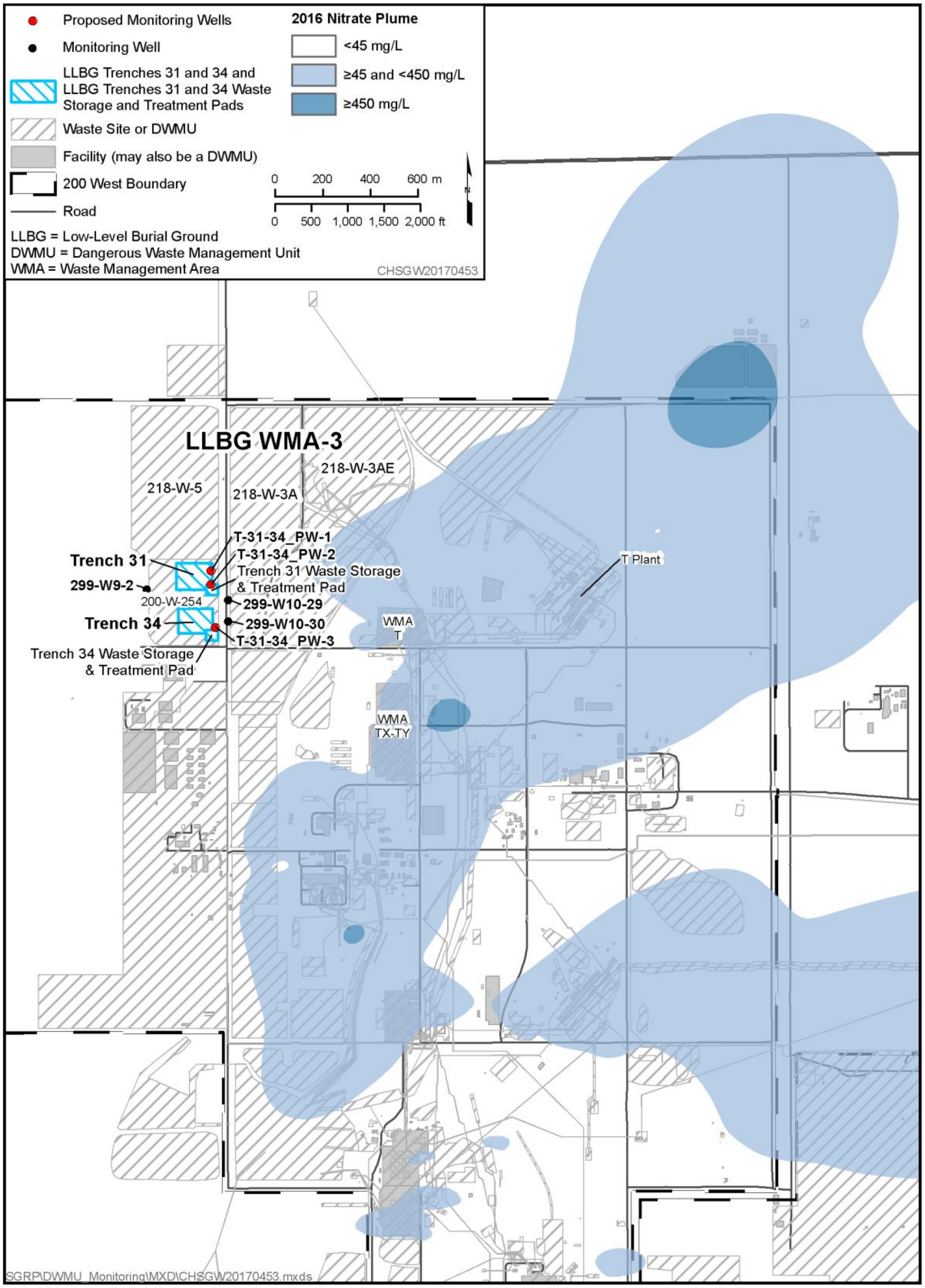

Figure D-2. Regional Nitrate Plume at LLBG Trenches 31 and 34 and LLBG Trenches 31 and 34 Waste Storage and Treatment Pads

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Appendix E

Well As-Built Diagrams and Proposed Well Design Information

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Contents

Figures

Tables

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E1 Introduction

This appendix provides the following information for the existing Low-Level Burial Grounds (LLBG) Trenches 31 and 34 groundwater monitoring wells:

- Well name
- Hydrogeologic unit monitored (the aquifer portion at the well screen-perforation) (Table E-1)
- The following sampling interval information, as provided in Table E-2:
  - Elevation at the top of the screen or perforated interval
  - Elevation at the bottom of the screen or perforated interval
  - Open interval length (i.e., difference between the top and bottom screen-perforation elevations)
  - Drilling method

For proposed wells, the following design information is provided in Table E-3:

- Well location
- Drill depth
- Well diameter
- Screen interval depth
- Sump and end cap interval

Figures E-1 through E-3 provide construction and completion summaries for the existing network wells.

Table E-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
TU	**Top of Unconfined.** Screened across the water table, or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table E-2. Sampling Interval Information for Existing Wells within the LLBG Trenches 31 and 34 Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])	Drilling Method
299-W9-2	TU	135.9 (445.8)	125.3 (411.1)	10.6 (34.8)[a]	Cable Tool
299-W10-29	TU	136.8 (448.8)	126.2 (414.0)	10.6 (34.8)*	Becker Hammer
299-W10-30	TU	136.9 (449.1)	126.2 (414.0)	10.7 (35.1)*	Becker Hammer

Reference: NAVD88, *North American Vertical Datum of 1988*.

* Due to rounding and conversion of metric units, the computed open interval length based on the top and bottom elevations may differ slightly from the actual open interval length reported in the Summary Sheets below.

TU = Top of Unconfined, as described in Table E-1

Table E-3. Planned Location, Depth, and Screen Interval for Proposed Wells within the LLBG Trenches 31 and 34 Network

Well ID	Northing (m)	Easting (m)	Surface Elevation (m [ft] NAVD88)	Water Table Elevation (m [ft] NAVD88)	Depth to Water (m [ft] bgs)	Drill Depth (m [ft] bgs)	Final Well Diameter (cm [in.])	Screen Interval (m [ft] bgs)	Sump and End Cap Interval (m [ft] bgs)
T-31-34_PW-1	566081.99	136951.00	213.6 (700.9)	136.3 (447.2)	77.3 (253.7)	87.4 (286.7)	10 (4)	75.8-86.5 (248.7-283.7)	86.5-87.4 (283.7-286.7)
T-31-34_PW-2	566082.98	136893.38	214.1 (702.3)	136.2 (446.8)	77.8 (255.1)	87.8 (288.1)	10 (4)	76.2-86.9 (250.1-285.1)	86.9-87.8 (258.1-288.1)
T-31-34_PW-3	566084.36	136654.20	212.5 (697.2)	136.3 (447.2)	76.2 (250.1)	86.3 (283.1)	10 (4)	74.7-85.4 (245.1-280.1)	85.4-86.3 (280.1-283.1)

Reference: NAVD88, *North American Vertical Datum of 1988*.

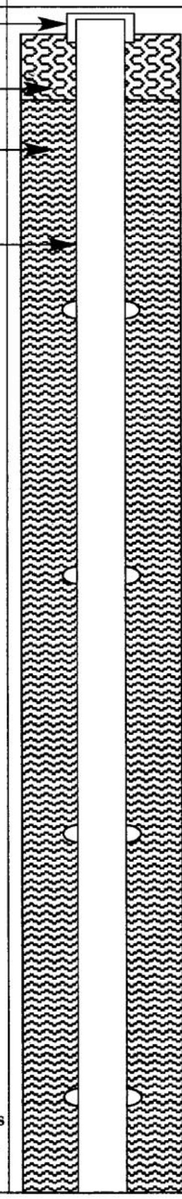
Note: Well coordinates, elevations, and projected well design are estimates and are subject to modification based on final well location survey and conditions encountered during drilling.

bgs = below ground surface

WELL SUMMARY SHEET	Start Date: 7/26/11 Finish Date: 9/22/11	Page 1 of 2

Well ID: C8201	Well Name: 299-W9-2
Location: 350 meters NNW of WRAP Building	Project: 2 M-24 RCRA Groundwater Wells
Prepared By: Patrick Cabbage — Date: 10/21/11	Reviewed By: DC Weekes — Date: 10/24/11
Signature:	Signature:

CONSTRUCTION DATA

Description	Diagram
Stainless Steel Protective Casing: 3.33 ft above ground surface Type I/II Portland Cement Grout: 0 - 10.2 ft bgs #8 Granular Bentonite Crumbles: 10.2 - 277.1 ft bgs 4-in I.D., Schedule 10, Type 304, Stainless Steel Permanent Casing: 2.35 ft ags - 284.69 ft bgs All temporary drill casing was removed from the ground. All depths are in feet below ground surface. The borehole was drilled with 10 ¾-inch O.D. casing from 0.0 - 119.4 ft bgs and with 8 5/8-inch O.D. casing from 119.4 - 325.0 ft bgs.	

GEOLOGIC/HYDROLOGIC DATA

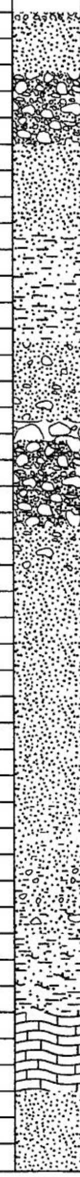
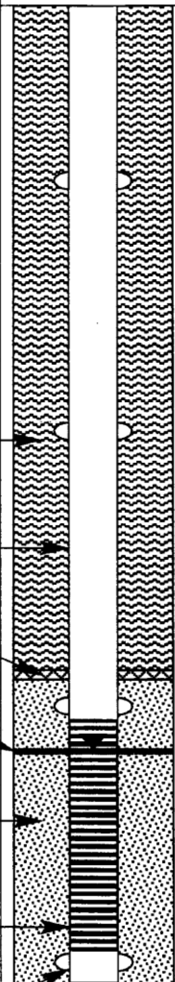
Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-1 Gravel Drill Pad (G)
		1-9 Sand (S)
		9-20 Sandy Gravel (sG)
20		20-33 Sand (S)
40		33-50 Slightly Silty Sand ((m)S)
		50-62 Gravelly Sand (gS)
60		62-65 Gravel (G)
		65-78 Silty Sandy Gravel (msG)
80		78-85 Gravelly Sand (gS)
		85-120 Sand (S)
100		
120		120-130 Sand (S)
		130-140 Slightly Silty Gravelly Sand ((m)gS) with caliche
140		140-152 Slightly Silty Sand ((m)S) with caliche
		152-164 Caliche
160		164-183 Sand (S)

Figure E-1. Well 299-W9-2 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 7/26/11 Finish Date: 9/22/11	Page 2 of 2
Well ID: C8201		Well Name: 299-W9-2	
Location: 350 meters NNW of WRAP Building		Project: 2 M-24 RCRA Groundwater Wells	
Prepared By: Patrick Cabbage	Date: 10/21/11	Reviewed By: DC Weekes	Date: 10/24/11
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
All temporary drill casing was removed from the ground. All depths are in feet below ground surface. The borehole was drilled with 10 ¾-inch O.D. casing from 0.0 - 119.4 ft bgs and with 8 5/8-inch O.D. casing from 119.4 - 325.0 ft bgs. #8 Granular Bentonite Crumbles: 10.2 - 277.1 ft bgs 4-in I.D., Schedule 10, Type 304, Stainless Steel Permanent Casing: 2.35 ft ags - 284.69 ft bgs 3/8-in Bentonite Pellets: 277.1 - 278.4 ft bgs Static Water Level: 289.4 ft bgs (9/12/11) Primary Filter Pack 10-20 Mesh Colorado Silica Sand: 278.4 - 325.0 ft bgs 4-in I.D., Schedule 10, Type 304, Stainless Steel 20-slot Screen: 284.69 - 319.65 ft bgs 4-in I.D., Schedule 10, Type 304, Stainless Steel Sump: 319.65 - 324.57 ft bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
180		164-183 Sand (S)
		183-280 Sandy Gravel (sG)
200		
220		
240		
260		
280		280-287 Silty Sand (mS)
		287-306 Sandy Gravel (sG)
300		
		306-314 Silty Sandy Gravel (msG)
320		314-325 Gravel (G)
		TD = 325.0 ft bgs (09-07-2011)
340		

Figure E-1. Well 299-W9-2 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 3/01/2006 Finish Date: 3/13/2006	Page 1 of 2
Well ID: C4988		Well Name: 299-W10-29	
Location: ~500 ft N. of Dayton and 23rd Intersection		Project: CY06 LLBG Monitoring Wells	
Prepared By: Jeffrey Weiss	Date: 4/5/06	Reviewed By: L. D. Walker	Date: 5/31/06
Signature: Jeffrey Weiss		Signature: LD Walker	

CONSTRUCTION DATA			GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)

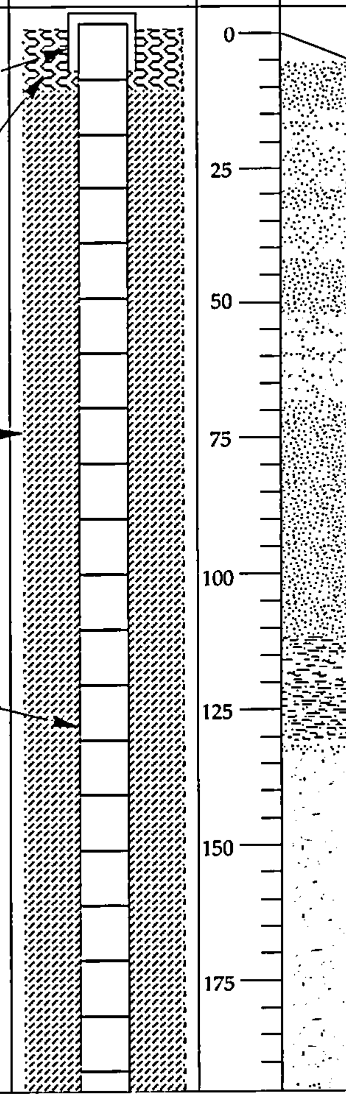
Description

6-in, inner diameter stainless steel protective casing
+2.8 ft

Portland Cement type I/II
0 - 10.1 ft

Bentonite Crumbles
10.1 - 229.8 ft

4-in, inner diameter stainless steel type 304, schedule 5 casing
+1.9 - 245.01 ft



Lithologic Description (ft bgs)

0-5 No recovery
5-9 Sand, S
9-14 Sand, S
14-29 Gravelly Sand, gS
29-34 Sand, S
34-43 Sand Gravel, sG
43-53 Silty Sandy Gravel, msG
53-63 Sandy Gravel, sG
63-69 Sandy Gravel, sG
69-112 Sand, S
112-116 Sandy Silt, sM
116-120 Silt w/ Caliche Nodules, M
120-131 Slightly Silty Sand, (m)S
131.5-133 Gravely Sandy Silt, gsM
133-196 Gravel, G
196-208 Sandy Gravel, sG

Figure E-2. Well 299-W10-29 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 3/01/2006 Finish Date: 3/13/2006	Page 2 of 2

Well ID: C4988	Well Name: 299-W10-29
Location: ~500 N. of Dayton and 23rd Intersection	Project: CY06 LLBG Monitoring Wells
Prepared By: Jeffrey Weiss; Date: 4/5/06	Reviewed By: L.D. Walker; Date: 5/31/06
Signature: Jeffrey Weiss	Signature: LD Walker

CONSTRUCTION DATA

Description:

1/4-in coated bentonite pellets 229.8 - 234.9

Static Water = 244.85 (3/9/06)

10-20 mesh Colorado silica sand 234.9 - 287.2

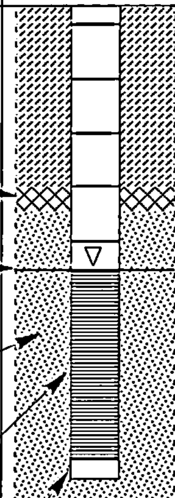
4-in, inner diameter stainless steel, type 304, 20 slot (0.02-in) screen 245.01 - 280.01

4-in, inner diameter stainless steel, type 304, schedule 5 sump 280.01 - 283.00

All temporary casing removed from the ground

All depths are in feet below ground

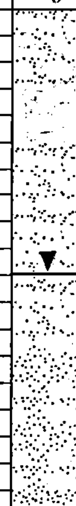
Diagram:



Depth in Feet: 200, 225, 250, 275, 300, 325, 350, 375

GEOLOGIC/HYDROLOGIC DATA

Graphic Log:



Lithologic Description (ft bgs)
196-208 Sandy Gravel, sG
208-220 Gravel, G
220-259 Sandy Gravel, sG
259-285 Gravelly Sand, gS
285-287.2 Sand, S
Total depth drilled = 287.2' bgs

Figure E-2. Well 299-W10-29 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 3/14/2006 Finish Date: 4/3/2006	Page 1 of 2
Well ID: C4989		Well Name: 299-W10-30	
Location: ~200 ft N. of Dayton and 23rd Intersection		Project: CY06 LLBG Monitoring Wells	
Prepared By: Jeffrey Weiss	Date: 4/7/06	Reviewed By: L.D. Walker	Date: 5/18/06
Signature: [signature]		Signature: [signature]	

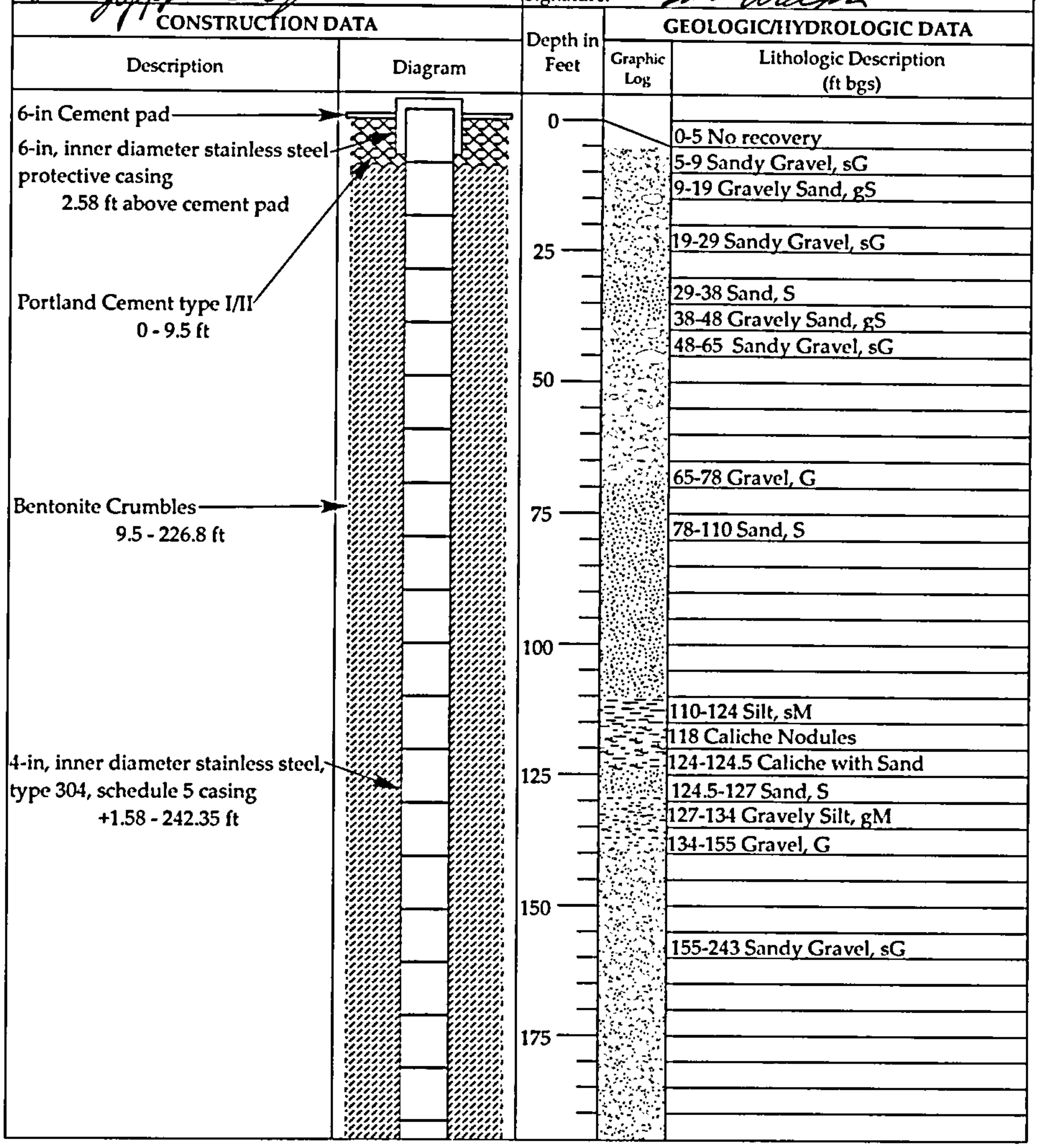
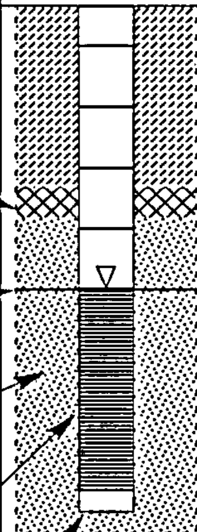


Figure E-3. Well 299-W10-30 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 3/14/2006 Finish Date: 4/3/2006	Page 2 of 2
Well ID: C4989		Well Name: 299-W10-30	
Location: ~200 N. of Dayton and 23rd Intersection		Project: CY06 LLBG Monitoring Wells	
Prepared By: Jeffrey Weiss	Date: 4/7/06	Reviewed By: L. D. Walker	Date: 5/18/06
Signature: Jeffrey Weiss		Signature: LD Walker	

CONSTRUCTION DATA

Description	Diagram	Depth in Feet
1/4-in coated bentonite pellets 226.8-231.5		225
Static Water = 243.02 (3/30/06)		
10-20 mesh Colorado silica sand 231.5 - 280.3		250
4-in, inner diameter stainless steel, type 304, 20 slot (0.02-in) screen 242.35 - 277.35		275
4-in, inner diameter stainless steel, type 304, schedule 5 sump 277.35-280.34		300
All temporary casing removed from the ground		350
All depths are in feet below ground		375



GEOLOGIC/HYDROLOGIC DATA

Depth scale (feet): 200, 225, 250, 275, 300, 325, 350, 375

Graphic Log

Lithologic Description (ft bgs)

243-246 Gravely Sand, gS

246-282 Sandy Gravel, sG

282-283 Sand, S

Total depth drilled = 283 ft

Figure E-3. Well 299-W10-30 Construction and Completion Summary (continued)

E2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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Appendix F

Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network – ECF-200W-17-0070

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The calculation ECF-200W-17-0070, *Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network*, was performed to evaluate the suitability of the current groundwater monitoring networks to detect hypothetical releases and, where appropriate, to evaluate the efficacy of the monitoring networks to detect the presence of, or significant increases in, groundwater contamination from the dangerous waste management units that are located in the 200 West Area of the Central Plateau. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065259H.

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Appendix G

Groundwater Flow and Migration Calculations to Support Assessment of the LLBG Trenches 31 and 34 Monitoring Network – ECF-200ZP1-16-0054

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Revision 2 of the calculation ECF-200ZP1-16-0054, *Groundwater Flow and Migration Calculations to Support Assessment of the LLBG Trenches 31 and 34 Monitoring Network*, was performed to evaluate monitoring well locations for the Low-Level Burial Grounds Trenches 31 and 34 groundwater monitoring network. The calculation is available at:
https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0064878H.

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Appendix H

Statistical Method Determination

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Contents

Figures

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H1 Introduction

An accelerated sampling program will be conducted to obtain a minimum of eight samples. The accelerated sampling program will monitor the constituents listed in Table 9-4 (Appendix 5 of Ecology Publication No. 97-407) of the main body at a quarterly frequency for 2 years. After 2 years of sampling is completed, the statistical test method can be determined using the flow charts presented in this appendix.

The flow charts (Figures H-1 through H-7) below represent a series of statistical analyses, consistent with EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, that describe basic methodology for determining the type of statistical test that would be most appropriate for implementation in a groundwater monitoring plan for regulated waste. These flow charts guide the user through tests to identify potential outliers, and evaluate statistical distributions, spatial variance, temporal trends and equality of variance for background and compliance wells. EPA 530/R-09-007 should be consulted for conditional data handling requirements related to normality of distribution for Rosner's, Modified Dixson's, and ANOVA tests. Based on these series of tests, the user is directed towards the type of test, interwell or intrawell, that is most appropriate based on the available data. The flow charts do not proclaim to provide every detail of every process but are to be used as a guide.

Figure H-8 provides a chart legend applicable to Figures H-1 through H-7.

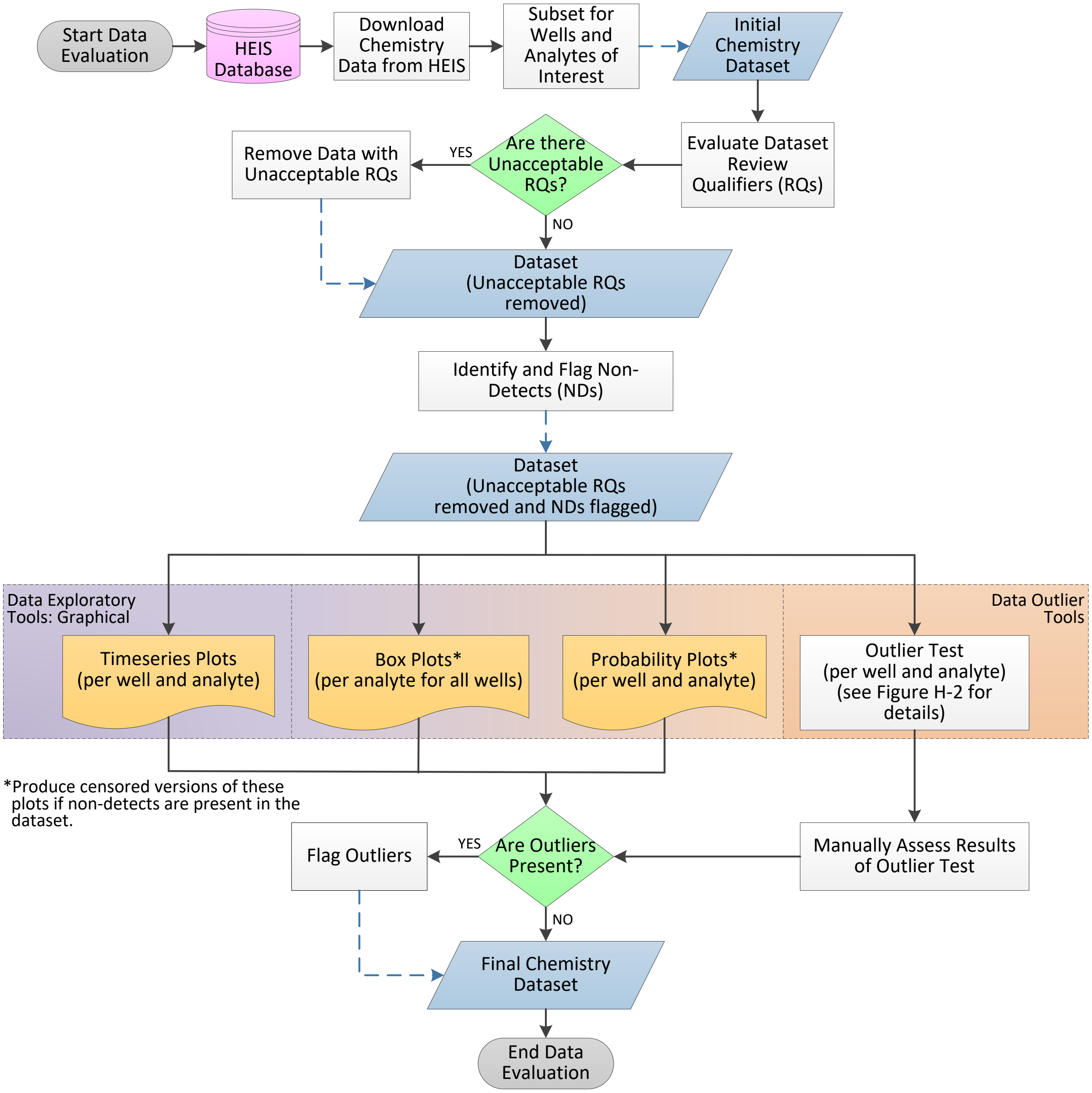

Figure H-1. Data Evaluation

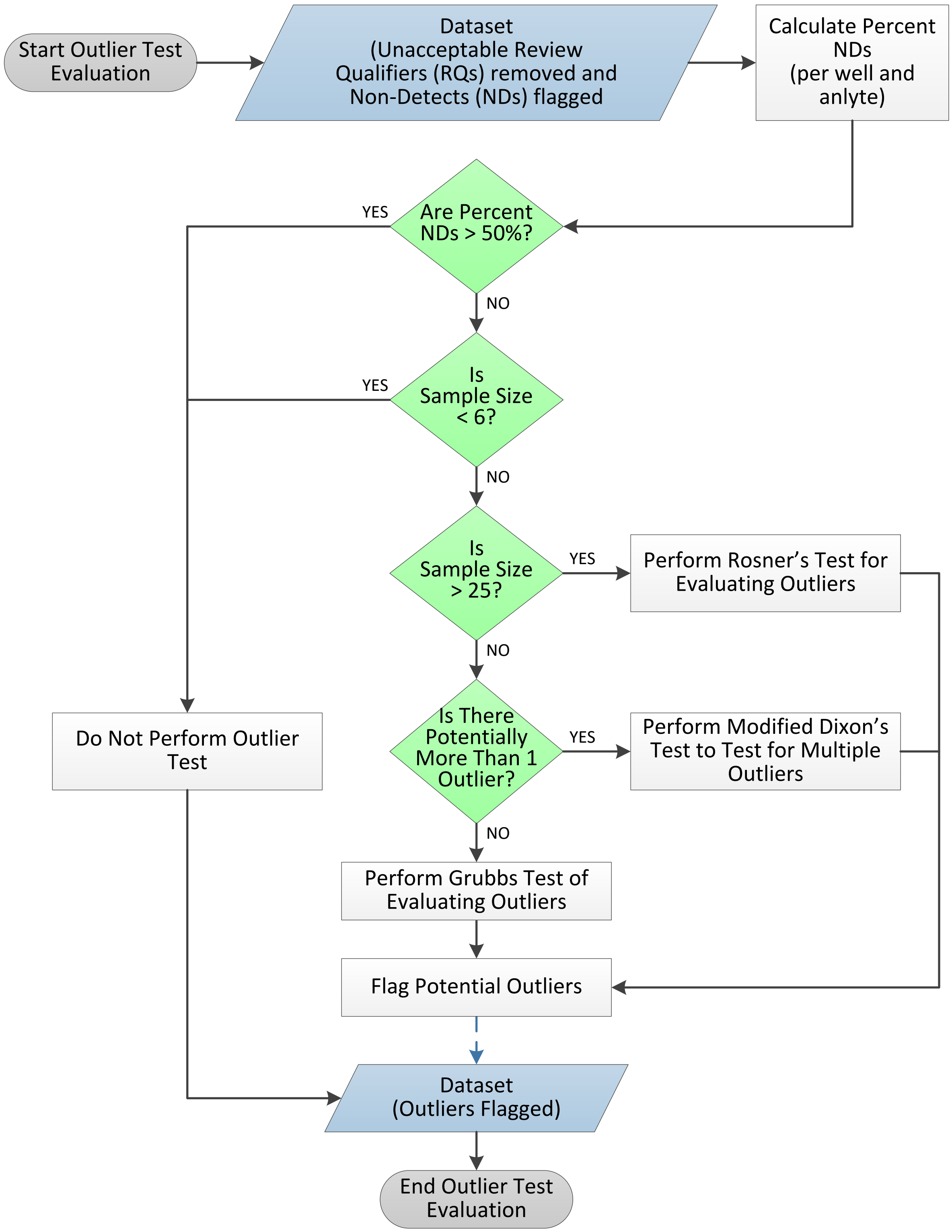

Figure H-2. Outlier Test Evaluation

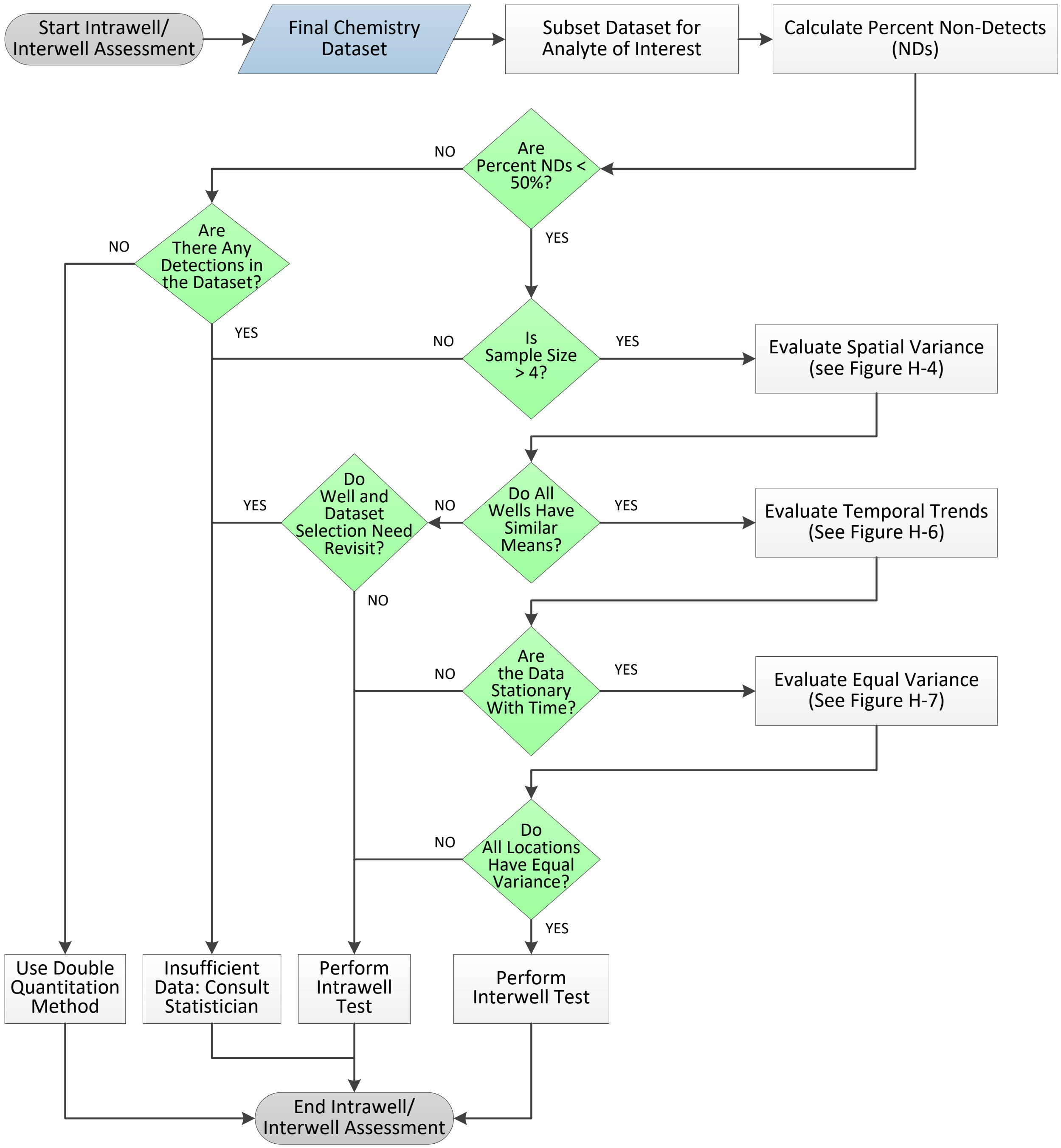

Figure H-3. Intrawell/Interwell Assessment

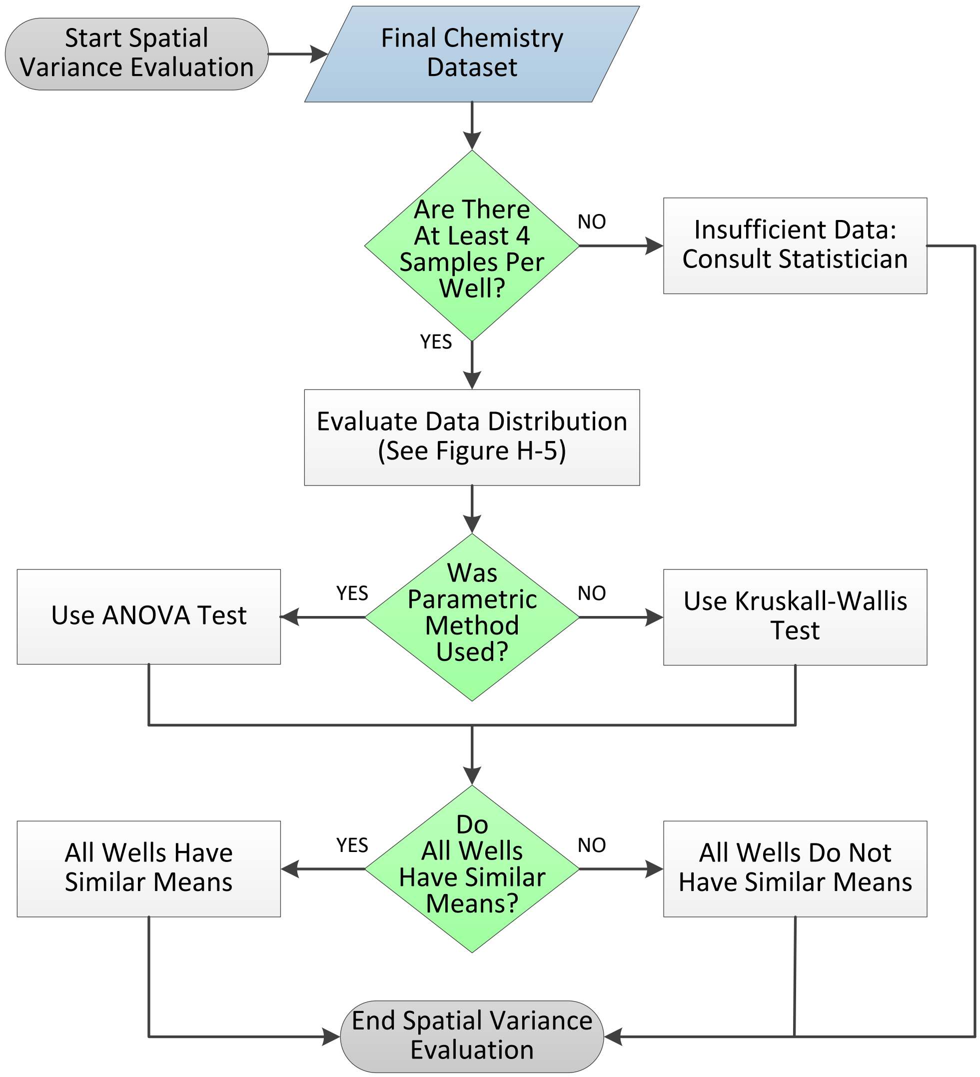

Figure H-4. Spatial Variance Evaluation

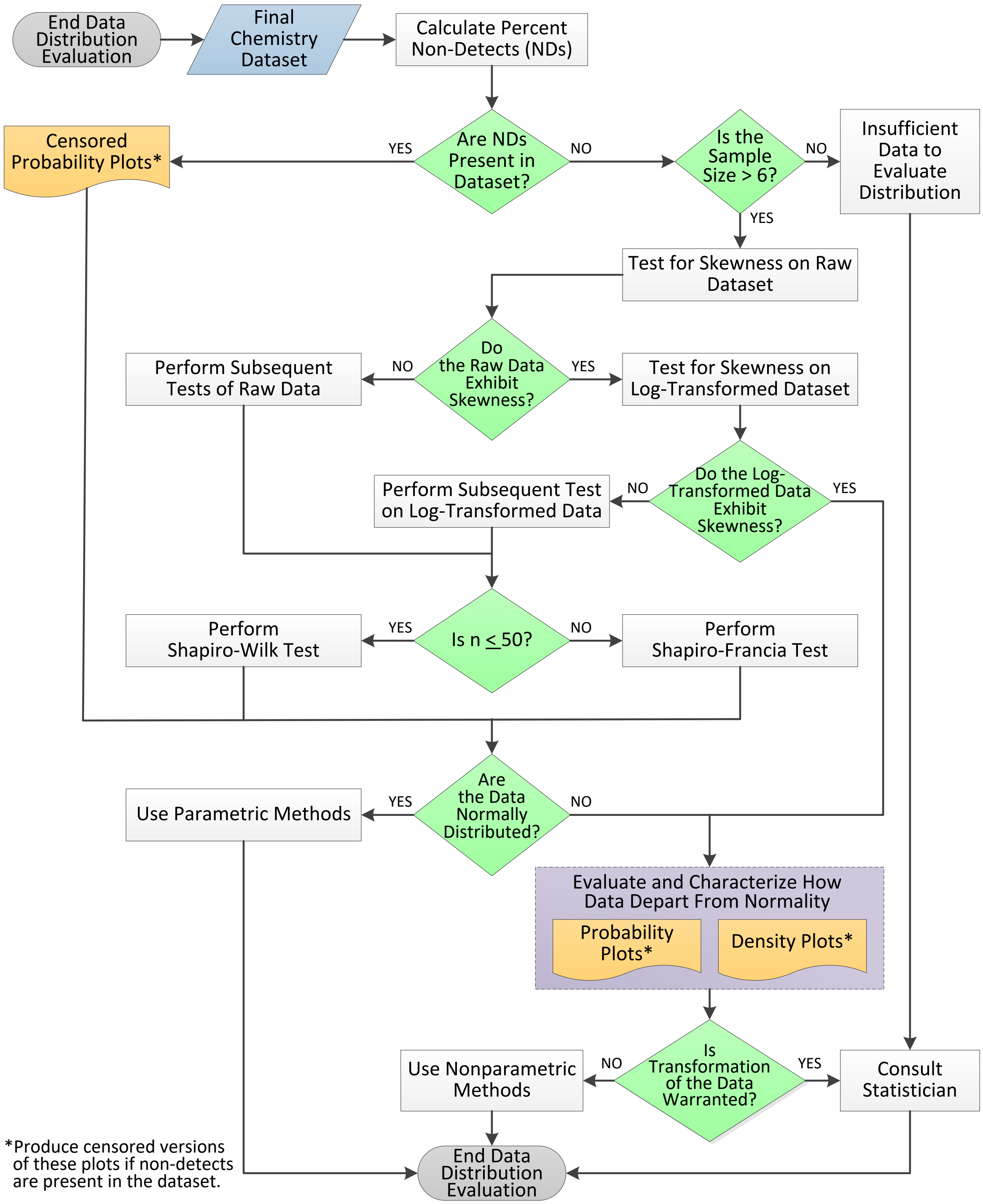

Figure H-5. Data Distribution Evaluation

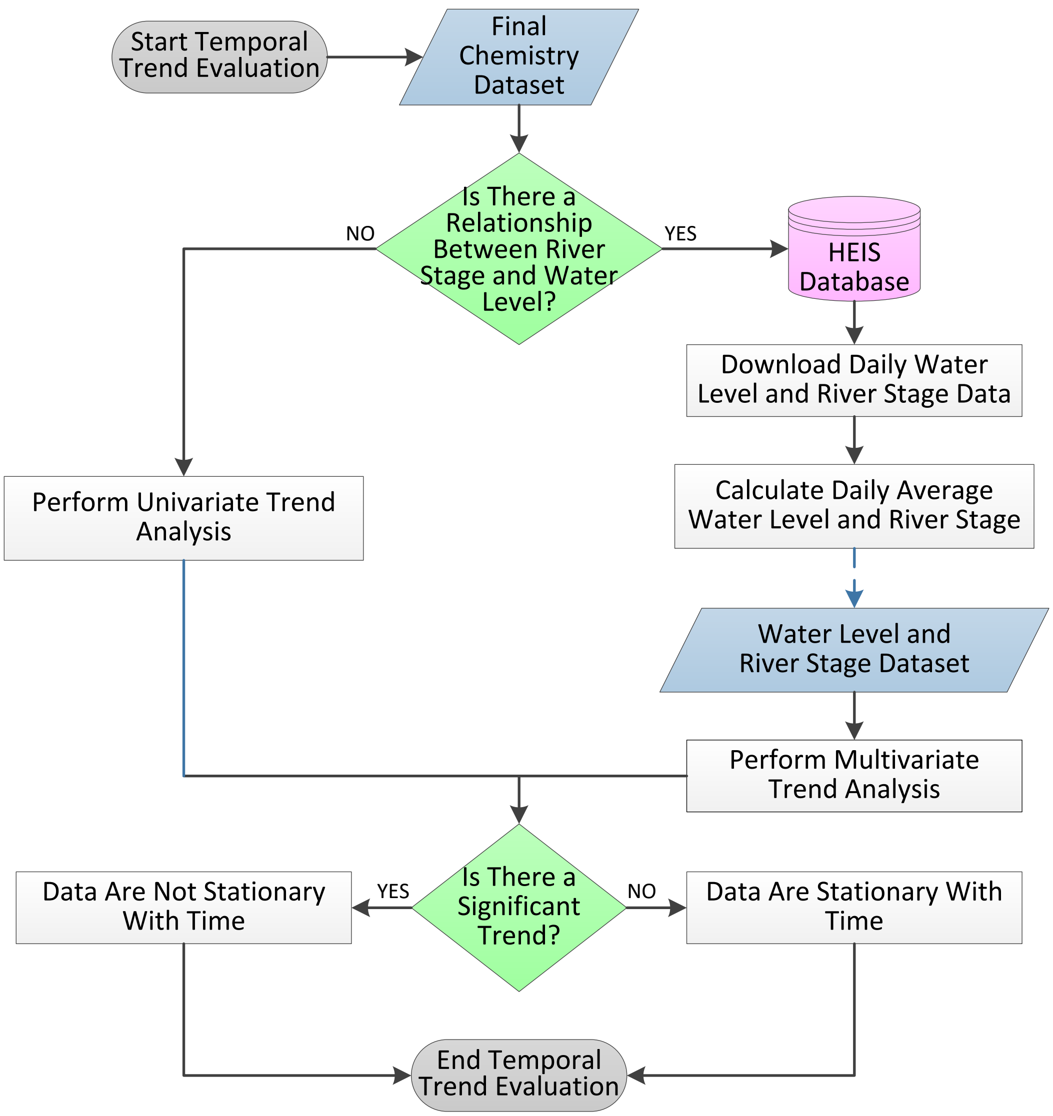

Figure H-6. Temporal Trend Analysis

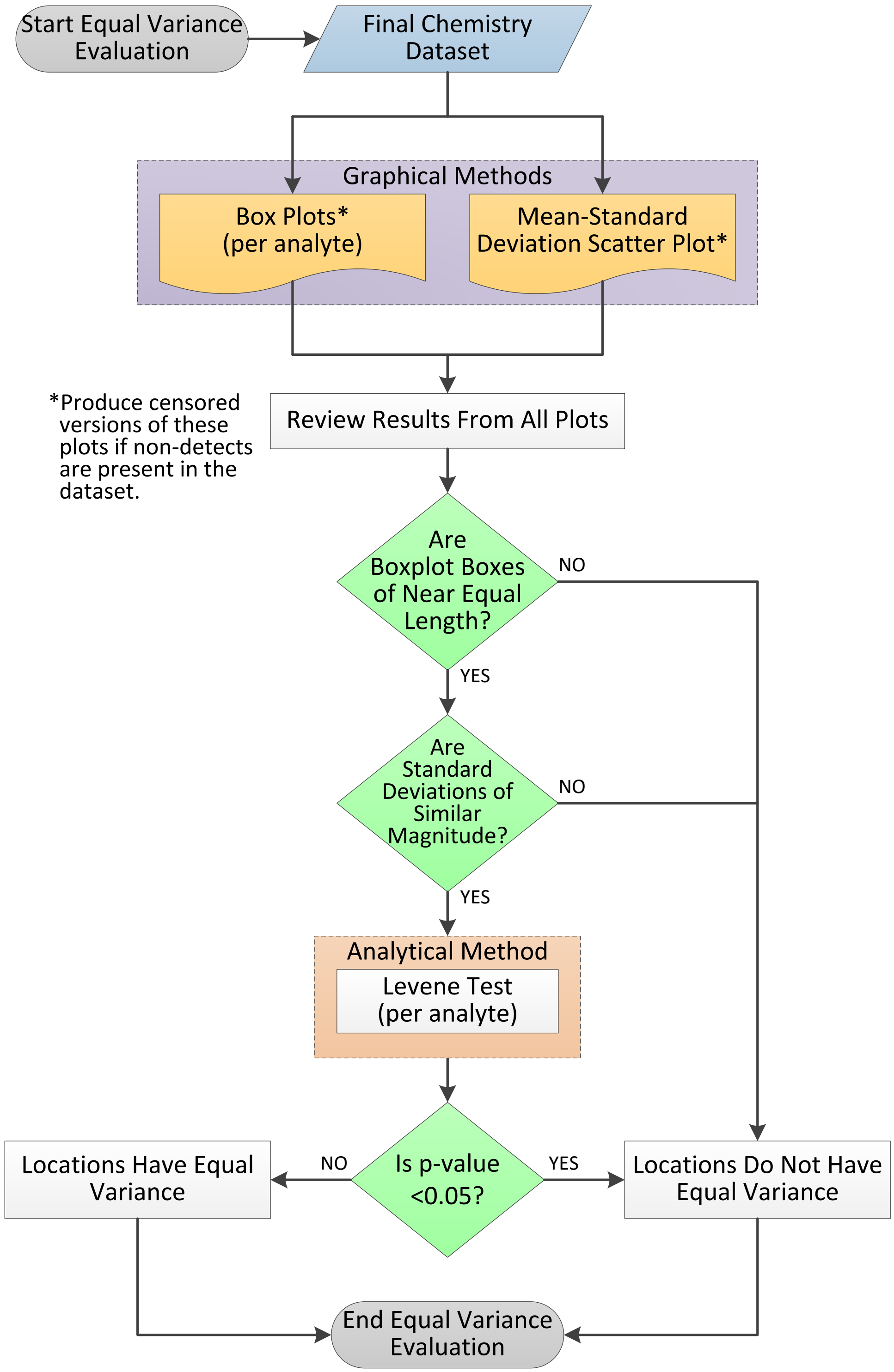

Figure H-7. Equal Variance Evaluation

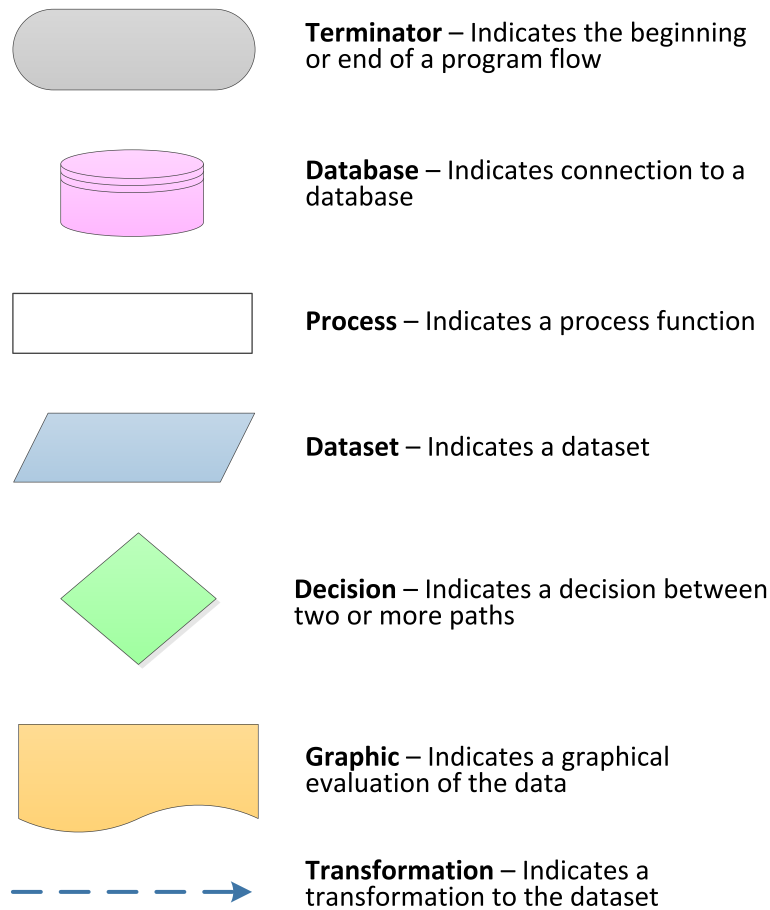

Figure H-8. Chart Legend

H2 Reference

EPA 530/R-09-007, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, Office of Resource Conservation and Recovery, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10055GQ.TXT.