SGW-60585
Revision 0

ENGINEERING EVALUATION REPORT FOR THE 216-S-10 POND AND DITCH 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

Approved for Public Release;
Further Dissemination Unlimited

SGW-60585
Revision 0

ENGINEERING EVALUATION REPORT FOR THE 216-S-10 POND AND DITCH GROUNDWATER MONITORING

Date Published
August 2018

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

APPROVED
By Mary P. Curry at 2:35 pm, Aug 15, 2018

Release Approval | Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

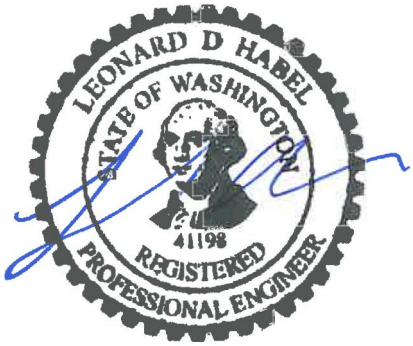
Statement of certification:

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 the 216-S-10 Pond and Ditch Groundwater Monitoring, SGW-60585, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington" and I certify that it demonstrates completeness in compliance with WAC 173-303-806(4)(a).

August 1, 2018

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

Date



This page intentionally left blank.

Contents

1 Introduction 1-1

2 Supporting Historical Information 2-1

2.1 Background 2-1

2.1.1 Operational History 2-1

2.1.2 Documented Releases 2-3

2.2 Regulatory Basis 2-3

2.3 Waste Characteristics 2-4

2.4 Interim Status Monitoring Network and Sampling History 2-5

3 Geology and Hydrogeology 3-1

3.1 Stratigraphy 3-1

3.2 Hydrogeology 3-1

3.3 Groundwater Flow 3-5

3.3.1 Hydrologic Conditions Prior to 200 West P&T Operations 3-5

3.3.2 Hydrologic Conditions Due to Operation of the P&T Remedy 3-6

4 Contaminant Migration Conceptual Model 4-1

4.1 Vadose Zone 4-1

4.2 Soil Moisture Factors 4-1

4.3 Hydrogeologic Considerations 4-2

4.4 Groundwater Chemistry 4-2

4.5 Summary of Vertical Contaminant Distribution 4-3

5 Groundwater Flow Simulations 5-1

5.1 Central Plateau Groundwater Model 5-1

5.2 Simulation Scenarios 5-3

6 Calculations 6-1

6.1 Principal Assumptions and Inputs 6-1

6.2 Particle Tracking 6-2

6.2.1 Particle Pathlines 6-4

6.2.2 Relative Detectability Calculations 6-4

6.3 Transport Calculations 6-4

7 Simulation Results and Conclusions 7-1

7.1 Breakthrough Curves and Release Unit Plume Maps 7-2

7.2 Particle-Tracking and Relative Detectability Maps 7-11

7.3 Breakthrough Curves for Proposed Wells 7-15

7.4 Modeling Conclusions 7-22

8 Identification of Site-Specific Monitoring Constituents 8-1

8.1 Selection Process for Monitoring Constituents 8-1
8.1.1 Hanford Facility RCRA Permit Part A Form Dangerous Wastes 8-1
8.1.2 Dangerous Waste Discharge History 8-1
8.2 Results of Selection of Groundwater Monitoring Constituents 8-1
9 Groundwater Monitoring 9-1
9.1 Final Status Groundwater Monitoring Program Determination 9-1
9.2 Point of Compliance Monitoring 9-1
9.3 Proposed Groundwater Monitoring Network 9-2
9.3.1 Groundwater Monitoring Well 699-33-76 9-5
9.3.2 Groundwater Monitoring Well 216-S-10_PW4 9-5
9.3.3 Groundwater Monitoring Well 299-W26-13 9-6
9.3.4 Groundwater Monitoring Well 299-W26-14 9-6
9.3.5 Groundwater Monitoring Well 699-32-76 9-7
9.3.6 Groundwater Monitoring Well 699-33-75 9-8
9.3.7 Groundwater Monitoring Well 216-S-10_PW1 9-8
9.3.8 Groundwater Monitoring Well 216-S-10_PW2 9-9
9.3.9 Groundwater Monitoring Well 216-S-10_PW3 9-10
9.4 Constituent List and Frequency 9-10
9.5 Statistical Method 9-17
10 Routine Evaluation of the Monitoring Network 10-1
11 References 11-1

Appendices

A Interim Status Data Summary ..... A-i
B Topographic Map ..... B-i
C Plume Maps ..... C-i
D Well As-Built Diagrams and Proposed Well Design Information ..... D-i
E Groundwater Flow and Migration Calculations to Support Assessment of the Hanford Central Plateau 200 West Area Facilities Monitoring Network – ECF-200W-17-0070 ..... E-i
F Groundwater Flow and Migration Calculations to Support Assessment of the 216-S-10 Pond and Ditch Monitoring Network – ECF-200W-17-0077 ..... F-i
G Statistical Method Determination ..... G-i

Figures

Figure 1-1. Location Map for the 216-S-10 Pond and Ditch 1-2
Figure 2-1. Location of the 216-S-10 Pond and Ditch South/Southwest of the 200 West Area 2-2
Figure 2-2. Liquid Effluent Volumes Discharged to the 216-S-10 Pond and Ditch 2-3

Figure 2-3. Wells Used During Interim Status Monitoring of the 216-S-10 Pond and Ditch 2-7
Figure 3-1. General Stratigraphy at the Hanford Site 3-2
Figure 3-2. West to East Geologic Cross Section through the 216-S-10 Pond and Ditch.....3-3
Figure 3-3. Northeast to Southwest Geologic Cross Section through the 216-S-10 Pond and Ditch.....3-4
Figure 3-4. Water Elevation Contours in June 2012 Prior to Startup of the 200 West P&T.....3-7
Figure 3-5. Water Elevation Contours in March 2016 During Current 200 West P&T Operations 3-8
Figure 5-1. Interim Status Groundwater Monitoring Network.....5-2
Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells 5-6
Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix E 6-3
Figure 7-1. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W26-13 7-3
Figure 7-2. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W26-14 7-3
Figure 7-3. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W27-2 7-4
Figure 7-4. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 699-32-76.....7-4
Figure 7-5. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 699-33-75.....7-5
Figure 7-6. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 699-33-76.....7-5
Figure 7-7. Release Concentration Breakthrough Curves at Monitoring Wells, Scenario 3.....7-7
Figure 7-8. Release Unit Plume Map, Scenario 1, Sub-Scenario A 7-8
Figure 7-9. Release Unit Plume Map, Scenario 2, Sub-Scenario A 7-9
Figure 7-10. Release Unit Plume Map, Scenario 3 7-10
Figure 7-11. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 1 Sub-Scenario A 7-12
Figure 7-12. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 2 Sub-Scenario A 7-13
Figure 7-13. Particle Pathlines Scenario 3.....7-14
Figure 7-14. Relative Detectability of Release, Scenario 1 7-16
Figure 7-15. Relative Detectability of Release, Scenario 2 7-17
Figure 7-16. Relative Detectability of Release, Scenario 3 7-18
Figure 7-17. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW1.....7-19
Figure 7-18. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW2.....7-19
Figure 7-19. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW3.....7-20
Figure 7-20. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW4.....7-20
Figure 7-21. Release Concentration Breakthrough Curves, Scenario 3, Proposed Monitoring Wells 216-S-10_PW1, 216-S-10_PW2, 216-S-10_PW3, and 216-S-10_PW4 7-21

Figure 7-22. Proposed Final Status Groundwater Monitoring Network Showing Combined Results for Relative Detectability and Release Unit Plume 7-23
Figure 9-1. Proposed Final Status Groundwater Monitoring Network for the 216-S-10 Pond and Ditch 9-3

Tables

Table 1-1. Pertinent Requirements....1-3
Table 2-1. Dangerous Wastes Identified for 216-S-10 Pond and Ditch in the Hanford Facility RCRA Permit Part A Application....2-5
Table 2-2. Interim Status Monitoring Plans....2-6
Table 5-1. Simulation Scenarios....5-3
Table 6-1. Properties Assumed for Transport Calculations Using the CPGWM....6-2
Table 7-1. Range of Unit Concentrations of Release Concentration Breakthrough Curves....7-6
Table 7-2. Range of Unit Concentrations of Release Concentration Breakthrough Curves....7-22
Table 8-1. Proposed Monitoring Constituents for the 216-S-10 Pond and Ditch....8-2
Table 9-1. Attributes for Wells in the 216-S-10 Pond and Ditch Groundwater Monitoring Network..9-4
Table 9-2. Monitoring Wells and Sample Schedule for the 216-S-10 Pond and Ditch....9-12
Table 9-3. Proposed Monitoring Constituents for the 216-S-10 Pond and Ditch....9-13
Table 9-4. Dangerous Waste Constituents for First 2 Years of Monitoring....9-13

Terms

AEA	*Atomic Energy Act of 1954*
API	American Petroleum Institute
CCU	Cold Creek unit
CPGWM	Central Plateau Groundwater Model
DOE	U.S. Department of Energy
DWMU	dangerous waste management unit
DWS	drinking water standard
Ecology	Washington State Department of Ecology
ECF	engineering calculation file
FY	fiscal year
MT3DMS	Modular 3-D Transport Multispecies
OU	operable unit
P&T	pump and treat
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	reduction-oxidation
TOX	total organic halogens

This page intentionally left blank.

1 Introduction

This engineering evaluation report provides information to support the proposed final status groundwater monitoring for the 216-S-10 Pond and Ditch based on evaluation of contaminants associated with the 216-S-10 Pond and Ditch, and the expected migration behavior of contaminants in the dangerous waste management unit (DWMU). 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*). The 216-S-10 Pond and Ditch are a nonoperational DWMU that will be incorporated into Revision 9 of WA7890008967, *Hanford Facility Dangerous Waste Permit (Site-Wide Permit)* (hereinafter referred to as the Hanford Facility Dangerous Waste 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.

The 216-S-10 Pond and Ditch are located south/southwest of the 200 West Area of the Hanford Site in Washington State and overlie the 200-UP-1 Groundwater Operable Unit (OU) (Figure 1-1).
The 216-S-10 Pond and Ditch were open, unlined excavations that began receiving wastewater discharges in 1951, consisting of chemical sewage, water tower overflow, cooling water, and rainwater from the Reduction-Oxidation (REDOX) Facility chemical sewer. Most of the unit was removed from operation by 1984; however, the north end of the 216-S-10 Ditch operated until 1991.

This report addresses the additional information for groundwater monitoring requested in Washington State Department of Ecology (Ecology) Letter 16-NWP-129, “Groundwater Engineering Report and Final Status Groundwater Monitoring Plan Requirements for 216-A-37-1 Crib, 216-A-36B Crib, 216-B-63 Trench, 216-B-3 Pond, 216-A-29 Ditch, and 216-S-10 Pond and Ditch Dangerous Waste Management Units.” The letter requests that the U.S. Department of Energy (DOE) develop engineering reports in advance of the complete permit application for the 216-S-10 Pond and Ditch, with an associated groundwater monitoring plan developed for the final status permit application. The enclosure to the letter requires submittal of an engineering report with the following information included:

1. 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 DWMUs resulting from changes in groundwater flow direction, declining water tables, and/or degrading wells that may be causing sample or groundwater contamination.

2. Information supporting design of the groundwater monitoring program that is capable of detecting significant statistical increases in groundwater contamination at the earliest practicable time.

3. Uncertainty in groundwater flow direction so that the appropriate number of wells can be located and drilled. This includes 1 year of background monitoring for WAC 173-303-110(3)(c) and (7), “Dangerous Waste Regulations,” “Sampling, Testing, Methods and Analytes,” constituents unless previously performed to Ecology’s satisfaction. Given the 3-year schedule for drilling and installing new wells, there should be at least 2 years minimum of planning, scheduling, and construction for any new wells or revised groundwater monitoring networks that are approved by Ecology.

4. Descriptions of the approach, input data, any additional information needs, and analysis proposed to evaluate and respond to changes listed in 1. Submit a full report of the complete analysis supporting the proposed approaches, including the methodology and results of validation of any modeling. Modifications of the groundwater monitoring network(s) may be needed to ensure they will continue to yield representative samples of groundwater potentially impacted by releases from DWMUs.

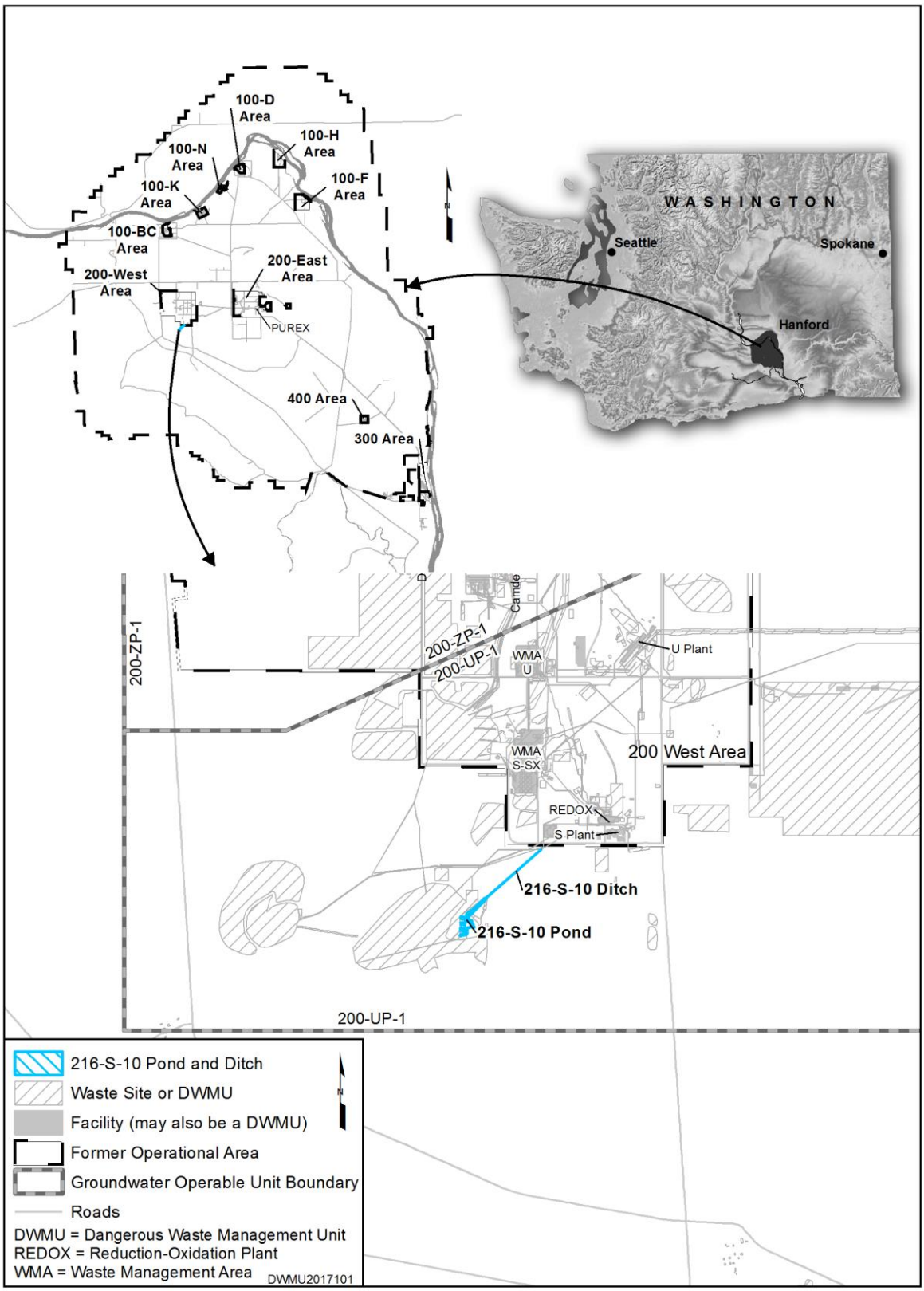


Figure 1-1. Location Map for the 216-S-10 Pond and Ditch

The analysis documented in this report complies with WAC 173-303-806, “Final Facility Permits,” 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) require 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. When the groundwater monitoring plan associated with this network is incorporated into the Hanford Facility Dangerous Waste Permit, it will replace any other groundwater monitoring plans associated specifically with the 216-S-10 Pond and Ditch under interim status.

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), 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.

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 CFR 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

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
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 B
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 C
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	Section 2.3 Chapter 8 Chapter 9 Appendix A
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
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

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
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 D
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 G
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 G

Table 1-1. Pertinent Requirements

Pertinent Requirement	Section Where Requirement is Addressed
WAC 173-303-645(9)(a)	Chapter 8
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 9
(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)	Chapter 9
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 section.	

a. WAC 173-303-806(4)(a)(xx)(D) is not applicable because discharges from the 216-S-10 Pond and Ditch have not created a contaminant plume in groundwater. However, plume maps of regional contaminants that are in the vicinity of the 216-S-10 Pond and Ditch are included in Appendix C.

b.WAC 173-303-645(8)(b) is not applicable because the 216-S-10 Pond and Ditch comprise one regulated unit. It is not being monitored as part of a group of regulated units.

Documented releases to the environment have occurred at the 216-S-10 Pond and Ditch. 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 of the 216-S-10 Pond and Ditch.
- 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 216-S-10 Pond and Ditch 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 topographic map.
- Appendix C contains regional plume maps in the vicinity of the 216-S-10 Pond and Ditch.
- Appendix D contains well as-built diagrams and proposed well design information.
- Appendix E contains the 200 West Area modeling environmental calculation file (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 F contains the 216-S-10 Pond and Ditch modeling ECF (ECF-200W-17-0077, *Groundwater Flow and Migrations Calculations to Support Assessment of the 216-S-10 Pond and Ditch Monitoring Network*).
- Appendix G contains the process for defining the groundwater monitoring statistical method.

This page intentionally left blank.

2 Supporting Historical Information

This chapter describes the 216-S-10 Pond and Ditch, its operations, regulatory basis, waste characteristics, and interim status groundwater monitoring history.

2.1 Background

The 216-S-10 Pond and Ditch are located south-southwest of the 200 West Area, directly outside of the perimeter fence (Figure 2-1). The initial configuration of the 216-S-10 Pond and Ditch unit was a single, open, unlined ditch (216-S-10 Ditch), approximately 1.2 m (4 ft) wide at its base, at least 1.8 m (6 ft) deep, and 686 m (2,250 ft) long. The ditch began receiving wastewater in August 1951 through a 30.5 cm (12 in.) diameter vitrified clay pipeline from the REDOX Facility chemical sewer.

The 216-S-10 Pond was added to the southwest terminus of the 216-S-10 Ditch in February 1954 to provide additional wastewater capacity. The 216-S-10 Pond resembles a backwards “E” with an extra leg; each “leg” was a separate leaching trench. The 216-S-10 Pond covered an area of 1.82 ac (0.74 ha) (Figure 2-1) and was approximately 2.4 m (8 ft) deep at its deepest point. Like the ditch, the pond was unlined and served as an evaporation/infiltration basin for liquid effluent.

Wastewater discharges were conveyed into the 216-S-10 Pond via the 216-S-10 Ditch. Together, the 216-S-10 Pond and Ditch were designed to percolate approximately 567,800 L (150,000 gal) of discharge per day. The process design capacity reflects the maximum volume of water discharged daily rather than the physical capacity of the 216-S-10 Pond and Ditch.

2.1.1 Operational History

Wastewater, consisting of chemical sewage, water tower overflow, cooling water, and rainwater, was first discharged from the REDOX Facility chemical sewer to the 216-S-10 Ditch for disposal in August 1951. In February 1954, increased wastewater discharge volumes necessitated the excavation of the 216-S-10 Pond, plus the excavation of two additional ponds on the southeast side of the 216-S-10 unit (216-S-11 Ponds) in May.

In September 1954, an unplanned release of ammonium nitrate nonahydrate to the REDOX Facility chemical sewer resulted in a reduction of the infiltration capacity in the 216-S-10 Ditch. During the summer of 1955, 0.6 m (2 ft) of contaminated sediment was dredged from the bottom of the ditch and buried in excavation pits along the sides of the ditch to improve infiltration within the ditch (Section III, S200-W in RHO-CD-673, *Handbook 200 Areas Waste Sites*, Volume III). The locations and depths of the excavation pits are unknown (Section III, S200-W in RHO-CD-673).

By 1965, the discharge volumes to the 216-S-10 Ditch had decreased to a level that wastewater no longer flowed into the 216-S-11 Ponds. The REDOX Facility was placed into standby in December 1966, with deactivation activities conducted from 1967 to 1969. Deactivation included numerous steps to remove potentially hazardous substances from the plant (including cleanout of process vessels) and otherwise reduce the risk of dangerous chemicals accidently entering the 216-S-10 Ditch (Section 4.0 in DOE, 1987, *216-S-10 Ditch and Pond Preliminary Closure/Post-Closure Plan*). Physical controls, including disconnection and/or capping of pipes in the REDOX Facility, were also performed (Table 4-1 in DOE, 1987). These controls reduced discharges from the REDOX Facility to only nondangerous chemical sewer effluent.

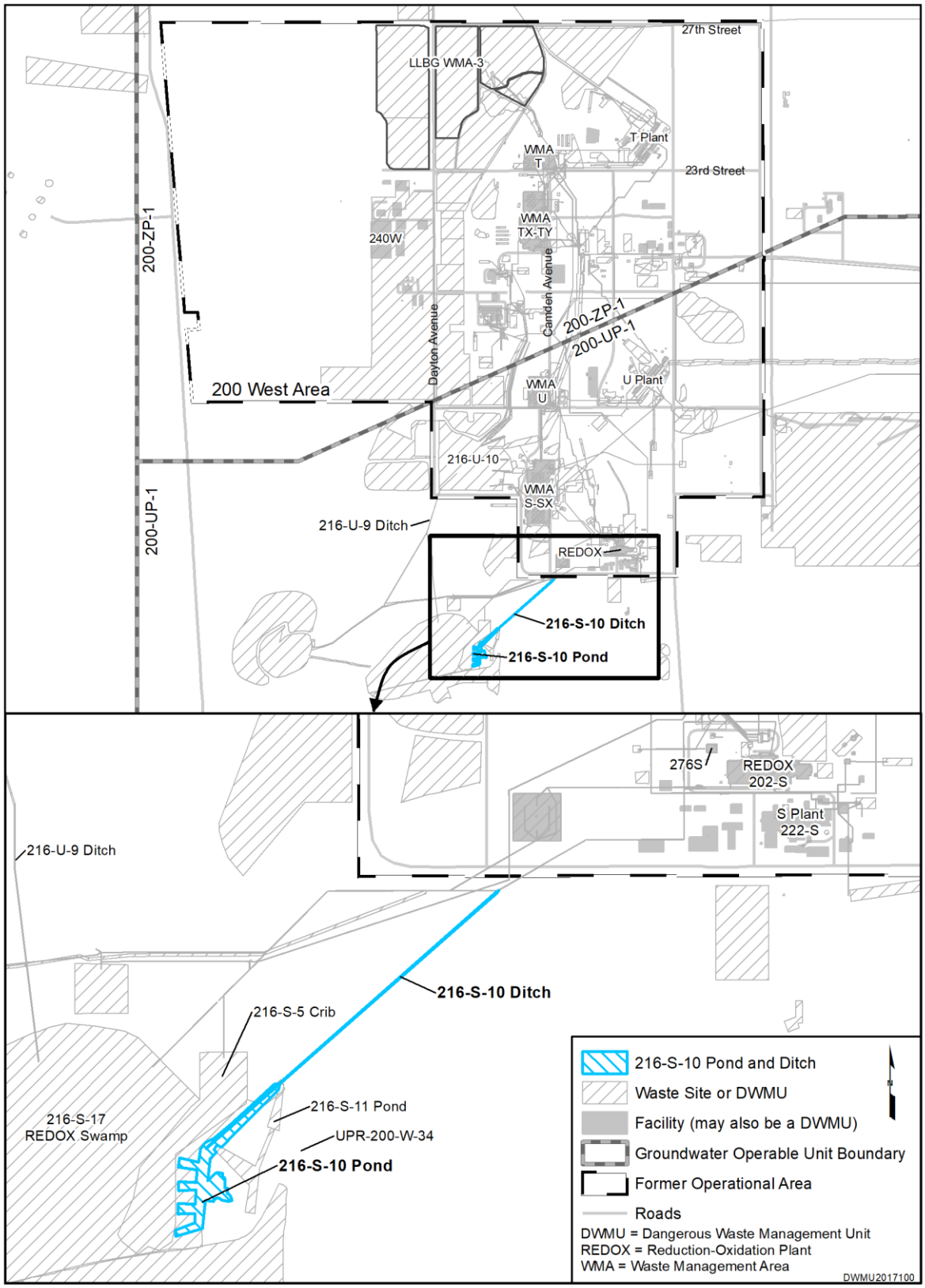
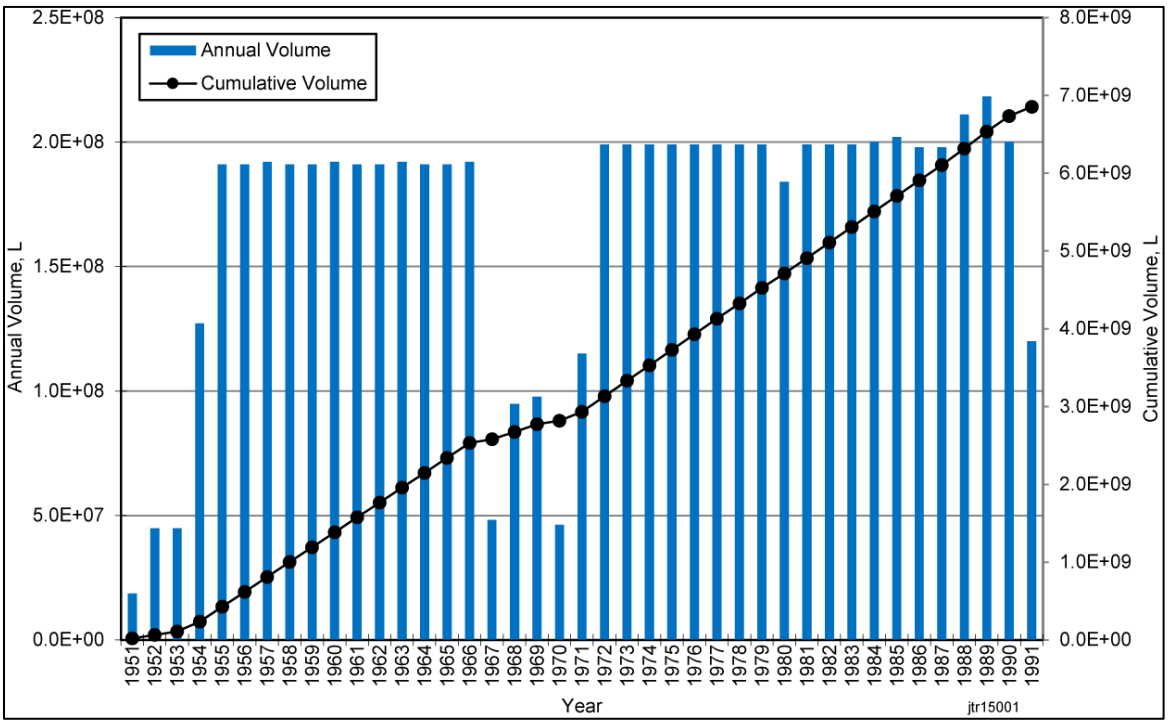


Figure 2-1. Location of the 216-S-10 Pond and Ditch South/Southwest of the 200 West Area

The 216-S-10 Pond and southwest end of the 216-S-10 Ditch were stabilized in October 1985. Stabilization at the 216-S-10 Ditch comprised adding 0.3 to 0.6 m (12 to 24 in.) of soil and grass seed (Section 4.3 in BHI-00176, *S Plant Aggregate Area Management Study Technical Baseline Report*). Stabilization at the 216-S-10 Pond comprised backfilling with soil to 0.3 to 0.6 m (12 to 24 in.) above grade and seeding with grass (Section 4.4 in BHI-00176). The northern portion of the ditch remained operational and received nondangerous chemical sewer waste from the REDOX Facility until October 1991 (Section 11.1.1 in DOE/RL-93-09, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*), when the remaining portion of the ditch was decommissioned. In July 1994, the effluent supply pipeline was plugged with concrete near the outfall. Figure 2-2 shows the annual and cumulative liquid effluent volumes discharged to the 216-S-10 Pond and Ditch from the REDOX Facility chemical sewer from 1951 to 1991.



Source: DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 1.

Figure 2-2. Liquid Effluent Volumes Discharged to the 216-S-10 Pond and Ditch

2.1.2 Documented Releases

The 216-S-10 Pond and Ditch received one documented dangerous waste discharge in September 1983 from the Chemical Engineering Laboratory. This laboratory produced synthetic waste tank slurry to test methods for recovering slurry from double-shell tanks (DOE, 1987). Details of this discharge are presented in Section 2.3.

2.2 Regulatory Basis

In May 1987, 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 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 the 216-S-10 Pond and Ditch. Under interim status, groundwater monitoring at the 216-S-10 Pond and Ditch has been conducted in accordance with WAC 173-303-400(3), "Interim Status Facility Standards" (and, by reference, 40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring"), which requires monitoring to determine whether the dangerous waste constituents from the DWMU have entered the groundwater in the uppermost aquifer underlying the unit.

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.

An interim status groundwater monitoring program (WHC-SD-EN-AP-018, *Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*) was initiated in 1990 at the 216-S-10 Pond and Ditch in accordance with 40 CFR 265, Subpart F, and WAC 173-303-400, "Interim Status Facility Standards." The unit comprised the 216-S-10 Pond and 216-S-10 Ditch only. Nearby facilities, such as the 216-S-11 Pond, were not part of the regulated unit.

Updated indicator evaluation monitoring plans were issued during the interim status period. The most recent monitoring plan was issued in 2017 (DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 1). Groundwater monitoring has been performed under an indicator evaluation program throughout the interim status period at the 216-S-10 Pond and Ditch.

Under Revision 9 of the Hanford Facility Dangerous Waste Permit, the 216-S-10 Pond and Ditch treatment, storage, and disposal unit, will become a final status closure unit group. Part II, Condition II.F of the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Rev. 8c (hereinafter referred to as 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). Plume maps of regional contaminants in the vicinity of the regulated unit are provided.

2.3 Waste Characteristics

Approximately 50 waste streams contributed to the 216-S-10 Ditch (Section 1.4.3 in DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*). The routine waste stream sources include the compressor cooling water from the 202S Building and the sanitary water overflow from the water tower. The remaining sources were infrequent additions and include 202S Building floor drains and funnel drains, 211S Tank Farm (a storage area) pump drains, tank drains, station drains, chemical sewer line man-holes, and 276S Building floor drains. The effluent to the

chemical sewer was composed of approximately 60% REDOX Facility raw water, 20% sanitary water, and 20% steam condensate (Section 1.4.3 in DOE/RL-2004-17).

The 216-S-10 Ditch last received wastewater discharges in October 1991. One documented dangerous waste discharge to the 216-S-10 Pond and Ditch occurred in September 1983 (Section 3.0 in DOE, 1987). This discharge was allowed to percolate into the soil column underlying the unit. In this incident, 420 L (110 gal) of synthetic double-shell tank slurry was discharged to the 216-S-10 Pond and Ditch during the pilot-scale evaporation crystallizer run at the Chemical Engineering Laboratory, located next to the REDOX Facility. The waste consisted largely of sodium nitrate (46%) and sodium hydroxide (41%), with small quantities of sodium phosphate, sodium fluoride, sodium chloride, and potassium dichromate (hexavalent chromium). Samples of this slurry taken from feed tanks TK-505 and TK-509 were analyzed before the discharge occurred (Section 3.0 in DOE, 1987).

The synthetic tank slurry constituents comprise the wastes identified in the Hanford Facility RCRA Permit Part A Application for the 216-S-10 Pond and Ditch. Dangerous wastes identified in the Part A Application include characteristic dangerous waste (ignitable [D001], corrosive [D002], and characteristic waste [D007 (chromium)]) and state-only toxic waste (WT01 and WT02) (Table 2-1).

Table 2-1. Dangerous Wastes Identified for 216-S-10 Pond and Ditch in the Hanford Facility RCRA Permit Part A Application

Dangerous Waste Code	Contaminant Description	Dangerous Waste Code	Contaminant Description
D001	Ignitable	WT01	Extremely hazardous waste/toxic dangerous waste
D002	Corrosive	WT02	Dangerous waste/toxic dangerous waste
D007	Chromium	--	--

Other potential contributors of hexavalent chromium in the vicinity of the 216-S-10 Pond and Ditch include the 216-S-17 REDOX Swamp and the 216-S-5 Crib. Until January 1953, the nearby 216-S-17 REDOX Swamp, a 6.9 to 8.5 ha (17 to 21 acre) pond, received process cooling water and steam condensate from the 202S Building (Waste Information Data System). After January 1953, the 216-S-17 site received the 202S Building effluent and the overflow from the 216-U-10 Pond via the 216-U-9 Ditch. In late 1952, the 216-S-17 site became unusable after a series of coil leaks occurred in the REDOX D-12 Waste Concentrator, resulting in discharges of radiologically contaminated process sewage from both the process sewer and the chemical sewer of the REDOX Plant. In March 1954, the 216-S-17 site was abandoned. In 1953, the 216-S-10 Ditch and Pond were constructed to replace 216-S-17 and receive the 202S Building chemical sewer. In March 1954, the 216-S-5 Crib was also constructed to replace the 216-S-17 site and receive the 202S Building process cooling water and steam condensate. Discharges of hexavalent chromium have been documented at both the 216-S-5 Crib and 216-S-17 Pond; however, the quantities are unclear.

2.4 Interim Status Monitoring Network and Sampling History

Table 2-2 identifies the interim status groundwater monitoring plans implemented at the 216-S-10 Pond and Ditch. Figure 2-3 provides the locations of wells discussed in this section. A summary of the

monitoring history for the 216-S-10 Pond and Ditch is presented in Appendix A. Appendix A also contains the interim status groundwater monitoring data collected at the 216-S-10 Pond and Ditch network wells 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 2-2 is provided in Appendix A.

Table 2-2. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program[a]
WHC-SD-EN-AP-018, *Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*	1990	Indicator Evaluation Program
ECN 113816	1990	
ECN 618168	1994	
ECN 618188	1995	
PNNL-14070, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*	2002	Indicator Evaluation Program
PNNL-14070-ICN-1	2003	
PNNL-14070-ICN-2	2006	
DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0	2010	Indicator Evaluation Program
DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 1	2017	Indicator Evaluation Program

* 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."

ECN = engineering change notice

ICN = interim change notice

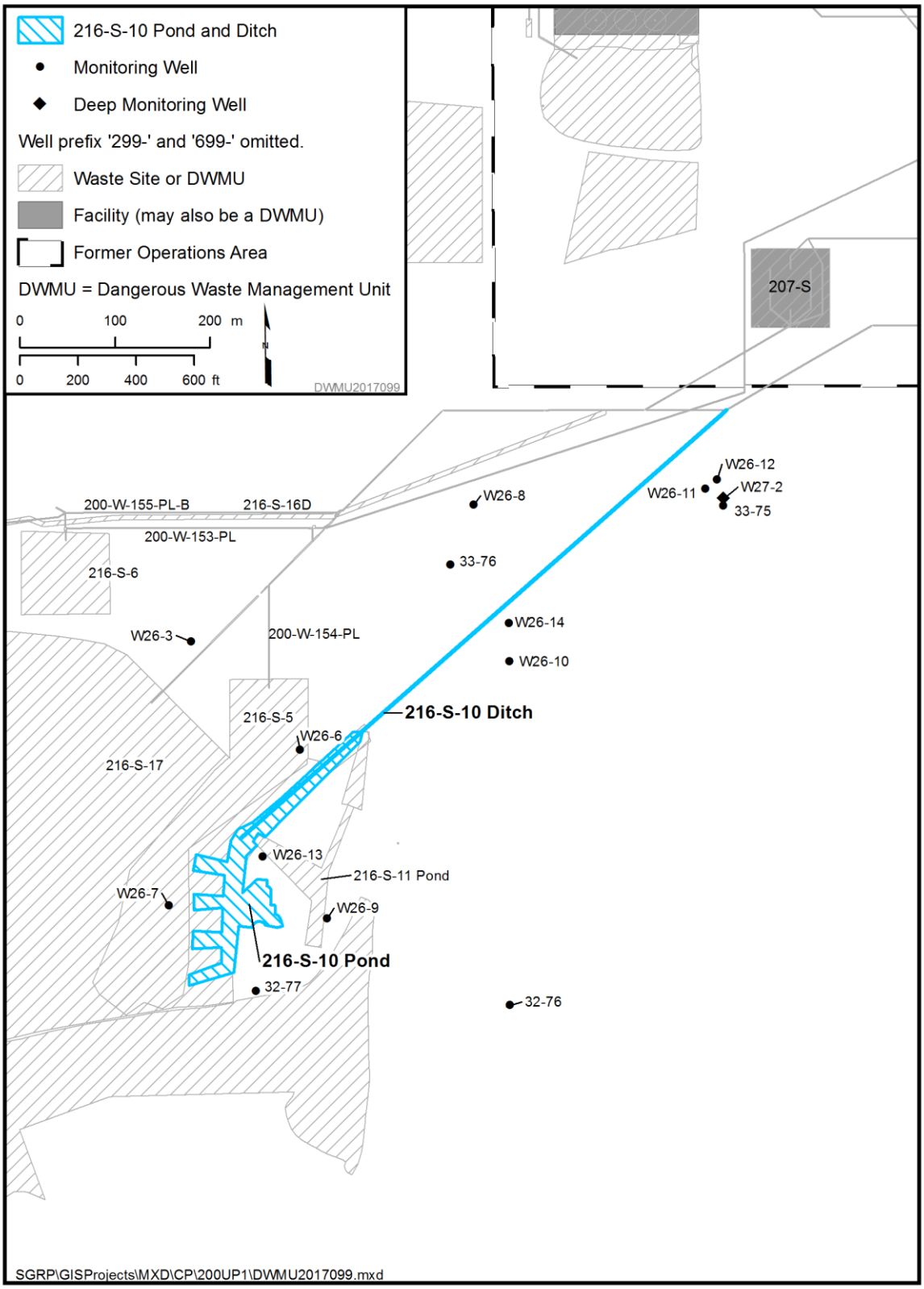


Figure 2-3. Wells Used During Interim Status Monitoring of the 216-S-10 Pond and Ditch

In 1990, the DOE Richland Operations Office initiated an interim status groundwater monitoring program at the 216-S-10 Pond and Ditch (WHC-SD-EN-AP-018) based on the interim status indicator evaluation program requirements of 40 CFR 265, Subpart F, and WAC 173-303-400. WHC-SD-EN-AP-018 identified three existing wells for evaluation (upgradient wells 299-W26-3 and 299-W26-6 and downgradient well 699-32-77) to determine if the wells should be added to the 216-S-10 Pond and Ditch monitoring network (p. 54 in WHC-SD-EN-AP-018). In addition, six new monitoring wells were planned; three to be installed in 1990 and three in 1991. 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." The groundwater flow direction beneath the unit was reported as east-southeast (p. 38 in WHC-SD-EN-AP-018).

The 216-S-10 Pond and Ditch monitoring wells installed in 1990 included upgradient well 299-W26-8 and downgradient well 299-W26-11 (Figure 2-3 in WHC-SD-EN-AP-018). Well 299-W26-11 was planned as a deep well; however, perched water was encountered during drilling and the well was completed as a perched water monitoring well (pp. 54 to 56 in ECN 113816, *Engineering Change Notice to Interim Status Monitoring Plan*). Wells installed in 1991 include upgradient well 299-W26-7 and downgradient wells 299-W26-10 and 299-W26-12.

Groundwater sampling was temporarily discontinued in June 1990 due to cancelation of the analytical laboratory contract. The Hanford Site 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*). Background sampling was completed in September 1991 for the 216-S-10 Pond and Ditch network wells, except for well 299-W26-11 (Sections 11.1.2 and 11.3 in DOE/RL-92-03). Field notes indicate that perched well 299-W26-11 was not sampled due to insufficient water.

In 1992, perched well 299-W26-11 was sample dry, and deep well 299-W27-2 was installed downgradient to monitor the base of the unconfined aquifer (Figure 2-3 in DOE/RL 93-09). Chromium (unfiltered) was detected at concentrations above the drinking water standard (DWS) in each of the 216-S-10 monitoring network wells that were sampled in fiscal year (FY) 1992. Upgradient well 299-W26-8 showed the highest concentrations for this constituent. Chromium (filtered) was detected at concentrations above the DWS in upgradient well 299-W26-7 and downgradient well 299-W26-9. Both of these wells are located at the south end of the facility, near the 216-S-10 Pond (Section 11.3.1 in DOE/RL-93-09).

In 1994, ECN 618168, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, modified the sampling plan and specified that sampling constituents after the first year of quarterly sampling include contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), gross alpha, gross beta, alkalinity, and turbidity (p. 56 in ECN 618168). In 1995, ECN 618188, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, identified that existing wells 299-W26-3, 299-W26-6, and 699-32-77 were to be used for water-level measurements only, and removed dry well 299-W26-11 from the network (p. 3 in ECN 618188). The monitoring network comprised two upgradient wells (299-W26-7 and 299-W26-8) and four downgradient wells (299-W26-9, 299-W26-10, 299-W26-12, and 299-W27-2 [deep]).

The groundwater monitoring plan was revised in 2002 (PNNL-14070, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*) to remove dry monitoring wells (299-W26-8, 299-W26-9, 299-W26-10, and 299-W26-12) from the network and update the monitoring constituents. The 216-S-10 Pond and Ditch network comprised one upgradient well (299-W26-7) and two downgradient wells (299-W26-13 and 299-W27-2 [deep]) (Table 6.1 in PNNL-14070). Because the network was inadequate for interim

status monitoring, the plan proposed deepening upgradient well 299-W26-7, since it was predicted to go dry in 2003, and deepening dry downgradient well 299-W26-12 (Section 6.3.1 in PNNL-14070). The plan also proposed repurposing a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* characterization borehole (for use as a downgradient monitoring well) that was planned to be drilled either within the footprint of, or slightly downgradient from, the 216-S-10 Ditch (Section 6.3.1 in PNNL-14070). The revised monitoring constituents included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), chromium, carbon tetrachloride, vanadium, chloroform, alkalinity, temperature, and turbidity (Table 6.4 in PNNL-14070).

In 2003, PNNL-14070-ICN-1, *Interim Change Notice to Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, added downgradient well 299-W26-14 to the network and identified upgradient well 299-W26-7 as dry (p. 1 in PNNL-14070-ICN-1).

From 2003 until 2010, total organic halogen (TOX) critical means could not be calculated because measurements were below detection limits (Table B.16 in PNNL-14548, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*). Until a new upgradient well was installed and background values established, statistical comparisons of indicator parameters were performed using data from well 299-W26-7 before it went dry (Section 1.5.17 in DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009 Volumes 1 & 2*). In 2008, two downgradient wells (699-32-76 and 699-33-75) and one upgradient well (699-33-76) were installed and quarterly sampling was conducted during 2009 to establish new background levels (Section 6.4.3.2 in DOE/RL-2010-11).

In 2010, a new groundwater monitoring plan was issued that revised the monitoring constituents and updated the monitoring network (DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0). The monitoring constituents included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), chromium, hexavalent chromium, copper, mercury, zinc, aroclor 1254, benzo(a)pyrene, oxidation-reduction potential, temperature, turbidity, alkalinity, anions (fluoride, nitrate, nitrite), and metals (calcium, potassium, magnesium) (Table 3-1 in DOE/RL-2008-61, Rev. 0). The monitoring network included one upgradient well (699-33-76) and five downgradient wells (299-W26-13, 299-W26-14, 299-W27-2 [deep], 699-32-76, and 699-33-75) (Table 3-1 in DOE/RL-2008-61, Rev. 0).

In 2011, two indicator parameter results exceeded the critical means. In May, TOX results in upgradient well 699-33-75 exceeded the critical mean; however, verification sample results were below the critical mean (Section 3.3.10.3 in DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). The elevated TOX result was attributed to the regional carbon tetrachloride plume in the 200 West Area (Section 3.3.10.3 in DOE/RL-2011-118). In December, the specific conductance result in downgradient well 699-32-76 exceeded the critical mean; however, verification sampling results were below the critical mean (Section 3.3.10.3 in DOE/RL-2011-118). Specific conductance had been elevated in this well since routine sampling began in 2008. The well also had slightly elevated alkalinity, sulfate, nitrate, calcium, and magnesium.

In 2012, specific conductance measurements approaching the critical mean were observed in downgradient well 699-32-76. Since 2007, specific conductance, chromium, and nitrate have trended upward at the 216-S-10 Pond and Ditch (p. UP-51 in DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*).

The 2016 Hanford Site RCRA groundwater monitoring report (DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*) reported the general groundwater flow direction for the 216-S-10 Pond and Ditch as east, and calculated the groundwater flow rate at 0.21 m/d (0.69 ft/d) (Table 2-27 in DOE/RL-2016-66). Elevated chromium concentrations continue to be reported in network

wells. In May, the DWS for chromium (100 μg/L) was exceeded at well 299-W26-13 (157 μg/L) (Section 2.8 in DOE/RL-2016-66). The 216-S-10 unit is a likely source of the chromium; however, other sources of chromium also exist, including the 216-S-11 Pond and 216-S-5 Crib (Section 2.8 in DOE/RL-2016-66). In particular, the chromium may have originated in whole or in part from the 216-S-11 overflow pond, which received some of the same waste as the 216-S-10 Pond and Ditch, but is not part of the regulated unit (Section 2.8 in DOE/RL-2016-66).

In 2017, DOE/RL-2008-61, Rev. 1, was issued. The monitoring constituents were modified with removal of copper, mercury, zinc, benzo(a)pyrene, aroclor 1254, fluoride, and oxidation-reduction potential, and addition of hexavalent chromium (Section 3.1 and Table 3-1 in DOE/RL-2008-61, Rev. 1). Carbon tetrachloride was added to provide supporting information to TOX analyses, and manganese and nickel were added to support evaluation of well screen corrosion (Table 3-3 in DOE/RL-2008-61, Rev. 1). Monitoring constituents included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), hexavalent chromium, anions (chloride, nitrate, and sulfate), metals (calcium, chromium (total), iron, magnesium, manganese, nickel, potassium, and sodium), alkalinity, carbon tetrachloride, and field parameters (temperature and turbidity) (Section 3.1 and Table 3-1 in DOE/RL-2008-61, Rev. 1). The groundwater monitoring network comprised five downgradient wells (299-W26-13, 299-W26-14, 299-W27-2 [deep], 699-32-76, and 699-33-75), and one upgradient well (699-33-76) (Table 3-1 in DOE/RL-2008-61, Rev. 1). The groundwater flow direction was reported as east-southeast (Table 3-3 in DOE/RL-2008-61, Rev. 1).

3 Geology and Hydrogeology

This chapter briefly describes the local geology and hydrogeology beneath the 216-S-10 Pond and Ditch. This information is summarized from PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, and DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Area S/SX*.

3.1 Stratigraphy

The generalized stratigraphy of the Hanford Site is shown in Figure 3-1. The local stratigraphy beneath the 216-S-10 Pond and Ditch consists of unconsolidated to semi-consolidated sediments overlying basalt bedrock of the Columbia River Basalt Group. Geologic cross sections prepared in the vicinity of the 216-S-10 Pond and Ditch are shown in Figures 3-2 and 3-3. The sedimentary units present, in descending sequence, include the following:

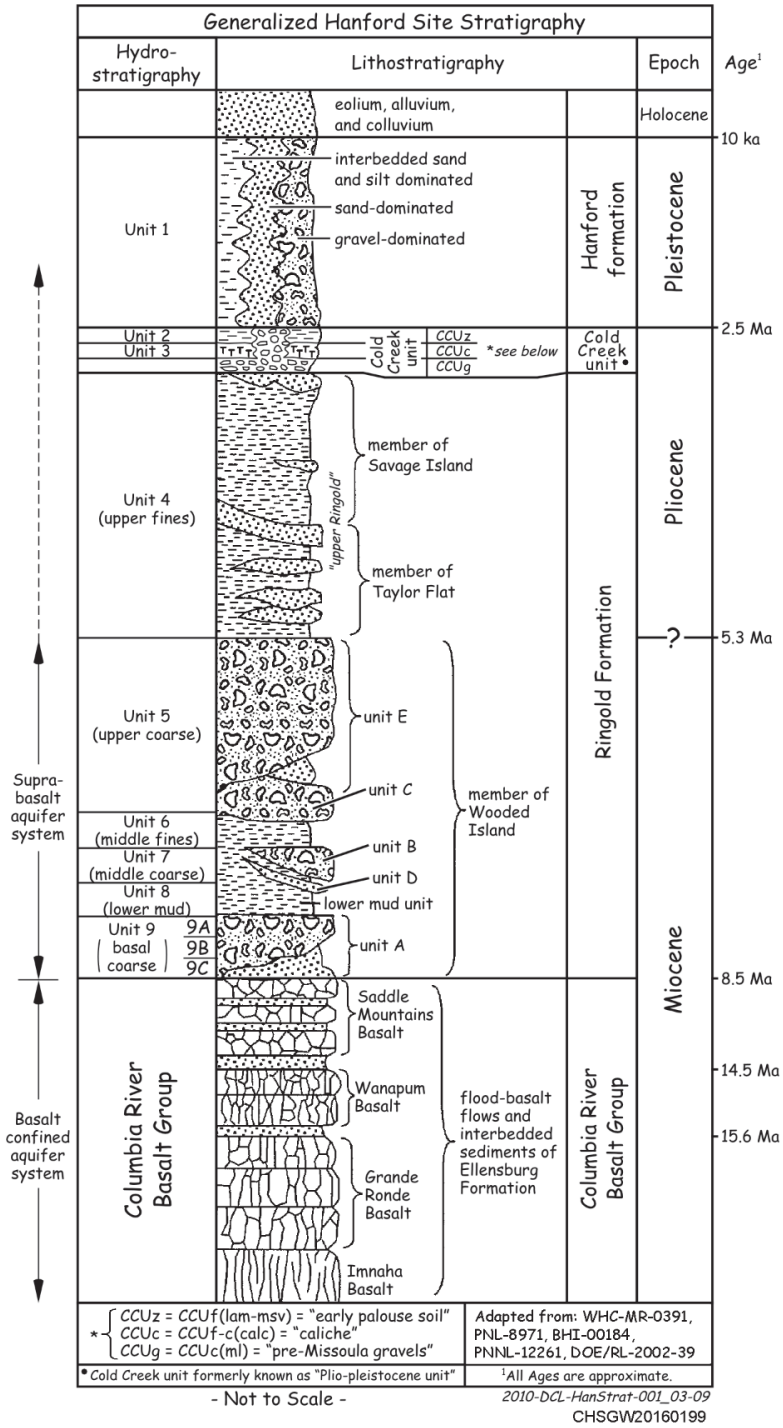
- Sand and gravel backfill
- Sand and gravel of the Hanford formation
- Fine-grained Cold Creek unit (CCU)
- Sand and gravel of the Ringold Unit E
- Fine-grained Ringold lower mud unit
- Sand and gravel of Ringold Unit A (which overlies the basalt)

The Ringold Formation consists of Miocene-Pliocene fluvial and lacustrine elastic sediment deposited by the ancestral Columbia River system. The sediment rests unconformably on the Miocene-age Columbia River Basalt Group. Using a depositional environment approach, a number of facies within the Ringold Formation were identified (BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*). The Ringold Formation was divided into three informal members using facies associations (Section 4.2 in BHI-00184). The Ringold Formation underlying the 216-S-10 Pond and Ditch belongs to the member of Wooded Island. The Member of Wooded Island is divided into five gravel-dominated fluvial depositional units, separated by widespread overbank, paleosol, and lacustrine deposits. The lower mud unit, a thick lacustrine deposit, separates gravel Unit A from the overlying deposits.

The CCU, which separates the Ringold Formation from the Hanford formation, is divided into two distinct sequences. The upper sequence of thinly laminated silts was identified as lacustrine deposits. Calcium carbonate-rich strata characterize the lower sequence. This lower interval consists of locally derived basaltic detritus, silt-rich eolian deposits, reworked Ringold material, and calcium carbonate-rich paleosols. The calcium carbonate occurs as thin (<2.5 cm [1 in.]) layers, nodules, and coatings on clasts.

3.2 Hydrogeology

Groundwater beneath the Central Plateau flows generally from west to east. Natural recharge to the unconfined aquifer comes from the Cold Creek Valley, Dry Creek Valley, Rattlesnake Hills, and infiltrating precipitation. Groundwater velocity generally ranges from a few millimeters to tenths of a meter per day.



Note: Complete reference citations are provided in Chapter 11.

Figure 3-1. General Stratigraphy at the Hanford Site

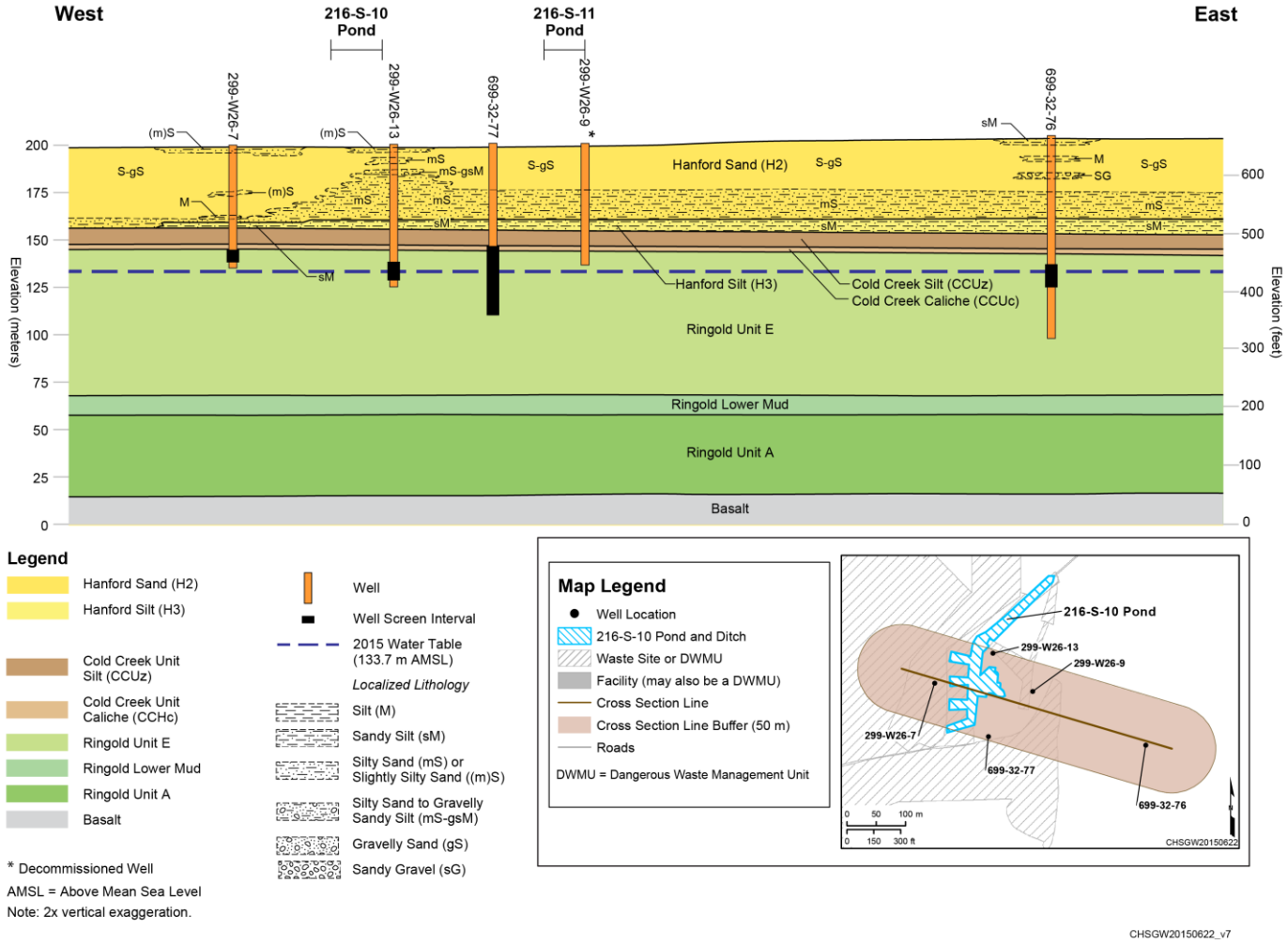


Figure 3-2. West to East Geologic Cross Section through the 216-S-10 Pond and Ditch

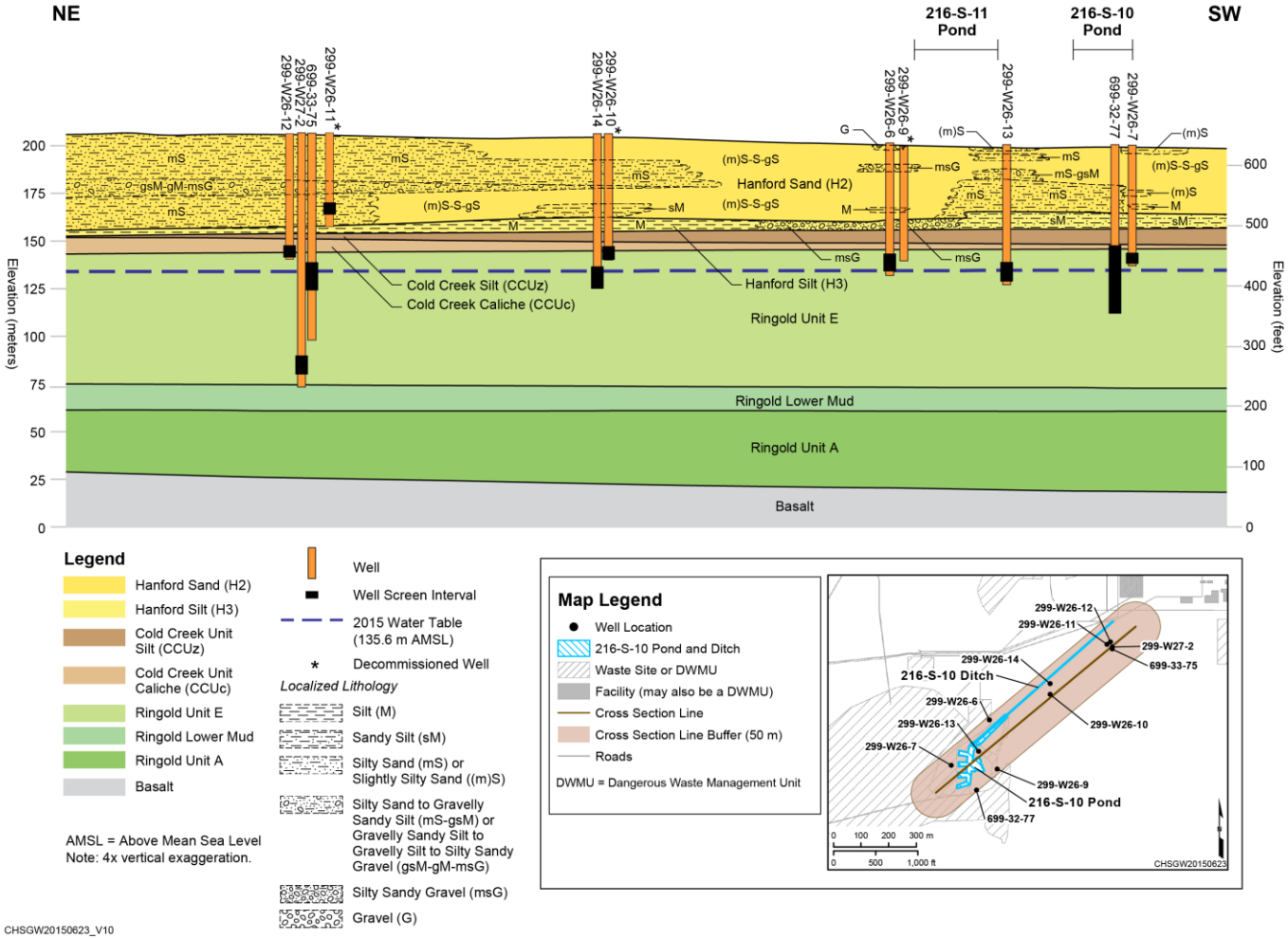


Figure 3-3. Northeast to Southwest Geologic Cross Section through the 216-S-10 Pond and Ditch

The water table beneath the 216-S-10 Pond and Ditch unit occurs within Ringold Unit E (Figure 3-3), and the vadose zone is approximately 66 to 74 m (217 to 243 ft) thick. The base of the unconfined aquifer is the top of the fine-grained Ringold lower mud unit. The water table elevation is approximately 134 m (440 ft) (NAVD88, *North American Vertical Datum of 1988*). The unconfined aquifer is approximately 63 m (207 ft) thick. The uppermost confined aquifer occurs in the Ringold Unit A and is confined above by the lower mud unit and below by basalt. The lower aquifer is considerably thinner than the unconfined aquifer beneath the 216-S-10 Pond and Ditch and there is no evidence of hydraulic connectivity between the two aquifers in the immediate vicinity of the area. Deeper confined aquifers occur between the basalt flows.

The groundwater flow direction is toward the east beneath the unit, with an average hydraulic gradient of 3.0×10^{-3} (Section 2.8 in DOE/RL-2016-66). The average flow direction beneath the 216-S-10 Pond and Ditch is almost due east at approximately 103° azimuth. Analysis of water-level data indicates that the average groundwater flow rate beneath the 216-S-10 Pond and Ditch is approximately 76 m/yr (252 ft/yr). The saturated hydraulic conductivity of the Ringold E unit underlying the 216-S-10 Pond and Ditch is 5 m/d (16.4 ft/d) (Table 4-9 in CP-47631). Saturated hydraulic conductivity ranges from 2.76 to 5.4 m/d (9.06 to 17.7 ft/d) based on field measurements (slug test data curve analysis) for the following wells:

- 5.4 m/d (17.7 ft/d) in well 299-W22-79 (Table 4.1 in PNNL-13378, *Results of Detailed Hydrologic Characterization tests – Fiscal Year 1999*)
- 2.76 m/d (9.06 ft/d) in well 299-W26-13 (Table 4.1 in PNNL-13514, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000*)
- 4.02 m/d (13.2 ft/d) in well 299-W26-14 (Table 4.2 in PNNL-14804, *Results of Detailed Hydrologic Characterization Tests Fiscal Year 2003*)

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. The Ringold lower mud and basalt are considered aquitards relative to other sediments beneath the 216-S-10 Pond and Ditch because of the units' very low hydraulic conductivities (Section 5.0 in PNNL-13858).

The water table has been declining at the 216-S-10 Pond and Ditch since the shutdown of 216-U-10 Pond (U Pond) (located 900 m [3,000 ft] north-northwest of the 216-S-10 Pond and Ditch) in 1984. The declining water levels caused many of the original network monitoring wells at the 216-S-10 Pond and Ditch to go dry. New wells were drilled in 1999 (299-W26-13), 2003 (299-W26-14, which replaced 299-W26-10), and 2008 (699-32-76; 699-33-75, which replaced 299-W26-12; and 699-33-76, which replaced 299-W26-8). From 2012 and 2016, water levels in the network wells have declined at an average rate of 0.27 m/yr (0.89 ft/yr) (Section 11.12.3 in DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*).

3.3 Groundwater Flow

Elements of the groundwater flow system beneath the 216-S-10 Pond and Ditch are described in the following subsections. These elements include the effects of historical anthropogenic discharges to ground in the 200 West Area, resulting in changes in groundwater elevation and flow direction and velocity, and more recently, implementation of groundwater remediation using P&T systems that remove, treat, and replace water into the aquifer.

3.3.1 Hydrologic Conditions Prior to 200 West P&T Operations

Natural recharge from precipitation is currently the only source of recharge to the vadose zone beneath the 216-S-10 Pond and Ditch. Lysimeter studies across the Hanford Site have shown that natural recharge

varies from near zero to 10 cm/yr (3.9 in./yr) depending on soil texture and vegetation (Table S.1 in PNNL-14744, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*). Recharge at the 216-S-10 Pond and Ditch is likely toward the higher end of this range because of the surface covering of coarse sand and sparse vegetation. Between 1947 and 2008, annual precipitation at the Hanford Meteorological Station averaged 17.2 cm (6.8 in.) and varied between 7.6 and 31.3 cm (3.0 and 12.3 in.) (Section 4.1.1 in PNNL-18807, *Soil Water Balance and Recharge Monitoring at the Hanford Site – FY09 Status Report*).

The average direction of groundwater flow beneath the 216-S-10 Pond and Ditch is presently determined by trend surface analysis of water-level measurements from monitoring wells (Section 2.4.3 in DOE/RL-2008-61, Rev. 1). Groundwater flow direction prior to the startup of the 200 West P&T can be found in Appendix A. Groundwater flow conditions at the 216-S-10 Pond and Ditch have been fairly stable since the facility was constructed in 1951, even while U Pond, located in the southwest part of the 200 West Area, was active (Section 2.4.3 in DOE/RL-2008-61, Rev. 1).

The water table has been declining at 216-S-10 since the shutdown of U Pond (Section 2.4.3 in DOE/RL-2008-61, Rev. 1). Baseline groundwater levels were evaluated in two dimensions by interpolating water-level data obtained during June 2012, at which time no groundwater remedy was operating. Figure 3-4 shows the 2012 water table map prior to the start of the 200 West P&T remedy. In 2012, the groundwater flow direction was to the east-southeast with an estimated hydraulic gradient of 2.6×10^{-3} m/m and an average linear velocity of 0.18 m/d (0.59 ft/d) (Table 3-1 in SGW-55438, *Hanford Site Groundwater Monitoring for 2012: Supporting Information*).

3.3.2 Hydrologic Conditions Due to Operation of the P&T Remedy

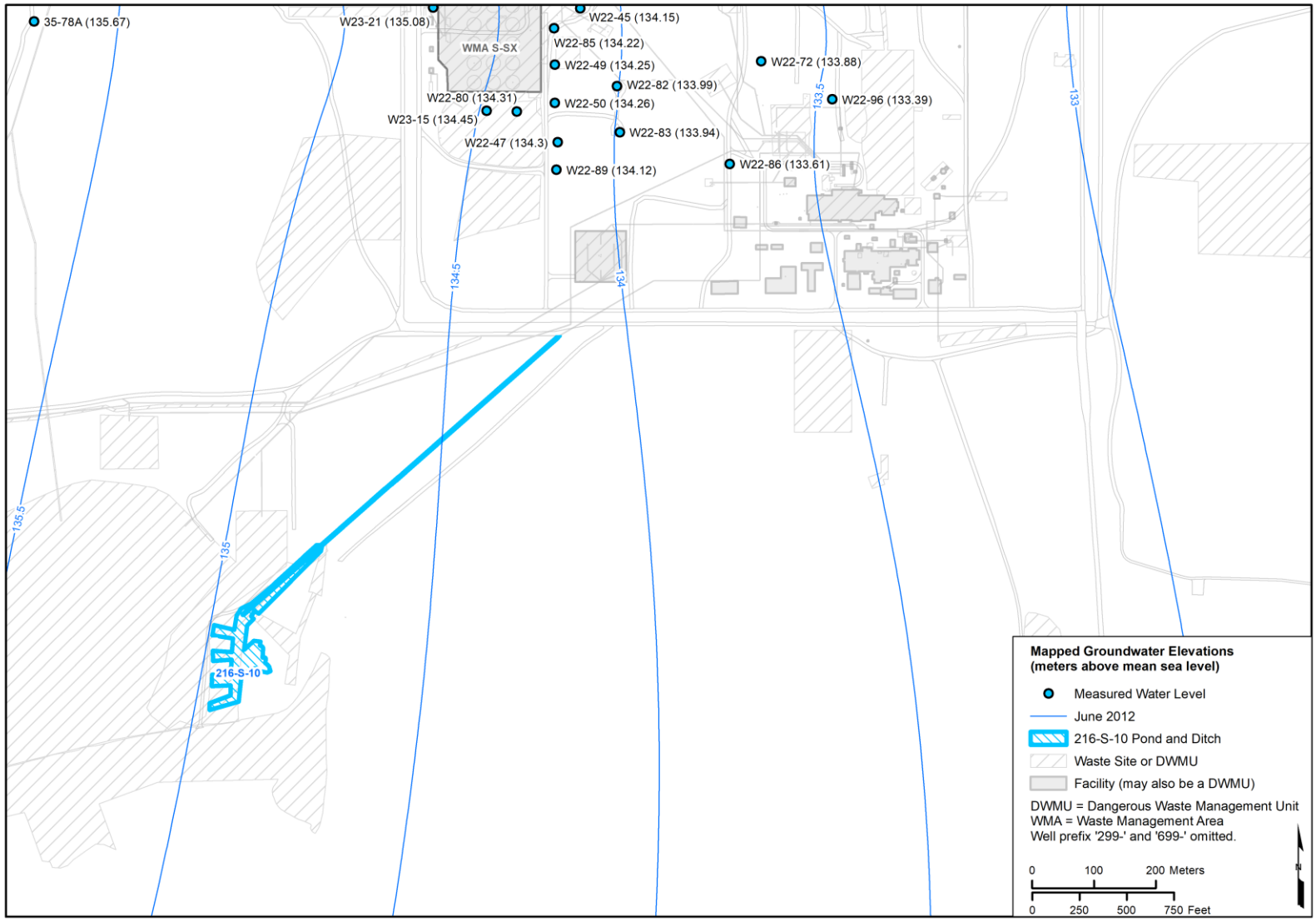
The 216-S-10 Pond and Ditch complex is located south and crossgradient to the 200 West P&T extraction and injection well network, which began operating in 2012. The 200 West P&T system extracts and treats contaminated groundwater. Extraction well 299-W22-92 is located northeast of the 216-S-10 Pond and Ditch.

Water levels in the 216-S-10 Pond and Ditch interim status monitoring network wells have been declining at an average rate of 0.27 m/yr (0.89 ft/yr) from 2012 to 2016. The hydraulic gradient, determined by trend surface analysis using water-level measurements collected during March, May, and November 2016 from five wells, had a magnitude of 3.0×10^{-3} m/m. The average calculated flow direction was east (103° azimuth) with an average velocity of 0.21 m/d (0.69 ft/d) (Section 2.8 in DOE/RL-2016-66). The decline is primarily due to two factors that are simulated with the CPGWM.

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

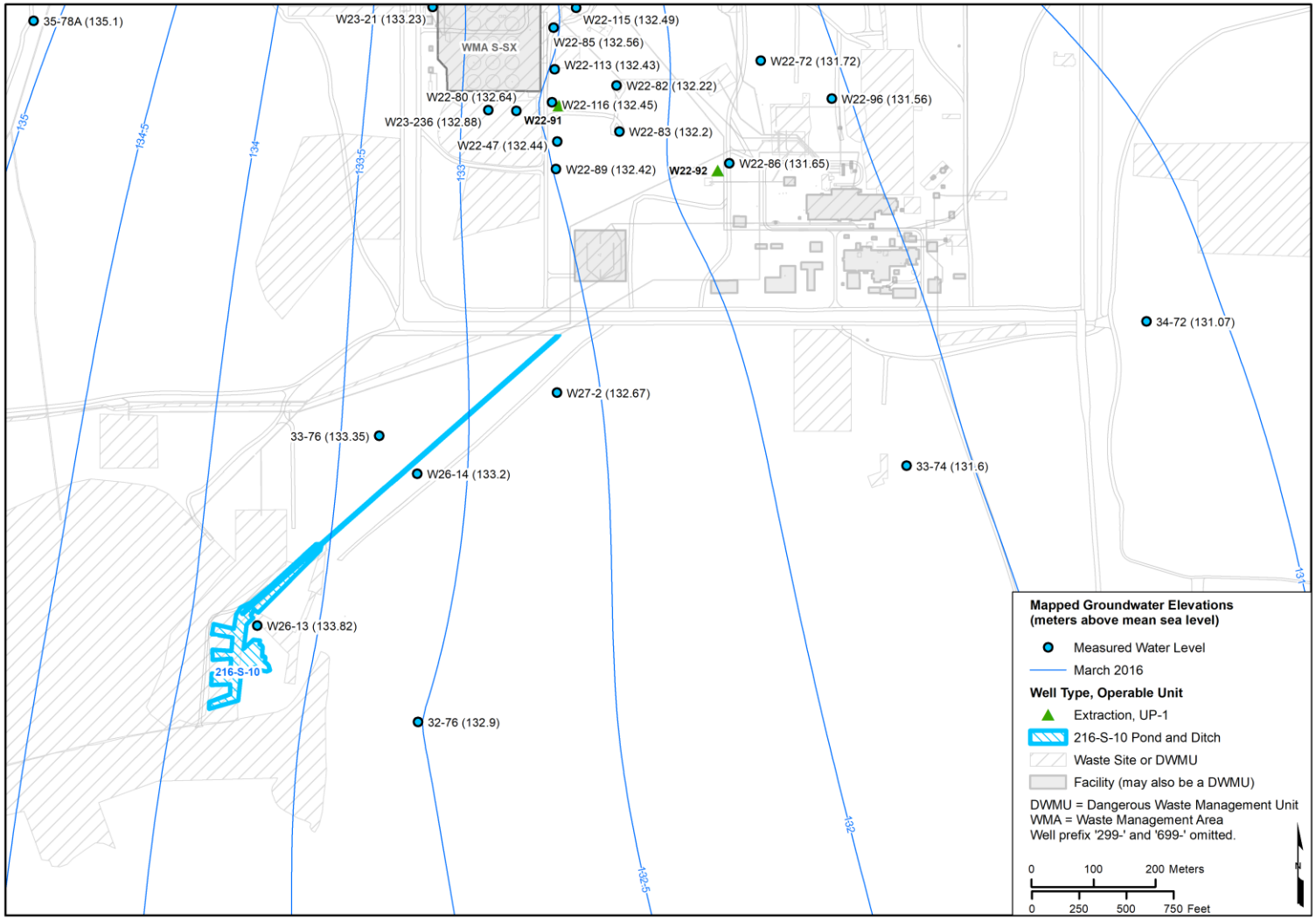
2. Commencement of operation of the 200 West P&T system in 2012. Water-level changes associated with the startup (SGW-50907, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site,* and ECF-200ZP1-12-0074, *Presentation & Initial Evaluation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

The March 2016 Hanford Site water table map shows groundwater flow direction to the east with a slight east-northeast direction in the northern extent of the 216-S-10 Pond and Ditch (Figure 3-5) due to extraction well 299-W22-92. Due to the distance from 200 West P&T system injection wells, there is no impact from injection wells in the area. Groundwater flow rate and direction are further described in Section 4.3.



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

Figure 3-4. Water Elevation Contours in June 2012 Prior to Startup of the 200 West P&T



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

Figure 3-5. Water Elevation Contours in March 2016 During Current 200 West P&T Operations

4 Contaminant Migration Conceptual Model

The conceptual model for contaminant release and transport through the vadose zone to groundwater at the 216-S-10 Pond and Ditch is based on the following assumptions:

- Average precipitation of about 18 cm/yr (~7 in./yr) has prevailed over the timeframe of interest (operational lifespan and post-closure monitoring period) (Section 4.5.2.2 in PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*).
- Net infiltration is assumed to occur directly to the vadose zone from the bottom of the pond and within the unlined ditch.
- Leaching of mobile contaminants from sediments comprising the bottom of the pond and unlined ditch are assumed to be the major potential source for contamination of vadose materials beneath the pond and ditch.
- Active artificial sources of water (e.g., leaking potable or raw water lines) are not present, based on Hanford Site drawings.

4.1 Vadose Zone

The vadose zone at the 216-S-10 Pond and Ditch is approximately 66 to 74 m (217 to 243 ft) thick and consists of (from top to bottom) the Hanford formation, the CCU, and the Ringold Formation. The lower hydraulic conductivities of the CCU are likely to slow downward movement of moisture and contaminants because of the finer textured sediments and associated calcium carbonate cementation that result in the small hydraulic conductivities of the units. Although the CCU is clearly restrictions to vertical migration of water (and associated dissolved contaminants) beneath the 216-S-10 Pond and Ditch, they are not impermeable and contaminated water can eventually reach the underlying groundwater. This is indicated by the apparent presence of contaminants from the 216-S-10 Pond and Ditch in groundwater near the site.

The unsaturated sediments above the water table affect how waste solutions move through the soil, how much is retained in the sediment column, and how much contamination eventually reaches the water table. The source of contamination for the 216-S-10 Pond and Ditch is liquid waste released to surface or subsurface sediments. These liquids would be expected to move through the sediment under both saturated and unsaturated conditions, depending on the volume of liquid released. In addition to expected vertical distribution in relatively homogeneous portions of the Hanford formation, lateral spreading may occur at changes in soil texture and hydraulic conductivity (i.e., silty lenses). Small-volume leaks would tend to be retained in the vadose zone near the leak point. Larger releases would be expected to move deeper in the soil, spreading laterally as the wetting front moves downward.

4.2 Soil Moisture Factors

Communication between the unconfined and Ringold Formation confined aquifers is assumed to be insignificant due to the thickness and relatively low permeability of the Ringold lower mud unit. As presented in PNNL-13858 (Section 3.1.2.2), based on hydrochemistry and hydrogeologic data, groundwater within the Hanford unconfined aquifer does not flow vertically through the lower mud unit. Thus, the unconfined aquifer is the only aquifer that could be potentially affected by releases from the 216-S-10 Pond and Ditch.

Perched water above the CCU was observed during well drilling when the 216-S-10 Pond and Ditch was operating (i.e., prior to 1992). One well, 299-W26-11, was completed within the perched water near the pipeline outlet at the north end of the 216-S-10 Ditch. In 1991, it was used to monitor dissipation of the perched water after liquid effluent disposal ceased at the facility. In 1990, this well was measured with groundwater at a depth of 40.9 m (134.1 ft) and was found to be dry at a depth of 42.4 m (138.95 ft) in 1993. Perched water has not been encountered in any wells drilled since that time. Reference points for the perched groundwater measurements, and consequently for the elevations for the groundwater, are not available. Well 299-W26-11 was decommissioned in 2010.

In May 1954, there was a documented release to a 0.4 ha (1 ac) overflow area that resulted from a break in the east trench (southeast 216-S-11) (Section: Index – Volume III, Outside the 200 West Area, South Quadrant in RHO-CD-673).

UPR-200-W-34: In May 1955, aluminum nitrate nanohydrate was inadvertently dumped to the 202S Building chemical sewer which resulted in plugged soil at the end of ditch (Section 2.3.5.2.1 in DOE/RL-91-60, *S Plant Aggregate Area Management Study Report*). As a result, the 216-S-10 Ditch overflowed in the area between the ditch and 216-S-11 (Waste Information Data System).

The 216-S-10 Pond site received one documented discharge of potentially dangerous waste in September 1983. The discharge consisted of simulated double-shell tank slurry that exhibited dangerous waste characteristics of ignitibility and corrosivity. Approximately 450 kg (1,000 lb) was discharged (Section 4.2 in DOE/RL-2006-12, *Hanford Facility Dangerous Waste Closure/Postclosure Plan for the 216-S-10 Pond and Ditch*).

4.3 Hydrogeologic Considerations

The 200 West P&T extraction at the 241-S-SX Tank Farms to the north has not been shown to cause an increase in hydraulic gradient beneath the 216-S-10 Pond and Ditch. P&T 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, the 200 West Area groundwater flow is anticipated to return to pre-200 West P&T startup conditions. Possible 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 the 216-S-10 Pond and Ditch in the simulations described in Chapters 5 through 7 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 the 216-S-10 Pond and Ditch 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.

Under the current groundwater flow regime, contaminants reaching the groundwater from a release at the 216-S-10 Pond and Ditch would migrate as dissolved contamination plume(s) toward the east with the groundwater flow. Dissolved chromium (hexavalent chromium) is mobile in the aquifer; it migrates at the same average flow rate (to the east) as groundwater (0.21 m/d [0.69 ft/d]). Routine sampling since 2009 at 299-W26-13 indicates that chromium is present within the aquifer (Section 11.12.3 in DOE/RL-2016-67) ranging from 37.9 μg/L (2009) to 157 μg/L (2016).

No indicator parameter critical mean exceedances occurred in 2016. Between 2007 and 2012, specific conductance generally trended upward in well 299-W26-13 from annual average values of 270 to 310 μS/cm. This increasing trend correlated to increasing nitrate concentrations. From 2012 through 2016, specific conductance has been relatively stable, consistent with a stable to slightly declining nitrate trend.

However, chromium has continued to increase, and exceeded the 100 μg/L total chromium DWS (157 μg/L maximum in May 2016). The 216-S-10 Pond and Ditch system is a probable contributor of chromium, but other sources of chromium (e.g., the 216-S-11 overflow pond and 216-S-5 Crib) also exist. In particular, the chromium may also originate from the 216-S-11 overflow pond, which received some of the same waste as the 216-S-10 Pond and Ditch, but is not part of the regulated unit.

Well 699-33-75 had the highest carbon tetrachloride concentration amongst the network wells (5.42 μg/L in 2017). This is above the 3.4 μg/L cleanup level for the 200-UP-1 OU. Carbon tetrachloride is also detected in upgradient well 699-33-76 (3.2 μg/L in 2017). This constituent does not originate from the 216-S-10 Pond and Ditch, but is widespread in the groundwater beneath and near the 200 West Area and originates from waste disposal sites at the Plutonium Finishing Plant (Chapter 12 in DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*).

Concentrations of chromium (unfiltered), iron (unfiltered), manganese (unfiltered), and nickel (filtered and unfiltered) continue to be elevated in deep well 299-W27-2. These constituents are stainless steel corrosion products, and this well has stainless steel components. A downhole video of the well screen confirmed that the source of the elevated metals is corrosion (Section 2.5.1 in DOE/RL-2008-61, Rev. 1).

Chromium analysis completed in 2016 includes filtered and unfiltered total chromium, as well as filtered and unfiltered hexavalent chromium. Total chromium analysis provides a summation of both trivalent chromium, as well as the mobile hexavalent chromium. The elevated chromium identified in well 299-W27-2 during 2016 comprised primarily undissolved trivalent chromium. Results for dissolved phase total chromium and both undissolved and dissolved hexavalent chromium were at or near the detection limit, which are 4.4 μg/L and 1.5 μg/L, respectively. The presence of undissolved trivalent chromium is consistent with well corrosion and is not indicative of the hexavalent chromium plume present at 216-S-10. The maximum concentration of undissolved trivalent chromium of 90.1 μg/L in 2016 at well 299-W27-2 is consistent with values attributable to well corrosion.

4.5 Summary of Vertical Contaminant Distribution

Dangerous waste constituents specific to release from the 216-S-10 Pond and Ditch are not present in groundwater at depth based on historical monitoring. Evaluation of vertical distribution data is limited to the location of the 216-S-10 Pond and Ditch within the context of regional plumes present in the 200-UP-1 OU, including contaminant plumes originating from the 216-S-10 Pond and Ditch. In monitoring well 699-32-76, constructed in 2008, depth-discrete data for benzene, carbon tetrachloride, chlorobenzene, and trichloroethene exhibit laboratory nondetections for each constituent. In monitoring wells 699-33-75 and 699-33-76, both constructed in 2008, maximum depth-discrete data during drilling showed concentrations of carbon tetrachloride were 43 μg/L and 6.8 μg/L, respectively, above the

cleanup level. Well 699-33-75 is on the periphery of the regional carbon tetrachloride plume but only had four depth-discrete samples taken for analysis. Based on the limited sample measurement data available, there is not enough vertical distribution data available to determine vertical distribution of contaminants at this location.

5 Groundwater Flow Simulations

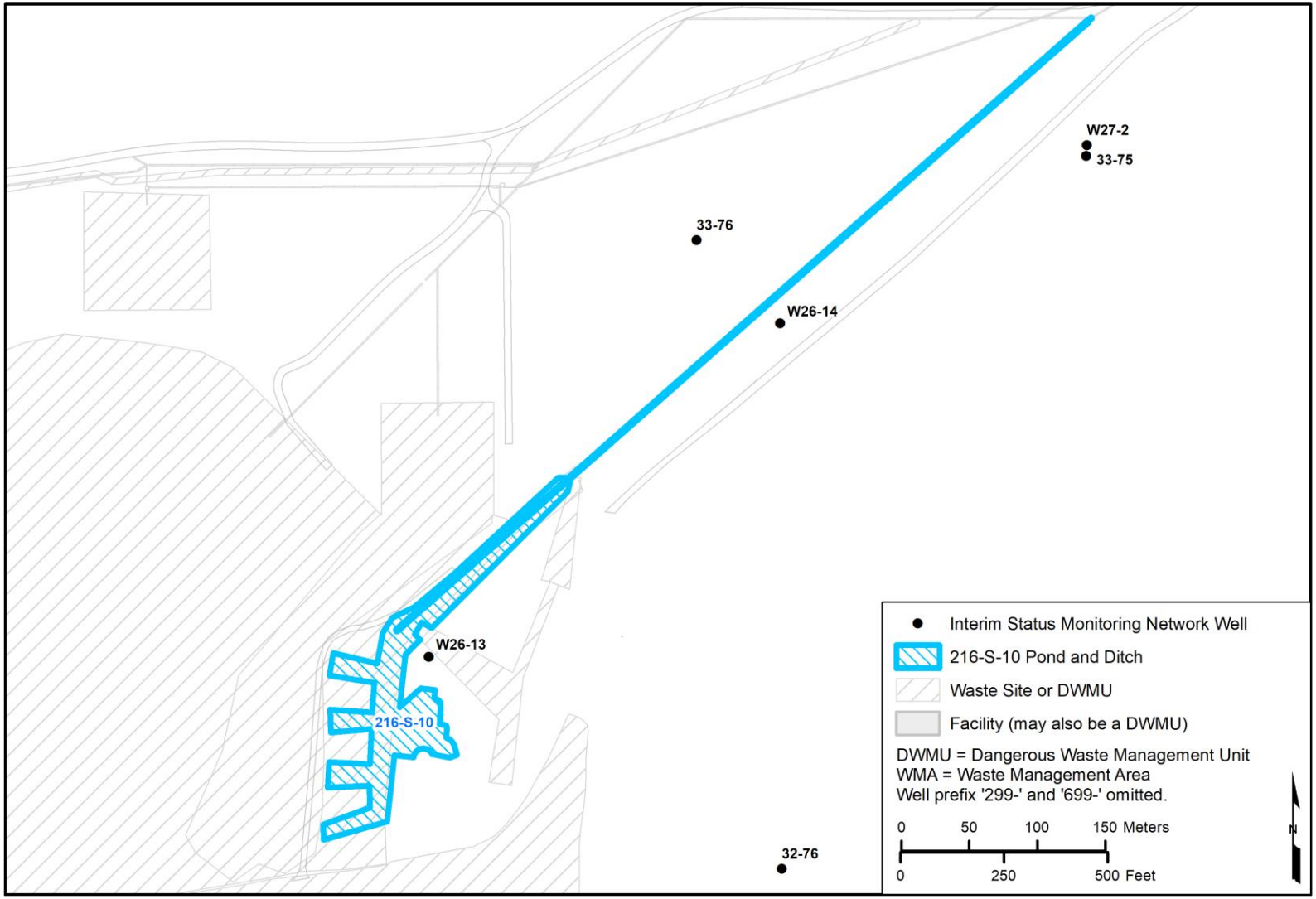
Groundwater flow simulations were conducted to evaluate the groundwater monitoring network for the 216-S-10 Pond and Ditch (Figure 5-1) for its ability to detect increases in groundwater contamination due to hypothetical releases from the facility both under the influence of the 200 West P&T system and after cessation of P&T operations. The wells included in the interim status groundwater monitoring network are documented in Table 2-26 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 E. 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 216-S-10 Pond and Ditch.

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 upon 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 E.



Source: Table 2-26 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016.*

Figure 5-1. Interim Status Groundwater Monitoring Network

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.

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.

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 the 216-S-10 Pond and Ditch and to assist in determining whether adjustment to the monitoring network is needed.

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

Table 5-1. Simulation Scenarios

Scenario	P&T System Capacity[a]	Sub-Scenario	Description	Scenario Weight (%)
1 (cont.)	2,305 gal/min (8,725 L/min)	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
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

Table 5-1. Simulation Scenarios

Scenario	P&T System Capacity[a]	Sub-Scenario	Description	Scenario Weight (%)
2 (cont.)	2,500 gal/min (9,464 L/min)	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 pathline 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 (composed 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 (composed 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 Operable Unit, is included in the extraction total for 200-ZP-1.

b. Current conditions as defined in Appendix F.

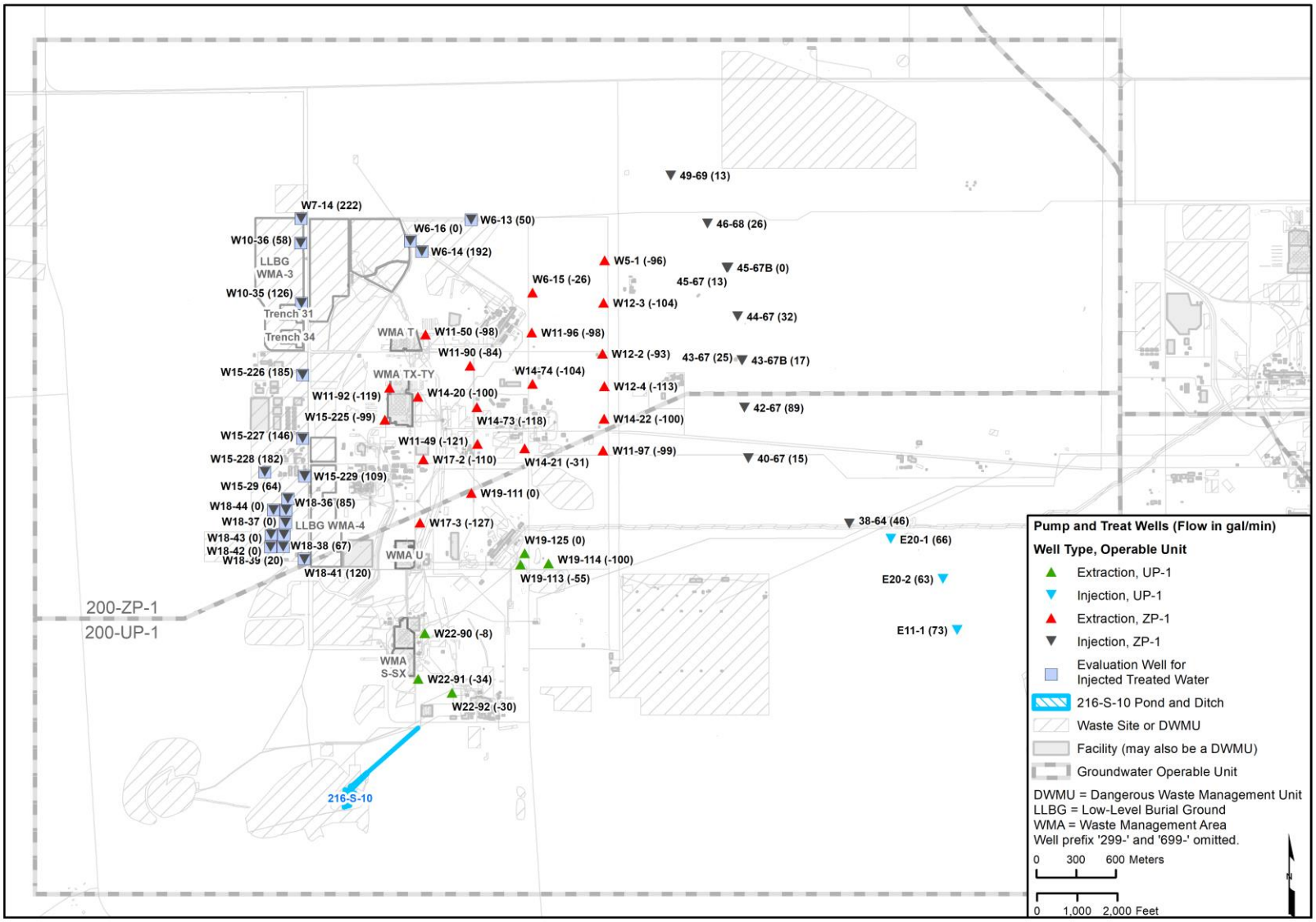


Figure 5-2. Locations and Average Pumping Rates (for December 2016) of 200 West P&T System Wells

As described in Appendix E, 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 E 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 EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*.

Simulations were run for each scenario to examine dilution from injection of treated water and particle pathlines of hypothetical releases from the 216-S-10 Pond and Ditch. The results of those simulations were used to evaluate the efficacy of the groundwater monitoring network to detect hypothetical releases from the 216-S-10 Pond and Ditch.

This page intentionally left blank.

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 at the 216-S-10 Pond and Ditch. 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 Appendices E and F.

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 E 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 the facility.

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 facility.

Particle-tracking and transport modeling calculations and the output produced for the 216-S-10 Pond and Ditch are described in the following sections and discussed in more detail in Appendix F.

6.1 Principal Assumptions and Inputs

The principal inputs to the modeling performed to evaluate the monitoring network for the 216-S-10 Pond and Ditch 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 facility. The parameters of the groundwater flow component of the CPGWM have been formally calibrated to historical data and conditions. As discussed in Appendices E and F, 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 E 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 E 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 agree 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 predominantly horizontal. The facility-specific results of the API calculator are presented in Section 7.5 of Appendix F. 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 E and F.

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 the 216-S-10 Pond and Ditch, 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 along the length of the 216-S-10 Pond and Ditch. The particle release locations are shown in Figure 6-1 in Appendix F. This "focused release" reflects a hypothetical leak from the facility 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 FY 2037, which is when the 200-ZP-1 groundwater P&T remedy component is expected to cease operation in accordance with EPA et al., 2008. 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.

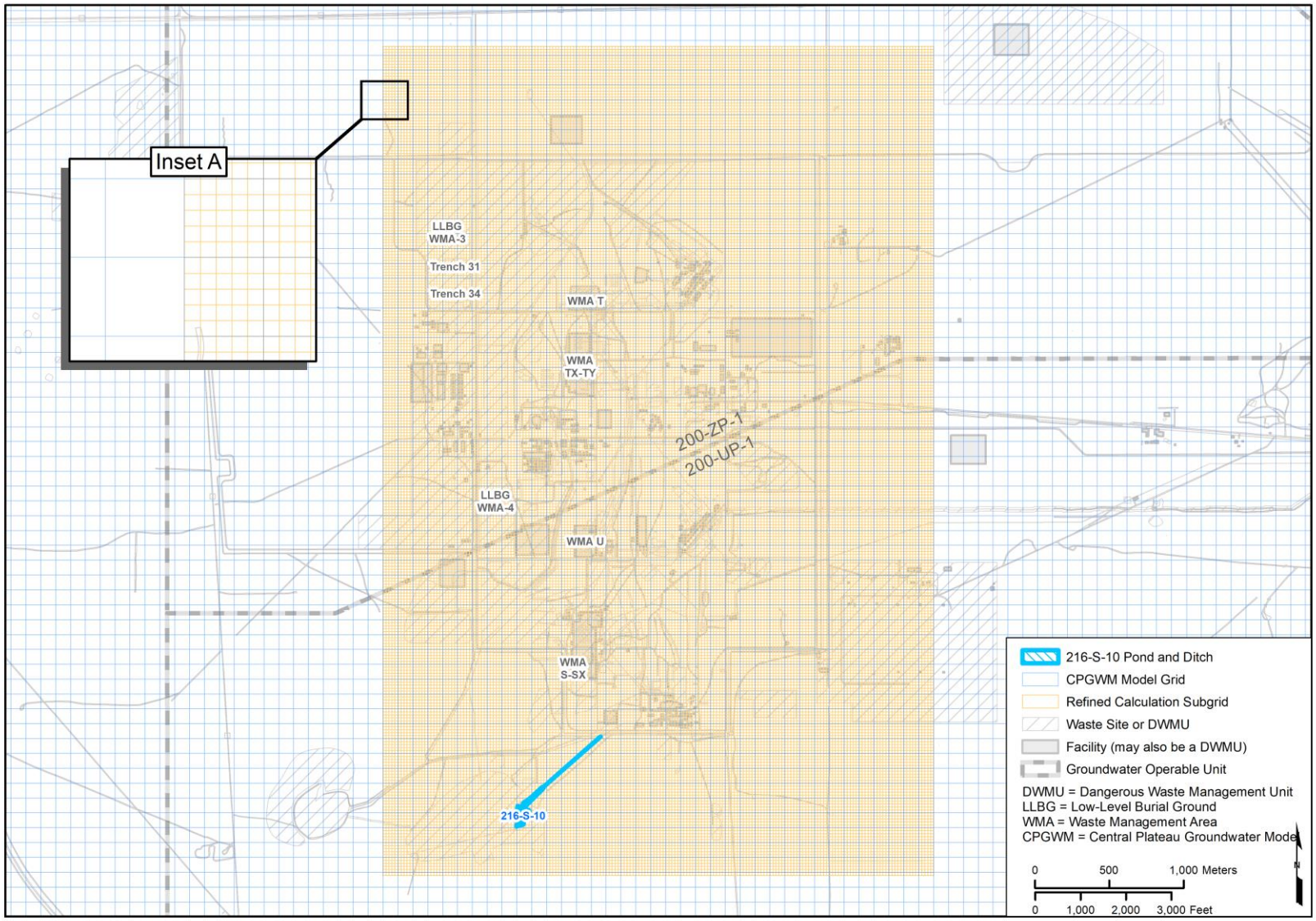


Figure 6-1. Location of Calculation Subgrid in Relation to 200 West Area Facilities Evaluated in Appendix E

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 E. 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 facility.

Particles were tracked for hypothetical releases from the 216-S-10 Pond and Ditch 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 E and F.

6.2.2 Relative Detectability Calculations

For each scenario, a calculation was performed to identify areas of the aquifer where a hypothetical release from the 216-S-10 Pond and Ditch to the water table 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 F. 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.

The resulting maps of relative detectability for each scenario show the overall distribution for a release from the 216-S-10 Pond and Ditch 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 facility 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 216-S-10 Pond and Ditch 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 216-S-10 Pond and Ditch, unit concentrations representing the hypothetical contaminant were released at the water table in eleven model grid cells representing the 216-S-10 Pond and Ditch (shown in Figure 6-1 in Appendix F). 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 the 216-S-10 Pond and Ditch 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 F.

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 216-S-10 Pond and Ditch 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 216-S-10 Pond and Ditch.

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 existing downgradient well locations, breakthrough curves for injected treated water dilution and release concentrations can be compared to evaluate which well locations are likely to show higher dilutions from injected treated water and which are likely to have more detectable concentrations from releases from the 216-S-10 Pond and Ditch. 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 maps and

particle-tracking maps are included in Sections 7.1 and 7.2, respectively. The maps represent conditions at the end of 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 the 216-S-10 Pond and Ditch 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 new 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.

For monitoring wells 299-W26-13, 299-W26-14, 299-W27-2, 699-32-76, 699-33-75, and 699-33-76 (Figure 5-1), injected treated water dilution breakthrough curves and release concentration breakthrough curves 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 indicate 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 injection of treated water 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 and the simulations were continued through 2037. For locations where injected treated water has impact, each well and each sub-scenario would have a unique injected treated water dilution breakthrough curve. However, for 216-S-10 Pond and Ditch, the treated water breakthrough curves at the monitoring wells do not show variability among the sub-scenarios or among wells. Due to the distance from the 200 West P&T system injection wells the injected treated water does not reach the 216-S-10 Pond and Ditch monitoring wells during the simulated time frame, and the breakthrough curves show unit concentrations of zero. This result suggests that the injection well operations do not influence the treated water observed at the 216-S-10 Pond and Ditch monitoring network wells. The injected treated water dilution breakthrough curves are included in Appendix F.

The release concentration breakthrough curves for monitoring wells 299-W26-13, 299-W26-14, 299-W27-2, 699-32-76, 699-33-75, and 699-33-76 for all sub-scenarios of scenario 1 are shown in Figures 7-1 through 7-6, respectively. The figures, which depict the simulated breakthrough of a unit-source release to the groundwater table from the 216-S-10 Pond and Ditch, 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.

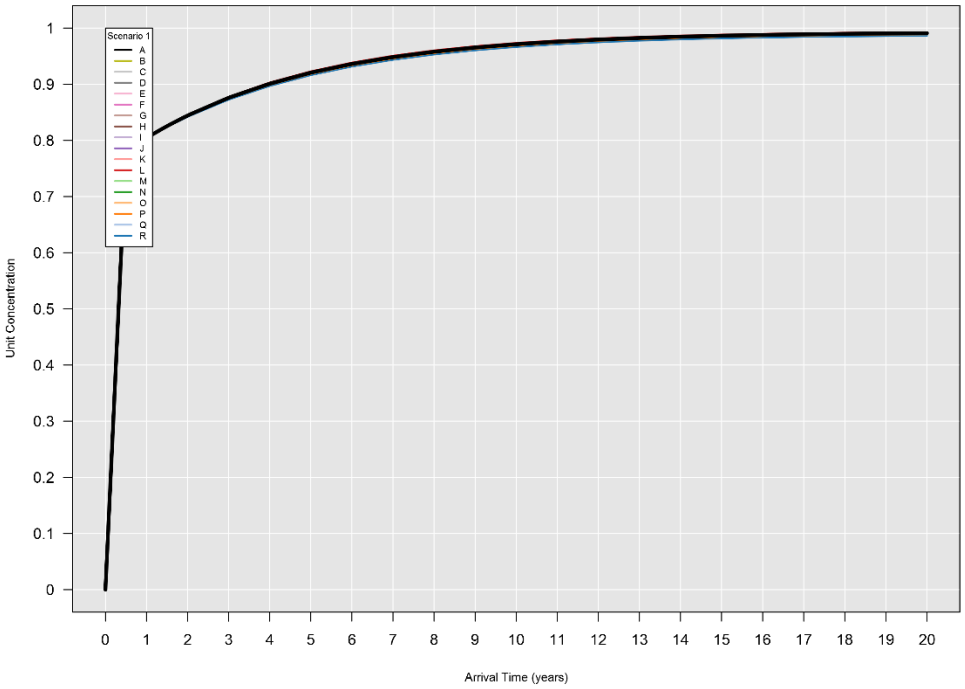


Figure 7-1. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W26-13

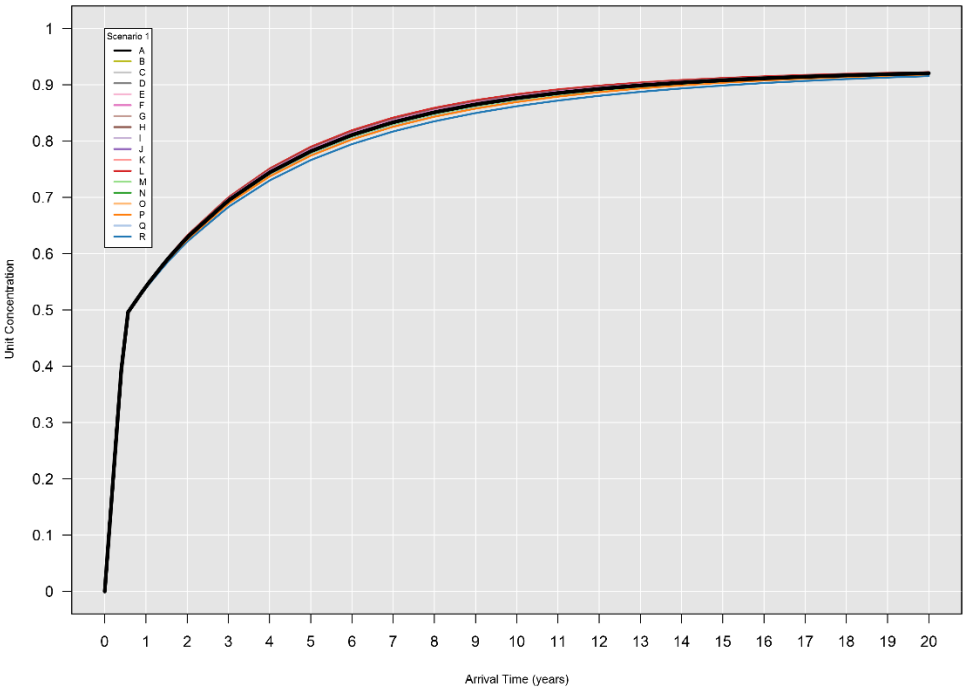


Figure 7-2. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W26-14

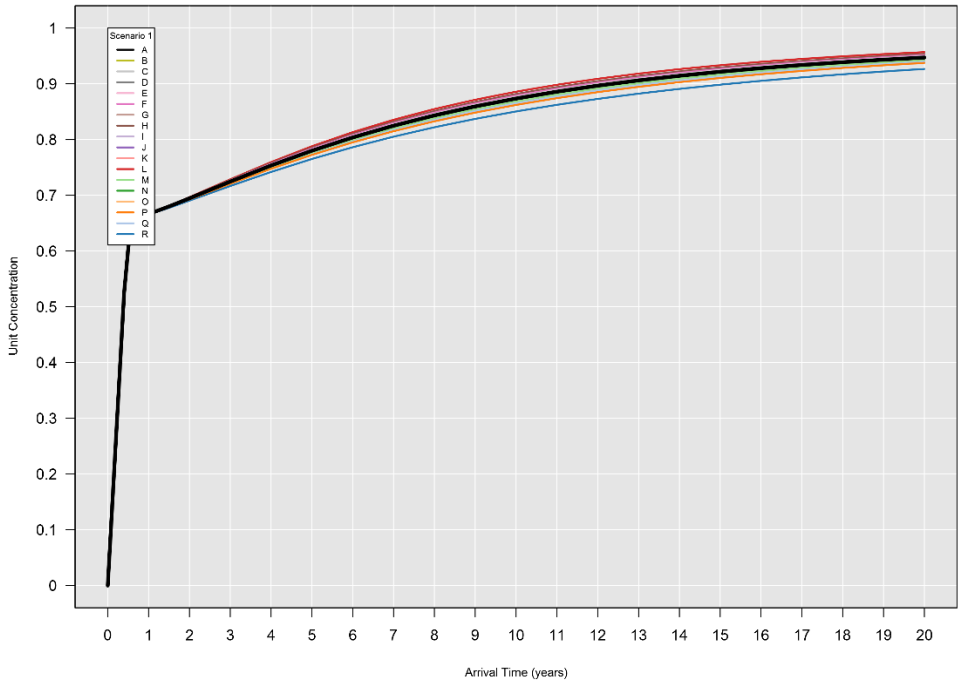


Figure 7-3. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 299-W27-2

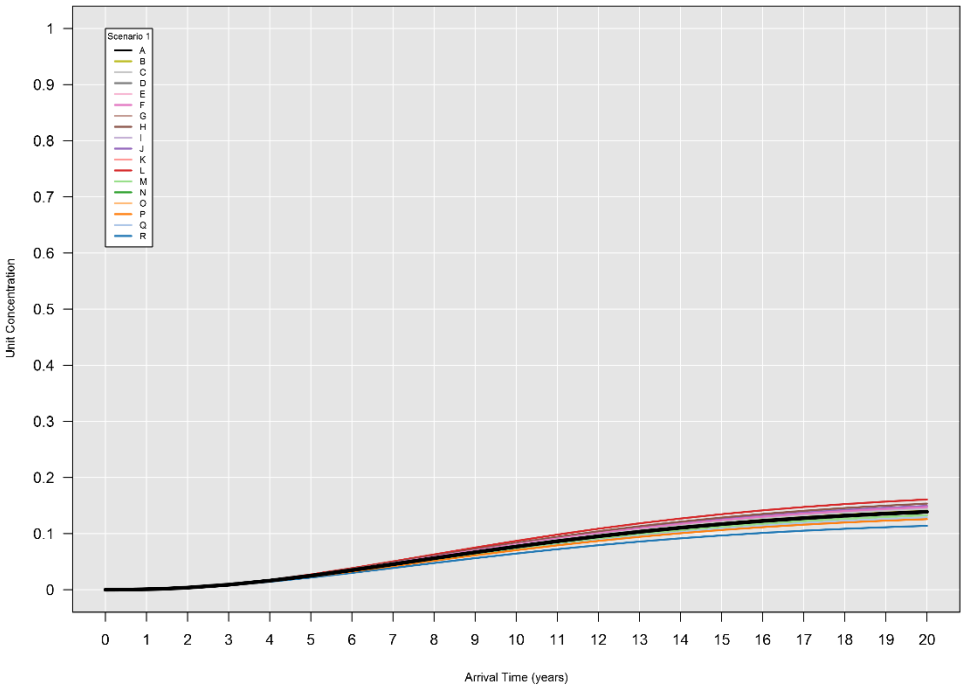


Figure 7-4. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 699-32-76

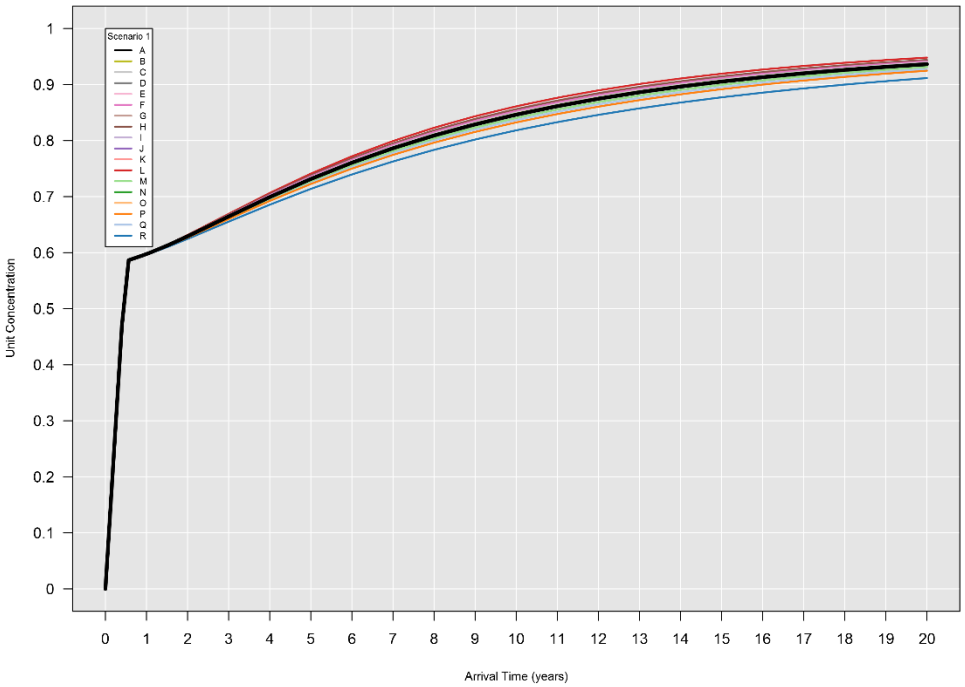


Figure 7-5. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 699-33-75

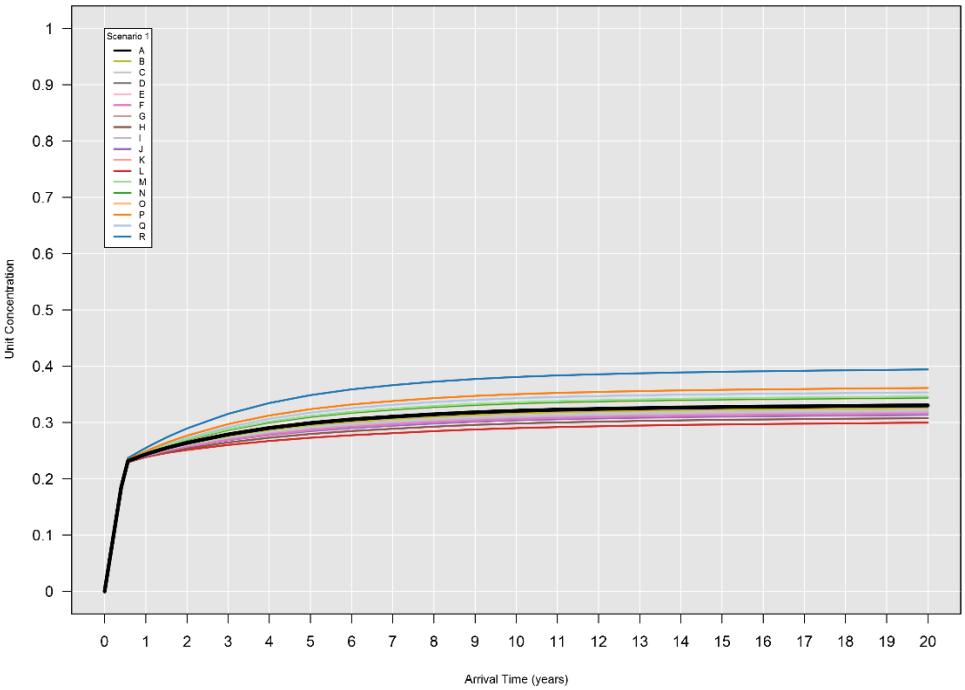


Figure 7-6. Release Concentration Breakthrough Curves, Scenario 1, Monitoring Well 699-33-76

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 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 7-1 through 7-6 show minimal variation in the breakthrough curves for the 200 West P&T system operating scenarios evaluated, indicating that detection of releases at the well locations is not sensitive to changes in the 200 West P&T system operating conditions. Results for upgradient well 699-33-76, located northwest of 299-W26-14, show the most variation indicating that well is the most sensitive to changes under all the operating scenarios. Breakthrough curves for the downgradient monitoring wells, 299-W26-13, 299-W26-14, 299-W27-2, and 699-33-75, show medium to high unit concentrations indicating the wells are located in areas having high potential for detecting releases from the 216-S-10 Pond and Ditch. The results for scenario 2 (included in Appendix F) are similar to those for scenario 1. Table 7-1 shows the range of the release concentration breakthrough curves for the monitoring wells for scenarios 1, 2, and 3.

Table 7-1. Range of Unit Concentrations of Release Concentration Breakthrough Curves

Well Name	Scenario	Minimum Unit Concentration	Maximum Unit Concentration	Weighted Average	Scenario 3
299-W26-13	1	0.986	0.993	0.991	0.985
	2	0.986	0.993	0.992	
299-W26-14	1	0.915	0.922	0.921	0.938
	2	0.915	0.923	0.922	
299-W27-2	1	0.927	0.957	0.947	0.974
	2	0.927	0.960	0.950	
699-32-76	1	0.114	0.161	0.139	0.317
	2	0.114	0.168	0.142	
699-33-75	1	0.912	0.948	0.936	0.968
	2	0.912	0.952	0.940	
699-33-76	1	0.300	0.394	0.331	0.281
	2	0.294	0.394	0.327	

The release concentration breakthrough curves for scenario 3 (Figure 7-7) indicate that the wells have unit concentrations similar to the unit concentrations detected under scenarios 1 and 2. The release time for scenario 3 (represented on the figure as arrival time year 0) corresponds to October 1, 2037.

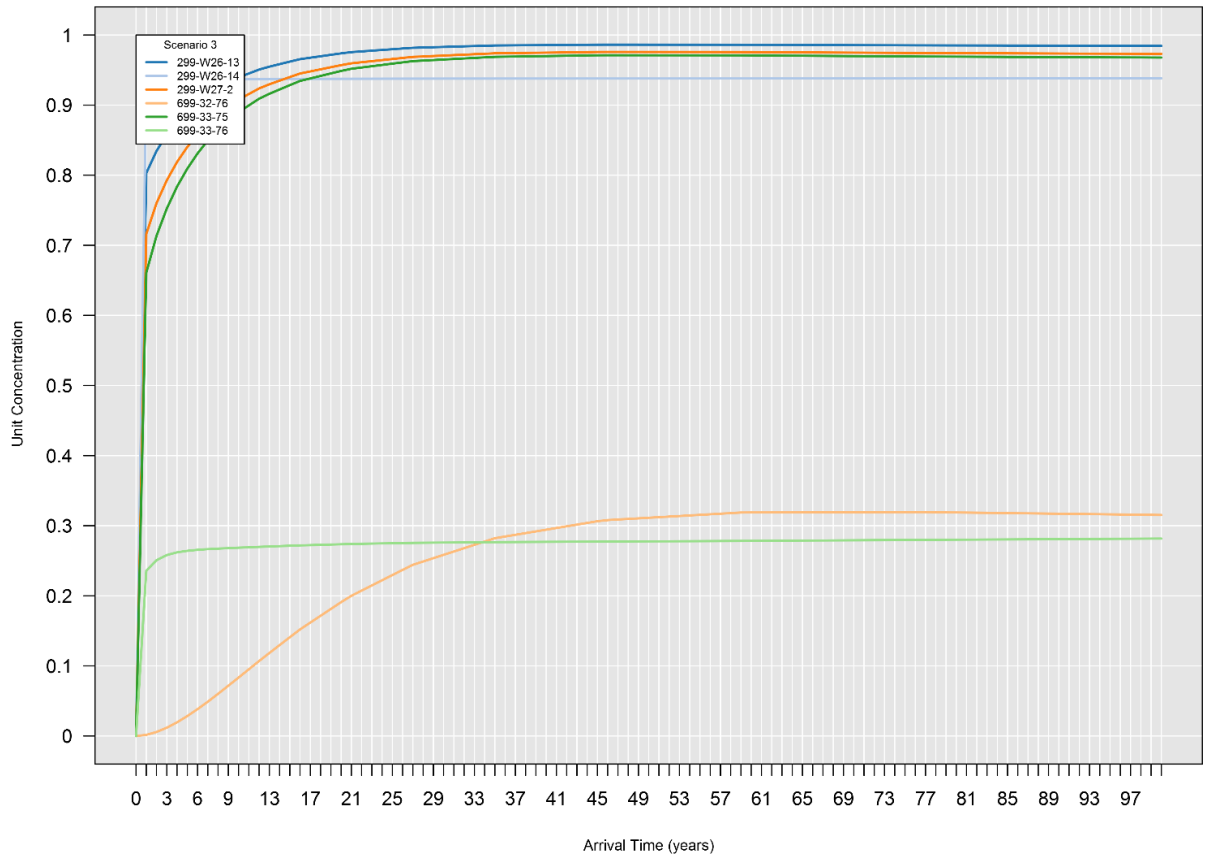


Figure 7-7. Release Concentration Breakthrough Curves at Monitoring Wells, Scenario 3

Figures 7-8 through 7-10 show plume maps of release unit concentrations based on transport modeling representing conditions at the end of 200 West P&T system operations in 2037 for scenarios 1 and 2 and in 2137 for scenario 3. Figures 7-8 and 7-9 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 F.

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.

™ ArcGIS is a trademark of Esri in the United States, the European Community, or certain other jurisdictions.

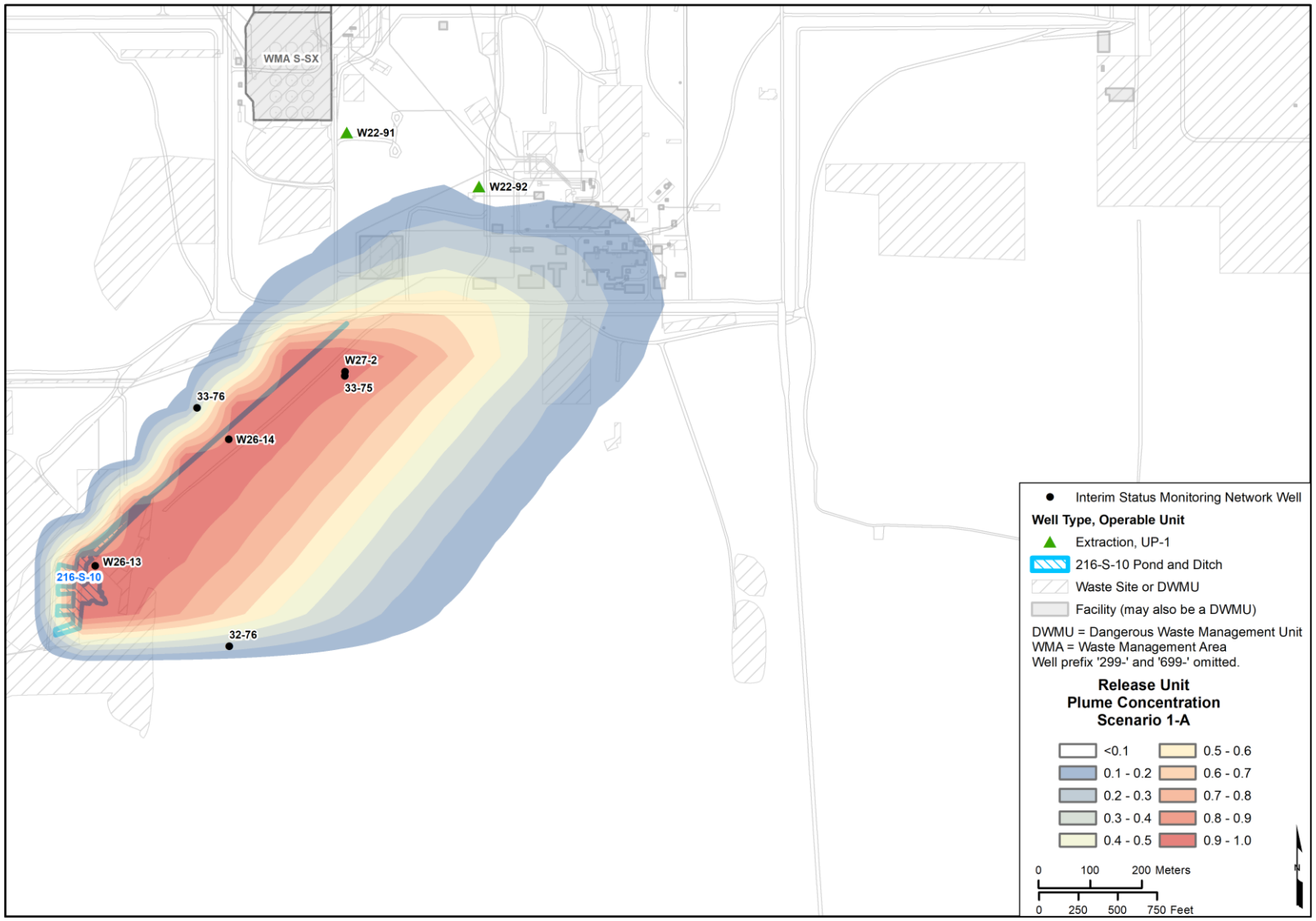


Figure 7-8. Release Unit Plume Map, Scenario 1, Sub-Scenario A

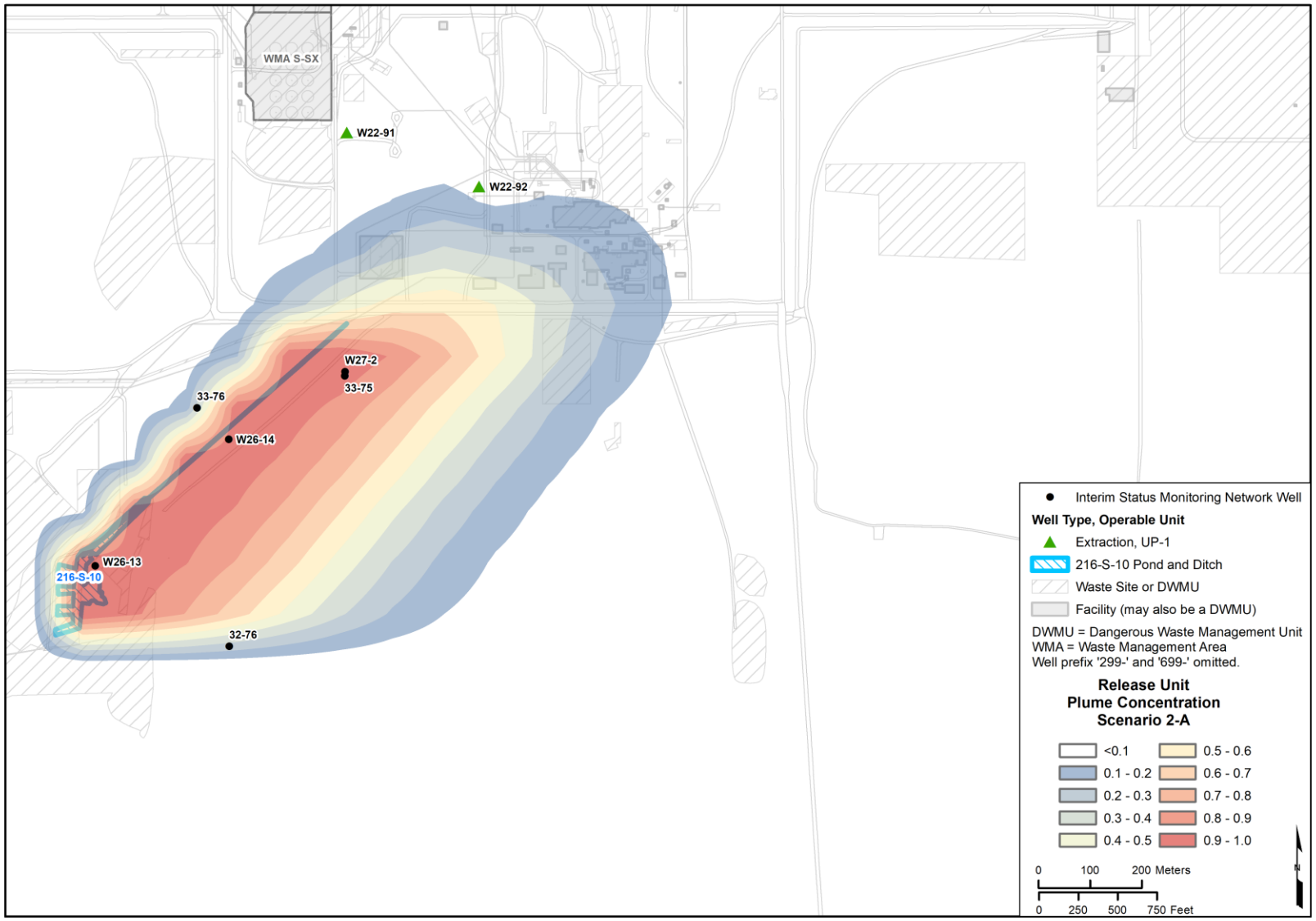


Figure 7-9. Release Unit Plume Map, Scenario 2, Sub-Scenario A

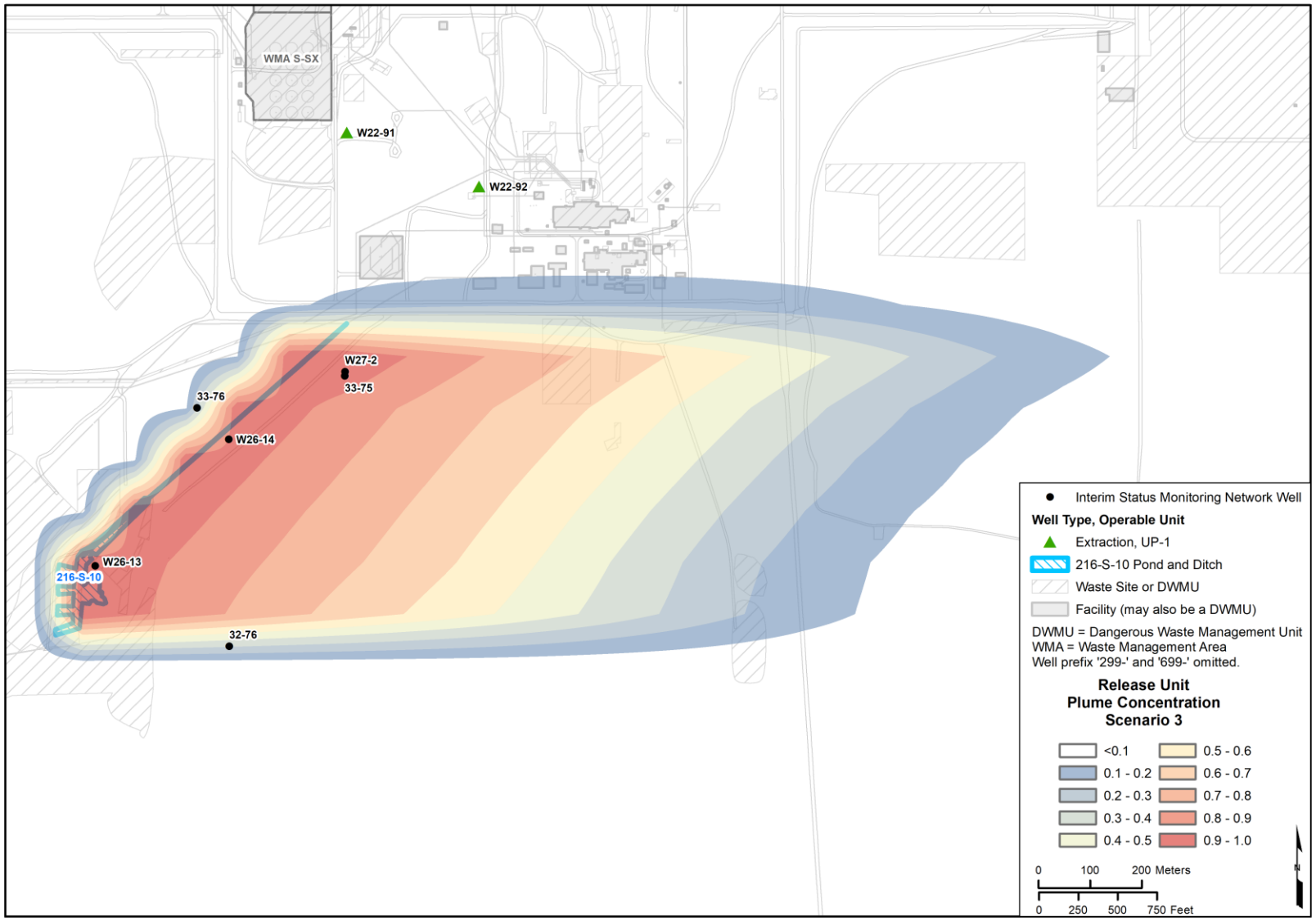


Figure 7-10. Release Unit Plume Map, Scenario 3

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.

For the 216-S-10 Pond and Ditch, upgradient well 699-33-76 is shown within an area of moderate release unit concentration for each of the scenarios. This result was reflected in the release concentration breakthrough curves for this well. This is because upgradient well 699-33-76 is located within a grid cell adjacent to two of the CPGWM grid cells representing the pond and ditch (in which the unit concentration of 1 was released). The unit concentration from the grid cells that represent the pond and ditch are interpolated as described above between the nodes of those grid cells and the node of the upgradient grid cell where 699-33-76 is located, which has a simulated unit concentration near zero. This results in a depiction of this well location being within an interpolated area of moderate release unit concentration. The particle-tracking results for releases from the 216-S-10 Pond and Ditch, which are discussed in Section 7.2, indicate that this well remains upgradient of the hypothetical release.

Figures 7-8 through 7-10 show that downgradient wells are generally well located for detecting releases from the 216-S-10 Pond and Ditch. Well 699-32-76 generally is within the unit plume but located in an area of low unit concentrations. These conclusions are consistent with the conclusions based on the breakthrough curves.

7.2 Particle-Tracking and Relative Detectability Maps

For each scenario, particle-tracking and relative detectability maps generated using particle-tracking calculations show the overall distribution, given advection and dispersion, of a hypothetical release to the water table below the 216-S-10 Pond and Ditch. 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 7-11 and 7-12 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 F. The particle-tracking map for scenario 3 (Figure 7-13) represents conditions after cessation of the 200 West P&T system operations and therefore does not have an injected treated water component.

The particle tracking indicates that most of the wells are well located for detecting releases from the facility. Wells that are not well located are well 699-32-76, which is located cross-gradient to the south of the release particle pathlines, and well 699-33-76, which is located upgradient. The particle-tracking maps also indicate that injected treated water will not reach the 216-S-10 Pond and Ditch during the modeled time frame.

Maps of relative detectability identify areas of the aquifer where a hypothetical release that impacts the water table beneath the 216-S-10 Pond and Ditch 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.

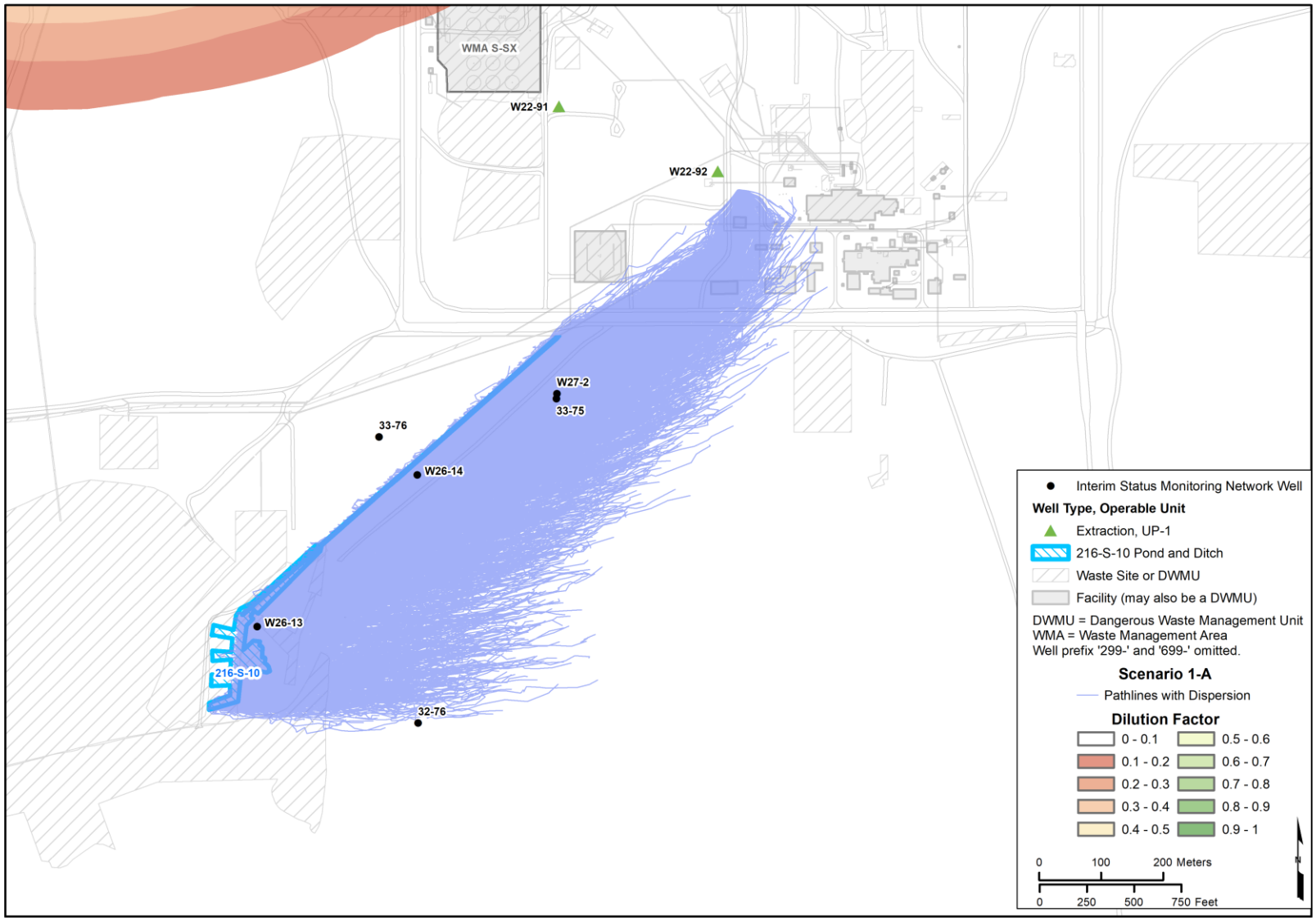


Figure 7-11. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 1 Sub-Scenario A

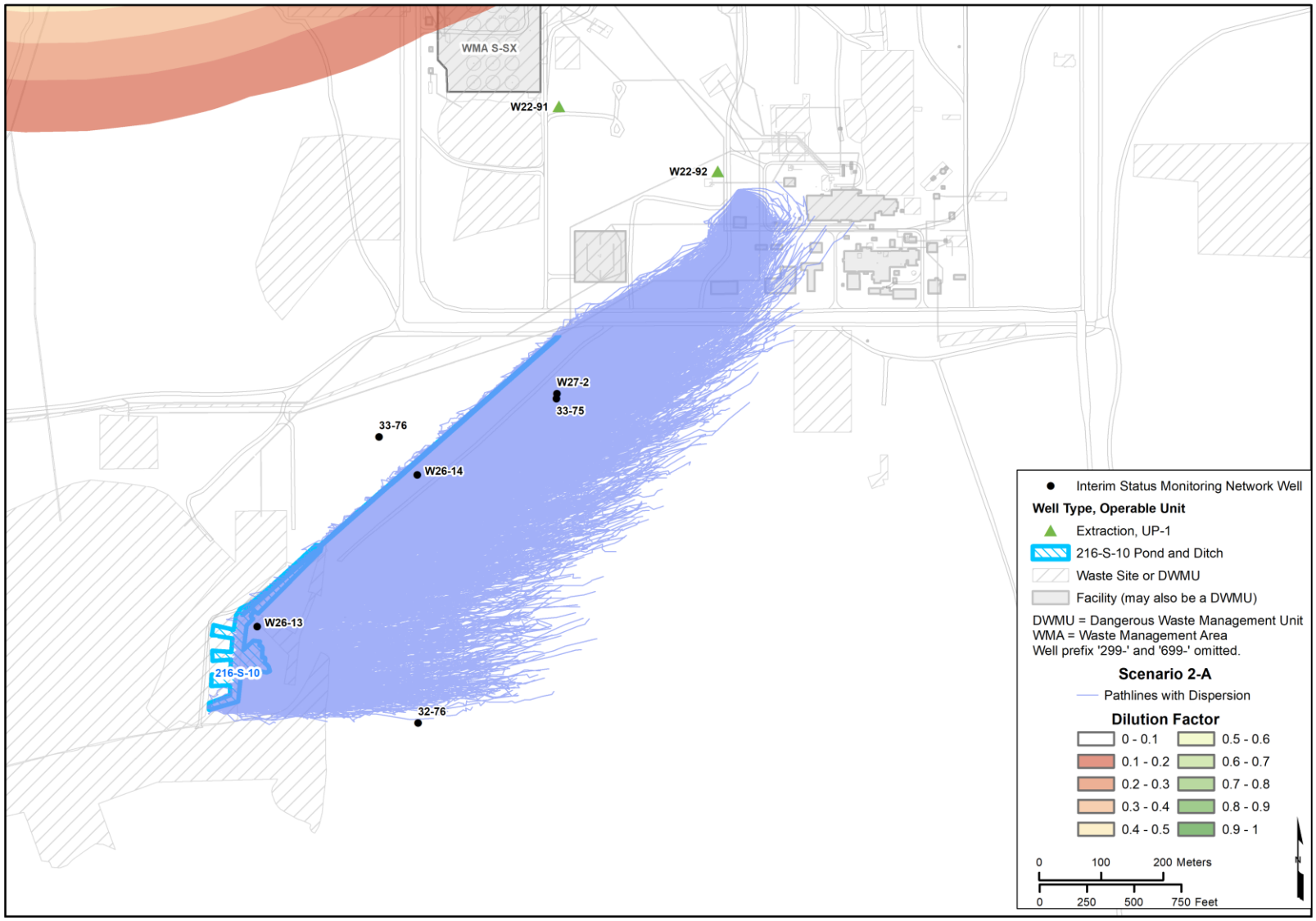


Figure 7-12. Particle Pathlines Superimposed on Injected Treated Water Dilution Plumes, Scenario 2 Sub-Scenario A

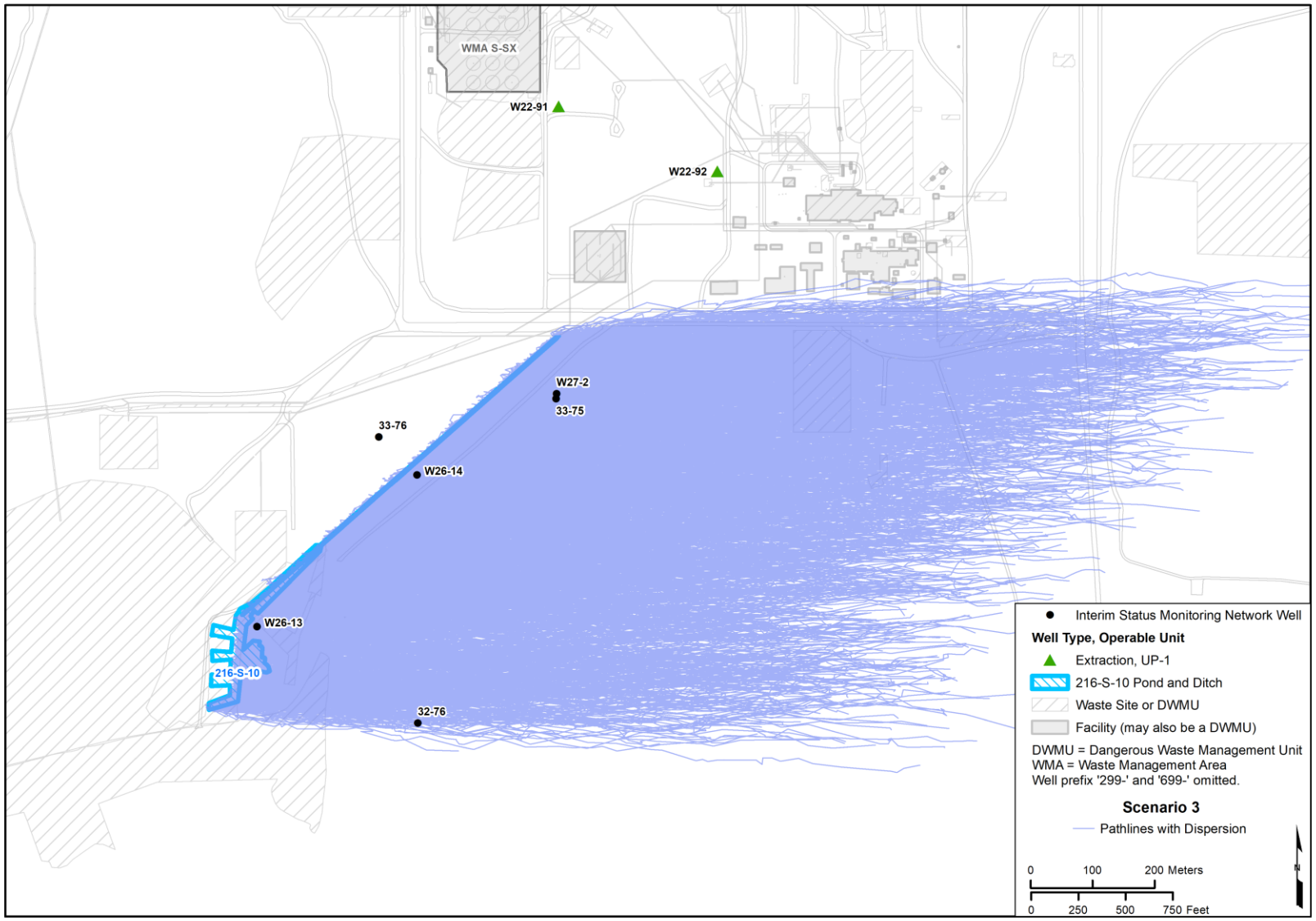


Figure 7-13. Particle Pathlines Scenario 3

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 F. 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 the scenario using the weights shown in Table 5-1 to account for the estimated relative probability of each sub-scenario.

Figures 7-14 through 7-16 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 generally are located in areas of high relative detectability for particle releases from the 216-S-10 Pond and Ditch. Downgradient monitoring well 699-32-76 is located outside of the relative detectability area in scenarios 1 and 2. After the cessation of 200 West P&T system operations, however, the shift in the groundwater flow direction from slightly northeast to east results in this well being within the relative detectability extents for scenario 3. For the final status monitoring well network, three new downgradient monitoring wells, 216-S-10_PW1, 216-S-10_PW2, and 216-S-10_PW3, are proposed along the west side of the facility in areas of high relative detectability. A new upgradient well, 216-S-10_PW4, is proposed to the southwest of well 299-W26-13. The proposed locations for these wells are shown in Figures 7-14 through 7-16.

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 wells, 216-S-10_PW1, 216-S-10_PW2, 216-S-10_PW3, and 216-S-10_PW4. Similar to the curves for the existing wells, the injected treated water breakthrough curves for the proposed wells show no sensitivity to variations in 200 West P&T system injection operations and indicate a unit concentration of zero for injected treated water at the well locations. The injected treated water dilution breakthrough curves for the proposed wells are included in Appendix F.

Figures 7-17 through 7-20 show release concentration breakthrough curves for the proposed wells for scenario 1. The release concentration breakthrough curves for the proposed wells under scenario 2 are included in Appendix F. Results for scenario 2 were similar to the results for scenario 1.

The release concentration breakthrough curves also indicate that the potential for the proposed downgradient wells to detect releases from 216-S-10 Pond and Ditch is minimally influenced by 200 West P&T system operations. Unit concentrations ranging from slightly more than 0.6 (sub-scenario L for 216-S-10_PW1) to more than 0.8 (all evaluated sub-scenarios for 216-S-10_PW2) indicate that the wells, in general, are well located for detecting releases to the water table from the facility.

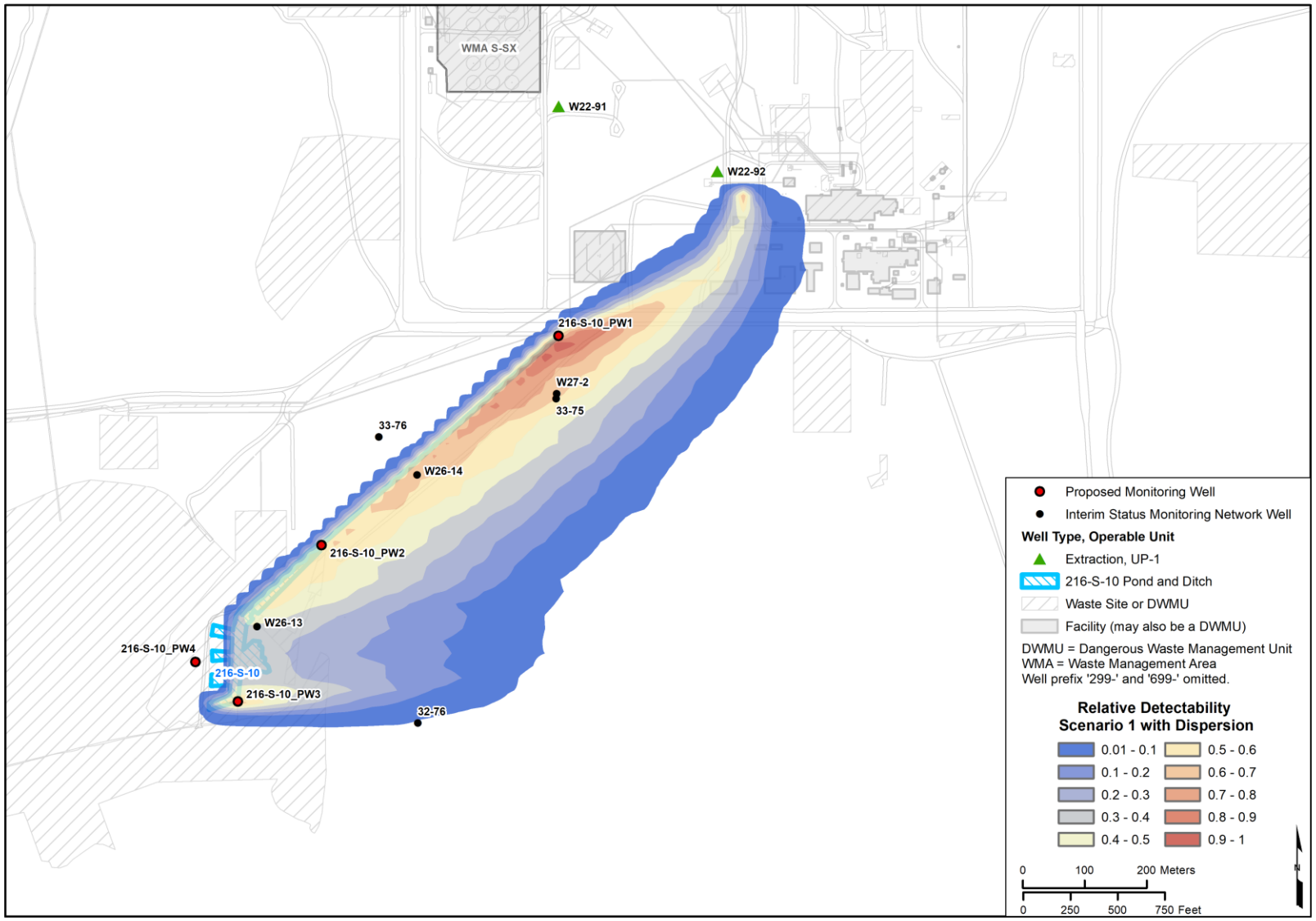


Figure 7-14. Relative Detectability of Release, Scenario 1

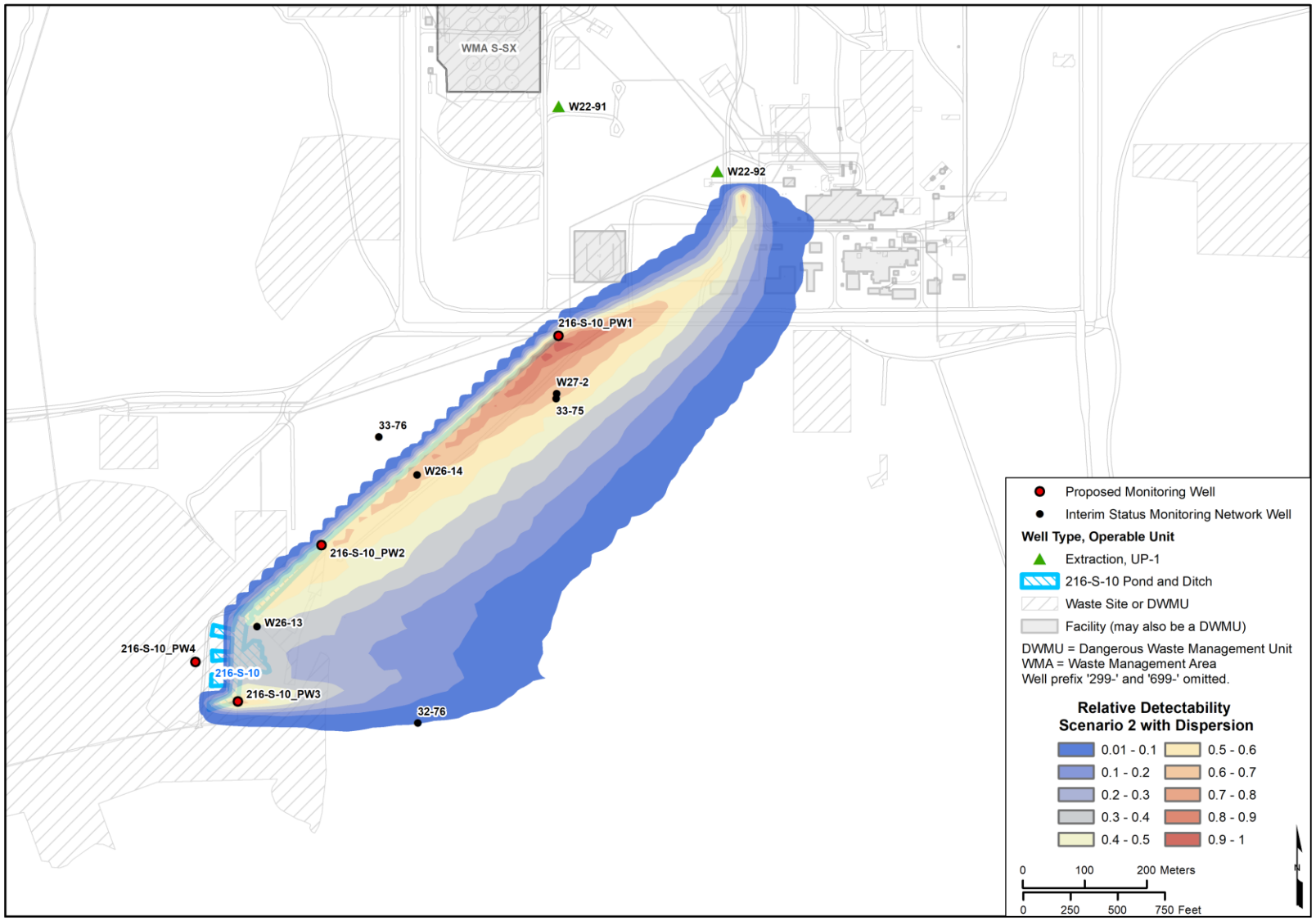


Figure 7-15. Relative Detectability of Release, Scenario 2

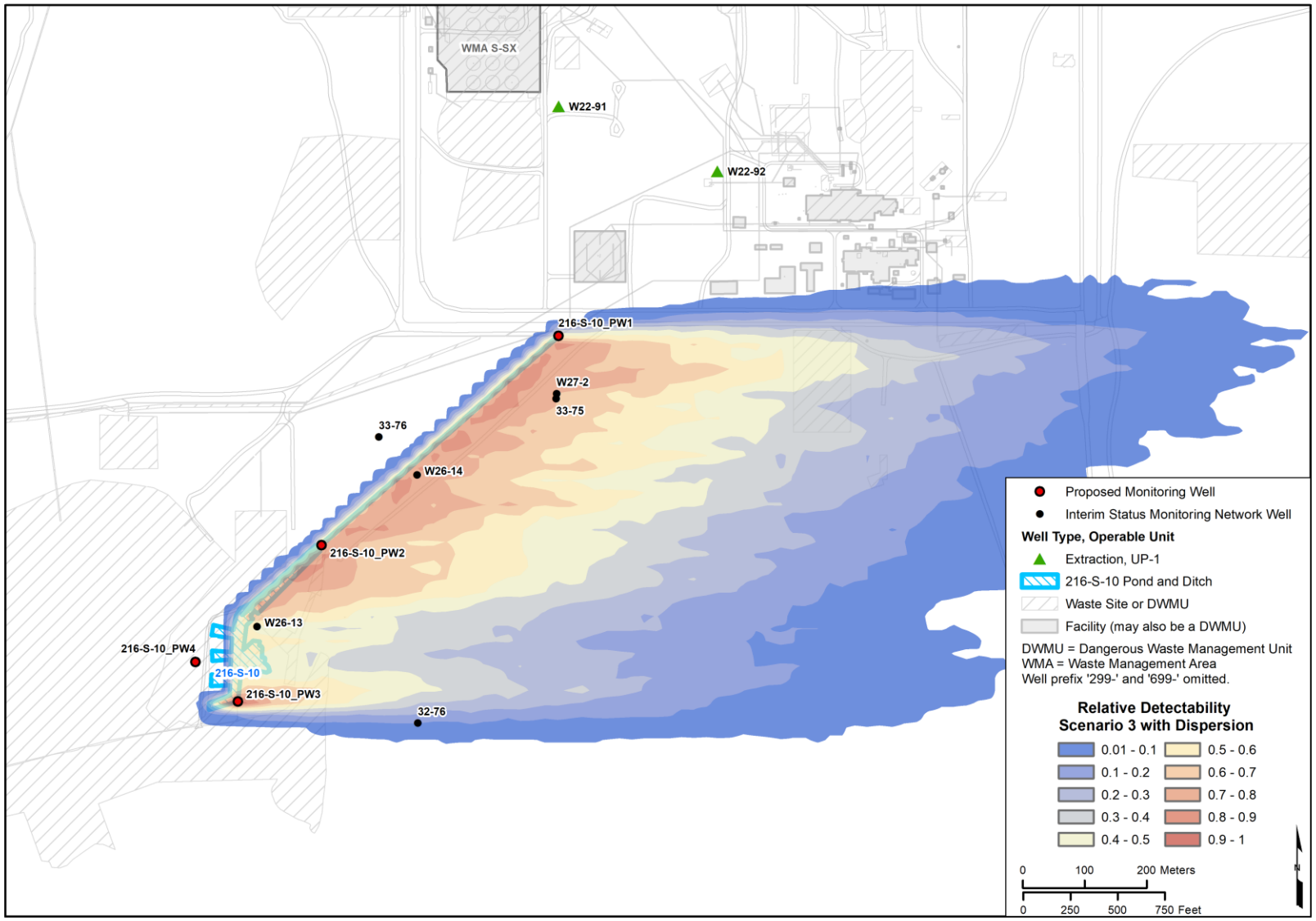


Figure 7-16. Relative Detectability of Release, Scenario 3

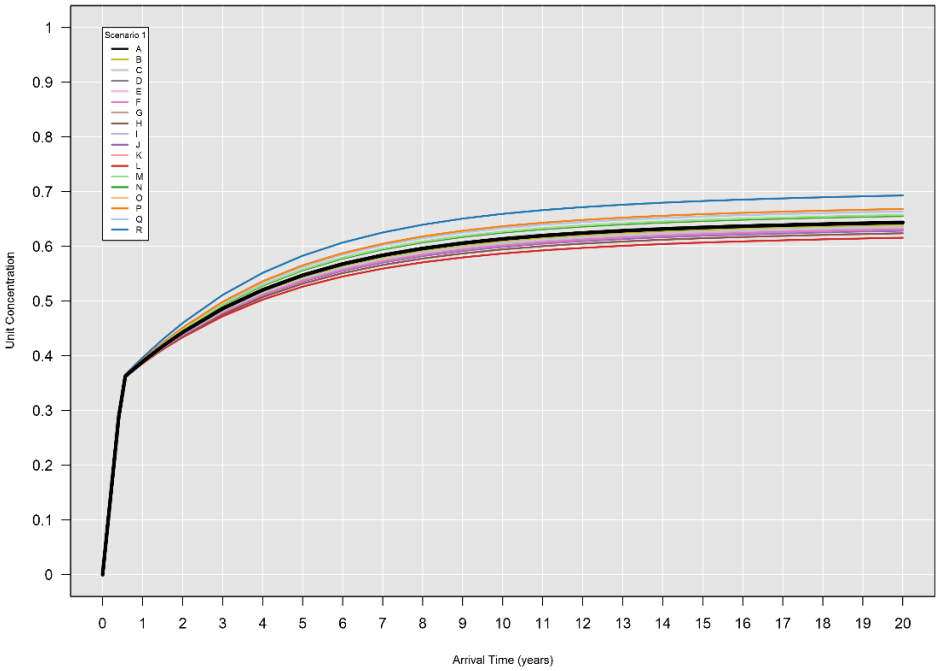


Figure 7-17. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW1

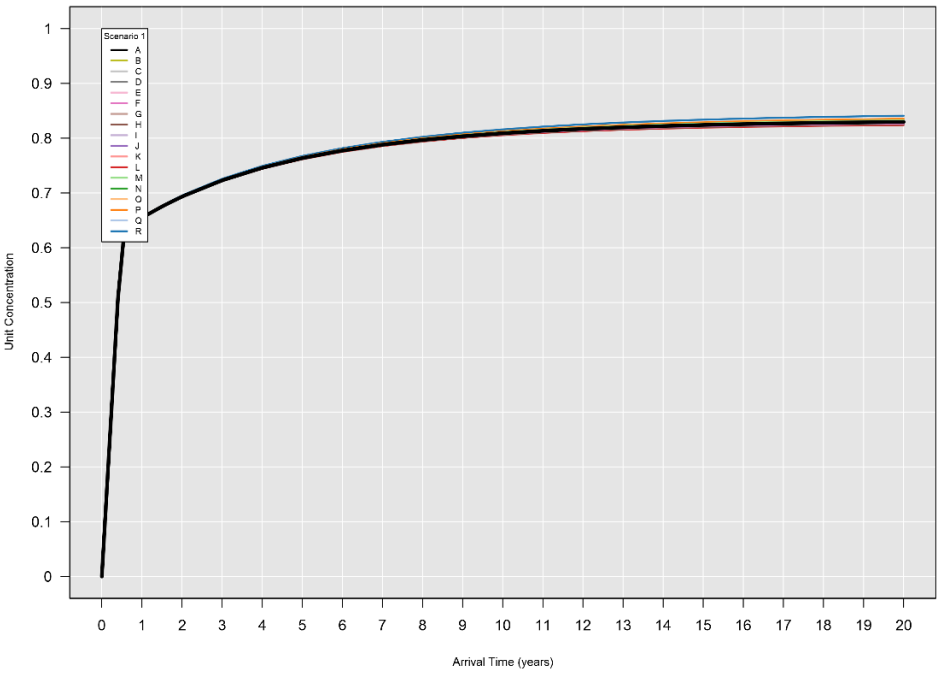


Figure 7-18. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW2

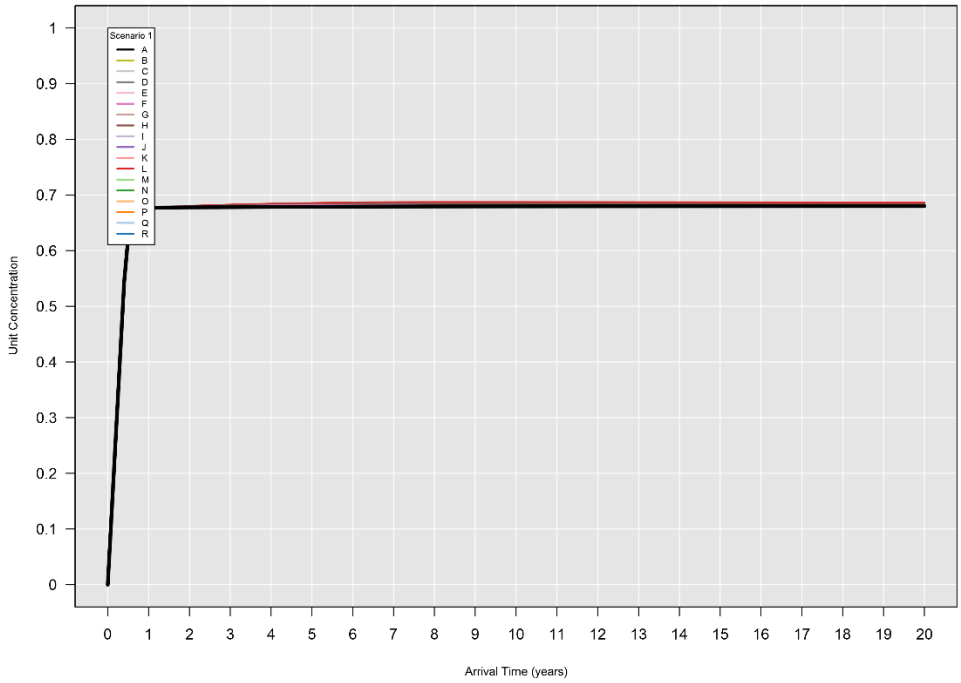


Figure 7-19. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW3

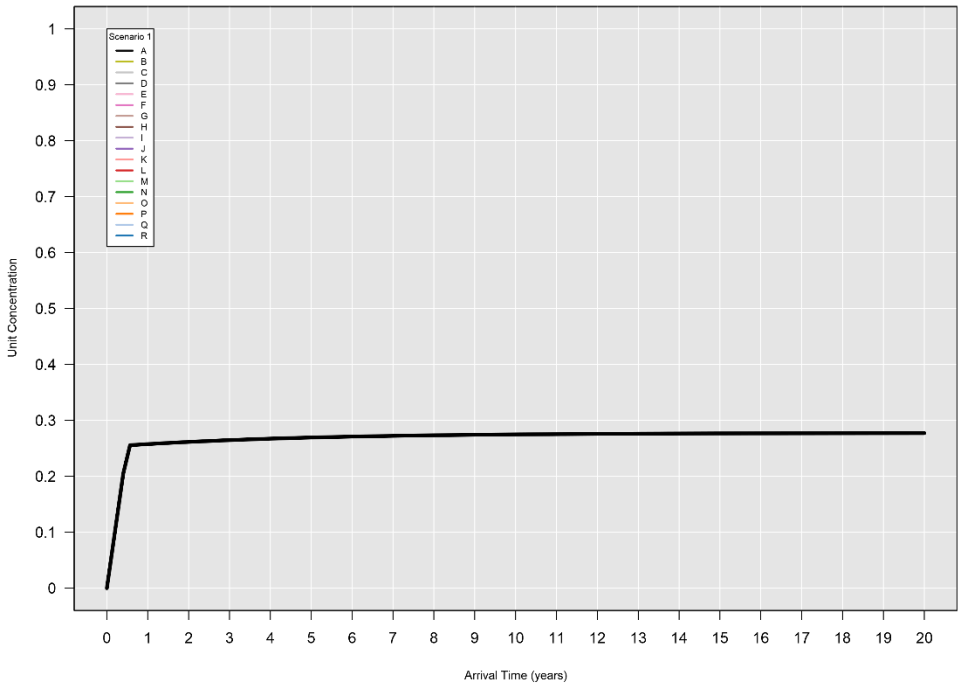


Figure 7-20. Release Concentration Breakthrough Curves, Scenario 1, Proposed Monitoring Well 216-S-10_PW4

The release concentration breakthrough curve for proposed upgradient well 216-S-10_PW4 shows a unit concentration of nearly 0.3. As with upgradient well 699-33-76, this result reflects the fact that well is located in an area where unit concentrations are interpolated between the model grid cells.

The release concentration breakthrough curves for scenario 3 for the proposed wells are shown in Figure 7-21. These curves indicate that proposed downgradient wells 216-S-10_PW1, 216-S-10_PW2, and 216-S-10_PW3 likely will be able to detect releases from the facility after cessation of P&T system operations, similar to during 200 West P&T system operations. Unit concentrations for those wells range from more than 0.7 to near 1.0 for scenario 3. Table 7-2 shows the range of the release concentration breakthrough curves for the proposed wells for scenarios 1, 2, and 3.

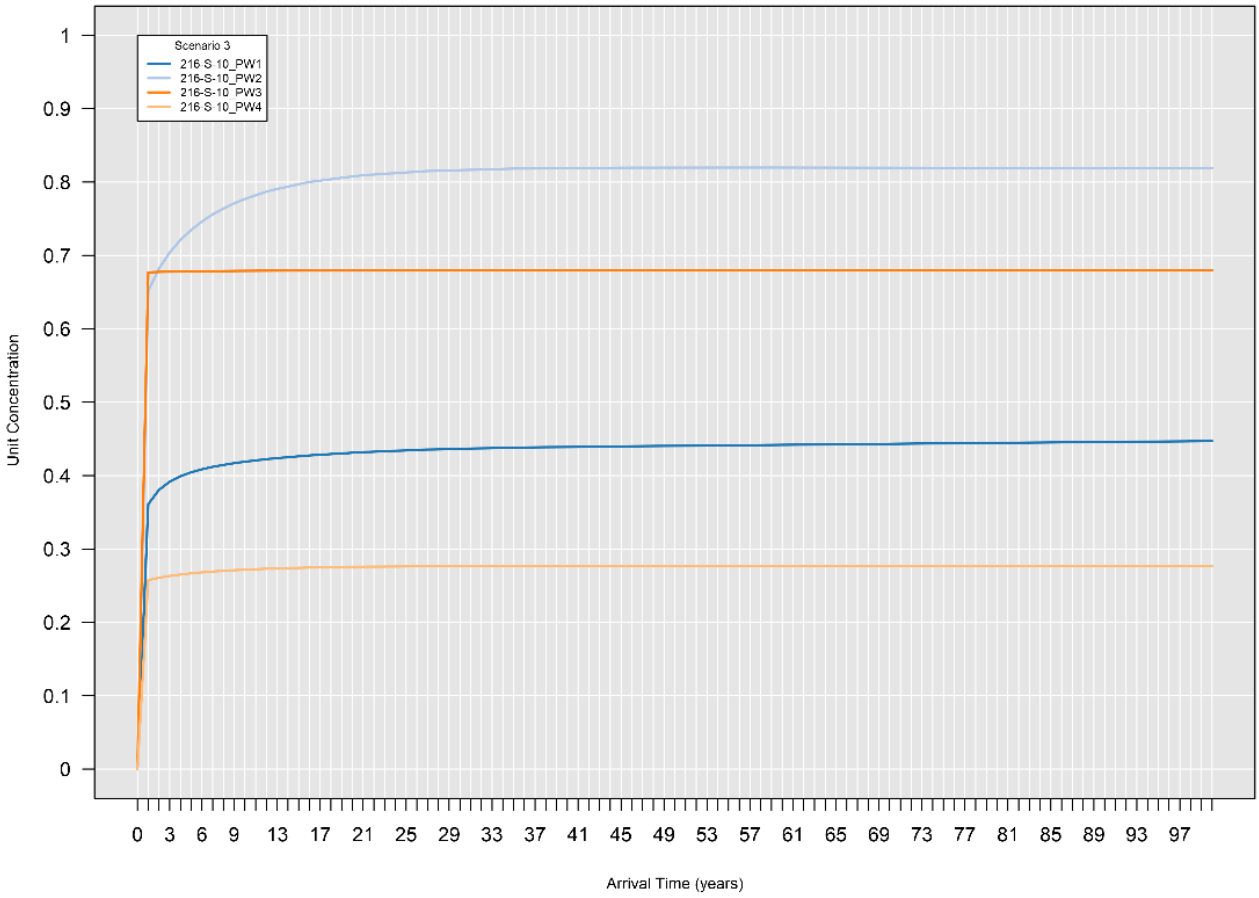


Figure 7-21. Release Concentration Breakthrough Curves, Scenario 3, Proposed Monitoring Wells 216-S-10_PW1, 216-S-10_PW2, 216-S-10_PW3, and 216-S-10_PW4

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
216-S-10_PW1	1	0.616	0.693	0.644	0.447
	2	0.612	0.693	0.642	
216-S-10_PW2	1	0.824	0.841	0.830	0.819
	2	0.823	0.841	0.829	
216-S-10_PW3	1	0.680	0.686	0.680	0.680
	2	0.680	0.688	0.680	
216-S-10_PW4	1	0.276	0.277	0.277	0.277
	2	0.276	0.277	0.277	

7.4 Modeling Conclusions

The proposed final status groundwater monitoring network for the 216-S-10 Pond and Ditch includes retaining existing upgradient well 699-33-76 and existing downgradient wells 299-W26-13, 299-W26-14, 699-32-76, and 699-33-75. Because it is a deep well, existing downgradient well 299-W27-2 is not retained for the 216-S-10 Pond and Ditch final status monitoring network. Four new monitoring wells, 216-S-10_PW1, 216-S-10_PW2, 216-S-10_PW3, and 216-S-10_PW4, are proposed for the final status monitoring well network. The proposed final status monitoring network is based on the results of the simulation scenarios presented in Appendix F and summarized herein.

The simulations indicate that, under the scenarios evaluated, upgradient monitoring wells 699-33-76 and 216-S-10_PW4, along with the seven downgradient groundwater monitoring wells (299-W26-13, 299-W26-14, 699-32-76, 699-33-75, 216-S-10_PW1, 216-S-10_PW2, and 216-S-10_PW3), are well placed for detecting a release to the water table from the 216-S-10 Pond and Ditch.

Figure 7-22 shows the final status monitoring network wells compared to the combined extents of a 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 release concentration breakthrough curves for the recommended downgradient monitoring network wells indicate a range of dilution of approximately 1%[1] to 89%[2] for the release unit concentrations. After cessation of the 200 West P&T system operations (scenario 3), this dilution range becomes approximately 1% to approximately 68%[3]. Each well is discussed further in Section 9.3.

[1] 1% dilution corresponds to a release unit concentration of approximately 0.99 at monitoring well 299-W26-13 for sub-scenario L of scenario 1 (Figure 7-1).

[2] 89% dilution corresponds to a release unit concentration of approximately 0.11 at monitoring well 699-32-76 for sub-scenario R of scenario 1 (Figure 7-4).

[3] 1%-68% dilution for scenario 3 corresponds to release unit concentrations of approximately 0.99 and 0.32 for wells 299-W26-13 and 699-32-76, respectively (Figure 7-7).

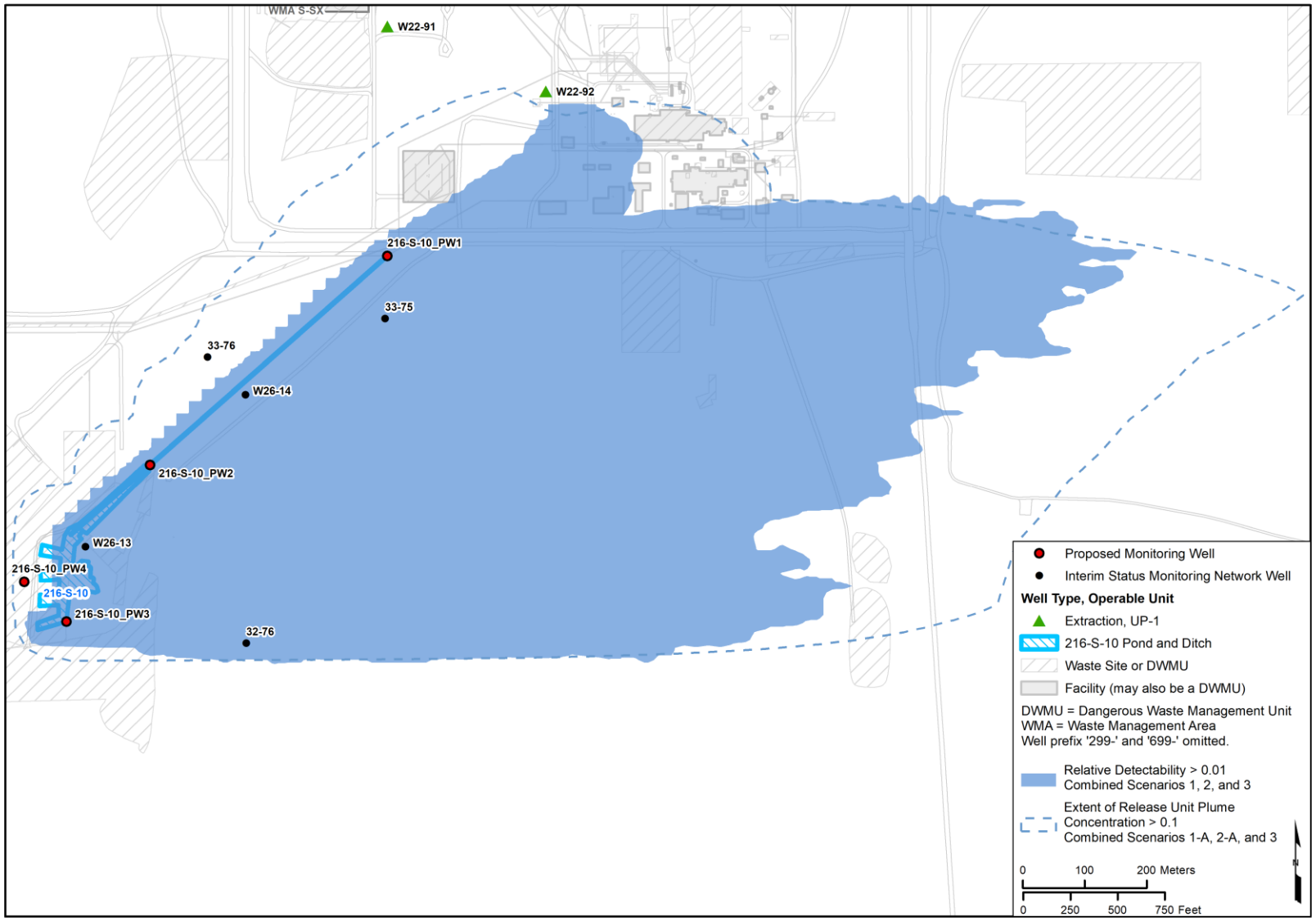


Figure 7-22. Proposed Final Status Groundwater Monitoring Network Showing Combined Results for Relative Detectability and Release Unit Plume

This page intentionally left blank.

8 Identification of Site-Specific Monitoring Constituents

An evaluation of the waste constituents associated with the 216-S-10 Pond and Ditch was performed to identify the proposed groundwater monitoring constituents to include in the final status groundwater monitoring program. The proposed groundwater monitoring constituents were identified in the Hanford Facility RCRA Permit Part A Application, or are known to have been discharged to the unit, as described in Section 2.3. The evaluation process and the resulting proposed constituents for monitoring are summarized as follows.

8.1 Selection Process for Monitoring Constituents

The dangerous wastes identified in the Hanford Facility RCRA Permit Part A Application for the 216-S-10 Pond and Ditch and the wastes associated with the dangerous waste discharge history for the unit (Section 2.3) were evaluated to determine the proposed monitoring constituents.

Use of the Part A Application dangerous waste information and the dangerous waste discharge history at the unit are discussed in the following subsections. To preserve known site contaminants within the list of proposed monitoring constituents, the dangerous wastes identified on the Part A Application and the wastes associated with the documented dangerous waste discharge were not subject to screening.

8.1.1 Hanford Facility RCRA Permit Part A Form Dangerous Wastes

The Hanford Facility Part A Application for the 216-S-10 Pond and Ditch identifies the dangerous wastes codes associated with the DWMU. The dangerous wastes identified in the 216-S-10 Pond and Ditch Part A Application are presented in Table 2-1. The only specific dangerous waste identified in the Part A Application is chromium (D007).

8.1.2 Dangerous Waste Discharge History

One documented release of dangerous waste, a synthetic double-shell tank slurry, occurred at the 216-S-10 Pond and Ditch in September 1983. As discussed in Section 2.3, samples of the discharged waste (taken prior to their release) indicated that the waste consisted largely of sodium nitrate and sodium hydroxide, with small quantities of sodium phosphate, sodium fluoride, sodium chloride, and potassium dichromate (hexavalent chromium). The synthetic tank slurry constituents comprise the chemical compounds identified in the Part A Application. As these constituents are known to have been released to the 216-S-10 Pond and Ditch, the elemental components of these wastes are included as proposed monitoring constituents.

8.2 Results of Selection of Groundwater Monitoring Constituents

Based on the evaluation of the dangerous wastes identified from the 216-S-10 Part A Application and dangerous waste discharge history for 216-S-10 Pond and Ditch, eight waste constituents are identified as proposed monitoring constituents to detect and monitor any groundwater impacts from dangerous waste releases at 216-S-10 (Table 8-1). Of the eight waste constituents, six are nondangerous waste constituents that are known to have been discharged during the 1983 release event.

Table 8-1. Proposed Monitoring Constituents for the 216-S-10 Pond and Ditch

Waste Constituent	CAS Number
Dangerous Waste Constituents	
Chromium	7440-47-3
Hexavalent Chromium	18540-29-9
Nondangerous Waste Constituents	
Nitrate	14797-55-8
Chloride	16887-00-6
Fluoride	16984-48-8
Phosphate	14265-44-2
Potassium	7440-09-7
Sodium	7440-23-5

CAS = Chemical Abstracts Service

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 the 216-S-10 Pond and Ditch. Therefore, the 216-S-10 Pond and Ditch will be in detection monitoring under WAC 173-303-645(9) when the DWMU becomes a final status closure unit group in Revision 9 of the Hanford Facility Dangerous Waste 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 seven downgradient wells proposed for the monitoring well network (existing wells 299-W26-13, 299-W26-14, 699-32-76, and 699-33-75 and proposed wells 216-S-10_PW1, 216-S-10_PW2, and 216-S-10_PW3) span the range of particle distribution as released from the 216-S-10 Pond and Ditch. The well placement is suitable for detecting releases to the water table from the 216-S-10 Pond and Ditch under the evaluated range of conditions. The proposed well locations comply with the intent of WAC 173-303-645(6), which is to detect waste constituents released from the unit 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.

9.3 Proposed Groundwater Monitoring Network

The proposed groundwater monitoring network for the 216-S-10 Pond and Ditch consists of two background (upgradient) and seven point of compliance (downgradient) wells to monitor for releases to the water table from the 216-S-10 Pond and Ditch (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 D. 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 9.3.9 provide details supporting the selection of each of the proposed locations. Based on the results of the API calculator (Section 7.5 of Appendix F), 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 the 216-S-10 Pond and Ditch 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), background (upgradient) wells have been selected that would be representative of ambient conditions under the currently operating 200 West P&T remedy. They do 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.

WAC 173-303-645(8)(g), 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 G. Selection of the statistical method for use in the 216-S-10 Pond and Ditch is discussed in Section 9.5.

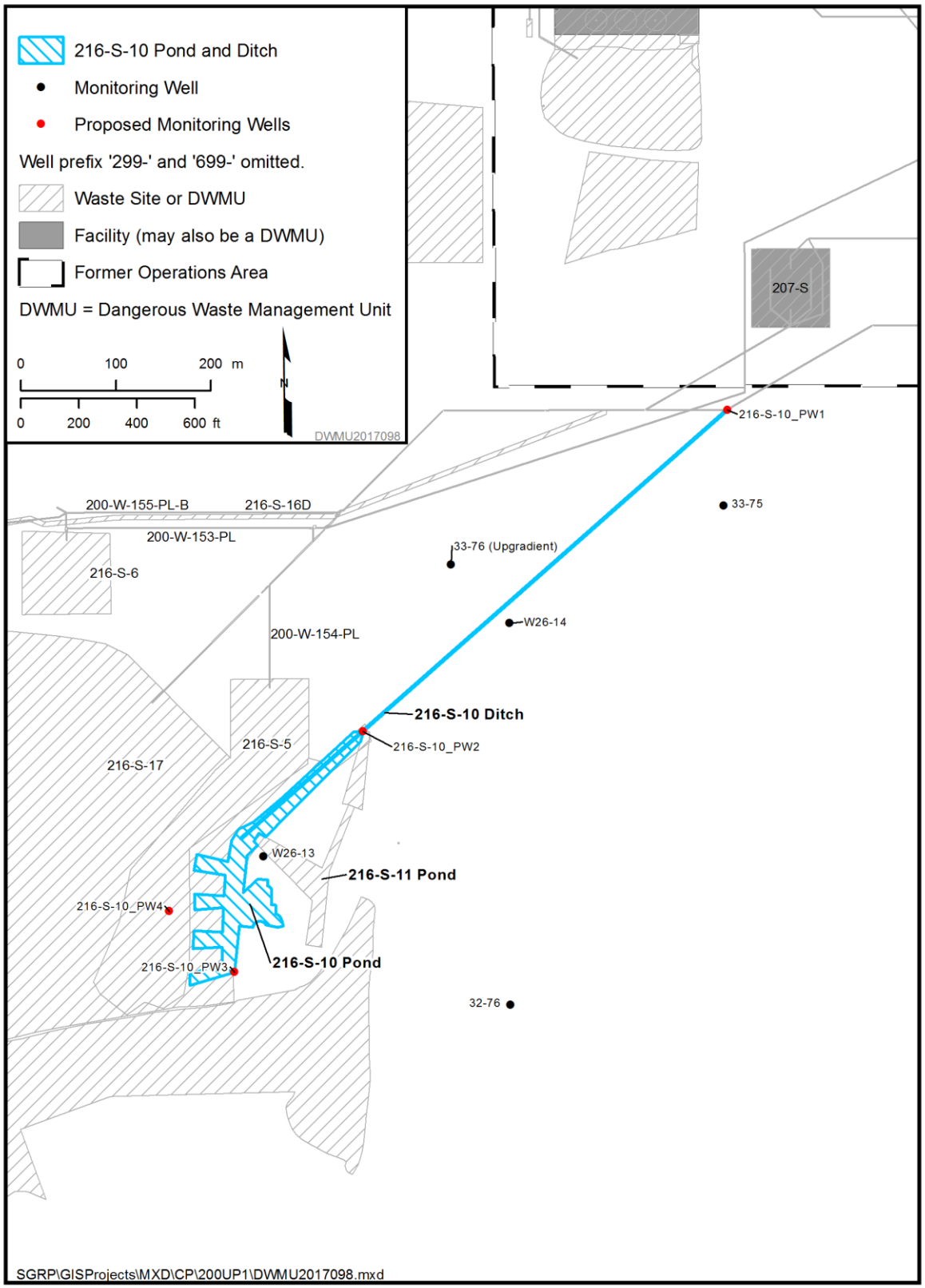


Figure 9-1. Proposed Final Status Groundwater Monitoring Network for the 216-S-10 Pond and Ditch

Table 9-1. Attributes for Wells in the 216-S-10 Pond and Ditch 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-W26-13	12/28/1999	566424.39	133293.60	199.82 (655.56)	133.61 (434.85)	66.21 (217.22)	6.12 (20.08)	11/1/2017
299-W26-14	4/3/2003	566682.69	133539.21	205.43 (673.98)	132.96 (432.73)	72.47 (237.76)	6.28 (20.61)	11/1/2017
699-32-76	1/4/2008	566683.94	133137.73	204.70 (671.60)	132.61 (431.58)	72.1 (236.55)	7.76 (25.45)	11/1/2017
699-33-75	1/31/2008	566907.78	133662.48	207.36 (680.32)	132.42 (430.97)	74.94 (245.86)	7.36 (24.14)	11/1/2017
699-33-76	3/27/2008	566621.21	133600.43	203.94 (669.11)	133.13 (433.28)	70.81 (232.32)	7.52 (24.68)	11/1/2017
216-S-10_PW1	TBD	566911.58	133763.41	TBD	TBD	TBD	9.1 (30)	TBD
216-S-10_PW2	TBD	566528.69	133425.42	TBD	TBD	TBD	9.1 (30)	TBD
216-S-10_PW3	TBD	566393.50	133172.34	TBD	TBD	TBD	9.1 (30)	TBD
216-S-10_PW4	TBD	566325.28	133236.61	TBD	TBD	TBD	9.1 (30)	TBD

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

* 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.

amsl = above mean sea level

bgs = below ground surface

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

Based on current groundwater flow direction to the east and predictions of future groundwater flow direction toward the east over time (Section 2.8 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 DWMU 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 F).

9.3.1 Groundwater Monitoring Well 699-33-76

Groundwater monitoring well 699-33-76 is proposed as a background well. It was constructed in 2008 to the standards of WAC 173-160. This well is also used in the interim status groundwater monitoring network for the 216-S-10 Pond and Ditch. The well is upgradient and screened from elevation 135.5 m (444.7 ft) to elevation 124.9 m (409.7 ft) (Appendix D). Based on 2017 water elevation data, well 699-33-76 is screened across the upper 7.52 m (24.68 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 699-33-76 is predominantly to the east at this well (Figure 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T operations (i.e., changes in operating conditions). Particle tracking simulations and transport modeling were performed (Appendix F and Chapter 7) 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. 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 7-11 through 7-13) indicate that this well will remain upgradient of the 216-S-10 Pond and Ditch under the scenarios evaluated. The modeling performed calculates that the injection of treated water associated with the final 200 West P&T system does not reach the monitoring well during the simulated time frame.

9.3.2 Groundwater Monitoring Well 216-S-10_PW4

Groundwater monitoring well 216-S-10_PW4 is a proposed background well. If the well location is approved it will be constructed according to WAC 173-160. The proposed location for the well is upgradient of the 216-S-10 Pond and Ditch and conceptually 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 at this location is predominantly to the east (Figure 3-5); however, future groundwater flow direction may be impacted by ongoing 200 West P&T operations (i.e., changes in operating conditions). Particle tracking simulations and transport modeling were performed (Appendix F and Chapter 7) to evaluate the impacts of 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. 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 7-11 through 7-13) indicate that this well will remain upgradient of the 216-S-10 Pond and Ditch under the scenarios evaluated. The modeling performed calculates that the

injection of treated water associated with the final 200 West P&T system does not reach the monitoring well during the simulated time frame.

9.3.3 Groundwater Monitoring Well 299-W26-13

Groundwater monitoring well 299-W26-13 is proposed as a point of compliance well. It was constructed in 1999 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for the 216-S-10 Pond and Ditch. The well is downgradient of the 216-S-10 Pond and Ditch and is screened from elevation 137.4 m (450.8 ft) to elevation 126.7 m (415.7 ft) (Appendix D). Based on 2017 water elevation data, well 299-W26-13 is screened across the upper 6.12 m (20.08 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 3-5); 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 (Appendix F and Chapter 7) 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. 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 transport calculations (Figures 7-8 through 7-10) and the results of particle-tracking calculations (Figures 7-11 through 7-13) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16) indicate that this well is centrally located within of the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well (Figures 7-1 and 7-7) indicate minimal dilution of the release concentration is expected at the well location. 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 1% (corresponding to a release unit concentration of approximately 0.99 shown in Figure 7-1) 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 does not reach the monitoring well during the simulated time frame. 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 the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.3.4 Groundwater Monitoring Well 299-W26-14

Groundwater monitoring well 299-W26-14 is proposed as a point of compliance well. It was constructed in 2003 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for the 216-S-10 Pond and Ditch. The well is downgradient of the 216-S-10 Pond and Ditch and is screened from elevation 136.6 m (448.1 ft) to elevation 125.9 m (413.1 ft) (Appendix D). Based on 2017 water elevation data, well 299-W26-14 is screened across the upper 6.28 m (20.61 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-northeast at this well (Figure 3-5); 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 (Appendix F and Chapter 7) 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. 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 transport calculations (Figures 7-8 through 7-10) and the results of particle-tracking calculations (Figures 7-11 through 7-13) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16) indicate that this well is centrally located within of the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well (Figures 7-2 and 7-7) indicate minimal dilution of the release concentration is expected at the well location. 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 8% (corresponding to a release unit concentration of approximately 0.92 shown in Figure 7-2) 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 does not reach the monitoring well during the simulated time frame. 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 the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.3.5 Groundwater Monitoring Well 699-32-76

Groundwater monitoring well 699-32-76 is proposed as a point of compliance well. It was constructed in 2008 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for the 216-S-10 Pond and Ditch. The well is downgradient of the 216-S-10 Pond and Ditch and is screened from elevation 134.8 m (442.2 ft) to elevation 124.1 m (407.2 ft) (Appendix D). Based on 2017 water elevation data, well 699-32-76 is screened across the upper 7.76 m (25.45 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 3-5]); 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 (Appendix F and Chapter 7) 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. 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 transport calculations (Figures 7-8 through 7-10) and the results of particle-tracking calculations (Figures 7-11 through 7-13) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16 indicate that this well is located outside the southern extent of the estimated area of detectability for scenarios 1 and 2 and located within the detectable area for scenario 3 (no flow from the 200 West P&T system). The release concentration breakthrough curves for this well (Figures 7-4 and 7-7) indicate significant dilution of the release concentration is expected at the well location. 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 86% (corresponding to a release unit concentration of approximately 0.14 shown in Figure 7-4) 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 does not reach the monitoring well during the simulated time frame. Collectively with the other proposed monitoring network wells, this well would allow for the detection of contamination should there be a release from the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.3.6 Groundwater Monitoring Well 699-33-75

Groundwater monitoring well 699-33-75 is proposed as a point of compliance well. It was constructed in 2008 to the standards in WAC 173-160. This well is also used in the interim status groundwater monitoring network for the 216-S-10 Pond and Ditch. The well is downgradient of the 216-S-10 Pond and Ditch and is screened from elevation 135.0 m (442.8 ft) to elevation 124.3 m (407.8 ft) (Appendix D). Based on 2017 water elevation data, well 699-33-75 is screened across the upper 7.36 m (24.14 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-northeast at this well (Figure 3-5); 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 (Appendix F and Chapter 7) 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. 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 transport calculations (Figures 7-8 through 7-10) and the results of particle-tracking calculations (Figures 7-11 through 7-13) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16) indicate that this well is centrally located within of the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well (Figures 7-5 and 7-7) indicate minimal dilution of the release concentration is expected at the well location. 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 6% (corresponding to a release unit concentration of approximately 0.94 shown in Figure 7-5) 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 does not reach the monitoring well during the simulated time frame. 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 the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.3.7 Groundwater Monitoring Well 216-S-10_PW1

Groundwater monitoring well 216-S-10_PW1 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 the 216-S-10 Pond and Ditch and conceptually, 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 northeast 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 (Appendix F and Chapter 7) 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. 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 transport and particle-tracking calculations (Figure 7-22) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16) indicate that this well is centrally located within of the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well (Figures 7-17 and 7-21) indicate some dilution of the release concentration is expected at the well location. 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 36% (corresponding to a release unit concentration of approximately 0.64 shown in Figure 7-17) 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 does not reach the monitoring well during the simulated time frame. 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 the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.3.8 Groundwater Monitoring Well 216-S-10_PW2

Groundwater monitoring well 216-S-10_PW2 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 the 216-S-10 Pond and Ditch and conceptually 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-northeast 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 (Appendix F and Chapter 7) 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. 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 transport and particle-tracking calculations (Figure 7-22) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16) indicate that this well is centrally located within of the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well (Figures 7-18 and 7-21) indicate minimal dilution of the release concentration is expected at the well location. 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 17% (corresponding to a release unit concentration of approximately 0.83 shown in Figure 7-18) 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 does not reach the monitoring well during the simulated time frame. 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 the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.3.9 Groundwater Monitoring Well 216-S-10_PW3

Groundwater monitoring well 216-S-10_PW3 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 the 216-S-10 Pond and Ditch and conceptually, 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 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 (Appendix F and Chapter 7) 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. 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 transport and particle-tracking calculations (Figure 7-22) indicate that the location of this well is suited for detecting releases from the facility. The results of the relative detectability evaluation (Figures 7-14 through 7-16) indicate that this well is centrally located within of the detectable area for the scenarios evaluated. The release concentration breakthrough curves for this well (Figures 7-19 and 7-21) indicate some dilution of the release concentration is expected at the well location. 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 32% (corresponding to a release unit concentration of approximately 0.68 shown in Figure 7-19) 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 does not reach the monitoring well during the simulated time frame. 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 the 216-S-10 Pond and Ditch under the range of operating conditions evaluated.

9.4 Constituent List and Frequency

The proposed 216-S-10 Pond and Ditch final status groundwater monitoring network detailed in this report consists of two upgradient (existing well 699-33-76 and proposed well 216-S-10_PW4) and seven downgradient wells (existing wells 299-W26-13, 299-W26-14, 699-32-76, and 699-33-75, and proposed wells 216-S-10_PW1, 216-S-10_PW2, and 216-S-10_PW3). Upgradient well 699-33-76 and downgradient wells 299-W26-13, 299-W26-14, 699-32-76, and 699-33-75 are part of the 216-S-10 Pond and Ditch interim status groundwater monitoring network (Table 3-1 in DOE/RL-2008-61, Rev. 1) 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,

eight waste constituents were selected to detect and monitor groundwater impacts from dangerous waste releases at the 216-S-10 Pond and Ditch.

Table 9-2 identifies the proposed monitoring network and sampling frequency for the 216-S-10 Pond and Ditch. 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, specific conductance, dissolved oxygen, oxidation-reduction potential, 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 the 216-S-10 Pond and Ditch.

In accordance with 16-NWP-129, performing 1 year of background monitoring for WAC 173-303-110(3)(c) and (7) constituents was established. 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 this sampling to establish background concentrations will be discontinued.

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 9.5.

When the groundwater monitoring plan for the 216-S-10 Pond and Ditch is incorporated into the Hanford Facility Dangerous Waste Permit, it will replace any other groundwater monitoring plan(s) associated specifically with this DWMU under interim status.

Table 9-2. Monitoring Wells and Sample Schedule for the 216-S-10 Pond and Ditch

Well Name	Purpose	WAC Compliant	Water Level	Site-Specific Constituents to Detect Release from Regulated Unit[a]								Dangerous Wastes[b]	Field Parameters[c]
				Chromium	Hexavalent Chromium	Chloride	Fluoride	Nitrate	Phosphate	Potassium	Sodium	Table 9-4	
699-33-76	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
216-S-10_PW4	Upgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
299-W26-13	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
299-W26-14	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
699-32-76	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
699-33-75	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
216-S-10_PW1	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
216-S-10_PW2	Downgradient	Y	E	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q/S	Q	Q/S
216-S-10_PW3	Downgradient	Y	E	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-129, and to support collection of sufficient samples to perform statistical testing (e.g., 8 samples), quarterly sampling for Ecology Publication No. 97-407 Appendix 5 constituents will be performed for a 2-year period.

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

E = each time the well is sampled

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 Monitoring Constituents for the 216-S-10 Pond and Ditch

Waste Constituent	CAS Number
Dangerous Waste Constituents	
Inorganic	
Hexavalent chromium	18540-29-9
Metal	
Chromium	7440-47-3
Nondangerous Waste Constituents	
Anions	
Chloride	16887-00-6
Fluoride	16984-48-8
Nitrate	14797-55-8
Phosphate	14265-44-2
Metals	
Potassium	7440-09-7
Sodium	7440-23-5

CAS = Chemical Abstracts Service

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
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

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

Constituent	CAS Number	Constituent	CAS Number
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
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

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

Constituent	CAS Number	Constituent	CAS Number
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
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

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

Constituent	CAS Number	Constituent	CAS Number
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 the 216-S-10 Pond and Ditch cannot be determined. EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, requires a minimum of eight samples to be able to define background. The proposed compliance wells for the 216-S-10 Pond and Ditch include two background (upgradient) wells and seven point of compliance (downgradient) wells. Of these, one of the background wells and three of the point of compliance wells are new wells. Given that four of the network 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 constituent in Table 9-4 at a quarterly frequency for 2 years. Quarterly monitoring will allow for sufficient 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 in Appendix G. In addition 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.

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.”

This page intentionally left blank.

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.

16-NWP-129, 2016, "Groundwater Engineering Report and Final Status Groundwater Monitoring Plan Requirements for 216-A-37-1 Crib, 216-A-36B Crib, 216-B-63 Trench, 216-B-3 Pond, 216-A-29 Ditch, and 216-S-10 Pond and Ditch Dangerous Waste Management Units" (letter to Doug S. Shoop, U.S. Department of Energy, Richland Operations Office, and John A. Ciucci, CH2M HILL Plateau Remediation Company) from Cheryl Whalen, Washington State Department of Ecology, Richland, Washington, July 28. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075636H.

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."

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-00176, 1995, *S Plant Aggregate Area Management Study Technical Baseline Report*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D198038143.

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/pdf.cfm?accession=0083482H.

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

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, 1987, *216-S-10 Ditch and Pond Preliminary Closure/Post-Closure Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196003121.

DOE/RL-91-60, 1992, *S Plant Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195065601.

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-93-09, 1993, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196136826.

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-2004-17, 2004, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group 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=D7005093.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D7005338.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D7005561.

DOE/RL-2006-12, 2008, *Hanford Facility Dangerous Waste Closure/Postclosure Plan for the 216-S-10 Pond and Ditch*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087003.

DOE/RL-2007-28, *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/docDetail?accession=0808050315.
http://pdw.hanford.gov/arpir/index.cfm/docDetail?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-2008-61, 2010, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331.

DOE/RL-2008-61, 2017, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/docDetail?accession=0069130H

DOE/RL-2009-73, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Area S/SX*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070707

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-2011-118, 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-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=0072146H.

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-200W-17-0077, *Groundwater Flow and Migrations Calculations to Support Assessment of the 216-S-10 Pond and Ditch Monitoring Network*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065096H.

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.

ECN 113816, 1990, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0013153.

ECN 618168, 1994, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196046461.

ECN 618188, 1995, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196004151.

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/publications/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 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.

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.

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-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-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-13378, 2001, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13378.PDF.

PNNL-13514, 2001, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13514.pdf.

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: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-13858.pdf

PNNL-14070, 2002, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D9181190.

PNNL-14070-ICN-1, 2003, *Interim Change Notice to Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D3522381.

PNNL-14070-ICN-2, 2006, *Interim Change Notice for Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04027618.

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-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0911300343.

PNNL-14744, 2004, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0911300325.

PNNL-14804, 2004, *Results of Detailed Hydrologic Characterization Tests Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14804.pdf.

PNNL-18807, 2009, *Soil Water Balance and Recharge Monitoring at the Hanford Site – FY09 Status Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-18807.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.

RHO-CD-673, 1979, *Handbook 200 Areas Waste Sites*, Volume III, Rockwell Hanford Operations, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196039029.

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.

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.

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."

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

303-400, "Interim Status Facility Standards."

303-645, "Releases from Regulated Units."

303-806, "Final Facility Permits."

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

303-9904, "Dangerous Waste Sources List."

WHC-SD-EN-AP-018, 1990, *Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196047854.

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.

Zheng, C., and P.P. 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*, Report SERDP-99-1, U.S. Army Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, Mississippi. Available at: https://hydro.geo.ua.edu/mt3d/mt3dmanual.pdf.

Appendix A

Interim Status Data Summary

This page intentionally left blank.

A1 Introduction

Section 2.4 of the main document summarizes the groundwater monitoring history at the 216-S-10 Pond and Ditch. An interim status indicator parameter groundwater monitoring program under 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," was initiated in 1991. To date, statistical analyses of the parameters used as indicators of groundwater contamination have not shown an exceedance relative to the statistical comparison value (as defined in 40 CFR 265.93(b), "Preparation, Evaluation, and Response"); therefore, the 216-S-10 Pond and Ditch has been monitored under an indicator evaluation program throughout its interim status period.

The interim status groundwater monitoring history of the 216-S-10 Pond and Ditch through 2016 was compiled. Information from annual reporting documents and groundwater monitoring plans was utilized to compile a summary of wells in the 216-S-10 Pond and Ditch 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 are 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."

265.93, "Preparation, Evaluation, and Response."

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

DOE/RL-91-03, 1991, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196047080.

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.

® Microsoft and Excel are registered trademarks of Microsoft Corporation in the United States and other countries.

DOE/RL-93-09, 1993, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196136826.

DOE/RL-93-88, 1994, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196094135.

DOE/RL-94-136, 1995, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196037232.

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-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-2008-61, 2010, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331

DOE/RL-2008-61, 2017, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0069130H.

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-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 Report 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 113816, WHC-SD-EN-AP-018, 1990, *Engineering Change Notice to Interim Status Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0013153.

ECN 618168, 1994, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196046461.

ECN 618188, 1995, *Engineering Change Notice to WHC-SD-EN-AP-018 Interim-Status Ground-Water Monitoring Plan for the 216-S-10 Pond and Ditch*, Westinghouse Hanford Company, Richland, Wasington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196004151.

PNNL-11470, 1997, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199132964.

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-12086, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199091099.

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-14070, 2002, *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D9181190.

PNNL-14070-ICN-1, 2003, *Interim Change Notice to Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D3522381.

PNNL-14070-ICN-2, 2006, *Interim Change Notice to Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04027618.

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-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-018, 1990, *Interim-Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196047854

Appendix B

Topographic Map

This page intentionally left blank.

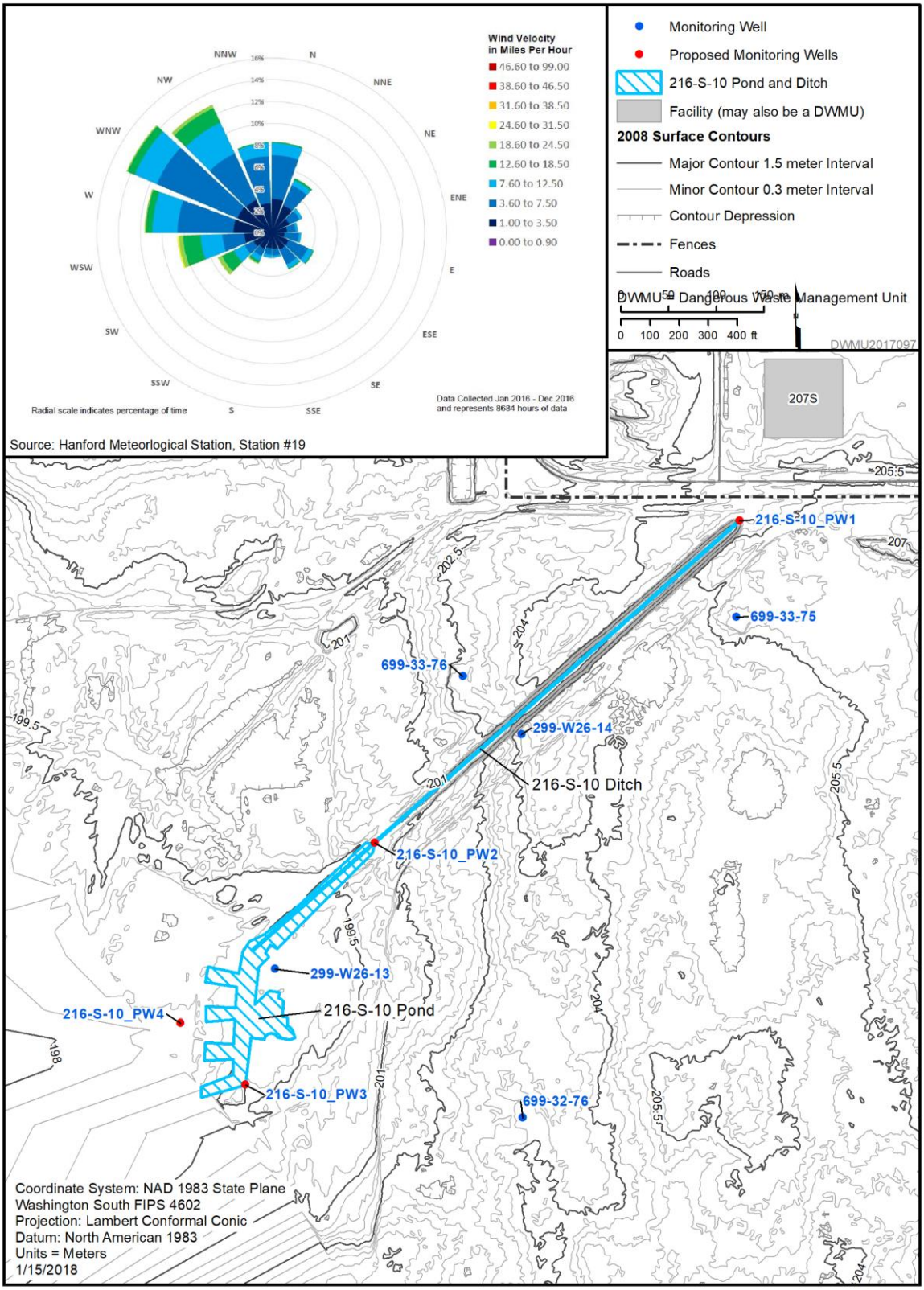


Figure B-1. Topographic Map

This page intentionally left blank

Appendix C

Plume Maps

This page intentionally left blank.

This appendix presents regional plume maps in the vicinity of the 216-S-10 Pond and Ditch.
The hexavalent chromium plume does not originate solely from the 216-S-10 Pond and Ditch, but rather the unit has likely contributed to the overall plume. The carbon tetrachloride plume does not originate from the 216-S-10 Pond and Ditch, but is a regional plume in the area of the unit.

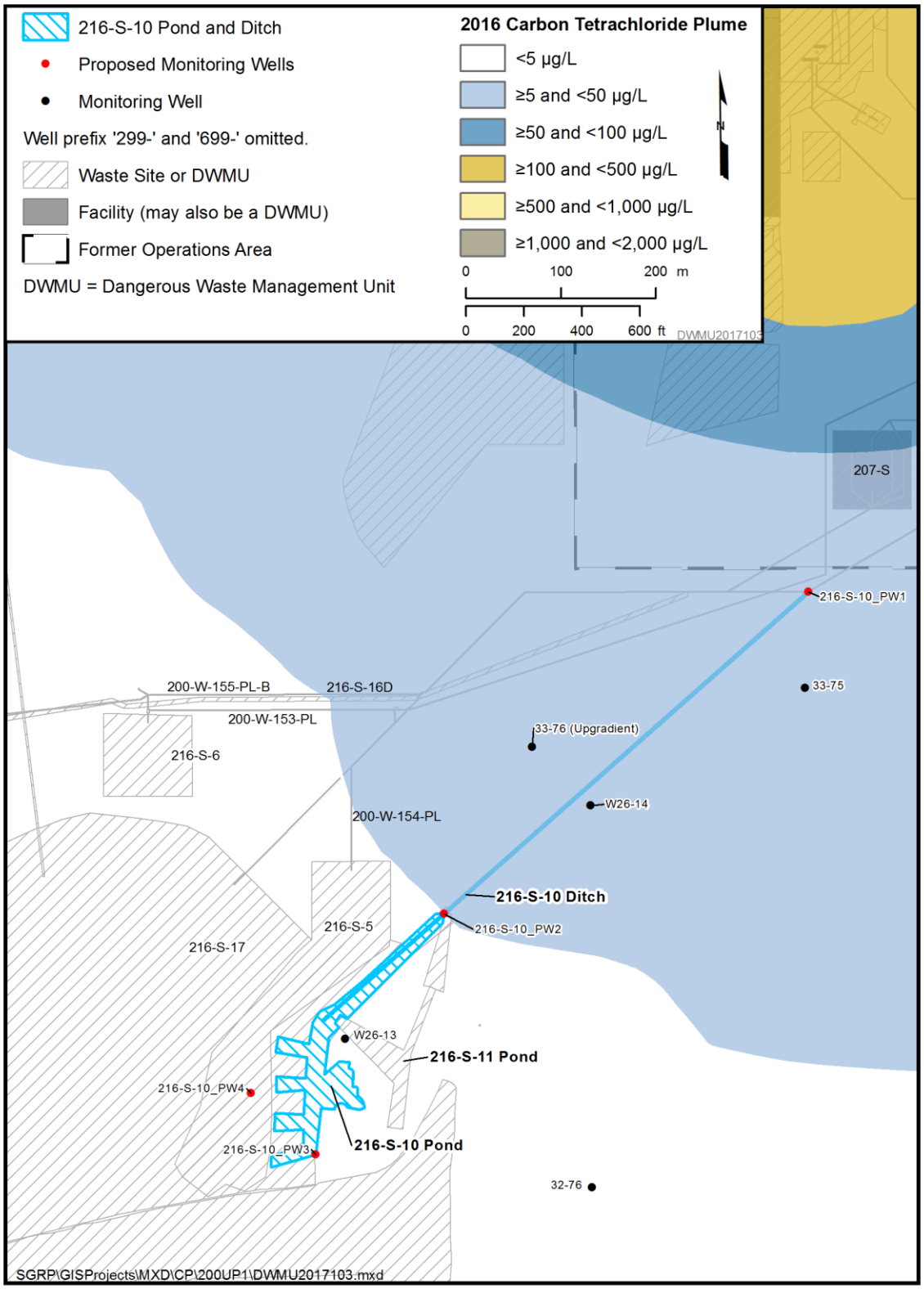
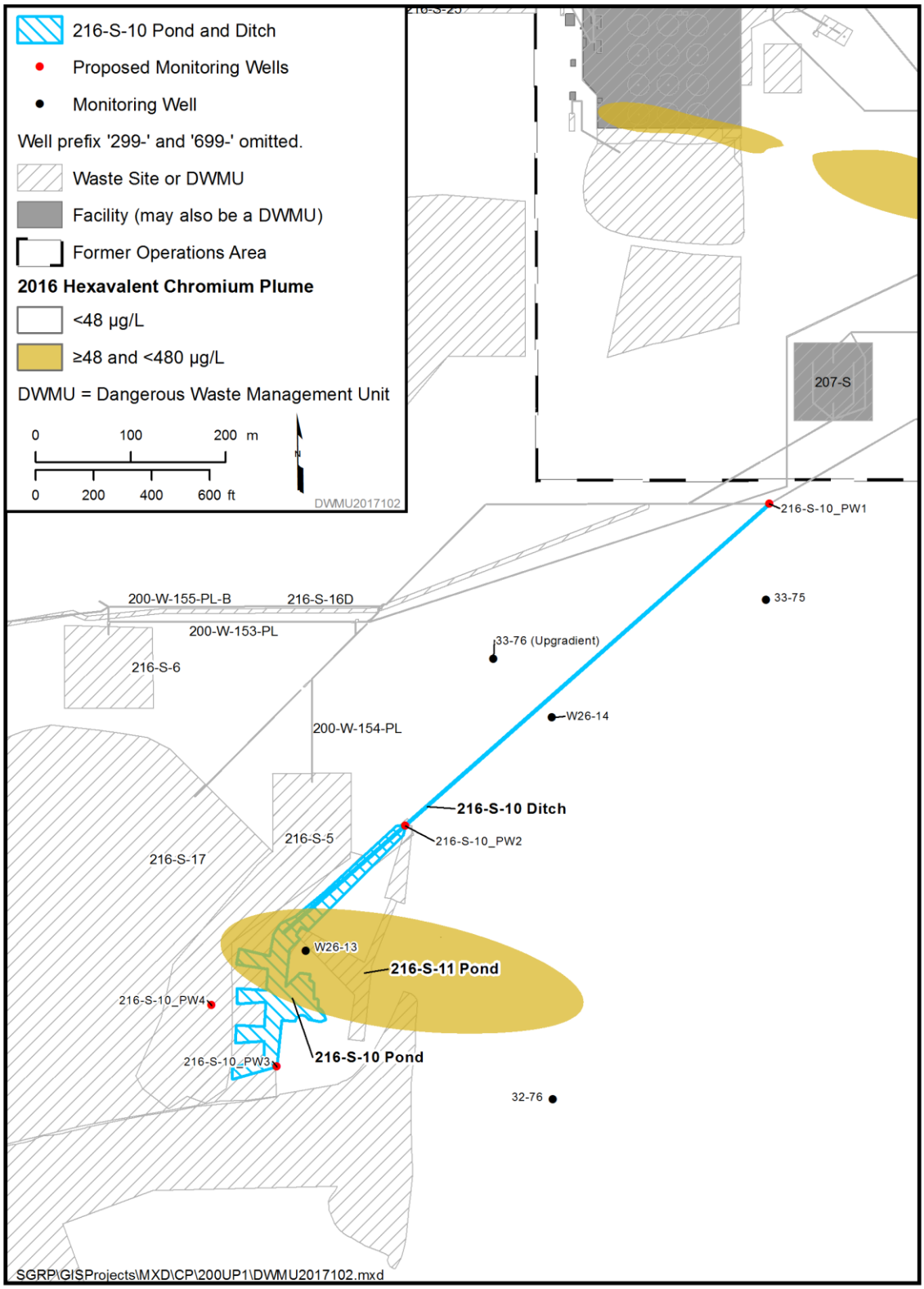


Figure C-1. Regional Carbon Tetrachloride Plume at the 216-S-10 Pond and Ditch



a

Figure C-2. Regional Hexavalent Chromium Plume at the 216-S-10 Pond and Ditch

This page intentionally left blank.

Appendix D

Well As-Built Diagrams and Proposed Well Design Information

This page intentionally left blank.

Contents

D1 Introduction D-1

D2 Reference D-19

Figures

Figure D-1. Well 299-W26-13 Construction and Completion Summary D-3
Figure D-2. Well 299-W26-14 Construction and Completion Summary D-4
Figure D-3. Well 299-W27-2 Construction and Completion Summary D-6
Figure D-4. Well 699-32-76 Construction and Completion Summary D-7
Figure D-5. Well 699-33-75 Construction and Completion Summary D-11
Figure D-6. Well 699-33-76 Construction and Completion Summary D-15

Tables

Table D-1. Hydrogeologic Monitoring Unit Classification Scheme D-1
Table D-2. Sampling Interval Information for Wells within the 216-S-10 Pond and Ditch Network D-1
Table D-3. Planned Location, Depth, and Screen Interval for Proposed Wells within the 216-S-10 Pond and Ditch Network D-2

This page intentionally left blank.

D1 Introduction

This appendix provides the following information for the existing 216-S-10 Pond and Ditch groundwater monitoring wells:

- Well name
- Hydrogeologic unit monitored (the aquifer portion at the well screen-perforation) (Table D-1)
- The following sampling interval information, as provided in Table D-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 D-3:

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

Figures D-1 through D-6 provide construction and completion summaries for the existing network wells.

Table D-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 D-2. Sampling Interval Information for Wells within the 216-S-10 Pond and Ditch 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-W26-13	TU	138.18 (453.36)	127.49 (418.26)	10.69 (35.1)	Cable Tool & Air Rotary
299-W26-14	TU	137.35 (450.61)	126.68 (415.61)	10.67 (35)	Cable Tool
699-32-76	TU	135.51 (444.6)	124.85 (409.6)	10.67 (35)	Air Rotary
699-33-75	TU	135.73 (445.32)	125.07 (410.32)	10.67 (35)	Air Rotary
699-33-76	TU	136.28 (447.11)	125.61 (412.11)	10.67 (35)	Air Rotary

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

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

Table D-3. Planned Location, Depth, and Screen Interval for Proposed Wells within the 216-S-10 Pond and Ditch 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)
216-S-10_PW1	133763.41	566911.58	204.81 (671.95)	132.85 (435.86)	71.96 (236.09)	133.39 (437.63)	10.16 (4)	70.44 (231.09) to 81.10 (266.09)	81.10 (266.09) to 82.02 (269.09)
216-S-10_PW2	133425.42	566528.69	200.11 (656.53)	133.65 (438.48)	66.46 (218.04)	129.84 (425.98)	10.16 (4)	64.94 (213.04) to 75.60 (248.04)	75.60 (248.04) to 76.52 (251.04)
216-S-10_PW3	133172.34	566393.5	199.27 (653.77)	134.07 (439.86)	65.2 (213.91)	131.17 (430.35)	10.16 (4)	63.67 (208.91) to 74.34 (243.91)	74.34 (243.91) to 75.26 (246.91)
216-S-10_PW4	133536.61	566325.28	199.70 (655.18)	134.23 (440.39)	65.47 (214.80)	130.14 (426.98)	10.16 (4)	63.95 (209.80) to 74.62 (244.80)	74.62 (244.80) to 75.53 (247.80)

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 CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Toll & Air Rotary	Sample Method:	Grab/Split Spoon
Drilling Fluid Used:	water as needed	Additives Used:	None
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909
Drilling Company:	Resonant Sonic Intl.	Company Location:	Woodland, Ca.
Date Started:	18Nov99	Date Completed:	28Dec99

WELL NUMBER: 299-W26-13 B8817 TEMPORARY WELL NO: Not Allowed

Coordinates: N Not documented

Coordinates: E Not documented

Start Card #: R43392

Elevation Ground Surface: Brass Marker

Depth to Water: 200.05 ft. ft 13Dec99
(Ground surface)

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.3 ft.

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 7.5 ft : Silty Silty SAND
7.5 - 12 ft : Gravelly SAND
12 - 22 ft : Silty SAND

22 - 36.5 ft : SAND

36.5 - 47 ft : Silty SAND

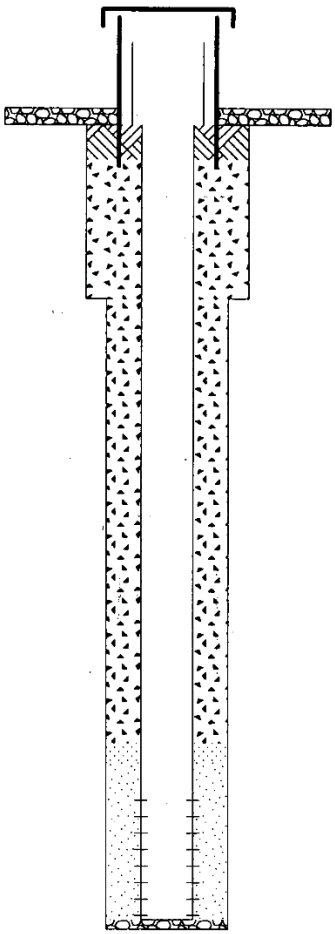
47 - 51 ft : Gravelly Sandy SILT
51 - 110 ft : Silty SAND

110 - 134 ft : Sandy SILT

134 - 139 ft : Caliche Zone
139 - 148 ft : Silty Sandy GRAVEL

148 - 234 ft : Sandy GRAVEL

234 - 237 ft : SAND
237 - 240.7 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 10.3 ft : 12-inch hole Cement Surface Seal	0 - 202.2 ft : 4 inch 4" SS Sch. 5 Well Csg.	
10.3 - 52 ft : 12-inch hole Bentonite Crumbles		
52 - 185.2 ft : 9-inch hole Bentonite Crumbles		
185.2 - 190.7 ft : 9-inch hole Bentonite Hole Plug		202.2 - 237.3 ft : 4 inch 4" SS Wire Wrap .010 Slot Scrn.
190.7 - 237.8 ft : 9-inch hole 20/40 Silica Sand		
237.8 - 240.7 ft : 9-inch hole Slough	237.3 - 237.8 ft : 4 inch 4" PVC Sch 40 End Cap	

240.7 ft : Borehole drilled depth

0 - 36.3 ft : 12-in. Cable Tool 11-3/4" CS Temp. Csg. to 36.3 ft.
36.3 - 52 ft : 9-in. Cable Tool 8-5/8" CS Temp. Csg. to 52 ft.
52 - 240.7 ft : 9-in. Air Rotary 8-5/8" CS Temp. Csg. to 90.7 ft. - Cable Tool 8-5/8" CS Temp. Csg. to 152 ft. - Air Rotary 8-5/8" to 170 ft - Cable Tool 8-5/8" to 240.7 ft.

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 07Mar00
Print Date: 07Mar00

Report Form: WELLS Project File: WELLS.GPJ

0515332

Figure D-1. Well 299-W26-13 Construction and Completion Summary

WELL SUMMARY SHEET

Start Date: 3/6/03
Finish Date: 4/3/03
Page: 1 of 2

Well ID: B8828	Well Name: 299-W26-14
Location: 216-S-10 ditch	Project: FY2003 CERCLA CS-1 DRILLING
Prepared By: Jess Hocking — Date: 4/3/03	Reviewed By: L. D. Walker — Date: 4/29/03
Signature: Jess Hocking	Signature: LD Walker

CONSTRUCTION DATA

Description

4" TP-304/304L sch 05s Riser
+2.00' → 223.37'

4" TP-304/304L sch 05s 0.020" Cont. Wire Wrap screen
223.37' → 258.37'

4" TP-304/304L sch 05s Sump
258.37' → 260.47'

Type I/II Portland Cement
0 → 9.65'

Pure Wyoming Bentonite Crumbles
9.65' → 200.98'

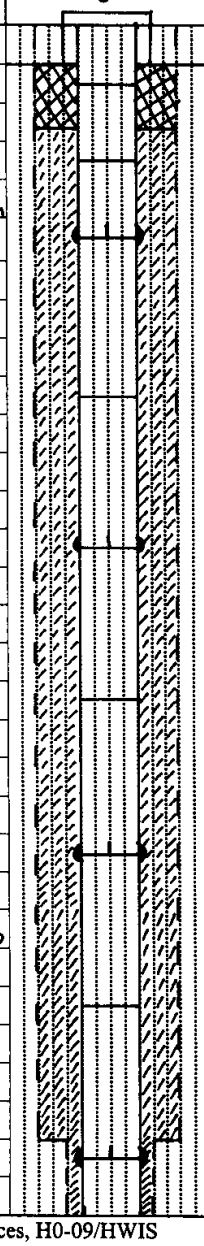
American Bentonite Pellets
200.98' → 211.05'

10-20 mesh Colorado Silica Sand
211.05' → 267'

Temporary Casing, 10¾" OD
0' → 143'

NOTE: ALL DEPTHS REPORTED IN FT. BELOW GROUND SURFACE.

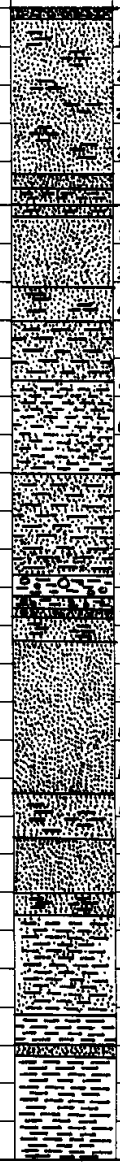
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 25, 50, 75, 100, 125

Graphic Log



Lithologic Description

0-1' Drill Pad: Misc. Fill
1-22' Slightly Silty Sand (m)S
22-24' Sand S
24-25' Silty Sand mS
25-26' Slightly Silty Sand (m)S
26-35.5' Sand S
35.5-40' Slightly Silty Sand (m)S
40-48' Silty Sand mS
48-60' Sandy Silt sM
60-74' Silty Sand mS
74-76' Gravelly Silt gM
76-77' Gravelly Sandy Silt gsM
77-78.5' Gravelly Sand gS
78.5-83' Slightly Silty Sand (m)S
83-103.5' Sand S
103.5-108' Slightly Silty Sand (m)S
108-115' Sand S
115-118' Slightly Silty Sand (m)S
118-131' Sandy Silt sM
131-135' Silt M
135-135.5' Sand S
135.5-163' Silt M

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

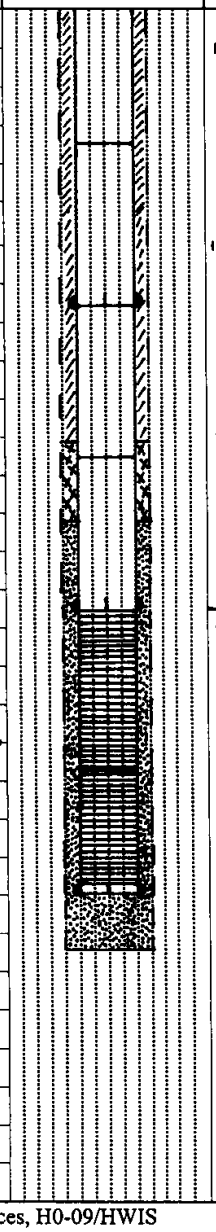
BHI-EE-189 (02-20-2002)

Figure D-2. Well 299-W26-14 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 3/6/03 Finish Date: 4/3/03	Page: 2 of 2
Well ID: B8828	Well Name: 299-W26-14	
Location: 216-S-10 ditch.	Project: FY 2003 CERCLA CS-1 DRILLING	
Prepared By: Jess Hocking	Date: 4/3/03	Reviewed By: L. D. Walker	Date: 4/29/03
Signature: Jess Hocking	Signature: L D Walker	

CONSTRUCTION DATA

Description	Diagram
Temporary Casing, 8 5/8" OD, to 267'	
NOTE: ALL TEMP. CASING REMOVED FROM GROUND.	
NOT TO SCALE	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
150		163 - 168' Sandy Gravel sG
		168 - 182' Gravelly Sand gS
		182 - 183' Slightly Silt Gravelly Sand (m)gS
		183 - 190' Gravelly Silty Sand gmS
175		190 - 192' Silty Sand mS
		192 - 214' Silty Sandy Gravel msG
		214 - 217' Sandy Gravel sG
		217 - 219' Silty Sandy Gravel msG
200		219 - 220' Sand S
		220 - 224' Sandy Gravel sG
		224 - 257' Silty Sandy Gravel msG
225		257 - 258' Sand S
		258 - 259' Silty Sandy Gravel msG
		259 - 260' Sandy Gravel sG
		260 - 267' Sand S
250		267 - Silty Sandy Gravel msG
		TD = 267.0' bgs
		PTW = 223' bgs (3/31/03)
275		

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-189 (02-20-2002)

Figure D-2. Well 299-W26-14 Construction and Completion Summary (continued)

0500613

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER: 299-W27-2 A5410	TEMPORARY WELL NO: None
Drilling Fluid Used:	NA	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	G. Lydin	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	KEH Constr. Forces	Company Location:	Hanford	Start Card #:	Not Available
Date Started:	06Oct92	Date Completed:	18Dec92	Elevation Ground Surface:	

Depth to Water: 215.9 ft 02Nov92
(Ground surface) 217.5 ft 15Dec92

Elevation of Reference Point: m

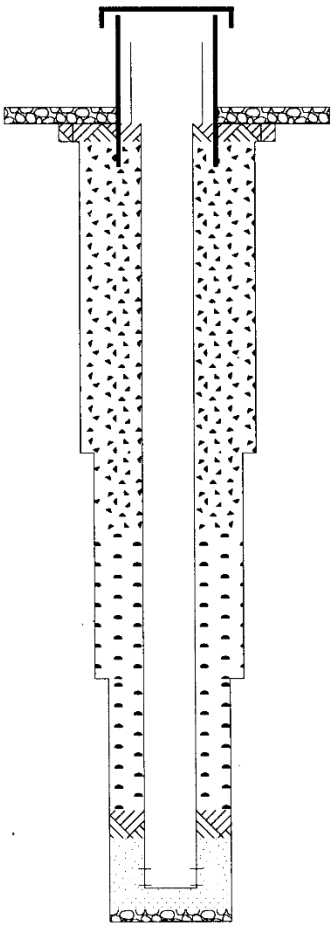
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 9.85 ft.

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 25 ft : Silty Sand
25 - 30 ft : Pebble and Gravel
30 - 70 ft : Silty Sand
70 - 75 ft : Silt and Clay
75 - 80 ft : Silty Sandy Gravel
80 - 100 ft : Silty Sand
100 - 140 ft : Silty Sand
140 - 145 ft : Silt and Clay
145 - 165 ft : Silty Sand
165 - 170 ft : Silt and Clay
170 - 185 ft : Silty Sandy Gravel
185 - 190 ft : Silty Gravelly Sand
190 - 195 ft : Silty Sandy Gravel
195 - 220 ft : Gravelly Sand
220 - 225 ft : Sand
225 - 235 ft : Gravel
235 - 245 ft : Silty Sandy Gravel
245 - 250 ft : Gravelly Sand
250 - 255 ft : Silty Sandy Gravel
255 - 265 ft : Gravelly Sand
265 - 270 ft : Silty Sand
270 - 275 ft : Gravel
275 - 280 ft : Gravelly Sand with Gravel
280 - 305 ft : Interbeds
305 - 330 ft : Gravel
330 - 355 ft : Sandy Gravel
355 - 365 ft : Gravel
365 - 375 ft : Sandy Gravel
375 - 380 ft : Gravel
380 - 390 ft : Sandy Gravel
390 - 395 ft : Gravelly Sand
395 - 400 ft : Sand
400 - 405 ft : Sandy Gravel
405 - 420 ft : Gravel
420 - 430 ft : Sandy Gravel
430 - 435 ft : Clay/Silt



435 ft : Borehole drilled depth

0 - 9.5 ft : 16-in. 16-3/4" CS Temp. Casing
9.5 - 179.88 ft : 13-in. 12-3/4" CS Temp. Casing
179.88 - 302.82 ft : 11-in. 10-3/4" CS Temp. Casing
302.82 - 435 ft : 9-in. 8-5/8" CS Temp. Casing

Fill	*Casing*	*Screen*
0 - 9.7 ft : 16-inch hole Cement	0 - 9.85 ft : 16 inch 16-3/4" CS Temp. Welded Csg.	
9.7 - 9.85 ft : 16-inch hole 8-20 Bentonite Crumbles	0 - 406.14 ft : 4 inch 4" Casing	
9.85 - 179.88 ft : 13-inch hole 8-20 Bentonite Crumbles	9.85 - 179.88 ft : 13 inch 12-3/4" CS Temp. Welded Csg.	
179.88 - 221.8 ft : 11-inch hole 8-20 Bentonite Crumbles	179.88 - 302.82 ft : 11 inch 10-3/4" CS Temp. Welded Csg.	
221.8 - 302.82 ft : 11-inch hole Bentonite Slurry		
302.82 - 374.5 ft : 9-inch hole Bentonite Slurry	302.82 - 435 ft : 9 inch 8-5/8" CS Temp. Welded Csg.	
374.5 - 389.4 ft : 9-inch hole Cement		
389.4 - 399.4 ft : 9-inch hole 10-20 Silica Sand	416.26 - 416.56 ft : 4 inch	406.14 - 416.26 ft : 4 inch 4" .010 SS Wire Wrap Pipe Size
399.4 - 416.56 ft : 9-inch hole 10-20 Silica Sand		
416.56 - 420 ft : 9-inch hole 10-20 Silica Sand		
420 - 428.2 ft : 9-inch hole Bentonite Plug		
428.2 - 435 ft : 9-inch hole Slough		

Drawing By: DLF
Reference: Hanford Wells
Revision: 0
Revision Date: 22Dec97
Print Date: 22Dec97

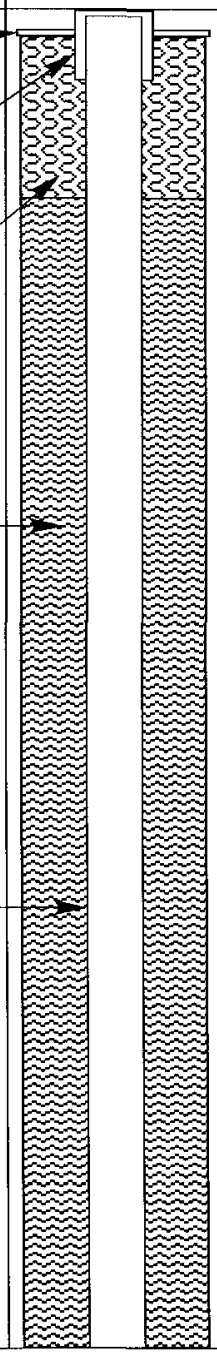
Report Form: WELLS Project File: WELLS.GPJ

Figure D-3. Well 299-W27-2 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 11/8/07 Finish Date: 01/4/08	Page 1 of 4
Well ID: C4975	Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 1/11/08	Reviewed By: L. D. Walker	Date: 4/17/08
Signature: Erika R	Signature:	

CONSTRUCTION DATA

Description	Diagram
6-in Concrete Pad	
6-in I.D. Type 304/304L Stainless Steel Protective Casing: +2.42 ft above Ground Surface	
Portland Cement Type I/II: 0 - 10.8 ft	
Granular Bentonite Crumbles: 10.8 - 212.4 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.82 - 227.0 ft	
All depths are in feet below ground surface.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-1 Gravel, G (Fill)
		1-8 Sandy Silt, sM
10		8-24 Sand, S
20		
		24-30 Silt, M
30		30-50 Sand, S
40		
50		50-55 Sandy Gravel, sG
		55-74 Sand, S
60		
70		
		74-130 Silty Sand, mS
80		

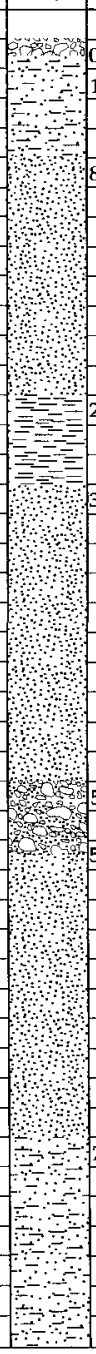


Figure D-4. Well 699-32-76 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 11/8/07 Finish Date: 01/4/08	Page 2 of 4

Well ID: C4975		Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 1/11/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika R		Signature: LD Walker	

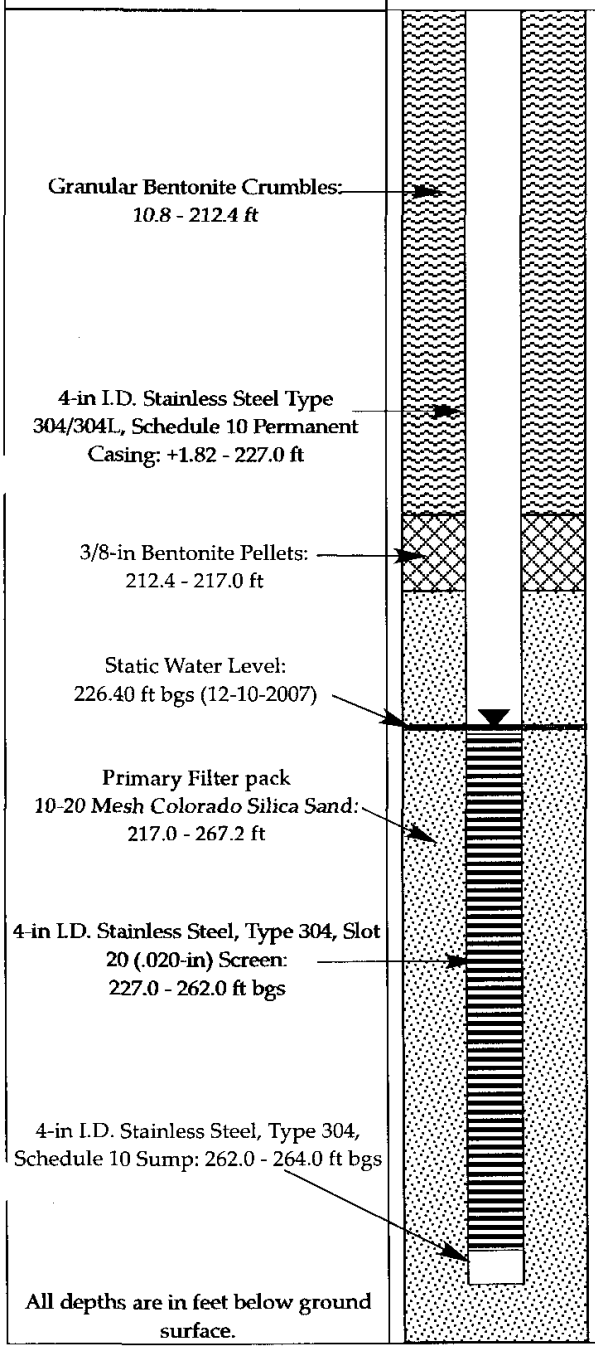
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
Granular Bentonite Crumbles: 10.8 - 212.4 ft		90		
		100		
		110		
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.82 - 227.0 ft		120		
		130		130-155 Sandy Silt, sM
		140		
		150		
				155-160 Sand, S
		160		160-163 Silty Sand, mS
				163-170 Silty Gravely Sand, mgS
		170		170-175 Gravely Sand, gS
All depths are in feet below ground surface.				175-200.5 Sandy Gravel, sG

Figure D-4. Well 699-32-76 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 11/8/07 Finish Date: 01/4/08	Page 3 of 4
Well ID: C4975	Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon — Date:1/11/08	Reviewed By: L.D. Walker — Date: 4/17/08	
Signature: Erika R	Signature:	

CONSTRUCTION DATA

Description	Diagram
Granular Bentonite Crumbles: *10.8 - 212.4 ft*	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.82 - 227.0 ft	
3/8-in Bentonite Pellets: 212.4 - 217.0 ft	
Static Water Level: 226.40 ft bgs (12-10-2007)	
Primary Filter pack *10-20 Mesh Colorado Silica Sand:* 217.0 - 267.2 ft	
4-in I.D. Stainless Steel, Type 304, Slot 20 (.020-in) Screen: 227.0 - 262.0 ft bgs	
4-in I.D. Stainless Steel, Type 304, Schedule 10 Sump: 262.0 - 264.0 ft bgs	
All depths are in feet below ground surface.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
180		
190		
200		200.5-210 Gravely Sand, gS
210		210-215 Sandy Gravel, sG
		215-230 Gravely Sand, gS
220		
230		230-236 Silty Sandy Gravel, msG
		236-237 Grab Sample for Sieve Analysis
		236-255 Sandy Gravel, sG
240		
		244 Water Sample HEIS: B1PM57 & B1PM85
250		
		255-257 Gravelly Silty Sand, gmS
		257-280 Silt Sandy Gravel, msG
		257 Grab Sample for Sieve Analysis
260		

Figure D-4. Well 699-32-76 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 11/8/07 Finish Date: 01/4/08	Page 4 of 4

ell ID: C4975		Well Name: 699-32-76	
Location: 1/2 mile SW of S-plant		Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 1/11/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika R		Signature: LD Walker	

CONSTRUCTION DATA

Description	Diagram
3/8-in Bentonite Pellets: 267.2 - 272.0 ft	
8-12 Mesh Colorado Silica Sand (Backfill): 272.0 - 344.0 ft	
All depths are in feet below ground surface.	
rehole drilled with 13-in threaded casing 0-198 ft and 10¾-in threaded casing 198-344 ft	
All temporary drill casing was removed from the ground.	

GEOLOGIC/HYDROLOGIC DATA

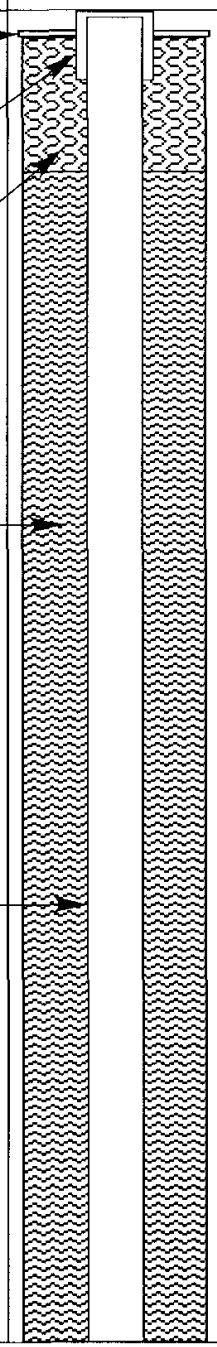
Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
270		
		273 Water Sample HEIS: B1PM54, B1PM58 & B1PM86
280		280-300 Sandy Gravel, sG
290		
300		299 Water Sample HEIS: B1PM59 & B1PM87 300-304 Silty Gravely Sand, mgS
		304-344 Sandy Gravel, sG
310		
320		
330		
340		342 Water Sample HEIS: B1PM60 & B1PM88 344 Total Depth (12/13/2007)
350		

Figure D-4. Well 699-32-76 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 01/08/08 Finish Date: 01/31/08	Page 1 of 4
Well ID: C4974	Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 2/1/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika Rincon	Signature: LD Walker	

CONSTRUCTION DATA

Description	Diagram
6-in Concrete Pad 6-in I.D. Stainless Steel Type 304/304L Protective Casing: +2.48 ft above Ground Surface Portland Cement Type I/II: 0 - 9.0 ft Granular Bentonite Crumbles: 9.0 - 220.9 ft 4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.48 - 235.0 ft All depths are in feet below ground surface.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-5 Gravely Sand, gS
		5-10 Sand, S
10		10-15 Silty Sand, mS
		15-35 Sandy Silt, sM
20		
30		
		35-40 Sand, S
40		40-60 Silty Sand, mS
50		
60		60-140 Sand, S
70		
80		

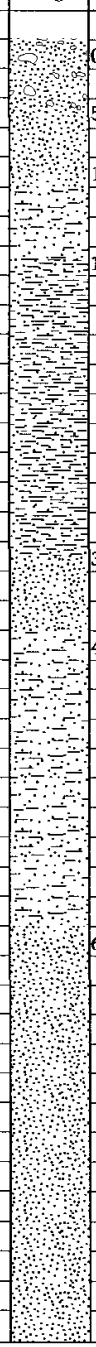


Figure D-5. Well 699-33-75 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 01/08/08 Finish Date: 01/31/08	Page 2 of 4
Well ID: C4974	Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon	Date: 2/1/08	Reviewed By: L.D. Walker	Date: 4/17/08
Signature: Erika R	Signature: LD Walker	

CONSTRUCTION DATA

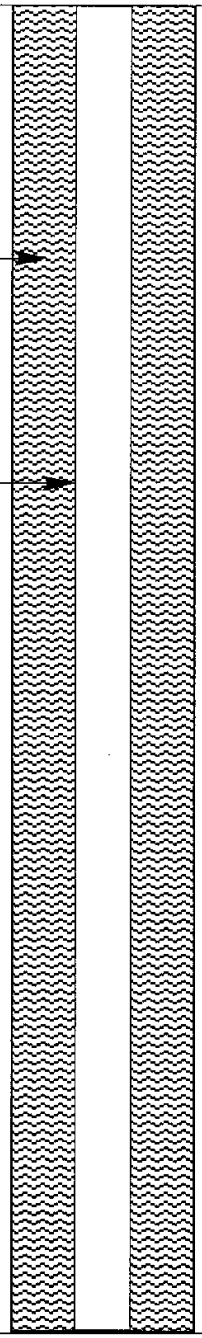
Description

Granular Bentonite Crumbles: 9.0 - 220.9 ft

4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.48 - 235.0 ft

All depths are in feet below ground surface.

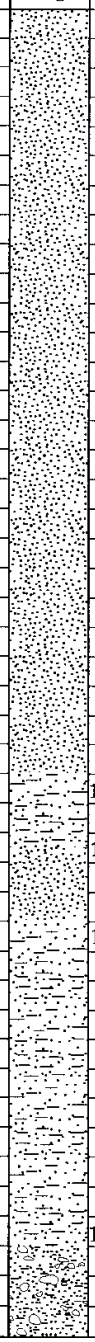
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 90, 100, 110, 120, 130, 140, 150, 160, 170

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

140-145 Silty Sand, mS

145-150 Sand, S

150-172 Silty Sand, mS

172-180 Silty Gravely Sand, mgS

Figure D-5. Well 699-33-75 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 01/08/08 Finish Date: 01/31/08	Page 3 of 4
Well ID: C4974	Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon — Date: 2/1/08	Reviewed By: L.D. Walker — Date: 4/17/08	
Signature: Erika R	Signature: LD Walker	

CONSTRUCTION DATA

Description

Granular Bentonite Crumbles: 9.0 - 220.9 ft

4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.48 - 235.0 ft

3/8-in Bentonite Pellets: 220.9 - 224.5 ft

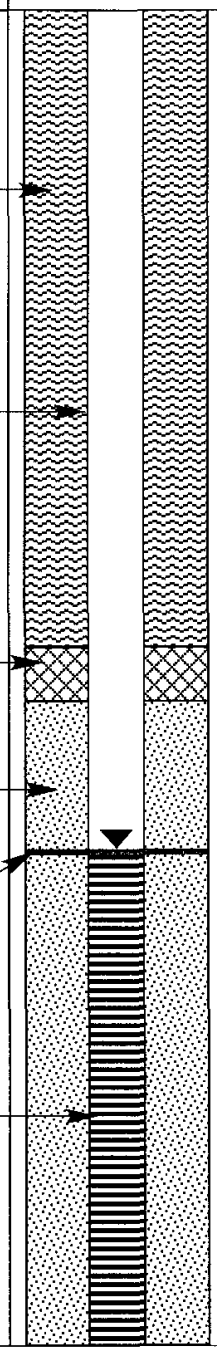
Primary Filter pack 10-20 Mesh Colorado Silica Sand: 224.5 - 274.0 ft

Static Water Level: 234.80 ft bgs (01-24-2008)

4-in I.D. Stainless Steel, Type 304, Slot 20 (.020-in) Screen: 235.0 - 270.0 ft bgs

All depths are in feet below ground surface.

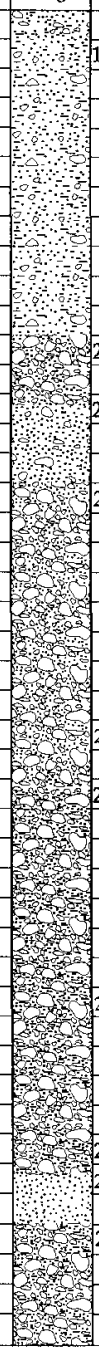
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

180-200 Gravely Silty Sand, gmS

200-205 Sandy Gravel, sG

205-210 Gravely Sand, gS

210-230 Sandy Gravel, sG

227-229 Split-Spoon Sample for Sieve Analysis

230-257 Silty Sandy Gravel, msG

244 Water Sample HEIS: B1PM53 & B1PM81

257-260 Sand, S

257-259 Split-Spoon Sample for Sieve Analysis

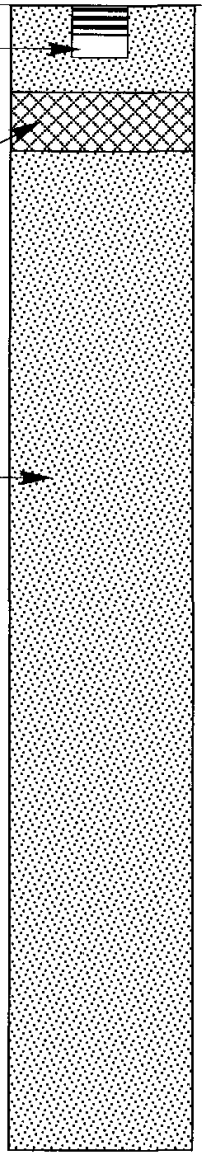
260-310 Silt Sandy Gravel, msG

Figure D-5. Well 699-33-75 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 01/08/08 Finish Date: 01/31/08	Page 4 of 4
Well ID: C4974	Well Name: 699-33-75	
Location: 1/4 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Rincon — Date: 2/1/08	Reviewed By: L.D. Walker — Date: 4/17/08	
Signature: Erika R	Signature: LD Walker	

CONSTRUCTION DATA

Description	Diagram
4-in, I.D. Stainless Steel, Type 304, Schedule 10 Sump: 270.0 - 272.0 ft	
3/8-in Bentonite Pellets: 274.0 - 277.8 ft	
8-12 Mesh Colorado Silica Sand (Backfill): 227.8 - 346.0 ft	



All depths are in feet below ground surface.

Borehole drilled with 13-in threaded casing 0-198.5 ft and 10¾-in threaded casing 198.5-346 ft

All temporary drill casing was removed from the ground.

GEOLOGIC/HYDROLOGIC DATA

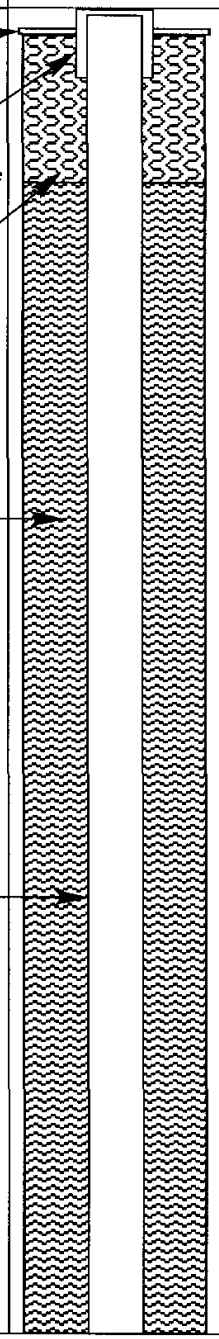
Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
270		
		277 Water Sample HEIS: B1PM54, B1PM82
280		
290		
300		
		307 Water Sample HEIS: B1PM55 & B1PM83
310		310-335 Sandy Gravel, sG
320		
330		
		335-340 Gravel, G
340		340-346 Sandy Gravel, sG
		346 Water Sample HEIS: B1PM56 & B1PM84
		346 Total Depth (01/21/2008)
350		

Figure D-5. Well 699-33-75 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 01/31/08 Finish Date: 03/27/08	Page 1 of 4
Well ID: C4976	Well Name: 699-33-76	
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Garcia Date: 4/21/08	Reviewed By: L.J. Walker	Date: 6/5/08
Signature:	Signature:	

CONSTRUCTION DATA

Description	Diagram
6-in Concrete Pad	
6-in I.D. Type 304/304L Stainless Steel Protective Casing: +2.42 ft above Ground Surface	
Portland Cement Type I/II: 0 - 10.0 ft	
Granular Bentonite Crumbles: 10.0 - 206.8 ft	
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.42 - 222.0 ft	
All depths are in feet below ground surface.	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-2 Gravel, G (Fill)
		2-35 Silty Sand, mS
10		
20		
30		
		35-70 Sandy Silt, sM
40		
50		
60		
70		70-78 Gravely Sandy Silt, gsM
80		78-100 Sandy Silt, sM

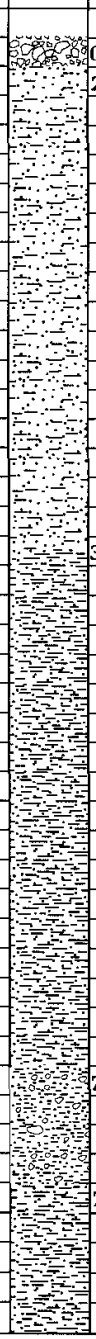


Figure D-6. Well 699-33-76 Construction and Completion Summary

WELL SUMMARY SHEET	Start Date: 01/31/08 Finish Date: 03/27/08	Page 2 of 4

Well ID: C4976	Well Name: 699-33-76
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.
Prepared By: Erika Garcia — Date: 4/21/08	Reviewed By: L.D. Walker — Date: 6-5-08
Signature: G.L. Kasza	Signature:

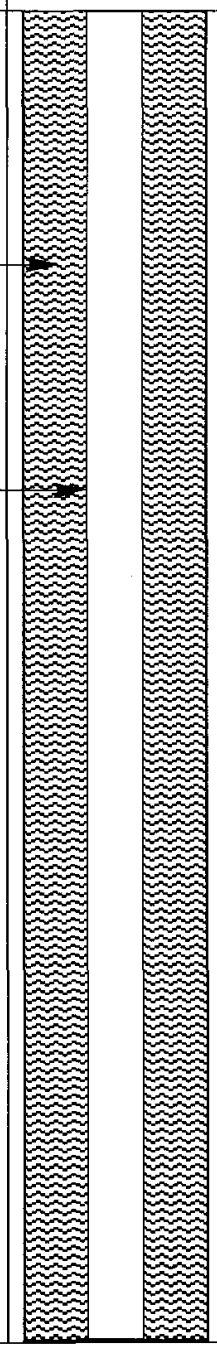
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
Granular Bentonite Crumbles: 10.0 - 206.8 ft		90		
		100		100-160 Silty Sand, mS
		110		
4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.42 - 222.0 ft		120		
		130		
		140		
		150		
		160		160-165 Sand, S
				165-170 Gravely Silty Sand, gmS
		170		175-200 Sandy Gravel, sG
All depths are in feet below ground surface.				

Figure D-6. Well 699-33-76 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 01/31/08 Finish Date: 03/27/08	Page 3 of 4
Well ID: C4976	Well Name: 699-33-76	
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Garcia — Date:4/21/08	Reviewed By: L.D. Walker — Date: 6-5-08	
Signature: G.L. Kasza	Signature:	

CONSTRUCTION DATA

Description

Granular Bentonite Crumbles: 10.0 - 206.8 ft

4-in I.D. Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: +1.42 - 222.0 ft

3/8-in Bentonite Pellets: 206.8 - 212.4 ft

Static Water Level: 222.75 ft bgs (03/17/2008)

Primary Filter pack 10-20 Mesh Colorado Silica Sand: 212.4 - 261.3 ft

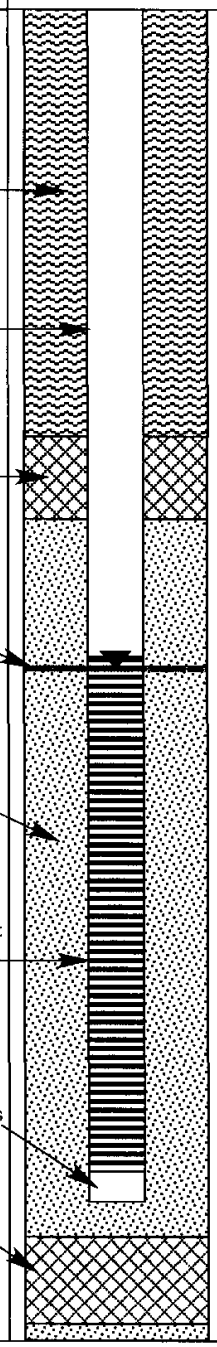
4-in I.D. Stainless Steel, Type 304, Slot 20 (.020-in) Screen: 222.0 - 257.0 ft bgs

4-in I.D. Stainless Steel, Type 304, Schedule 10 Sump: 257.0 - 259.0 ft bgs

3/8-in Bentonite Pellets: 261.3 - 267.2 ft

All depths are in feet below ground surface.

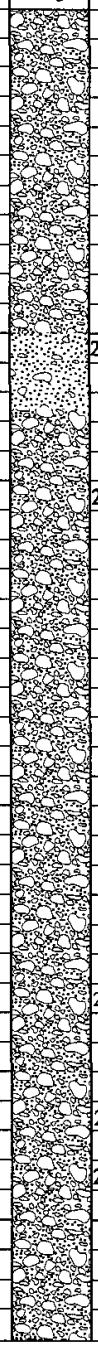
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

200-205 Gravely Sand, gS

205-342.4 Sandy Gravel, sG

243 Water Sample HEIS: B1PM61 & B1PM89

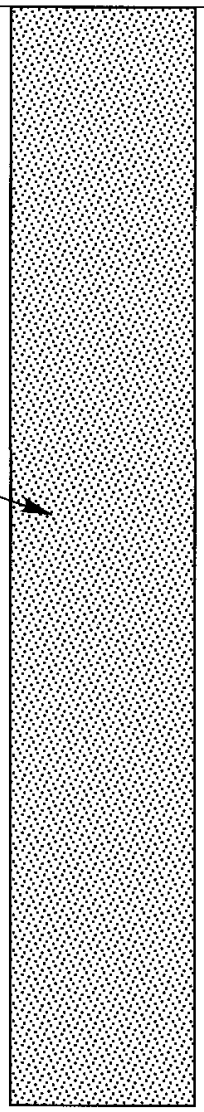
252.5-255 Split-Spoon for Sieve Analysis

257-280 Silt Sandy Gravel, msG

Figure D-6. Well 699-33-76 Construction and Completion Summary (continued)

WELL SUMMARY SHEET	Start Date: 01/31/08 Finish Date: 03/27/08	Page 4 of 4
Well ID: C4976	Well Name: 699-33-76	
Location: 1/2 mile SW of S-plant	Project: Monitoring Wells for the UP-1 O.U.	
Prepared By: Erika Garcia — Date: 4/21/08	Reviewed By: L. D. Walker — Date: 6/5/08	
Signature: G. L. Kasza	Signature:	

CONSTRUCTION DATA

Description	Diagram
10-20 Mesh Colorado Silica Sand (Backfill): 267.2 - 342.4 ft	

All depths are in feet below ground surface.

Borehole drilled with 11¾-in threaded casing 0-205 ft and 9⅝-in threaded casing 198-344 ft

All temporary drill casing was removed from the ground.

GEOLOGIC/HYDROLOGIC DATA

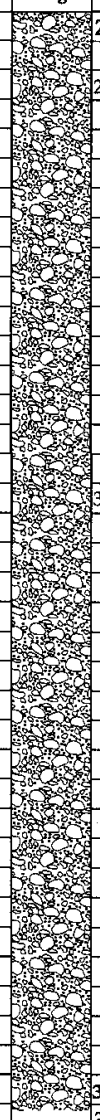
Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
270		205-342.4 Sandy Gravel, sG
		273 Water Sample HEIS: B1PM62 & B1PM90
280		
290		
300		302 Water Sample HEIS: B1PM63 & B1PM91
310		
320		
330		
340		342.4 Water Sample HEIS: B1PM64 & B1PM92
		342.4 Total Depth (03/17/2008)
350		

Figure D-6. Well 699-33-76 Construction and Completion Summary (continued)

D2 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/.

This page intentionally left blank.

Appendix E

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

This page intentionally left blank.

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.

This page intentionally left blank.

Appendix F

Groundwater Flow and Migration Calculations to Support Assessment of the 216-S-10 Pond and Ditch Monitoring Network – ECF-200W-17-0077

This page intentionally left blank.

The calculation ECF-200W-17-0077, *Groundwater Flow and Migration Calculations to Support Assessment of the 216-S-10 Pond and Ditch Monitoring Network*, was performed to evaluate monitoring well locations for the 216-S-10 Pond and Ditch groundwater monitoring network. The calculation is available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065096H.

This page intentionally left blank.

Appendix G

Statistical Method Determination

This page intentionally left blank.

Contents

G1 Introduction G-1

G2 References G-10

Figures

Figure G-1. Data Evaluation G-2
Figure G-2. Outlier Test Evaluation G-3
Figure G-3. Intrawell/Interwell Assessment G-4
Figure G-4. Spatial Variance Evaluation G-5
Figure G-5. Data Distribution Evaluation G-6
Figure G-6. Temporal Trend Analysis G-7
Figure G-7. Equal Variance Evaluation G-8
Figure G-8. Chart Legend G-9

This page intentionally left blank.

G1 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, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*) 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 G-1 through G-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 G-8 provides a chart legend applicable to Figures G-1 through G-7.

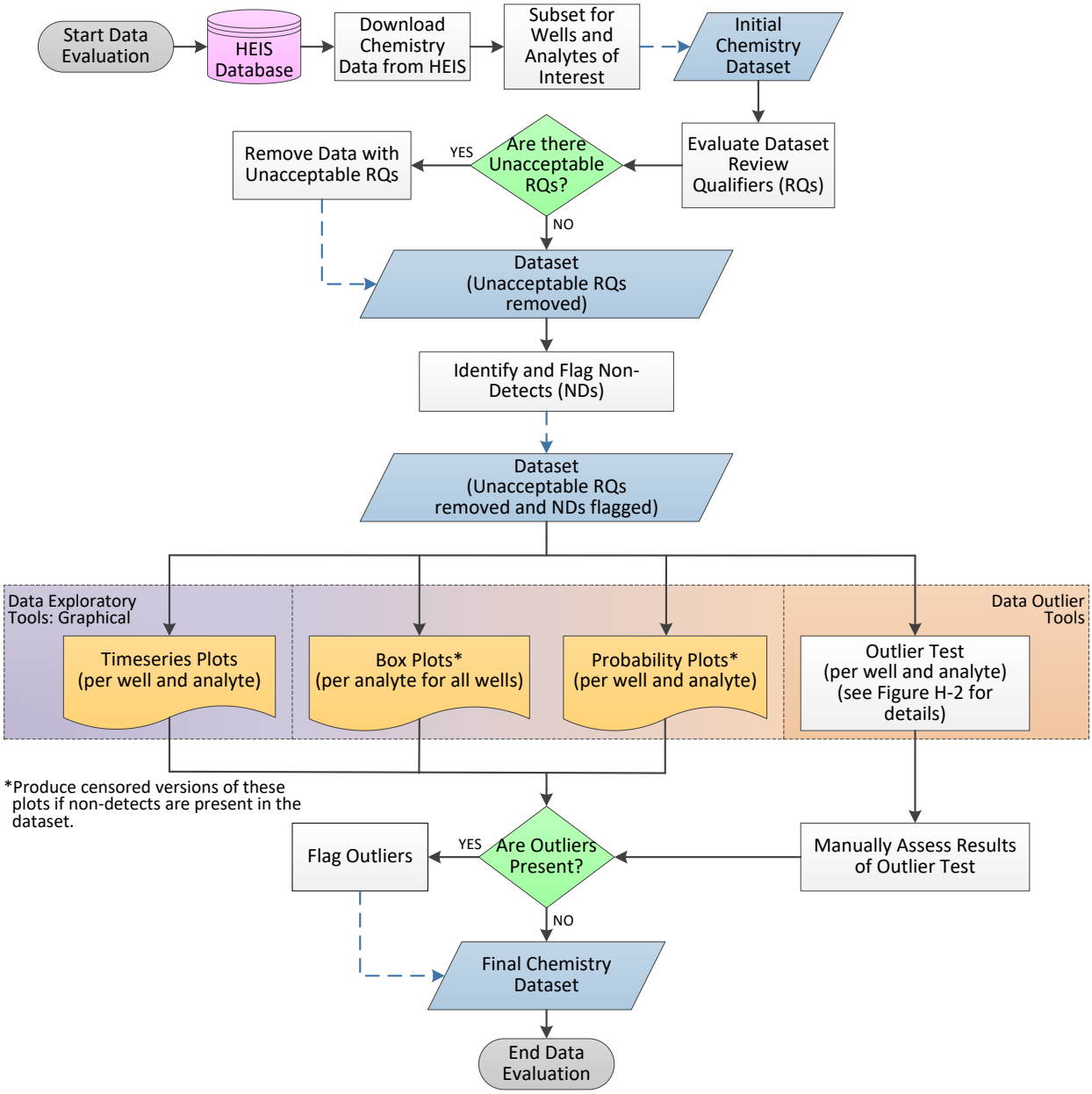


Figure G-1. Data Evaluation

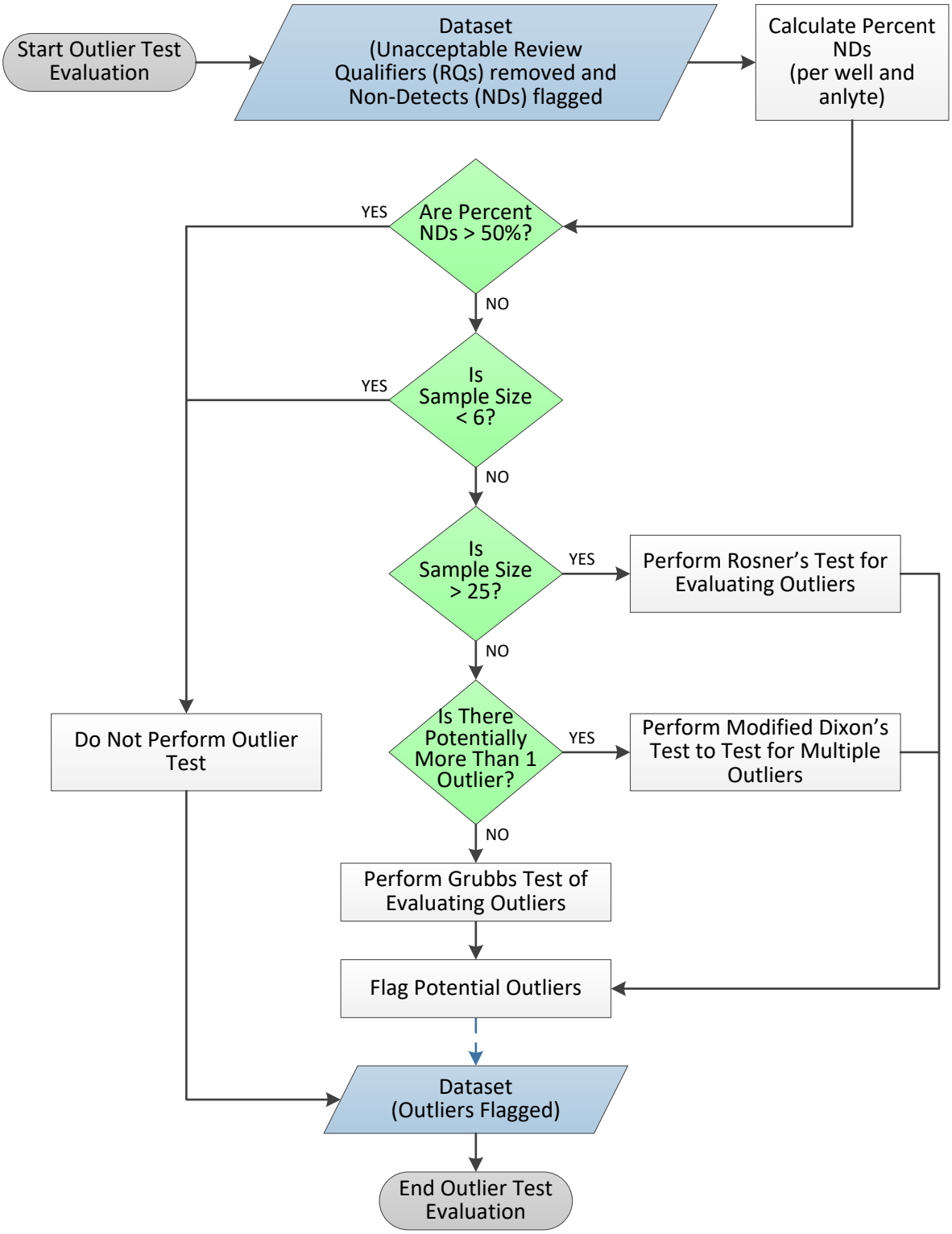


Figure G-2. Outlier Test Evaluation

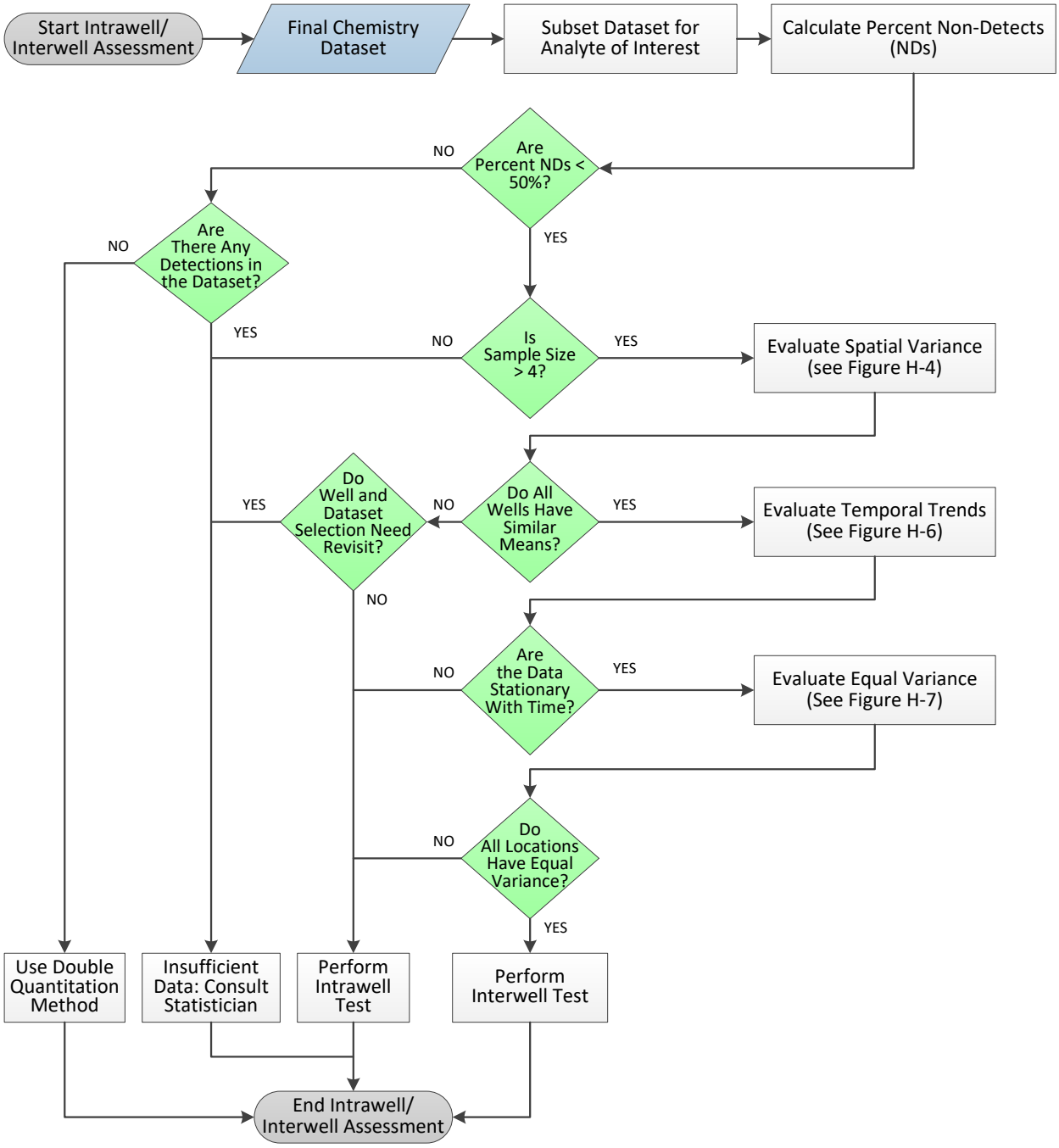


Figure G-3. Intrawell/Interwell Assessment

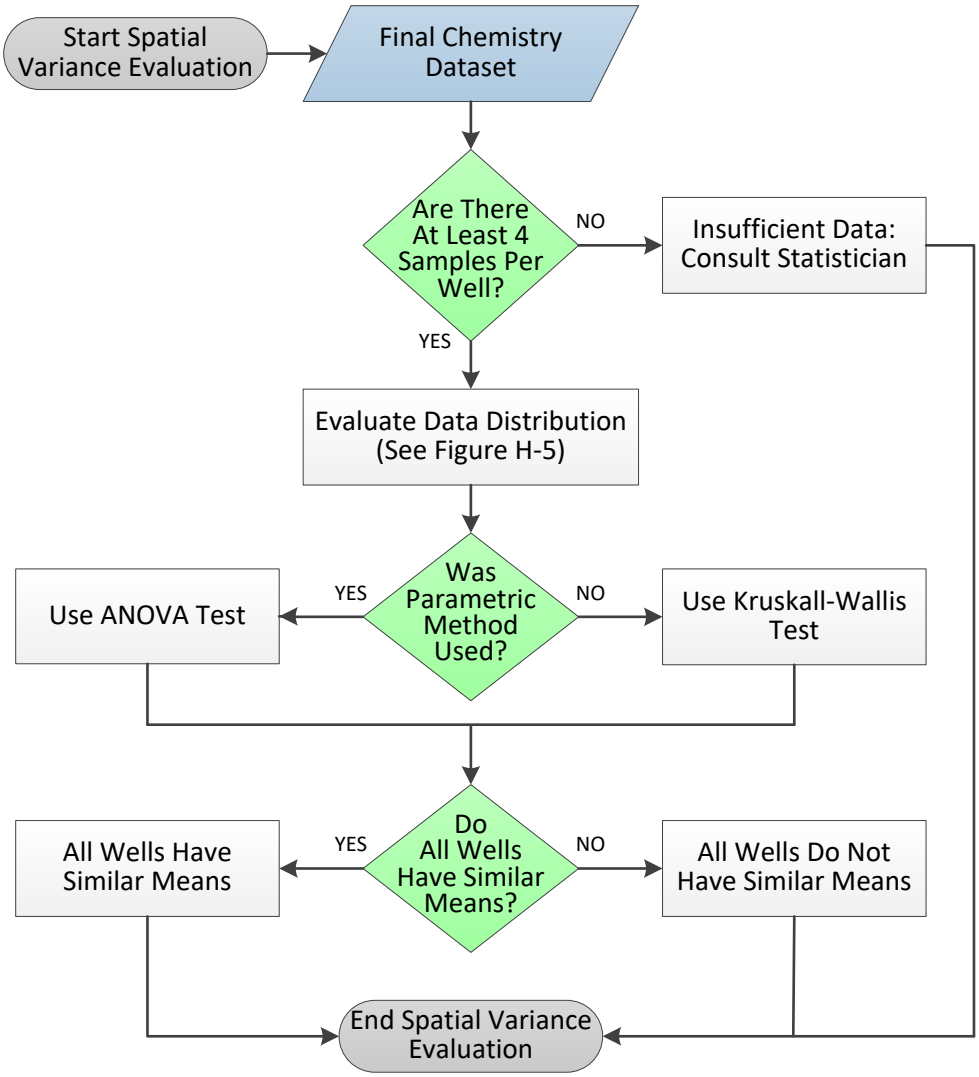


Figure G-4. Spatial Variance Evaluation

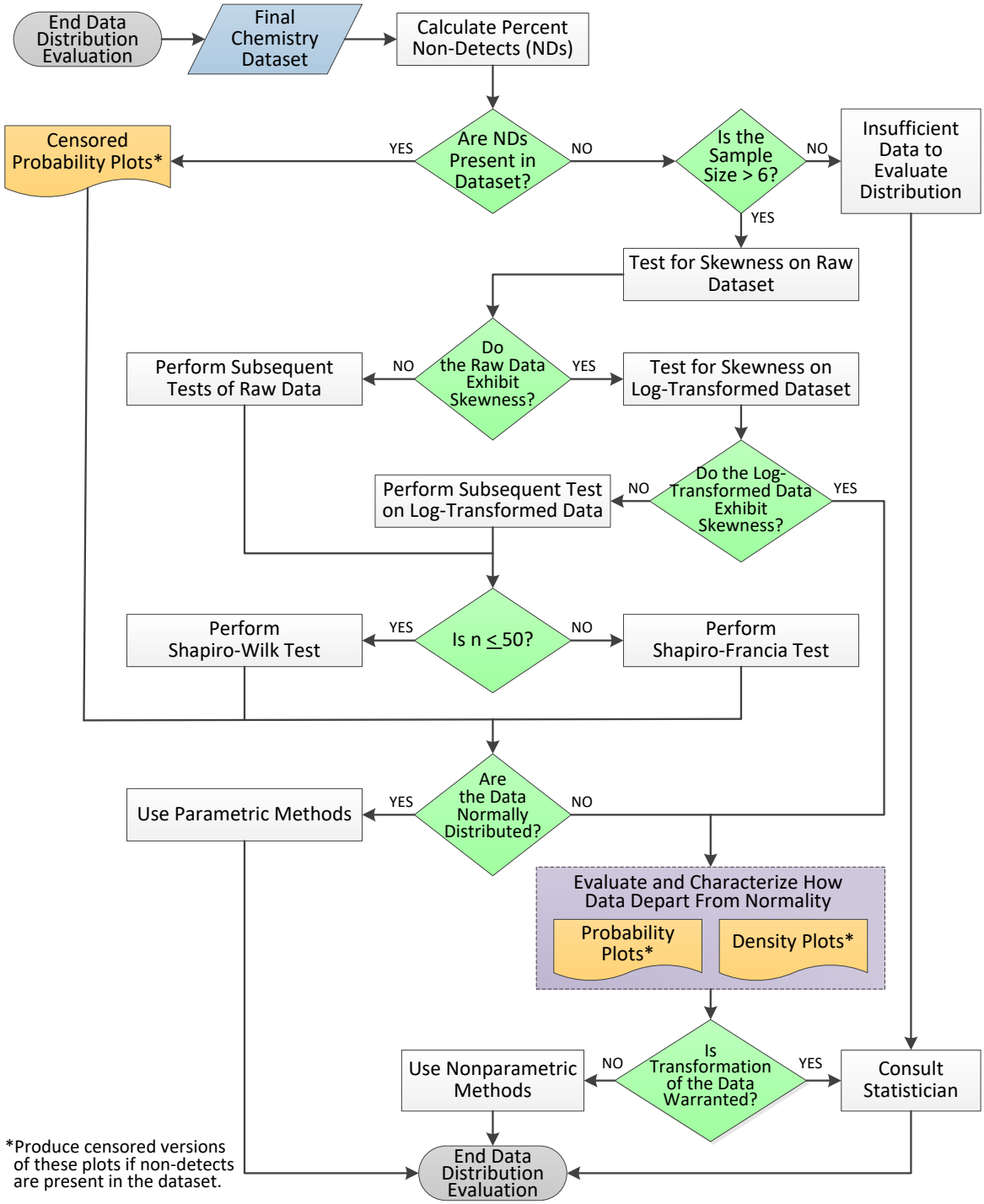


Figure G-5. Data Distribution Evaluation

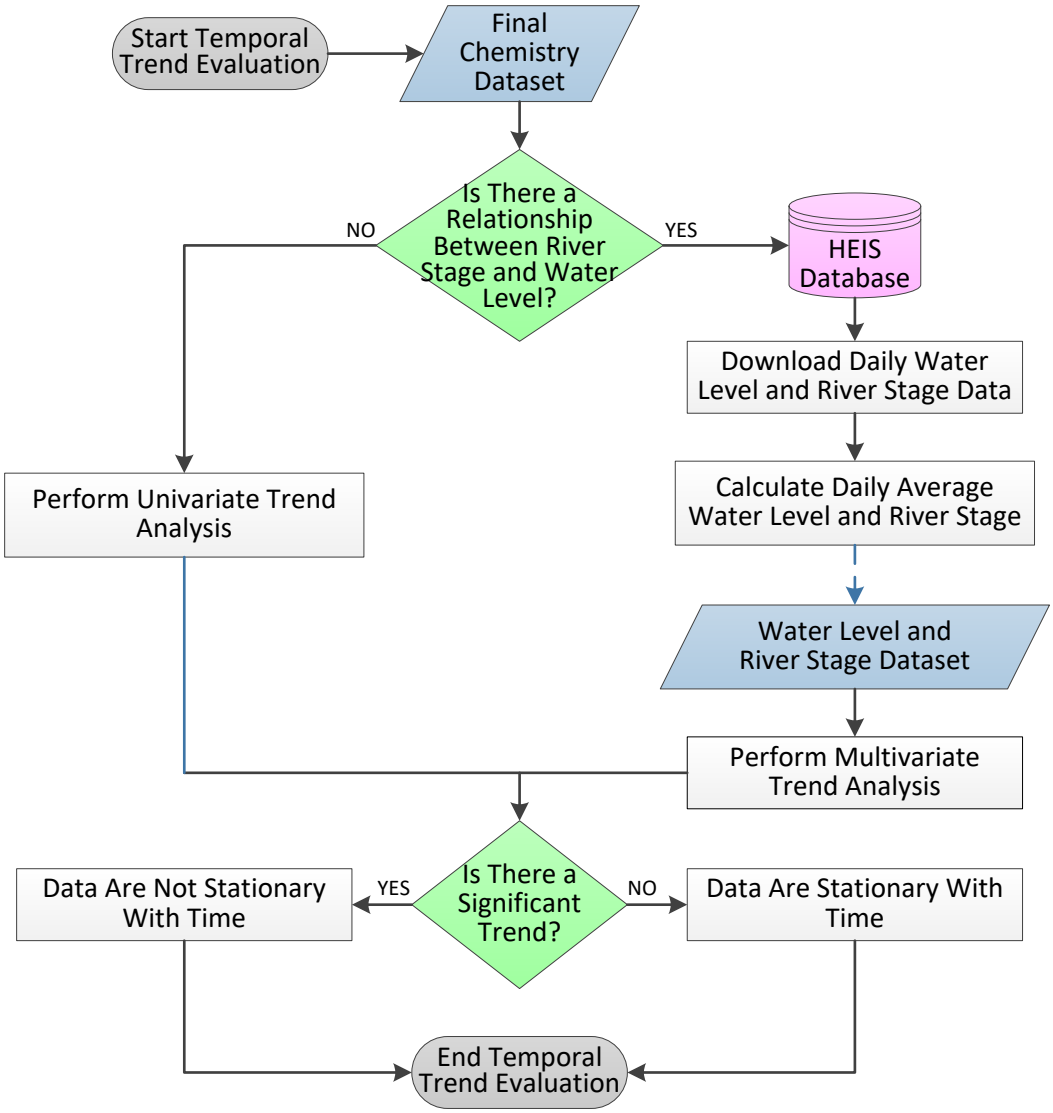


Figure G-6. Temporal Trend Analysis

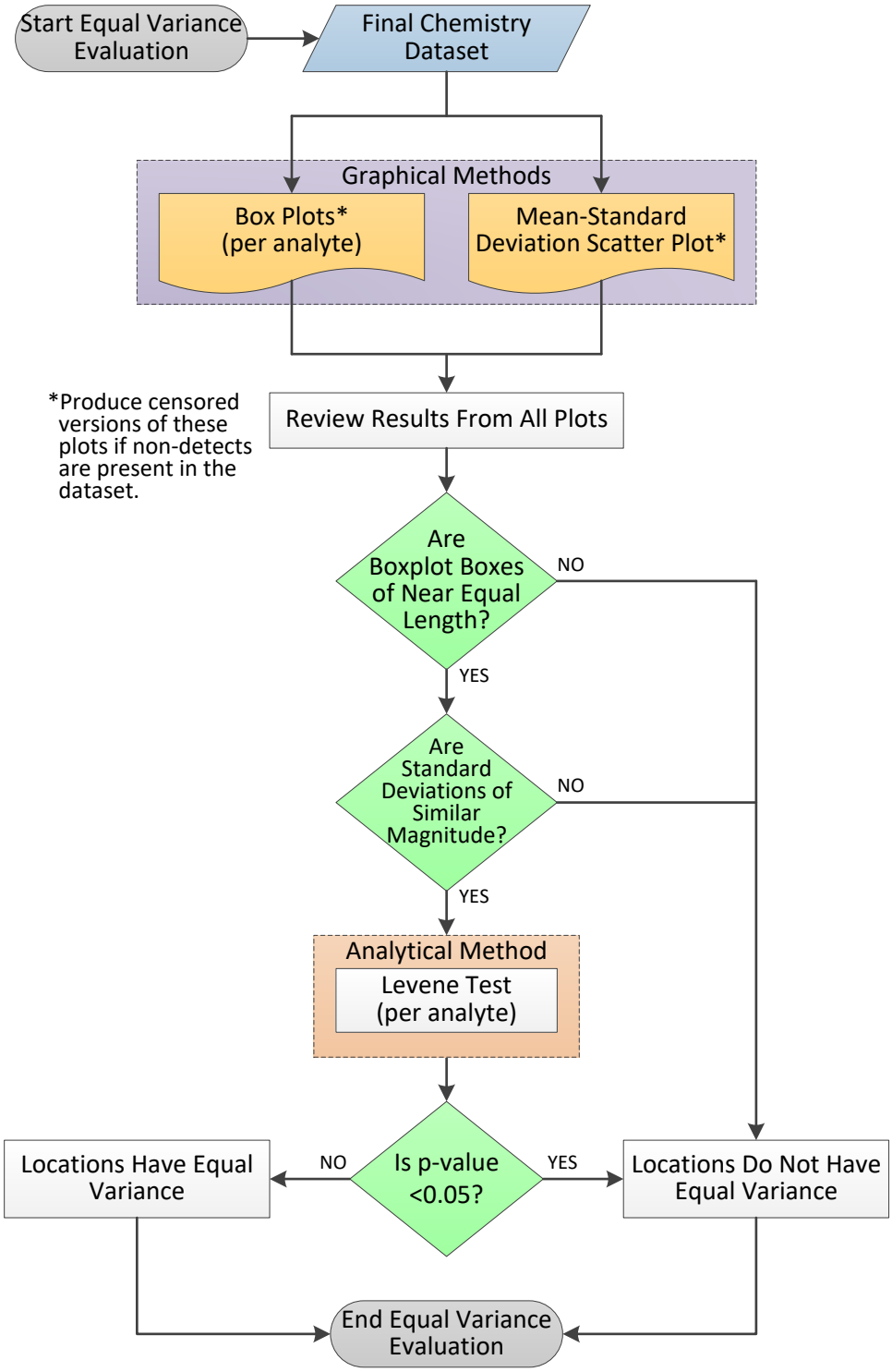


Figure G-7. Equal Variance Evaluation

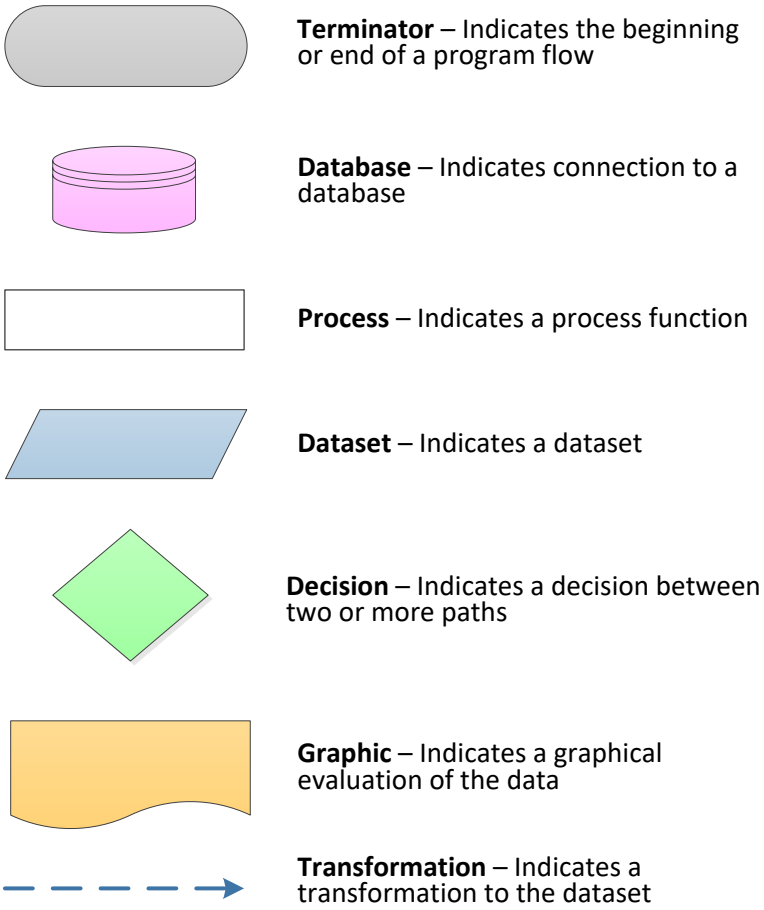


Figure G-8. Chart Legend

G2 References

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/publications/97407.pdf.

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